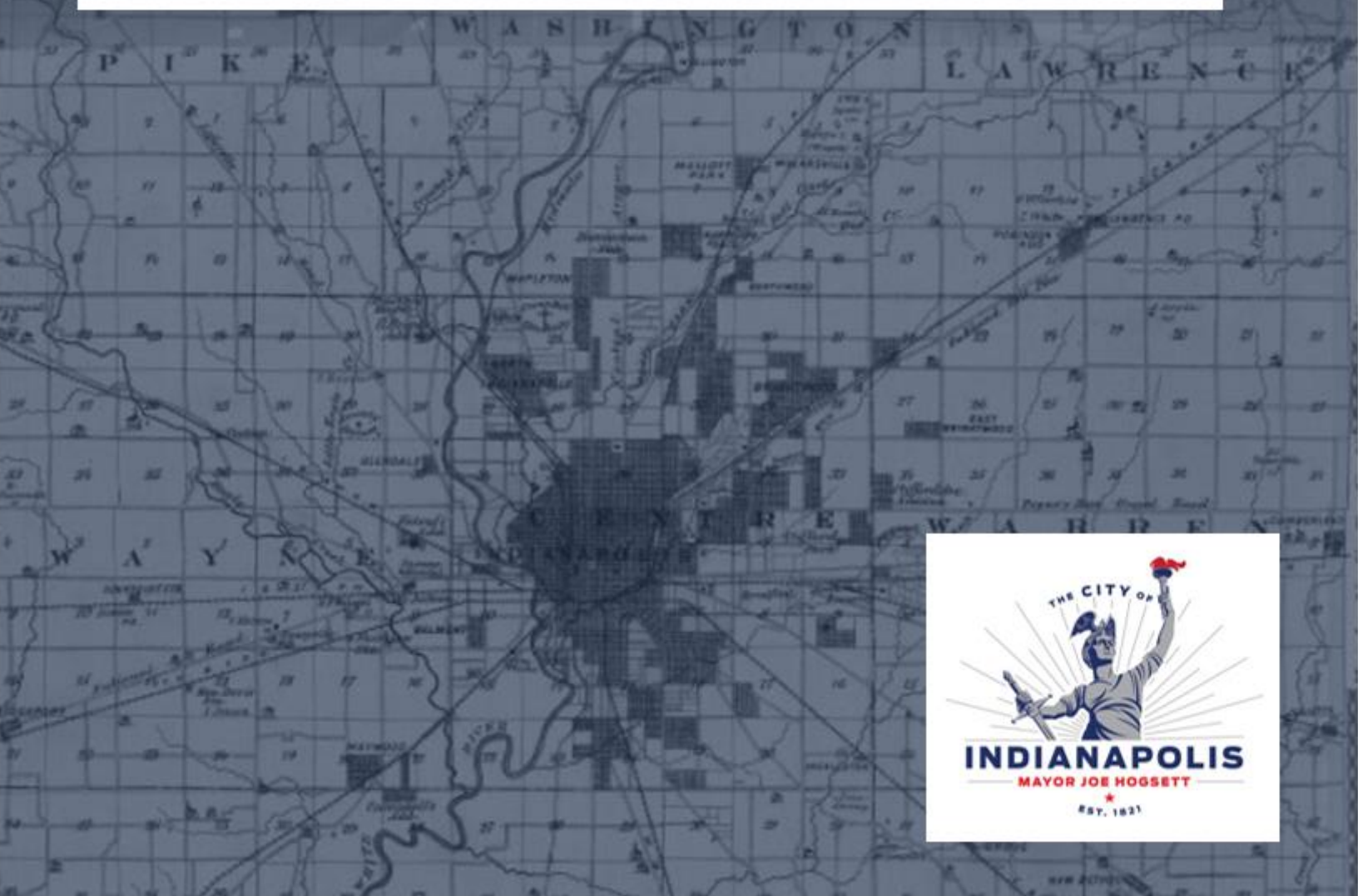
ARCADIS Design & Consultancy for natural and built assets

MARION COUNTY, IN 2018 MULTI-HAZARD MITIGATION PLAN



THE CITY OF INDIANAPOLIS
MAYOR JOE HOGSETT
EST. 1821

2018 MULTI-HAZARD MITIGATION PLAN

PREPARED BY:

ARCADIS Design & Consultancy for natural and built assets

150 West Market Street
Indianapolis, IN 46204

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PREPARED FOR:

Marion County, Indiana
City of Indianapolis, Indiana
City of Beech Grove, Indiana
City of Lawrence, Indiana
Town of Speedway, Indiana
City of Southport, Indiana

PREPARED WITH FUNDING FROM:

City of Indianapolis/Marion County Office of Sustainability
Department of Homeland Security
200 East Washington Street, Suite 2460
Indianapolis, IN 46204

THRIVE INDIANAPOLIS:

This document is part of a series being produced under the heading of *Thrive Indianapolis*, an effort to help the City of Indianapolis and Marion County become more sustainable and resilient in the face of all threats, shocks, stressors, and opportunities.

Date: July 2018

July 6, 2018

Dear Fellow Indianapolis Residents:

In Indianapolis, the threat of flooding, high winds, tornadoes, and more are real—but with solid plans in place, we can ensure we do all we can to mitigate these disasters and provide the best possible protections for our residents. To meet these needs, I am pleased to present an updated Multi-Hazard Mitigation Plan (MHMP), a vital guide to local agencies to help keep our city safe and thriving.

The 2018 Marion County MHMP was prepared in conjunction with *Thrive Indianapolis;* the City's first ever Sustainability and Resilience Action Plan to guide and support local agencies. During its development process, the project team and stakeholder group collected data, evaluated the greatest hazards to Marion County, and developed mitigation goals and practices that will contribute to community-wide resilience.

Here in our city, we know that real progress only happens as long as we work collaboratively. The challenges we face may be great, but the MHMP does not just cover reactionary measures—it provides holistic, preventative solutions that will be long-lasting, ensuring we set up residents young and old with a bright and healthy future.

Each of the hazards and actions outlined in this report have been carried forward into *Thrive Indianapolis*. I encourage you to visit www.ThriveIndianapolis.com for additional information.

The integration of sustainability and resilience into the disaster preparedness process makes our community stronger and safer for all—thank you for joining me as we act today in order to invest in tomorrow. I look forward to working with you as we achieve these goals.

Warm regards,

Joe Hogsett

Joe Hogsett
Mayor
City of Indianapolis

History has shown that Marion County faces a variety of environmental hazards that can have adverse effects on our community. Flooding, high winds, thunderstorms, tornadoes, and hazardous material incidents all pose a risk to the health and safety of residents, economic vitality of the community, and quality of the natural environment. With this in mind, we have updated the Marion County Multi-Hazard Mitigation Plan (MHMP) so as to ensure the best preparation for the potential consequences of such events.

The updated MHMP will serve as a guide to local agencies' efforts to protect county residents and is centered around two cross-cutting themes: climate change and social vulnerability. By addressing social vulnerability, the MHMP brings attention to the fact that the neighborhoods least equipped to handle the effects of catastrophic events often faces more consequences than affluent neighborhoods. Through the empowerment of these neighborhoods, our cumulative response capacity is strengthened.

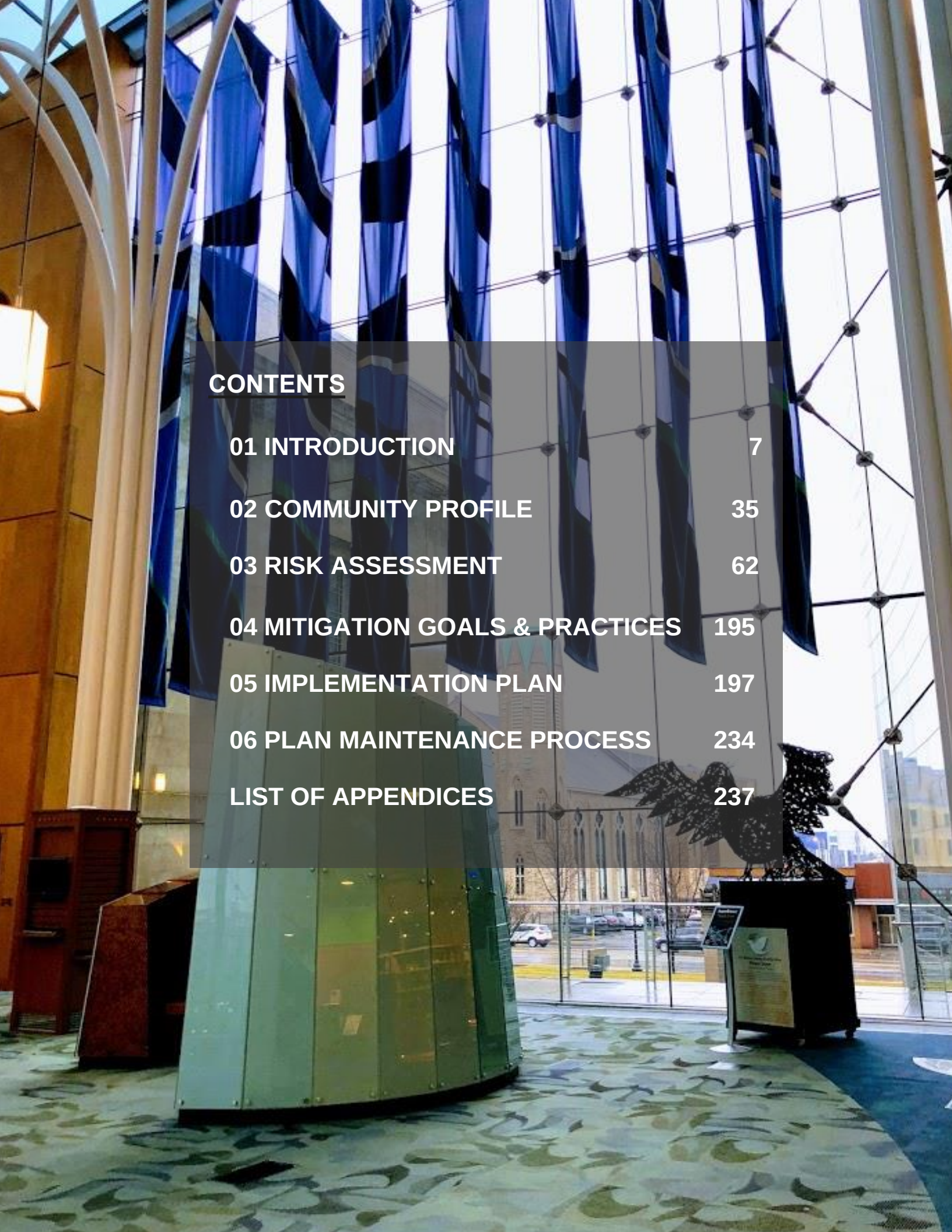
Reflected in the theme of climate change, five new hazards have been added to the MHMP: Air Quality, Increased Heat Waves, Urban Heat Island, Increased Precipitation, and Regional and National Displacement. Through the identification of these hazards, the MHMP is able to preemptively identify risks and the appropriate hazard mitigation projects that will reduce damage to homes, businesses, schools, and county infrastructure.

The 2018 Marion County MHMP stands as a cornerstone of the *Thrive Indianapolis* collaborative movement. Led in part by the City of Indianapolis Office of Sustainability, the development of this update was the result of coordination between city and county agencies, excluded cities, and local citizens. As a result, the MHMP will provide for the protection and empowerment of all Marion County neighborhoods and lead our community as we maintain responsible environmental risk management policies for years to come.

Katie Robinson

Katie R. Robinson

Director, Office of Sustainability
City of Indianapolis



CONTENTS

Gary Scott Coons

Indianapolis, Indiana
Jan 15, 1972 – May 13, 2018

This 2018 Multi-Hazard Mitigation Plan is dedicated to the memory of former Chief of Indianapolis Homeland Security, Gary Coons. Gary dedicated his professional life to serving the people and communities of Marion County. Gary was a key architect of this 2018 Multi-Hazard Mitigation Plan and the Thrive Indianapolis project. He experienced firsthand the chronic and acute challenges faced by the people he served and their strength in the face of those challenges. Gary's spirit and dedication to the people of Marion County lives on through this plan to improve the quality of life for all Marion County residents.

ACRONYMS AND ABBREVIATIONS

ACS	American Community Survey: U.S. Census Bureau
CERLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CRS	Community Rating System
CSO	Combined Sewer Overflows
DHS	Department of Homeland Security
DMA 2000	Federal Disaster Mitigation Act of 2000
F	Fahrenheit
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
IU	Indiana University
IUPUI	Indiana University – Purdue University – Indianapolis
MHMP	Multi-Hazard Mitigation Plan
NIBS	National Institute of Building Sciences
NFIP	National Flood Insurance Program
NPL	National Priority List
O&M	Operations and Maintenance
OoS	Office of Sustainability
PDM	Pre-Disaster Mitigation
PTSD	Post-traumatic Stress Disorder
RFC	Repetitive Flood Claims
RLP	Repetitive Loss Properties
SFHA	Special Flood Hazard Areas
SRAP	Indianapolis' Sustainability and Resilience Action Plan

EXECUTIVE SUMMARY

Like all communities, Marion County faces a variety of hazards that pose a risk to the health and safety of residents, economic vitality of the community, and quality of the natural environment. Historical experience has demonstrated that the county and its municipalities can be affected by flooding, high winds associated with thunderstorms, tornados, hazardous material incidents and many other hazards. To prepare for the potential impacts of these hazards, Marion County has updated the Multi-Hazard Mitigation Plan (MHMP) to guide local agencies' efforts to protect the health and welfare of the county and its residents.

Substantial updates to the MHMP include **the addition of five hazards and two cross cutting themes**. The five new hazards are Air Quality, Increased Heat Waves, Urban Heat Island, Increased Precipitation, and Regional and National Displacement. The cross-cutting themes are climate change and social vulnerability. In many cases, the neighborhoods least equipped to handle the effects of catastrophic events face more consequences than if the same hazard impacted a more affluent neighborhood. Empowering our most vulnerable residents goes beyond emergency preparedness – it is part of a holistic effort to protect the county from chronic stressors that create social vulnerabilities, reducing capacity and resilience.

Marion County's MHMP identifies natural, technological, and human-made hazards and assesses their potential impacts on the county's people, assets, and critical facilities. Based on the identified hazards and corresponding risk assessments, the MHMP proposes appropriate hazard mitigation projects to reduce damage to homes, businesses, schools, and government offices within the county. Hazard mitigation is the only phase of emergency management specifically intended to break the cycle of damage, reconstruction, and repeated damage.

The 2018 Marion County MHMP is a foundational element of Thrive Indianapolis – an effort to ensure that the City of Indianapolis and Marion County is prepared for current and future shocks and stressors. The development of this update to the Marion County MHMP was the result of coordination between city and county agencies, excluded cities and towns, and local citizens. This collaborative effort was led by the City of Indianapolis Office of Sustainability, Office of Public Health and Safety, Indianapolis Metropolitan Police Department, and the IMPD Homeland Security Bureau.

01 INTRODUCTION

Hazards are a reality in the world around us. The types of hazards relevant to any given place are dependent on geography and on the capabilities of the people and infrastructure systems in that location. The Marion County 2018 Multi-Hazard Mitigation Plan (MHMP) addresses 15 different hazards as shown on Figure 1-1. There are also two cross-cutting themes which are considered with respect to each hazard:

- Climate change and its impact on the frequency and severity of these hazards is explored.
- Social vulnerability is considered in respect to how to align emergency management and hazard mitigation with broader goals of supporting safe and thriving Marion County residents, particularly vulnerable populations.

Figure 1-1: 15 Hazards in 2018 MHMP Update

This plan is a component in a larger system of plans shown in Figure 1-2. In particular, it is a major component of the City's *Thrive Indianapolis* initiative, an effort to ensure the City and County are investing in strategies that will create a more sustainable and resilient future for all.

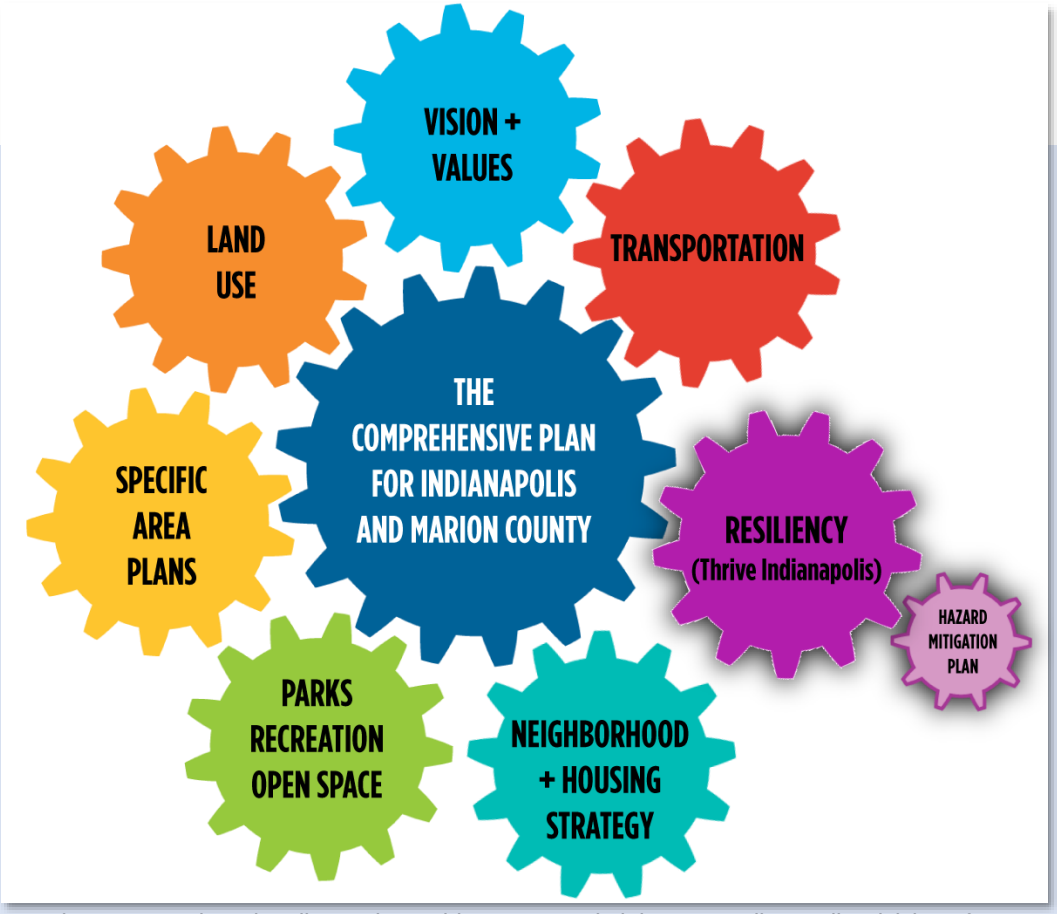


Figure 1-2: Marion County Plans (credit: Brad Beaubien, AICP, Administrator, Indianapolis Division of Long Range Planning). The gears illustrate how each plan is a "gear" in the system, where, changes in one part of the system must be considered in other parts.

In addition to the plans shown on Figure 1-2, numerous additional plans have been developed by the Indianapolis Department of Homeland Security (DHS), which are relevant to the MHMP. The Comprehensive Emergency Management Plan (CEMP) should be considered a companion plan to this MHMP and every effort should be made to integrate these documents by the City during development. The CEMP provides extensive guidance on the response by governmental and non-governmental organizations to emergencies, including situations which arise from natural hazards covered in this MHMP.

PLAN OVERVIEW

This MHMP is organized to mirror the planning process for its creation, to communicate numerous risks, and to provide actions to prevent and prepare for future shocks and stressors. Chapter 1 provides a general introduction and describes the organization of the document and how it was created through stakeholder engagement and community outreach.

Marion County is vulnerable to a large range of both acute and chronic hazards, ranging from winter storms and tornadoes to the displacement of people. These hazards present challenges to the community and thus, the likelihood of the hazards occurring must be considered in tandem with the impacts of those hazards. These challenges are magnified for a range of vulnerable populations in Marion County, especially those with less economic means and those with pre-existing health conditions. For disadvantaged populations, a hazard can quickly become a disaster. Chapters 2 and 3 include a Social Vulnerability Index that explores community risk indicators, which are important components to the County's full risk assessment.

Chapters 3 and 4 describe the hazard and their associated consequences. Each of the 15 hazard profiles includes recent occurrences and assessment of risks, with continued consideration of two cross-cutting themes: social vulnerability and climate change.

Chapters 5 and 6 explore the many types of mitigation measures available to help minimize impacts from hazardous events and identify strategies to enhance community-wide resilience. These strategies fall into several categories: prevention, property protection, natural resource protection, public education and awareness, emergency services, and structural projects. A table of 58 actions integrates specific strategies which were compiled via stakeholder engagement. Each action references linkages to City and County plans and identifies key and supporting implementers and potential funding sources. These distinctions are key to making this MHMP actionable and solution-oriented. It is recommended that Indianapolis continue to build community awareness and engagement while ensuring consistency between departments and divisions in how to prepare for and mitigate hazardous events.

Chapter 1

Planning Process: for a **Safe and Thriving** Marion County

Chapter 2

Community Profiles: **Strong and Connected**

Chapter 3

Hazard Profiles: **Metrics for Sensitivity to Risk**

Chapter 4

Mitigation Goals: **A Prepared and Responsive County**

Chapter 5

Plan Maintenance: **Collaboration** to maximize adaptive capacity

Chapter 6

Implementation Plan: **Actionable and Data-Driven**

FEMA Definition of Hazard Mitigation:

"Any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards."

APPROACH: STRATEGIC & COST-EFFECTIVE PRIORITIZATION

The magnitude and frequency of natural hazards, such as winter storms or tornadoes, are largely out of people's control. However, the County can plan for and prepare to reduce the consequences and the risks that could occur when a hazardous event takes place. Improved preparedness can prevent a hazard from becoming a disaster. Adaptive capacity to extreme events is increased by augmenting community resources and cultivating a culture of preparedness. The concept of reducing consequences, and ultimately risks, is at the heart of hazard mitigation.

To effectively prioritize risk reduction measures, it is vital to compare the costs and benefits of the actions to the cost of doing nothing. Planners must also take co-benefits into account to maximize protection and return on investment. Figure 1-3 illustrates the findings of a recent report which showed that for every one dollar spent on disaster mitigation, six dollars of costs were avoided (e.g., from disaster recovery), according to the National Institute of Building Sciences' Natural Hazard Mitigation Saves: 2017 Interim Report.

A comprehensive review of funding opportunities to support mitigation measure implementation will be completed as part of the Thrive Indianapolis project.

Rainfall in July of 2015 broke the 1875 record, making it the wettest month on record for Indianapolis. The 2018 Indiana Climate Change Impacts Assessment indicates more precipitation is falling in Indiana. The 2013 Multi-Hazard Mitigation Plan ranked **flooding and dam/levee failure as two of the top three potential hazards** (tornadoes are the third). Within the **current** flood hazard area, there are over 28,000 structures, including 177 critical facilities (three hospitals, 11 emergency response facilities, and 40 schools). Potential damages to these structures range from $500,000,000 for those in floodways to nearly $7 billion for facilities within the 500-year floodplain.

A 2017 analysis of federally funded hazard mitigation grants demonstrated that mitigation funding can save the United States $6 of future disaster costs for every $1 invested in mitigation.

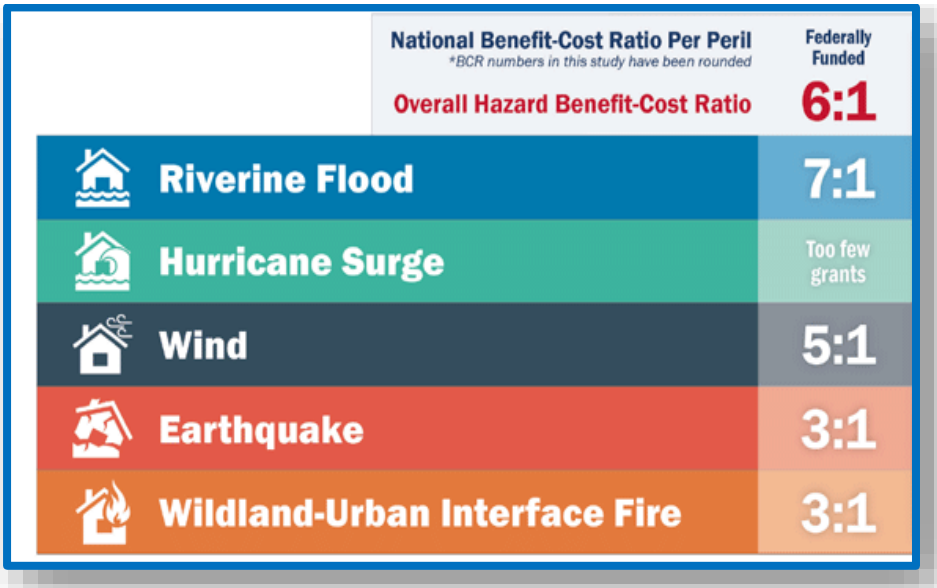


Figure 1-3: Benefit-Cost Ratio by Hazard (source: www.nibs.org/page/mitigationsaves)

To facilitate readers' review of the document, short descriptions of the specific regulations from 44 CFR 206[1] are included in the relevant sections, beginning with (CFR) 201.6(d)(3) below.

44 Code of Federal Registration (CFR) 201.6(d)(3)
A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within 5 years in order to continue to be eligible for mitigation project grant funding.

LOCAL JURISDICTION REVIEW

This community-based local hazard mitigation plan establishes a vision, goals, and path forward for the communities of Marion County to avoid and reduce risks presented by hazards that may occur in the County and to improve the quality of life for its citizens. This update is a multi-jurisdictional planning effort led by the City of Indianapolis, the City of Beech Grove, the City of Lawrence, the Town of Speedway, and the City of Southport. Representatives from these communities attended the stakeholder meetings, provided valuable information, reviewed and provided comments on the draft document, and assisted with local adoption of the approved

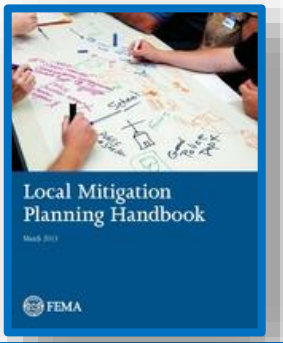
[1] Title 44 – Emergency Management and Assistance, Part 206 Federal Disaster Assistance

MHMP. Each of the communities had an equal opportunity to participate in the planning process. Therefore, the process to update the Marion County MHMP satisfies the requirements of DMA 2000 in which multi-jurisdictional plans may be accepted.

Project Scope and Purpose

This plan is an update to the 2013 Marion County MHMP. Throughout the document, the major hazards that could affect Marion County are evaluated, progress on ongoing hazard mitigation efforts in the County is reviewed, new actions that will help us prepare for existing and projected future risks are presented, and techniques for how the County will maintain the plan and the public engagement that went into its creation are established. The 2018 MHMP update expands on the 2013 plan by integrating at climate change and a series of other chronic stressors that impact the County's ability to create a resilient and sustainable community. This plan is designed to integrate with a number of other planning processes and activities unfolding in the region, thereby helping to ensure that the plan translates into real-world actions that build the region's resilience to natural hazards, climate change, and socio-economic stressors.

This Marion County MHMP was prepared in accordance with guidelines set forth by Indiana DHS and FEMA, including but not limited to, FEMA Local Multi-Hazard Mitigation Planning Guidance and 44 CFR 201.6. The process also followed the Community Rating System (CRS) 10–step planning process as required for communities participating in the CRS.



The **purpose** of the MHMP update is to:

- Update the existing MHMP to demonstrate progress and reflect current conditions;
- Increase public awareness and education of hazards and hazard mitigation;
- Maintain grant eligibility for participating jurisdictions;
- Update plans in accordance with Community Rating System requirements;
- Maintain compliance with state and federal legislative requirements for local hazard mitigation plans;
- Identify specific actions that will/can be implemented to reduce the likelihood and severity of hazards; and
- Identify specific actions that will/can enhance the community's resilience.

Planning Process

44 CFR 201.6(c)(1)
Documentation of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

The steps involved in creating the 2018 MHMP included:

1) Creating a Task Force (the MHMP Task Force);
2) Hosting a project kickoff meeting;
3) Developing an outreach strategy to engage the public, elected officials, and others in the planning process (described in detail in *Appendix A - Public Outreach)*;
4) Facilitation of two regional planning team meetings, in March and April of 2018;
5) Conducting targeted outreach to the public and elected leaders, with presentations to Councils for all jurisdictions;
6) Refining the plan based on public feedback; and
7) Documenting the full planning process. More detailed information about the planning process, including meeting notes and stakeholder attendee sheets can be found in *Appendix A - Public Outreach*.

The mitigation plan belongs to the local community. To ensure this, the following guiding principles were adopted:

1. **Focus on the mitigation strategy:** the plan's primary purpose.
2. **Process is as important as the plan itself:** the plan is only as good as the process and people involved in its development.
3. **This is the community's plan:** it should reflect the current needs and values of the community and be useful for local officials and community members.

Planning Timeline

Updating the 2013 Marion County MHMP began in 2017 when the Indianapolis DHS submitted a Pre-Disaster Mitigation (PDM) Grant application to Indiana DHS. The grant was approved by the Federal Emergency Management Agency (FEMA) and funds were awarded in 2017. The formal process concluded in late 2018 when this plan was formally adopted by all the municipalities within Marion County and approved by the Indiana DHS and FEMA. While late 2018 symbolizes the end of the formal plan update process, the plan is designed to

be a living document. This is a component of a continuous planning effort to develop and implement solutions that will make the County more resilient.

To ensure the plan is actionable, the public, City departments, elected leaders, businesses, and other stakeholders must be engaged to partner on this effort.

The schedule of events for the 2018 MHMP project is shown on Figure 1-4. It includes two MHMP Mitigation Meetings with the Multi-Hazard Mitigation Task Force, a DHS and Office of Sustainability (OoS) review period, a public comment period, a public meeting, an Indianapolis City Council review period, an excluded cities and towns review period, an Indiana DHS review period, and the final submittal of the plan to FEMA. This process spanned approximately eight months.

March 2018: First MHMP Mitigation Meeting at Indianapolis Central Library with Katie Robinson (Director, Office of Sustainability) and Andrew Ohrt (Project Manager, Arcadis)

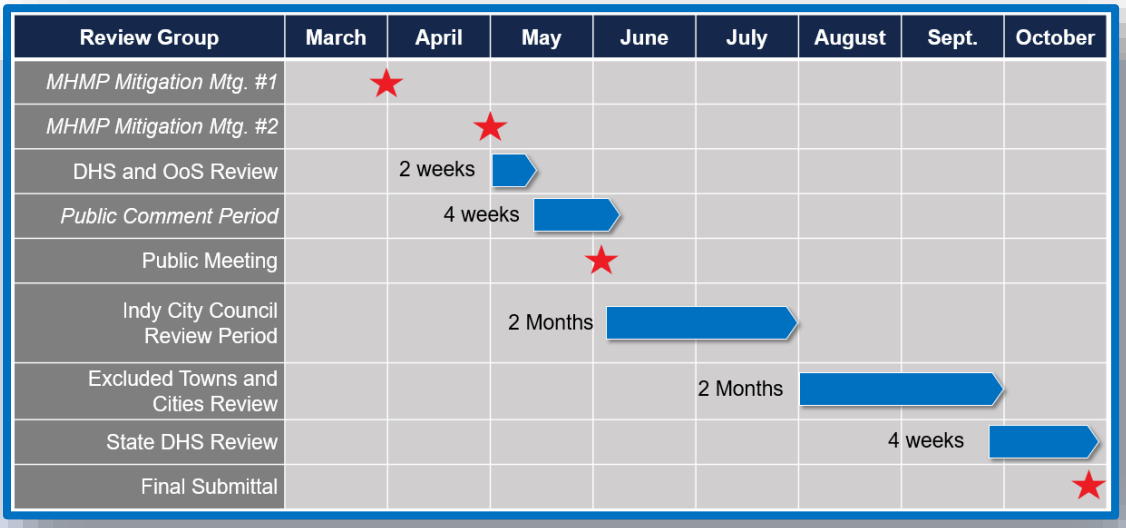


Figure 1-4: 2018 MHMP Schedule/Stakeholder Timeline

2018 New Plan Components

In updating the 2018 MHMP, Marion County MHMP Task Force members decided to continue doing several things that have been working well and update those areas where enhancements would increase the plan's effectiveness. The 2018 planning process saw significant changes in the following areas:

1) **New vision and goals,** with an eye towards creating long-term resilience and ensuring that all residents have what they need to work, play, and thrive in Marion County.
2) **Two Cross-cutting Themes:** Social Vulnerability and Climate Change and the threats they pose both as standalone hazards and as **threat multipliers** were added to the plan analysis. Climate change increases the frequency and magnitude for several hazards. Social vulnerability can exacerbate the consequences of a hazard, as susceptible people, populations, or neighborhoods might not have the capacity to prepare in advance.
3) Alignment with the ***Thrive Indianapolis* Sustainability and Resilience Action Plan.** In order to ensure as many departments and divisions within Marion County and Indianapolis are collaborating to create a more resilient and sustainable future, this 2018 MHMP is aligned with the City's sustainability and resilience planning process: *Thrive Indianapolis*.
4) **New mitigation action recommendations,** especially those focused on addressing the chronic stressors that lead to disproportionate impacts on certain populations of the community.
5) **Five new hazards** are included in this updated version of the MHMP. These hazards are shown on Figure 1-5.

Figure 1-5: Five New Hazards

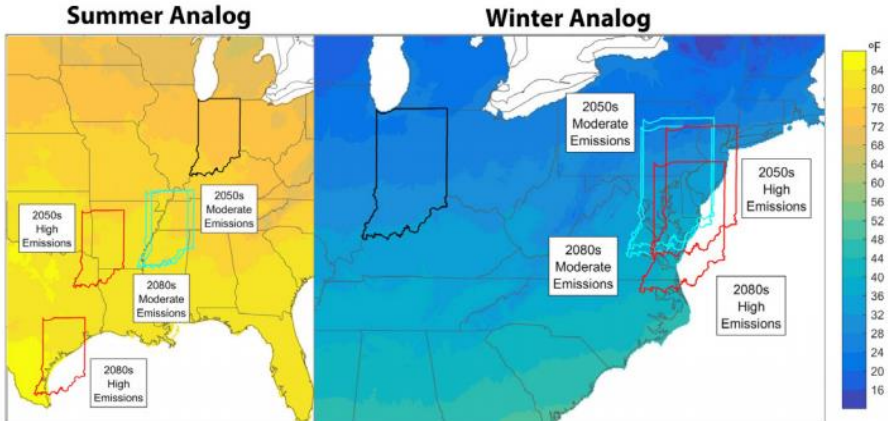
More on Cross-cutting Themes

Unique to the 2018 planning process is the addition of five new hazards and the consideration of climate change and social vulnerability as potential threat multipliers for each risk. We, as a County, felt that it was essential to integrate both climate change and vulnerable populations into this updated 2018 MHMP. Without it, the County would likely be under-preparing for future hazards and not anticipating or providing for the needs of the most vulnerable citizens. The boxes below provide more context and introduce icons that will be used to help readers navigate the plan.

Throughout this plan, the thermometer and globe icon will be used to denote how a hazard has already been impacted by changing climate conditions such as increasing temperatures and extreme weather, as well as how the impacts are projected to be influenced by future climate change scenarios. The icon is used to highlight facets of existing hazards, or to highlight the new hazards through the lens of climate change.

Changes related to **extreme weather** events that have **already occurred,** as well as projections for future change, were reviewed. Climate change is used as a lens to evaluate the potential future frequency, intensity, and duration of hazards. For example, climate change is expected to **increase precipitation** and thus increase instances of flooding, so within the **flooding** hazard profile section, this icon will be seen where there is flooding information pertinent to climate change effects. More than this, however, the project team considered how climate change can influence existing community challenges and how public health issues, such as **mental health,** connect to hazards. For example, increased **heat waves** have been correlated to anger driven violence and may impact hazards such as **civil disturbance**.

As **climate change is largely human-caused**, predicted changes vary based on **emissions scenarios**. For many of the scenarios, the projections differ depending on if people continue to emit significant amounts of carbon pollution or whether people change course to a low emissions path. **Indianapolis has Resolution 21, which commits the City to be carbon neutral by 2050**.



These maps (left) illustrate how Indiana's summers and winters will shift to climates that are more like other region's climates are today. The severity of these shifts depends on the emissions scenario realized – high (red) emissions or moderate (aqua) emissions.

Throughout this plan, the **equity icon** will be used to denote how a hazard might impact various vulnerable members of the community.

The distinction of vulnerability and its unequal distribution among populations is crucial for assessment of the consequences of physical risks. There are clear health and safety implications of social vulnerability in this plan. This does not in any way imply a victimhood label on any Marion County resident or neighborhood. The diversity of our residents is a source of pride for our community as we aim towards inclusion and participation from everyone. However, it is important to acknowledge the inequities and disparities that more advantaged Marion County residents and affluent neighborhoods do not face, including historical and systemic discrimination, exclusion, marginalization, exploitation, underrepresentation, and disinvestment. Nothing about an individual's race, ethnicity, gender identity, sexual orientation, age, social class, physical ability or attributes, religious or ethical values system, national origin, immigrant status, dialect, or zip code makes them inherently vulnerable. **We see acknowledging vulnerability as an assessment of the system's deficiencies, rather than as a judgment of any Marion County resident or neighborhood.**

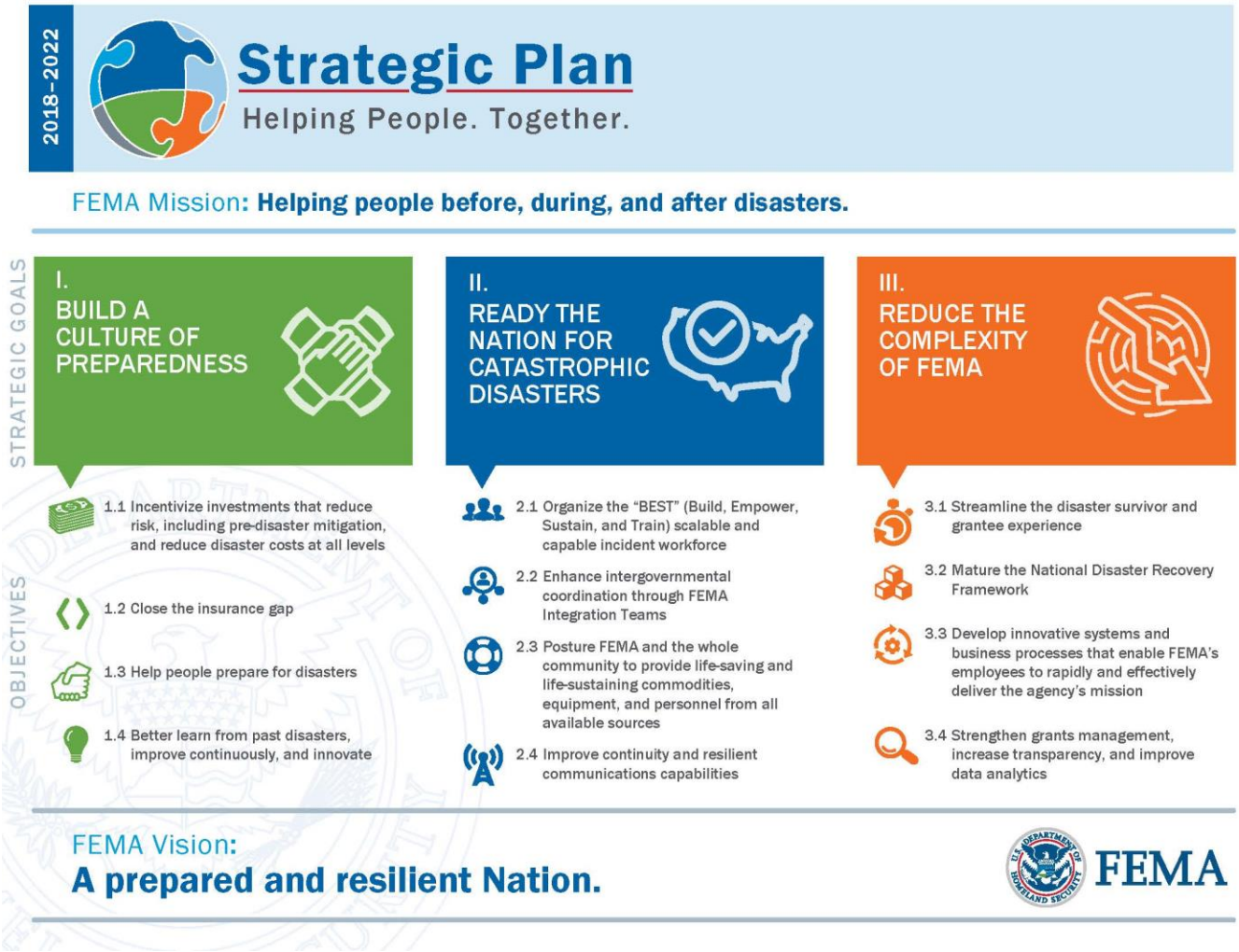
Social vulnerability is defined as the disproportionate susceptibility of some social groups to the impacts of hazards, including death, injury, loss, or disruption of livelihood. Social vulnerability also affects a population's resilience: the ability to adequately avoid or recover from impacts.

Vulnerability is a function of demographic characteristics of the population, as well as environmental and community conditions such as healthcare provision, social capital, access to social networks, and social isolation.

Preparing the 2018 Plan Update

As noted previously, local hazard mitigation plans must be updated every five years for a local community to remain eligible for federal mitigation funding. This means that without an update to the MHMP in 2018, Marion County would risk being ineligible for hazard mitigation grants. More than that, however, the County realizes the importance of fostering a culture of preparedness and sees this updated MHMP as a means to continue engaging the public in hazard mitigation.

FEMA's 2018-2022 Strategic Plan creates a shared vision for the field of emergency management and sets an ambitious, yet achievable, path forward to unify and further professionalize emergency management across the country. The first goal is to build a culture of preparedness.



With public engagement and the shift to a new way to foster preparedness as a primary motivation, in 2018 stakeholders within the Indianapolis OoS and the Indianapolis DHS hired Arcadis and Kim Lundgren and Associates, Inc. (KLA) to provide professional mitigation planning services and prepare this MHMP for submittal to Indiana DHS and FEMA. The entire planning process was collaborative, with County-wide community stakeholders directly engaging with the consultant team to ensure that the plan not only met FEMA requirements but also aligned with the City's goals of creating a more sustainable and resilient community.

From the onset of the planning process, the County has reviewed each element of the planning process (Figure 1-6) and section of the plan, making refinements and revisions throughout. A key stakeholder in the plan generation and review process is the **MHMP Task Force**, a group of technical advisors that cover a wide range of responsibilities within the County. This group of individuals participated in three meetings to help develop this plan and have been instrumental in the plan's review, refinement, and improvement. In addition, feedback was solicited and received from members of the community, elected officials, and other City-County employees. This

process not only allowed us to create a strong MHMP, but to also educate and engage the public on issues related to their own personal preparedness.

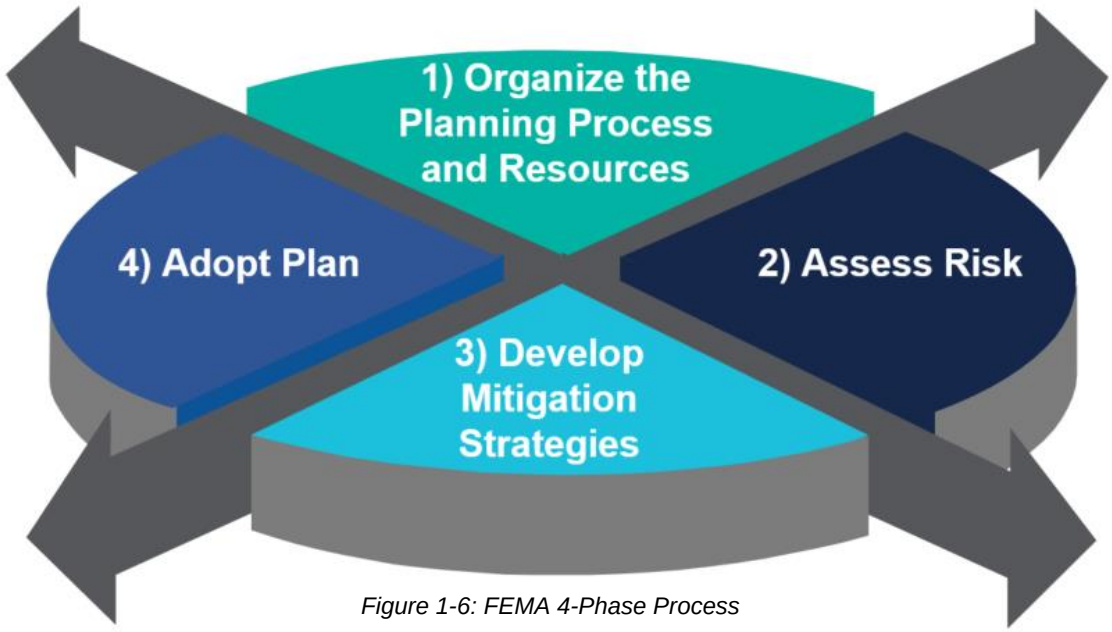


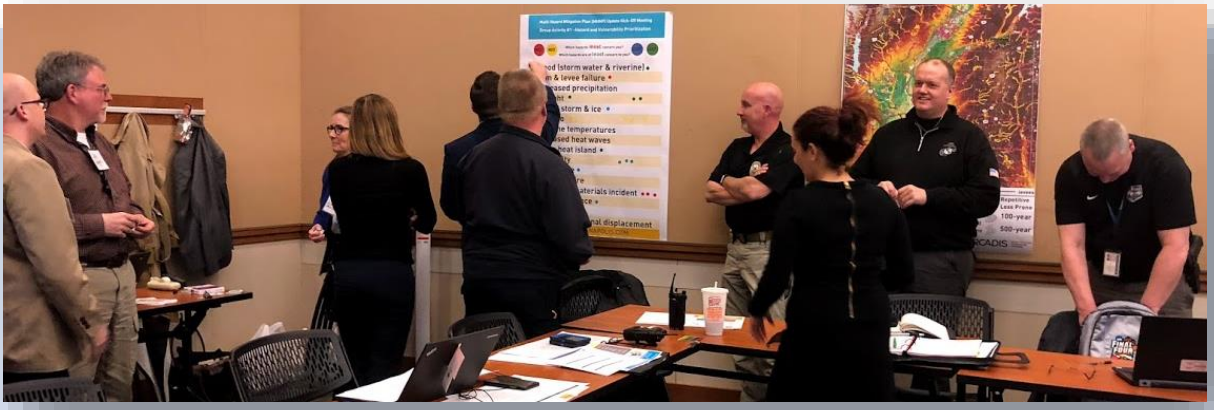
Figure 1-6: FEMA 4-Phase Process

Throughout every phase of this process, the project team followed the latest mitigation planning process recommended by FEMA: Local Mitigation Planning Handbook (2013) and the Local Mitigation Plan Review Guide (2011). Where possible, efforts were also made to tie the planning process and the outputs from this MHMP update (e.g., risk assessment, mitigation strategies) to the City's *Thrive Indianapolis* project – an effort to create a more resilient and sustainable local community. This alignment is helping to ensure that this MHMP informs not only the City's/County's emergency preparedness activities, but also preparedness and resilience activities within other departments such as planning, public works, sustainability, parks and recreation, finance, building and neighborhood services, and more.

March 2018: First MHMP Mitigation Meeting at Indianapolis Central Library. The activity depicted involved stakeholders placing stickers in areas on the map that they were aware of hazard specific vulnerabilities.

Plan Update Committee and Responsibilities

A MHMP Task Force (the planning committee) was formed to assist in the MHMP update process. The individuals solicited for this group were invited based on their knowledge of local hazards, involvement in hazard mitigation, possession of the tools necessary to lessen the impact of future hazard events, and/or participation as a planning committee member for the 2013 MHMP. Table 1-1 provides the names, titles, and organizations for all the members of the 2018 MHMP Task Force. Representatives from each of the excluded cities/towns were invited to participate in the task force or participated in other ways outside of the formal task force.



March 2018: First MHMP Mitigation Meeting. The colors of the stickers from the previous photo correlated to the top five hazards of concern, which had been determined in an earlier hazard prioritization exercise, described further in Chapter 3 and depicted in the above image.

Table 1-1: MHMP Task Force Committee

Name	Organization	Title
City/County		
Al Stovall	Department of Public Health and Safety Communications	Chief, Public Safety Communications
Anna M. Gremling	Metropolitan Planning Organization	Administrator
Brad Beaubien	Indianapolis Department of Metropolitan Development	Long Range Plan Administrator
Brent A. Kintner	Indianapolis Metropolitan Police Department	Ranger
Brett Wineinger	Indianapolis Office of Finance and Management	Deputy Controller
Catherine L. Kostyn	Metropolitan Planning Organization	Senior Planner
Cristina Padilla	Indianapolis Office of Sustainability	Intern, OoS
David Schwartz	Department of Public Health and Safety Communications	Deputy Chief, Public Safety Communications
Donna Price	Indianapolis Department of Business and Neighborhood Services	Asst Administrator - Permitting
Gary Coons	Indianapolis Division of Department of Homeland Security under Indianapolis Metropolitan Police Department	Director
Gregory Hall	Marion County Public Health Department	Emergency Preparedness Coordinator
Jeff Larmore	Marion County Public Health Department	Supervisor, Hazardous Materials
Jeffrey Meek	Indianapolis Office of Sustainability	Project Manager, OOS
Katie Robinson	Indianapolis Office of Sustainability	Director, OOS
Ken Clark	City of Indianapolis	Chief Information Officer
Bill Kincius	Indianapolis Department of Public Works	Urban Forrester
Mary McKee	Marion County Public Health Department	Director of Public Health Practices
Matt Mosier	Indianapolis Office of Sustainability	Senior Project Manager, OOS
Melody Park	Indianapolis Department of Public Works	Chief Engineer
Mike Pennington	Indianapolis Parks and Recreation	Property and Risk Manager
Nathan Self	Indianapolis Department of Public Works	Senior Project Manager
Peggy J. Frazier	Indianapolis Metropolitan Police Department	Deputy Director, Operations
Rita Reith	Indianapolis Fire Department	Public Information Officer
Sara Woodson	Indianapolis Division of Department of Homeland Security under Indianapolis Metropolitan Police Department	Planner
Shannon Norman	Indianapolis Department of Metropolitan Development	Principal Planner
Steve G. Pruitt	Indianapolis Department of Public Works	Assistant Administrator
Excluded Cities and Towns		
David Hofmman	Lawrence Police Department	Chief
Gary Woodruff	City of Lawrence Police Department	Deputy Chief
Robert Cheshire	Beech Grove Fire Department	Chief
Robert Wallace	City of Lawrence Fire Department	Deputy Chief

Name	Organization	Title
Thomas Reuss	City of Lawrence Police Department	Training Coordinator
Robert Fishburn	Speedway Fire Department	Chief
Thomas Vaughn	Southport Police Department	Chief
External Partners		
AJ DeRose	Citizens Energy Group	Director Health, Safety & Security
Anne Edwards	MESH Coalition	Director of Intel and Emergency Operations
Ann McIver	Citizens Energy Group	Director, Environmental Stewardship
Barney Levengood	CIB	Executive Director
Bill Stinson	Indianapolis International Airport	Public Affairs
Brian Luellen	IndyGo	Vice President, Public Affairs
Chad Priest	American Red Cross of Greater Indianapolis	Regional Emergency Services Director
Charles Maltbie	American Red Cross of Greater Indianapolis	Regional Disaster Officer
Jennifer Pitcher	MESH Coalition	Executive Director
John E. Havard	Citizens Energy Group	Environmental Engineer
Justin Mast	Eskenazi Health	Emergency Preparedness and Response Manager
Mark Emmons	IndyGo	Director of Safety, Security & Training
Mary Moran	Indiana Department of Homeland Security	Hazard Mitigation Officer
Michael Kaufmann	Health and Hospital Corporation of Marion County	VP of Civic Investment
Neil Johnson	Eskenazi Health	System Chief Operating Officer
Torrey Glover	Indiana Department of Homeland Security	Hazard Mitigation Officer
Vanessa Davis	American Red Cross of Greater Indianapolis	Executive Director, West Central Chapter
Zac Elliot	Indianapolis Power and Light	Manager, Demand Side Management

The specific responsibilities assigned to the MHMP Task Force included:

- **Participate in MHMP Task Force meetings and one public event;**
- **Provide best available data as required for the MHMP risk and vulnerability assessment;**
- **Provide local insights related to local hazards and projected future hazards;**
- **Validate recent local hazard data, vulnerability assessments and maps;**
- **Review and, as needed, provide suggested updates to the vision and goals for the 2018 MHMP;**
- **Evaluate existing mitigation actions and help identify new mitigation projects;**
- **Review materials for public participation;**
- **Review and provide timely comments on all study findings and draft plan deliverables;**
- **Support the adoption of the 2018 Marion County MHMP; and**
- **Be stewards of hazard mitigation and preparedness during and after the MHMP planning process.**

Engagement Process

Beginning in January 2018, the project team established the MHMP Task Force. This began with an informal kick-off call in March. The consultants and the Office of Sustainability discussed how to conduct a climate vulnerability assessment as well as a FEMA required risk assessment. At the same time, formal invitations were extended to all identified possible MHMP Task Force members.

The first official meeting of the MHMP Task Force took place on March 27, 2018 at the Indianapolis Central Library. During this meeting, Task Force members discussed the planning process for the MHMP update, the major hazards and risks of concern to the County (including five additional hazards not included in the 2013 plan) and the critical infrastructure within the City and any new additions since the 2013 MHMP. They also discussed the draft goals and vision for the MHMP and historical hazard events and their impacts. The meeting culminated with a prioritized list of hazards based on local stakeholder knowledge.

During a mapping session at the Indianapolis Sustainability Summit participants provided valuable input in the MHMP and *Thrive Indianapolis* planning processes. Participants shared their experiences with hazards and what their greatest concerns were for their neighborhoods and the County. Additional details are provided in *Appendix A - Public Outreach*.

Mapping session at Sustainability Summit, IUPUI, March 2018

The second official meeting of the MHMP Task Force took place on April 26th, 2018 at the Indianapolis Regional Operations Center (ROC). This meeting focused on validating recent local hazard data and the results from the draft vulnerability and risk assessments. This meeting also focused on identifying appropriate hazard mitigation options, reviewing current capabilities, checking the status of previously identified hazard mitigation actions, and creating a draft implementation plan and plan maintenance strategy for the MHMP.

In addition to these full, formal MHMP Task Force meetings, the expertise of the MHMP Task Force was leveraged in five ways:

- Used an interactive survey to get their opinions on the vision and goals to drive the MHMP update;
- Asked for their assistance in spreading the word about community-wide events and the open comment period of the MHMP;
- Asked for their attendance at the June public meeting, and their help facilitating;
- Solicited feedback through regular email correspondence, which included progress reports and requests for assistance; and
- Hosted a bi-weekly planning call in which several (or critical) members of the MHMP Task Force were invited to attend and share their expertise.

To document participation, sign-in sheets were present at meetings to record attendees. Meeting sign-in sheets, agendas, and presentation slide decks are included in *Appendix A - Public Outreach*. Overall, the MHMP Task Force engaged in two face-to-face meetings, participated in a survey, and reviewed the draft document to support preparation of this plan. The contribution of the Task Force members was crucial for the plan's process of development.

Public Involvement

44 CFR 201.6(b)(1)

An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval.

Engagement from a wide range of stakeholders and a diversity of perspectives is essential for building a culture of preparedness in Marion County. As such, efforts were made to ensure that a number of opportunities existed for the public to engage in the MHMP planning process. This section outlines the various public events that were held as part of this planning process, what was covered at those events, and how those events shaped the production of this final MHMP.

Five main in-person meetings were held as part of this planning process, and these events were held in conjunction with the *Thrive Indianapolis* initiative:

- The first MHMP Task Force meeting was held on March 27th, 2018 at the Indianapolis Central Library
- A community asset, vulnerability, and opportunity mapping session was held at the inaugural Indianapolis Sustainability Summit on March 28th, 2018;
- The second MHMP Task Force meeting was held on April 26th, 2018 at the Indianapolis Regional Operations Center;
- A community-wide training on how to host a community asset, vulnerability, and opportunity mapping session was held on April 26th, 2018; and
- A community-wide meeting in June specifically focused on soliciting feedback about the draft MHMP.

In addition to these meetings, the consultant team also hosted an open call as part of the larger *Thrive Indianapolis* project for ideas from the public about actions the City should take to enhance sustainability and resilience. One of the major areas for which actions were solicited was the topic of public health and safety. Given the direct overlap between this element of the *Thrive Indianapolis* process and the MHMP, every effort was made to ensure that the ideas suggested by the public were integrated into this plan. While not all ideas could be integrated due to time constraints, the fact that some of the strategies overlap will help the County and City move forward in aligning their efforts to build greater preparedness.

MHMP Task Force Meeting 1

The first MHMP Task Force meeting was held on March 27th, 2018 at the Indianapolis Central Library. The meeting lasted for the scheduled two hours and was attended by a broad range of stakeholders. The list of attendees and meeting description are included in *Appendix A - Public Outreach*.

The goals of the kickoff meeting were to:

1. Guide prioritization of the 15 hazards being assessed;
2. Establish agreement on proposed goals;
3. Collect information on current and future mitigation projects; and
4. Ensure that current methods and data sources being utilized for the plan update are robust and endorsed by stakeholders.

MHMP Task Force Meeting 2

The second MHMP Task Force meeting was held on April 26th, 2018 at the Regional Operations Center. The meeting lasted for the scheduled two hours and was attended primarily by public health and public safety stakeholders. The list of attendees and meeting description are included in *Appendix A - Public Outreach*.

The goals of the second Task Force meeting were to:

1. Continue the process of updating the County's MHMP;
2. Prioritize hazards;
3. Review and augment list of current and future mitigation actions; and
4. Prioritize current and future mitigation actions.

Additional MHMP Events

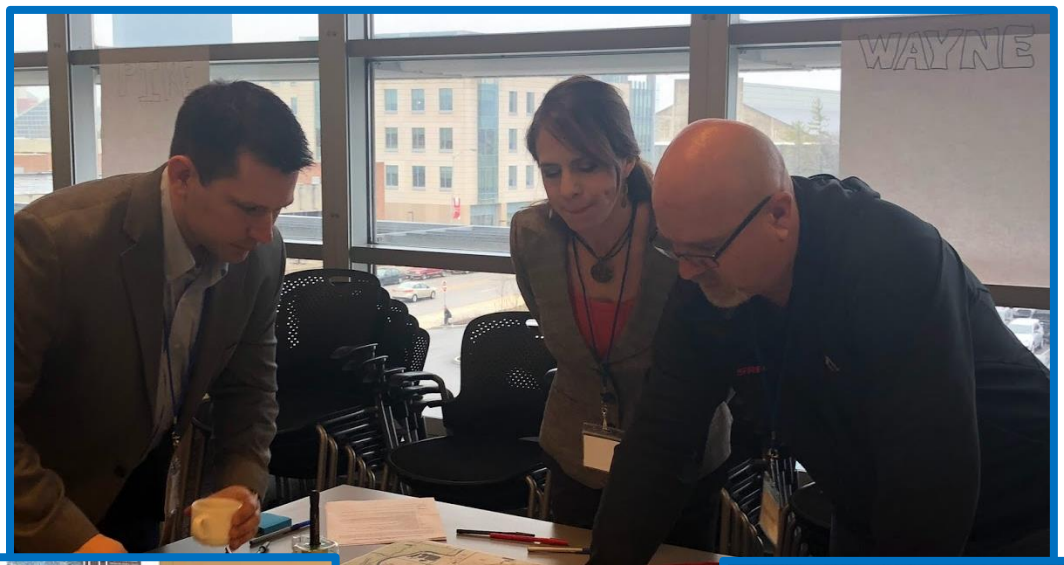
The meeting descriptions of the following events are also included in *Appendix A - Public Outreach*.

- **Community Asset, Vulnerability, and Opportunity Mapping Session**
  - March 28th from 10:30am-11:30am at the Indiana University - Purdue University - Indianapolis (IUPUI) Campus Center in Indianapolis
- **Community-Wide Training on Interactive Asset, Vulnerability, and Opportunity Mapping**
  - April 26th from 5:30pm-6:30pm at the Indianapolis Central Library
- **MHMP Task Force Survey**
  - Issued on May 1, 2018

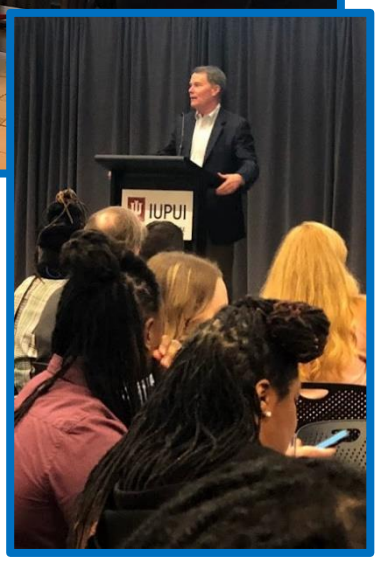
- **Public Meeting**
  - June 6th from 6pm-8pm at the Brookside Park Center

Public Comment Period

In addition to the above, once the MHMP was drafted, it was posted online and paper copies were placed in the main library branches and the City of Indianapolis OoS for public review and comment. Two press releases announcing details of the public review period were released in the Indianapolis Star. Copies of the MHMP were provided to the City-County Councilors and OoS hosted open-houses with the Councilors. Fliers were also distributed to committee members to display at stakeholder offices. In addition, all MHMP Task Force members were asked to advertise the public comment period with their various constituencies.



Mapping session at Sustainability Summit, IUPUI, March 2018



Mayor Hogsett at Sustainability Summit, IUPUI, March 2018

Involvement of Other Interested Parties

44 CFR 201.6(b)(2)

An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia, and other private and non-profit interests to be involved in the planning process.

Multiple stakeholders and stakeholder groups were invited to review and comment on the MHMP 2018 update. This includes neighboring jurisdictions, key community groups, agencies involved in hazard mitigation activities, and/or climate change activities, and agencies that have the authority to regulate development. There were generally five channels used to reach these audiences: 1) Direct personal outreach; 2) The dissemination of e-correspondence such as newsletters, specific email requests, etc., 3) Press releases; 4) Presentations at relevant events (either directly presenting or through partner organizations); and 5) A public survey. A significant effort was made to reach not only a wide range of stakeholders, but a diverse and often under-represented group of stakeholders. For example, the consultant team presented the findings of the MHMP risk and vulnerability assessment to seniors and youth that regularly meet at a local organization known as the Kheprw Institute. The Kheprw Institute focuses on empowering youth and the community in Indianapolis through social entrepreneurship, mentorship, leadership, and critical thinking.

Overall, opportunities for involvement, comment, and deeper engagement were provided for local officials, residents, businesses, community groups, academic partners, utilities, emergency personnel, and any other interested party within the County as well as the surrounding area.

Plans, Studies, Reports, and Technical Information

44 CFR 201.6(b)(3)

Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

During the 2018 update of the Marion County MHMP and through the *Thrive Indianapolis* process, a breadth of resources were consulted. The sources included not only documents but also interviews and discussions with local stakeholders. A summary list of those interviewed is included in *Appendix B - Stakeholder Interviewee List*. The review of this information was critical to provide a comprehensive update to the 2013 MHMP and to develop additional mitigation measures to address the hazards identified.

There are several **resources** that stood out in shaping this MHMP. *Appendix C - Plans Reviewed* includes a table of the 55 plans reviewed as well as a description of how each plan was considered/integrated into the MHMP. When applicable, relation to a hazard is indicated, and links are listed in the table. Several of the key documents are listed below, and several are highlighted in more detail on the following pages:

- **2045 Long Range Transportation Plan** (2017)
- **Committing to Inclusive Growth:** Lessons for metro areas from the Inclusive Economic Development Lab (2017)
- **Green Infrastructure Master Plan** for Water Quality Improvement (2010)
- **Greenways Master Plan** (2014)
- **Incident and Emergency Action Plans** (Eagle Creek Reservoir Dam; Morse Reservoir Dam; Pogue's Run Dam), Indiana Department of Natural Resource Dam records
- Marion County Preliminary Flood Insurance Rate Maps (2017)
- Marion County **Land Use Plan Pattern Book** (2017) and supporting Neighborhood and local area plans, tailored specifically to each area's needs with the intention of driving future growth.
- **Indiana State Hazard Mitigation Plan** (2014**)**
- **Low Impact Developmen**t Plan (2015)
- **Marion County MHMP** Update (2013)
- **Neighborhood Investment Strategy** (2017)
- **Plan 2020** – The Bicentennial Plan for Indianapolis
- **Rebuilding the Dream: Inclusive Growth in the Indianapolis Region** (2018)
- **Sustainability and Social Responsibility** Report (2017)

20 INDY 20

FORGING A COMPELLING FUTURE FOR INDY

A number of additional resources were leveraged by the project team during the preparation of this MHMP. The list of these resources is provided in *Appendix D - Additional Resources*.

Key Resources that stood out in shaping this MHMP are listed below, with a few highlighted on the following pages:

- Incident and Emergency Action Plans (Eagle Creek Reservoir Dam; Morse Reservoir Dam; ***Geist Reservoir Dam***; Pogue's Run Dam)
- Indiana Department of Natural Resource Dam records

Consolidated City of Indianapolis' Comprehensive Emergency Management Plan (CEMP; 2013):

Defines the planned response to extraordinary emergency situations associated with natural and man-made disasters, technological incidents, and national security emergencies in or affecting the Consolidated City of Indianapolis.

Part I of the CEMP integrates multi-hazard emergency preparedness and focuses on the structure of the Consolidated City of Indianapolis Division of Homeland Security organization. Part II of the CEMP focuses on the initial emergency response by volunteers and trained emergency responders. In this phase, the CEMP incident-specific checklist would be utilized to ensure proper emergency response by field-level responders. Part III of the CEMP addresses extended emergency responses, such as shelter and long term medical needs in the recovery phase. Part III establishes Lead Agencies, Support Agencies and their Emergency Support Functions. The details, descriptions, and responsibilities are listed in the Support Functions Checklist and Support Function Descriptions appendices. Part IV of CEMP pursues recovery initiatives and focuses on resiliency efforts to mitigate future hazardous events, in addition to obtaining assistance funds for restoration projects.

Flood Response Plan (FRP) 2017 Update

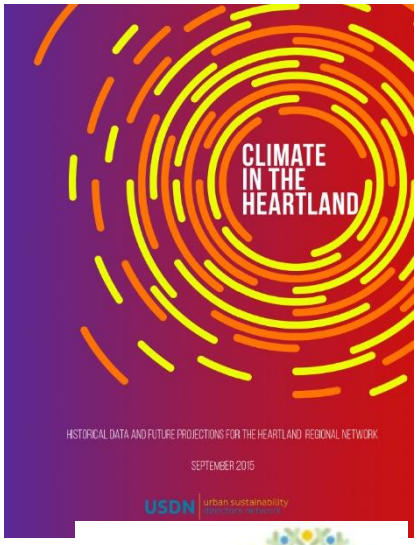
The Flood Response Plan is an active response and recovery plan that is activated during a flood. Marion County may activate the Plan when a flood stage is detected from White River, Eagle Creek, or Fall Creek. Additionally, rainfall events resulting in small to intermediate streams may be cause for activation of the FRP. The FRP outlines four steps that must be taken in event of a flood occurrence:

1. Event detection and level determination
2. Notification and communication
3. Expected actions
4. Termination and follow-up

Each step has specific guidelines and checklists of procedures that must be followed to actively recover in the event of a flood. The FRP serves as guidelines for a range of intensities of flooding events.

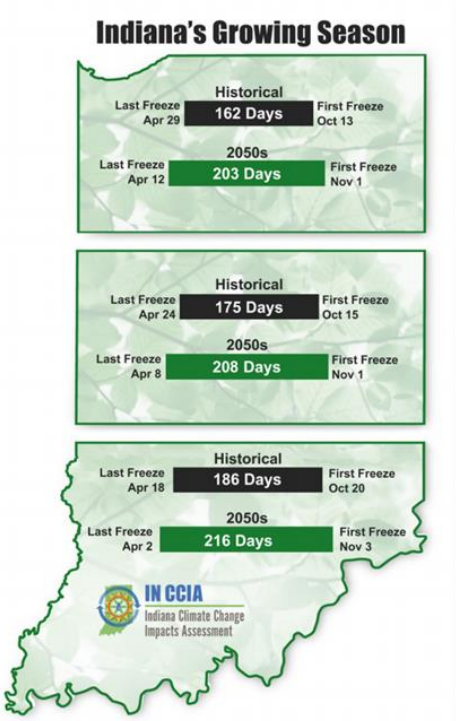
Important resources related to climate change

- **National Climate Assessment Report** (2017)
- **Great Lakes Integrated Sciences + Assessments** (GLISA)
- **Climate in the Heartland Report** Historical Data and Future Projections for the Heartland Regional Network (2015)
- **Knozone** works with residents and businesses to improve the region's air quality, making Central Indiana a great place to live, work and visit.
- **Hoosier Environmental Council**
- **Earth Charter Indiana** is leading a statewide, grassroots initiative to persuade policymakers to adopt a State Climate Plan for Indiana.
- **Indiana University:** Grand Challenges: Prepared for Environmental Change, will position Indiana to combat the growing threats caused by extreme and unpredictable weather patterns and environmental changes that result.
- Led by the Purdue Climate Change Research Center (PCCRC), the **Indiana Climate Change Impacts Assessment** (IN CCIA) provides the latest scientific research to help Hoosiers understand and prepare for the impacts of a changing climate. **A series of reports present key takeaways, such as the one below, which are highlighted throughout this plan.**



Hoosier Environmental COUNCIL

KNOZONE



KEY TAKEAWAY

Key finding: Indiana has already warmed 1.2°F since 1895. Temperatures are projected to rise about 5°F to 6°F by mid-century, with significantly more warming by century's end.

Why it matters: A rising average temperature increases the chance of extreme heat and reduces the chance of extreme cold, and it also changes the timing and length of the frost-free season when plants grow. These shifts will impact air quality, extend the growing season and the allergy season, and create more favorable conditions for some pests and invasive species.

http://indianaclimate.org

IN CCIA
Indiana Climate Change Impacts Assessment

Disaster Life Cycle - TRANSFORMATION FROM BUSINESS-AS-USUAL

The disaster life cycle is defined by FEMA as the process through which emergency managers respond to disasters when they occur; help people and institutions recover from them; reduce the risk of future losses; and prepare for future emergencies and disasters.

The four phases of the disaster life cycle include:

Preparedness – Planning, organizing, training, equipping, exercising, evaluation, and improvement activities to ensure effective coordination and enhance capabilities (i.e., preparedness plans, emergency exercises/training, warning systems).

Response – Mobilization of first responders and emergency services (i.e., search and rescue, emergency relief).

Recovery – Restoration of the affected area to its pre-disaster state (i.e., rebuilding destroyed property, repair of infrastructure, reemployment). *The affected area has an opportunity to rebuild to be more resilient to future hazards during this phase.*

Mitigation – Prevention or reduction of the effects of disasters (i.e., building codes, zoning, vulnerability analyses, public education).

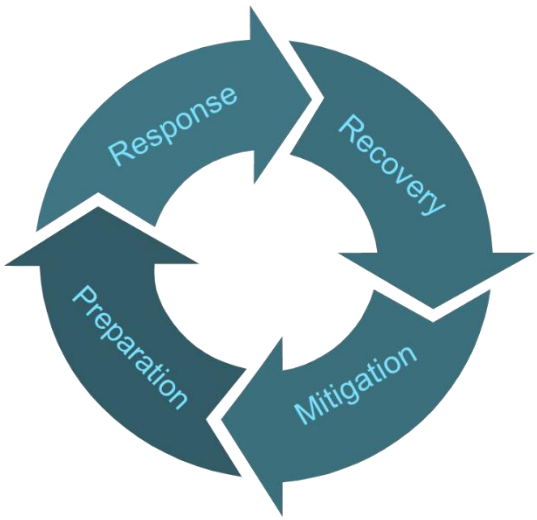


Figure 1-7: Four Phases of the Disaster Lifecycle

The MHMP concentrates on the mitigation phase of the disaster life cycle. FEMA defines hazard mitigation as any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards (44 CFR 201.2). Mitigation is most effective when it is a component of a comprehensive, long-term plan developed and implemented before a disaster occurs. The MHMP works to identify hazards, and their likelihood of impact for Marion County, and develops mitigation practices to reduce the physical, social, and economic impacts of the hazard. This plan goes beyond identification of historic or current hazards, looking at future hazards as well. That is why chronic stressors such as climate change and social vulnerability are included in the 2018 MHMP update. Breaking the disaster cycle necessitates planning for today and tomorrow, and that ensuring all residents, regardless of age, income, ethnicity, sexual orientation, gender, ability, or language, are able to live and thrive in Marion County.

Floodplain Management Planning Activities (Section 510 of the Community Rating System)

The Community Rating System (CRS) is a voluntary incentive program that encourages floodplain activities within the community that would exceed the minimum National Flood Insurance Program (NFIP) requirements. Depending on the points accumulated, flood insurance premiums may be discounted to reflect the reduced flood risk that results from the community's actions if they meet the following goals of the CRS: (1) reduce flood losses; (2) facilitate accurate insurance rating; and (3) promote education and awareness of flood insurance. Flood insurance premium savings are proportional to the points achieved for various activities. To participate in the CRS program and receive a 5% flood insurance premium discount, a community must achieve a minimum of 500 points. This MHMP update may be eligible for up to 294 points towards participation in the CRS. Currently, the City of Indianapolis participates in the CRS and is categorized as a Class 8 community. Because of this, flood insurance policyholders receive a 10% discount, based on the point classification depicted in Table 1-2.

The CRS program credits NFIP communities up to 100 points (each) for various activities. Some of the activities used to fulfill the credit requirements include: organizing a planning committee with staff from various departments, engaging stakeholders in the planning process, and coordinating with outside agencies and departments to resolve challenges relating to known hazards.

Table 1-2: NFIP CRS - Credits, Classifications, Premium Reductions[2]

Credit Points	Class	Premium Reduction SFHA[1]	Premium Reduction Non-SFHA[2]
4,500+	1	45%	10%
4,000 – 4,499	2	40%	10%
3,500 – 3,999	3	35%	10%
3,000 – 3,499	4	30%	10%
2,500 – 2,999	5	25%	10%
2,000 – 2,499	6	20%	10%
1,500 – 1,999	7	15%	5%
1,000 – 1,499	8	10%	5%
500 – 999	9	5%	5%
0 – 499	10	0	0

[1] Special Flood Hazard Area
[2] Preferred Risk Policies are available only in B, C and X Zones for properties that are shown to have a minimal risk of flood damage

Table 1-3 summarizes the 10-step guidance outlined in the NFIP CRS User's Manual for MHMP plan preparation and how those steps relate to the 4-phase process promoted by FEMA (seen in Figure 1-6). The 2018 MHMP Plan update aims to accomplish each of these steps.

[2] https://www.fema.gov/national-flood-insurance-program-community-rating-system

Table 1-3: FEMA Guidance and CRS Hazard Mitigation Planning Guidance

FEMA Guidance	CRS Guidance
Phase I: Organize Resources	
Step 1. Get Organized **Step 2. Plan for Public Involvement** **Step 3: Coordinate with Other Departments & Agencies**	Step 1. Organize Step 2. Involve the Public Step 3. Coordinate
Phase II: Assess Risk	
Step 4: Identify the Hazards **Step 5: Assess the Risks**	Step 4. Assess the Hazard Step 5. Assess the Problem
Phase III: Develop Mitigation Plan	
Step 6: Review Mitigation Alternatives **Step 7: Draft an Action Plan** **Step 8: Set Planning Goals**	Step 6: Set Goals Step 7: Review Possible Activities Step 8: Draft an Action Plan
Phase IV: Adopt & Implement	
Step 9: Adopt the Plan **Step 10: Implement the Plan**	Step 9: Adopt the Plan Step 10: Implement, Evaluate, Revise

02 COMMUNITY PROFILE

Marion County is just over 400 square miles and located in the heart of Indiana, as shown on Figure 2-1. Marion County was established from the Delaware New Purchase in 1822. It was named after Francis Marion, a Brigadier General from South Carolina in the American Revolutionary War.

Indiana means "Land of Indians." Various Native American tribes are a significant part of Indiana's history, including the Miami, Chippewa, Delaware, Erie, Shawnee, Iroquois, Kickapoo, Potawatomie, Mahican, Nanticoke, Huron, and Mohegan.

Figure 2-1: Marion County, IN

Transportation has been a central theme in the County's history. Indianapolis' aspiration of becoming a large inland market center was unsuccessful when the White River proved unnavigable and construction of the Central Canal ceased. Indiana's internal improvements went bankrupt in the late 1830s. Marion County residents relied on the National Road and the Michigan Road for transportation of goods until the advent of the railroad in 1847.

COUNTY GOVERNMENT AND MUNICIPALITIES

In 1970, the City of Indianapolis expanded to include all of Marion County and created a consolidated city-county government known as Unigov. The City-County government is led by the City-County Council. Indianapolis and eleven additional municipalities within the County are classified as "included towns" and are generally governed by the City-County Council. The City of Beech Grove, the City of Lawrence, the Town of Speedway, and the City of Southport, which are physically located in Marion County, were not annexed into the Consolidated City of Indianapolis and are classified as "excluded cities and towns." Table 2-1 summarizes the status of the various cities and towns within Marion County, with the "excluded cities and towns" mapped in Figure 2-2.

Marion County and the excluded cities/towns have significant mitigation capabilities that will ensure forward progress to adopt and enact the mitigation plan. The support of the elected Marion county officials is apparent through their support of this plan and outreach and mitigation activities conducted throughout the planning process. Marion County, with the support and resources from its 42 departments will cover a large portion of the personnel, financial and technical resources for this plan due not only to the County's size but also its diversity and complexity. Among many of the plans and programs (both publicly available and internal) which are currently

underway, the County can call on any of the planners, engineers, subject matter experts, emergency managers or other necessary skill sets which it already has on staff. The County intends dovetail the recommendations of this mitigation plan with existing plans, studies, reports and technical information which already exist or incorporate them into future plans. While the capabilities of the excluded cities do not span the breadth of those possessed by Marion county, the excluded jurisdictions each have specific capabilities which ensure they are well suited to execute the recommendations of this plan. Where gaps exist, Marion County and the excluded jurisdictions have pledged to work together to guarantee progress.

Table 2-1: Included and Excluded Cities & Towns

Excluded Cities & Towns	Included Towns	
• Beech Grove • Lawrence • Southport • Speedway	• Clermont • Crows Nest • Cumberland • Homecroft • Indianapolis • Meridian Hills	• North Crows Nest • Rocky Ripple • Spring Hill • Warren Park • Williams Creek • Wynnedale

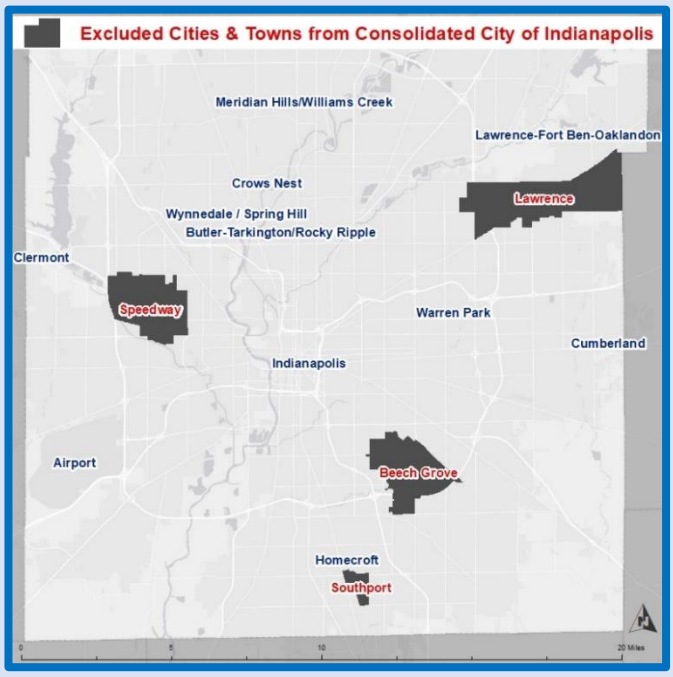


Figure 2-2: Marion County's Excluded Cities & Towns

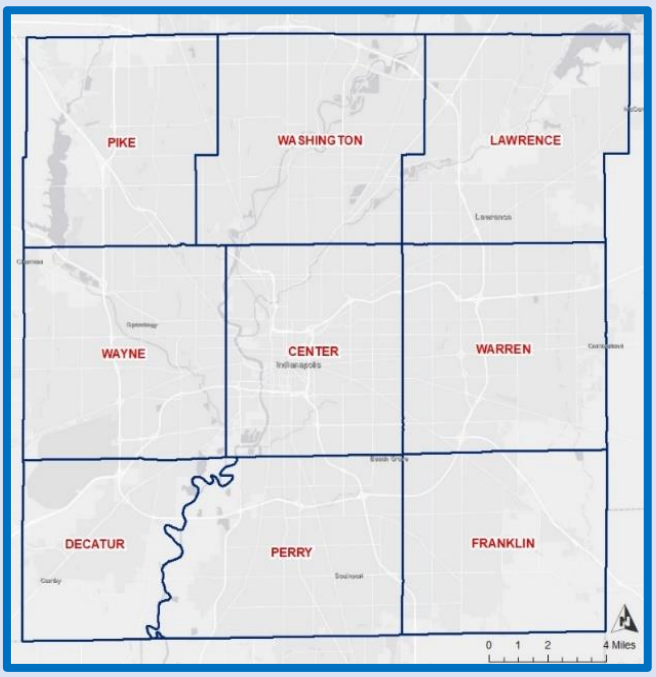


Figure 2-3: Marion County's Nine Townships

Marion County is divided into nine townships organized in roughly a three-by-three grid pattern as shown in Figure 2-3. The townships in Marion County are:

- Pike
- Washington
- Lawrence
- Wayne
- Center
- Warren
- Decatur
- Perry
- Franklin

Population & Demographics

The 2017 population of Marion County is estimated to be 950,082, making it the most populous County in the state (US Census). Marion County has approximately 14.3% of the total state population (US Census ACS, 2012-2016). All population and demographics statistics in this section are from the 2012-2016 American Community Survey (ACS) unless otherwise stated. Regional population distributions can be seen below in Figure 2-4, showing that 91% of Marion County's residents are in the Consolidated City of Indianapolis, while 9% reside in other Cities and Towns.

Indianapolis is home to the Indy 500, the largest sporting event in the world.

The Indy 500 is consistently one of the world's best attended single-day sporting events. The Indianapolis Motor Speedway is the world's largest spectator sporting facility, hosting more than 250,000 permanent seats. At the 100th running of the race in 2016, the event sold out with an estimated 350,000 attendees. In 2017, attendance was approximately 300,000 fans, which would have made Speedway the 2nd largest city in Indiana on that day.

Source: https://www.indianapolismotorspeedway.com/

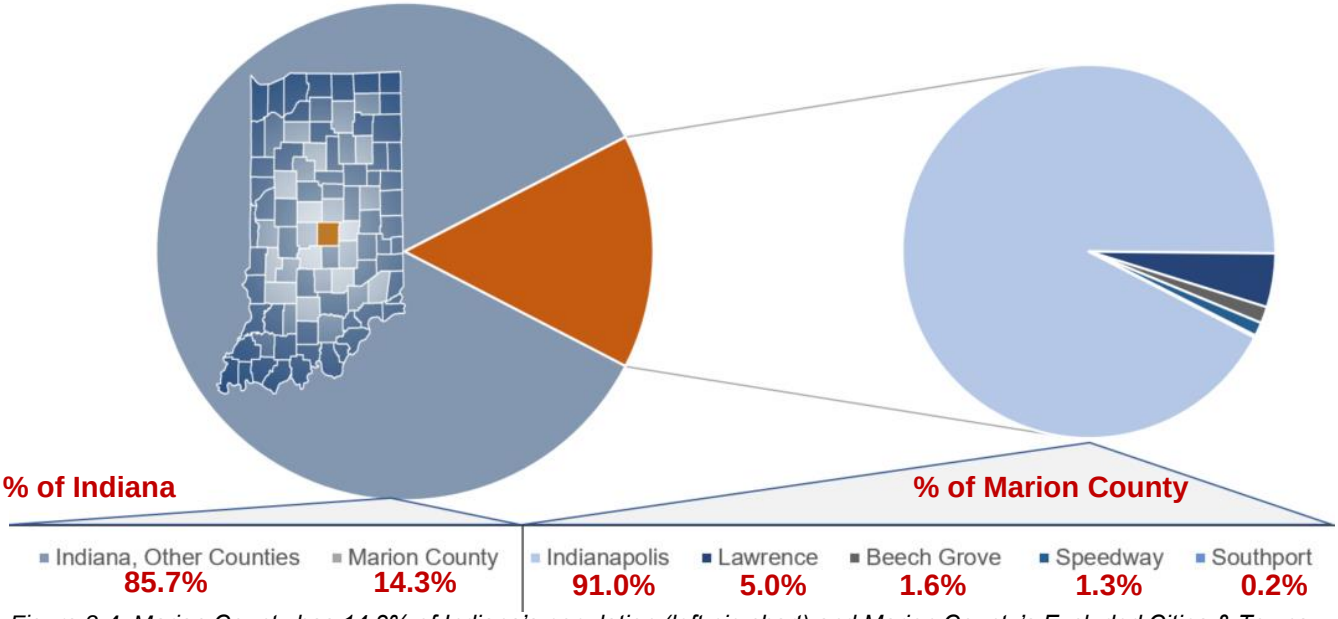


Figure 2-4: Marion County has 14.3% of Indiana's population (left pie chart) and Marion County's Excluded Cities & Towns have 9% of the County's population. (ACS 2012-2016)

Figure 2-5 shows the variation in population density for Marion County's census tracts. Per tract, the population ranges from 400 to 9,392 people per square mile. The distribution of the Marion County population by age is shown on Figures 2-6 & 2-7, with comparisons to Indiana totals and a breakdown into categories of generations. In 2016, the median age of Marion County was 34.2 years of age, while the median age of Indiana is significantly higher at 37.6. The largest demographic age group is young adults (25-44 years) accounting for approximately 29.4% of the population, followed by older adults as approximately 24.4% of the population total. Native-born citizens, with a median age of 37.5, were generally younger than foreign-born citizens, with a median age of 38.3. Marion County has 51,779 veterans. In terms of race and ethnicity, Marion County has 534,336 White residents, 252,707 Black residents, and 91,656 Hispanic residents. There is also a significant Bengali population, and 8.7% of the population is foreign born.

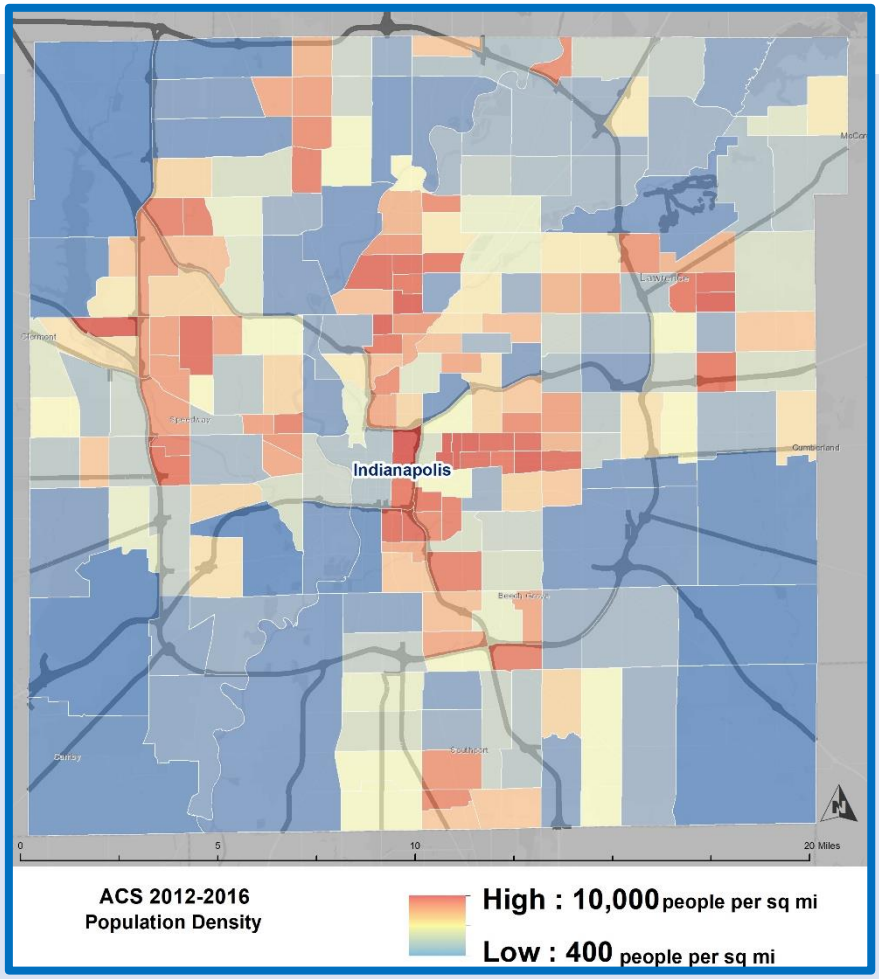


Figure 2-5: Population Density Distributions by Census Tract (ACS 2012-2016)

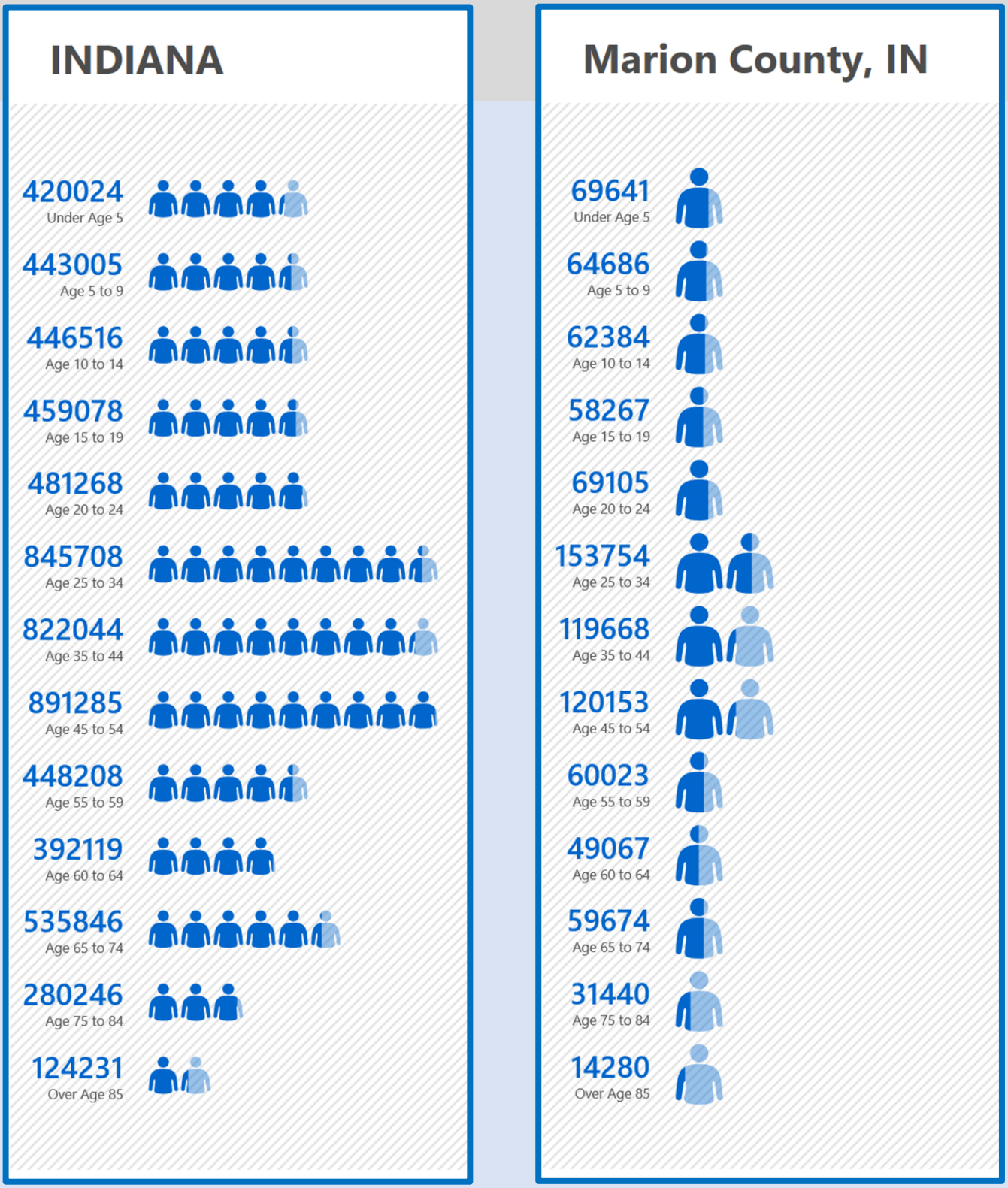


Figure 2-6: Age Distributions, comparing Marion County's population to the State of Indiana's (ACS 2012-2016)

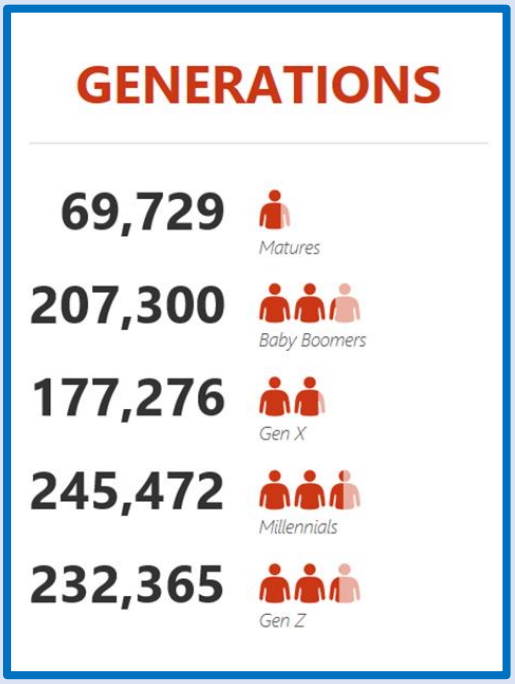


Figure 2-7: Age Distributions for Marion County by Generation (ACS 2012-2016)

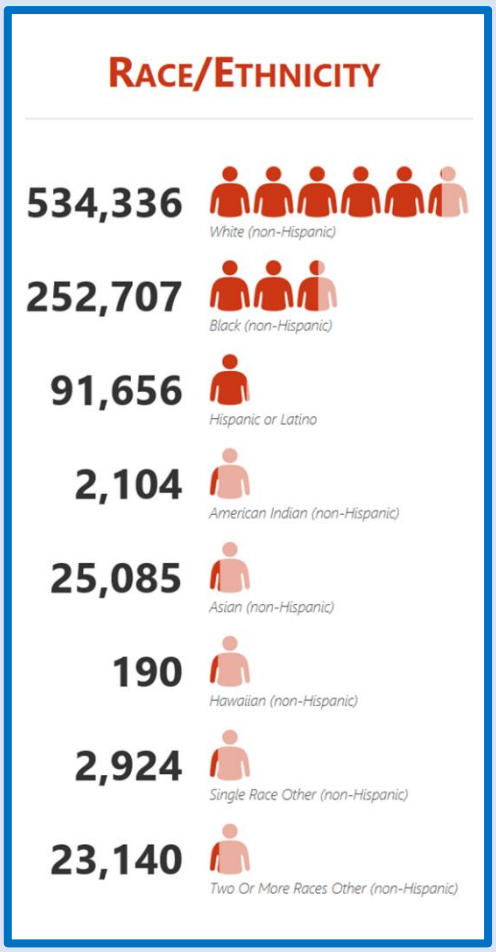


Figure 2-8: Race/Ethnicity Demographic Information for Marion County (ACS 2012-2016)

The distribution of the Marion County race/ethnicity demographics is shown on Figure 2-8. In 2016, 21.8% of the population was married without children, followed by 14.2% married with children. Median rent is $806, and the average residential home value is $120,500.

Approximately 85.7% of adults older than 25 years hold a high school diploma or higher, and 29.0% have a Bachelor of Arts or higher degree. See Figures 2-9 and 2-10 for an overview of Marion County educational attainment and bachelor's degree recipient fields. Figures 2-11 and 2-12 illustrate poverty rates and median household income by census tract, respectively. The median household income is $45,300 and the County poverty rate is 18.9%. The poverty rate among children under 18 years old is 28.0%. The map of poverty rates shows census tracts ranging from a minimum of 1% and up to a maximum of 49% of total households below the poverty level. The median household income shows that the ranges within census tracts go from $13,252 per year to $123,958 per year.

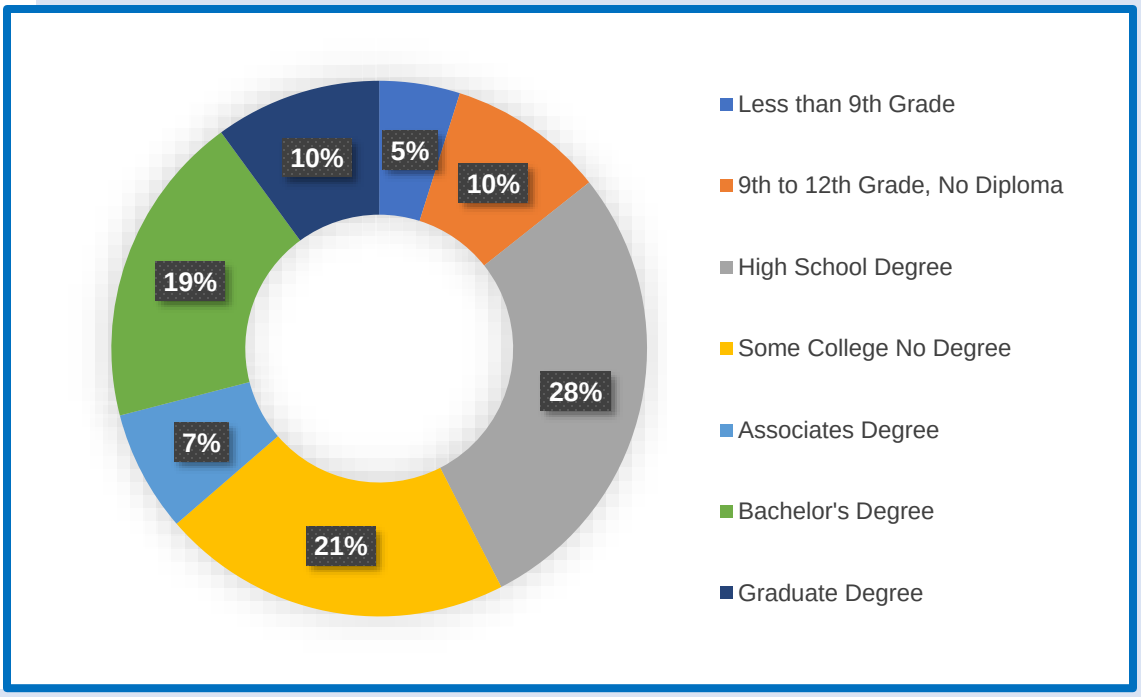


Figure 2-9: Educational Attainment (ACS 2012-2016)

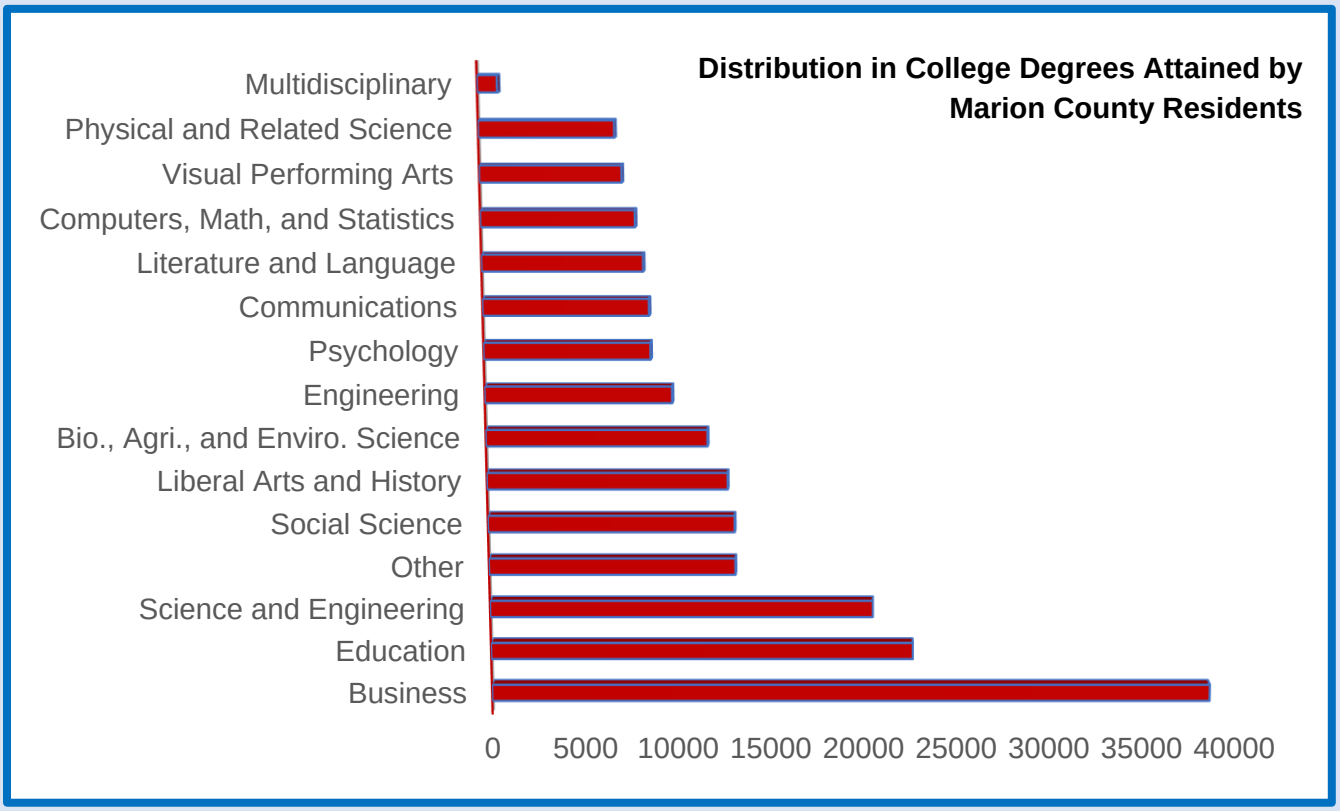


Figure 2-10: Number of Bachelor's Degrees Received for all Residents. (ACS 2012-2016)

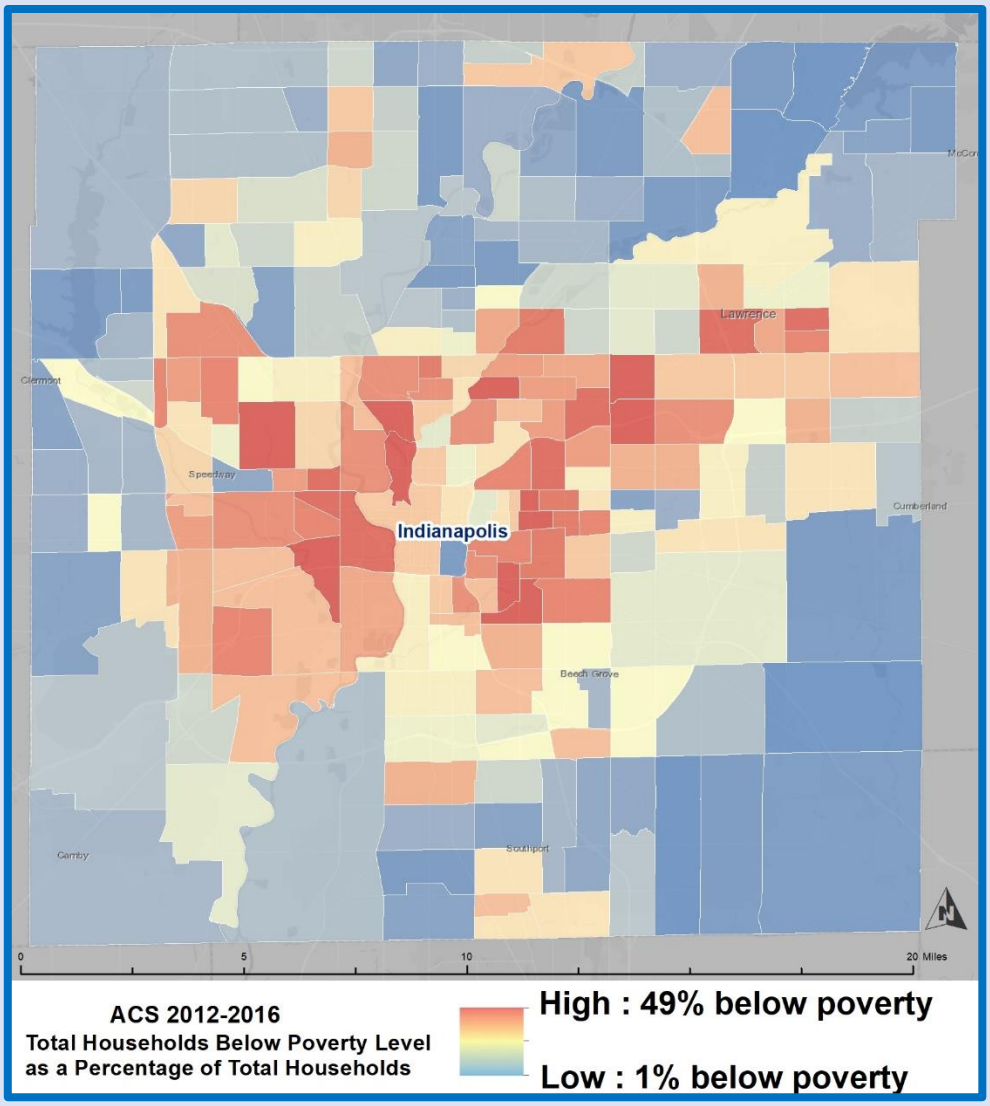


Figure 2-11: Household Poverty Rates (ACS 2012-2016)

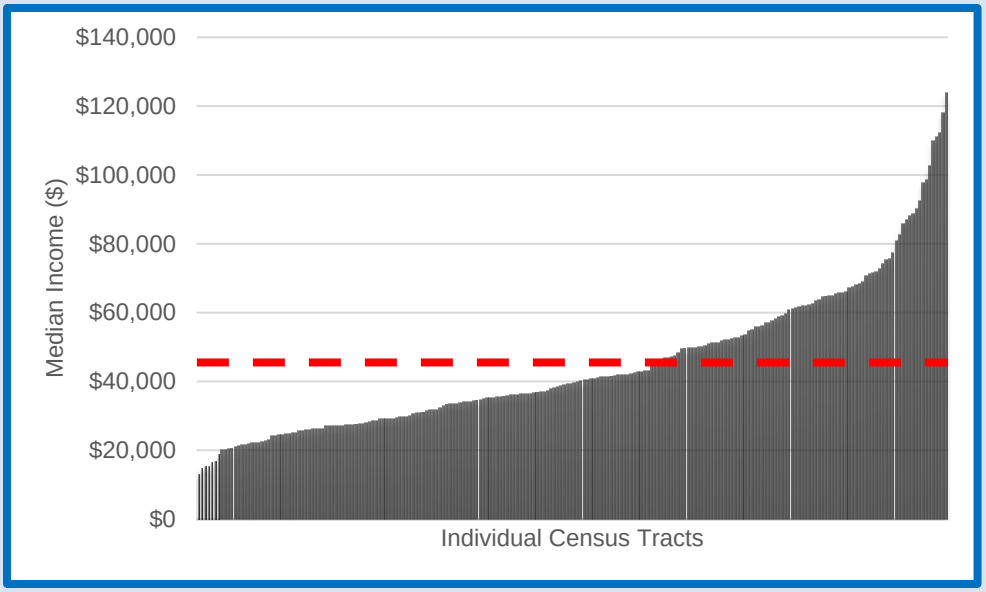


Figure 2-12: Histogram of Median Household Income for each of the 224 Census tracts within Marion County. County-wide median income shown by the red dashed line. (ACS 2012-2016)

Employment

According to 2016 data, the total resident labor force is approximately 483,993. This includes 462,513 employed residents and 21,480 unemployed residents, translating to an unemployment rate of 4.4%. This ranks Marion County 54th in the state out of 92 counties. Estimates from the Department of Workforce Development in February 2018 put that number even lower at a rate of 3.6% unemployment, still ranked 54th in the state. It should be noted that these numbers likely do not account for those who are underemployed or who have given up looking for work, thus effectively removing themselves from the workforce statistics collected by the state and federal government[3].

Of those employed, 88.8% work in a private industry and 11.2% work in local, state or federal government. While 27.1% are employed in unspecified private employment positions, Health Care/Social Services make up the second highest category of workers at 13.1%.

Table 2-2 lists the major employers in Marion County as determined by the number of employees.

Table 2-2: Major Employers in Marion County[4]

IU Health University Hospital	Eli Lilly & Co
St. Vincent Emergency Department	IU School of Medicine
St. Vincent Senior Services	Roche Diagnostic Corp
Peyton Manning Children's Hospital	IU Health Methodist Hospital
IUPUI	

Transportation & Commuting Patterns

Contributing to the tagline of "Crossroads of America," Marion County hosts many major transportation routes including Interstate Highways 65, 69, 70, 74, and 465, Federal Highways 31, 36, 40, 52, 136, and 421, and State Roads 37, 67, and 135. The major transportation routes are shown on Figure 2-13. The percentage of the population commuting via public transportation ranges from 0 to 16% of the working population ages 16 and over for each of the 224 census tracts in Marion County. The higher rates of public transportation use are clustered to the northwest of the center.

[3] https://www.bls.gov/cps/lfcharacteristics.htm#discouraged
[4] http://www.hoosierdata.in.gov/major_employers.asp?areaID=097

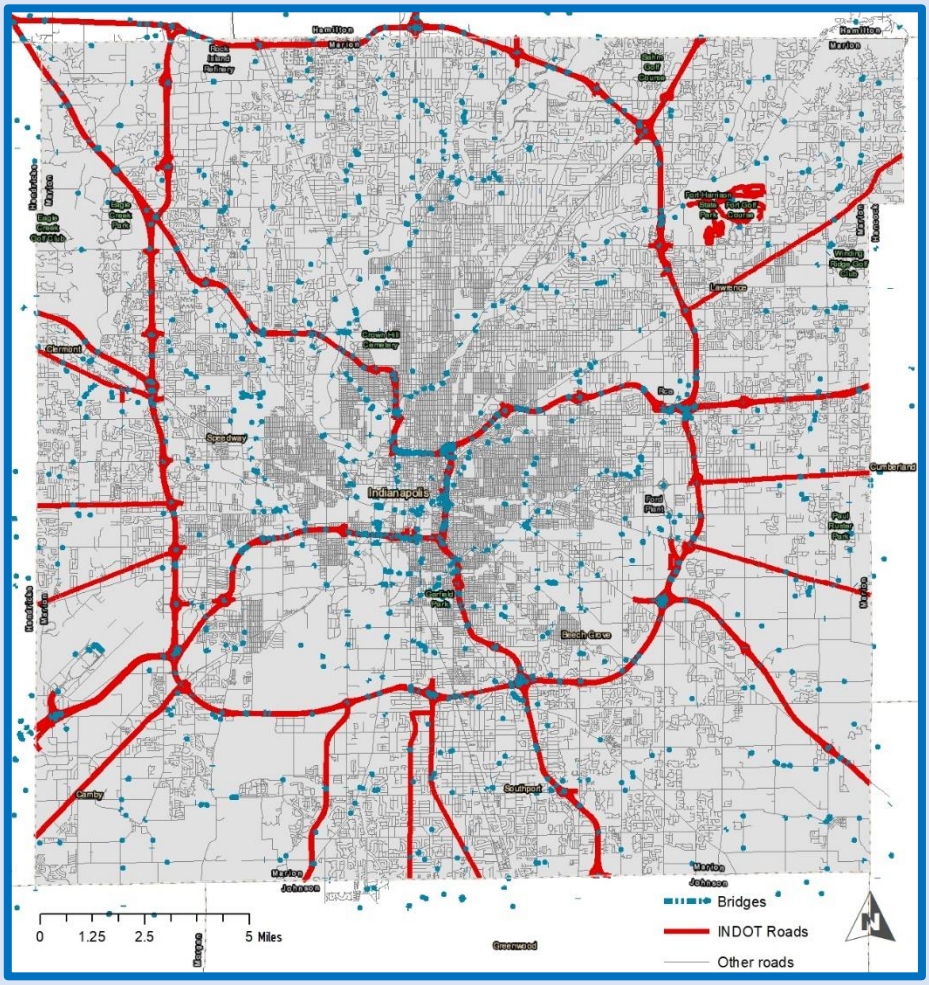
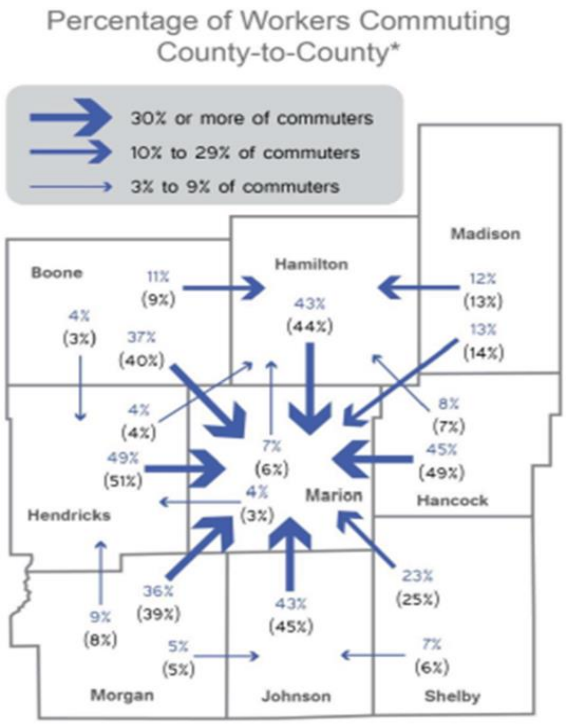
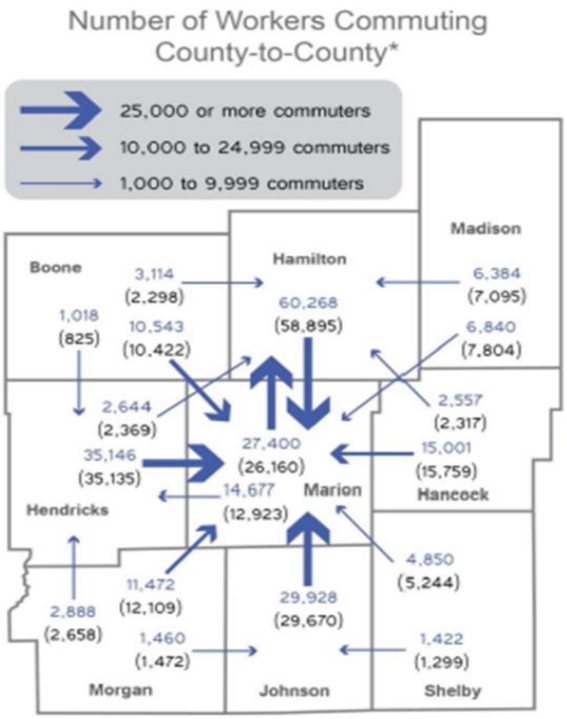


Figure 2-13: Major Transportation Routes

Figure 2-14 shows the number of workers over the age of 16 who live outside of Marion County but commute into Marion County for work. Figure 2-15 shows the number of Marion County residents over the age of 16 who commute outside the County for work. There is a significantly larger portion of commuters from surrounding counties coming into Marion County for work. There is also clearly a larger proportion of these commuters in the higher income brackets who work in Marion County but live in surrounding counties (also sometimes referred to as Donut Counties). According to 2016 tax data, approximately 20.5% of the Marion County workforce comes from workers who live outside the County but work in Marion County. Conversely 6.9% of the Marion County labor force lives inside Marion County but works outside the County[5]. ***This translates to an estimated $250 million in tax revenue lost by commuters who work outside the County.***

[5] http://www.indympo.org/whats-underway/lrtp





Source: American Community Survey 2009-2014 (Blue), 2006-2010 (Black) *Commuter flows of 3% or more of total

Figure 2-14 Commuting Workers into Marion County (ACS 2009-2014)

Figure 2-15: Commuting Workers out of Marion County (ACS 2009-2014)

Utilities and Services

Indianapolis Power and Light is the primary electric provider for Indianapolis, Lawrence, Beech Grove, and Speedway[6].

Citizens Energy Group provides natural gas, water, and wastewater service throughout the Indianapolis area. The map in Figure 2-16 illustrates the locations of various infrastructure and emergency services in Marion County, in addition to flood zones and repetitive loss areas, discussed further in the Flood Hazard Profile in Chapter 3.

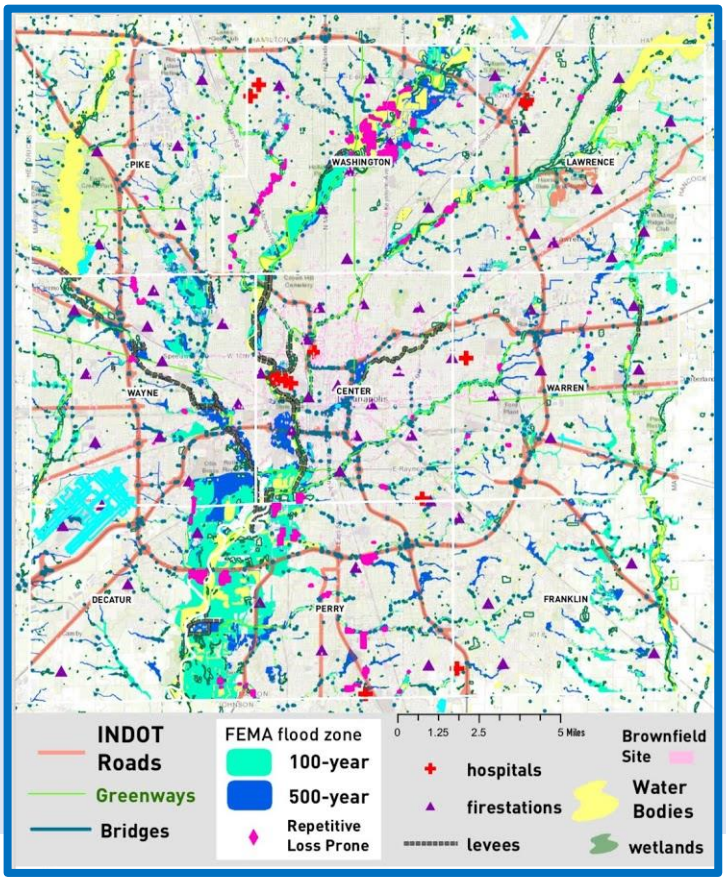
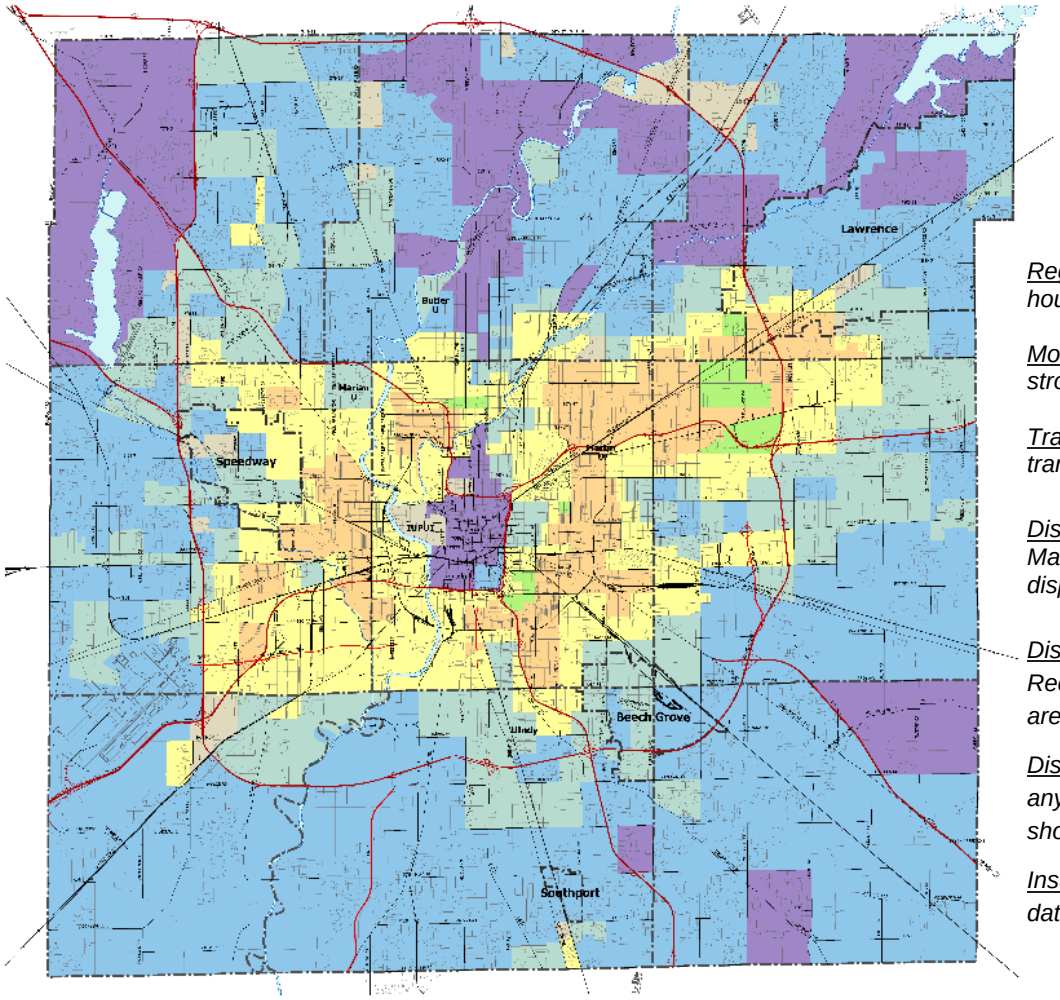


Figure 2-16: Flood Risk, Infrastructure and Emergency Services

[6] www.indianaenergy.org/electric-utility-service-areas.html

Market Value Analysis

Figure 2-17 shows the results from a Market Value Analysis (MVA) of Marion County that was completed in coordination with the Neighborhood Investment Strategy.[7] The MVA is a tool to assist residents and policymakers in understanding their local real estate markets. It is an objective, data-driven tool used to assess neighborhood investment and economic development. With an MVA, more precisely targeted intervention strategies in weak markets can be implemented and support given to foster the sustainable growth in stronger markets. The MVA is a multi-factored analysis that includes real estate values, stressed properties, density, land uses, occupancy, subsidy, and recent investment. The list on the right explains the legend. The "ring of poverty" around downtown is apparent with the various distressed areas.



Regional Choice: Strongest housing markets

Moderate Strength: Relatively strong housing market

Transitional: Market is transitioning

Distressed, Strength adjacent: Market pressure threatens to displace existing residents

Distressed, Internal Strength: Recent signs that sales prices are improving

Distressed, Isolated: Not near any strong markets, nor showing any signs of growth

Insufficient Data: Not enough data

MARKET VALUE ANALYSIS, 2015
INDIANAPOLIS - MARION COUNTY

Regional Choice
Moderate Strength
Transitional
Distressed, Strength Adjacent
Distressed, Internal Strength
Distressed, Isolated
Insufficient Data

Figure 2-17: 2015 Market Value Analysis[7]

[7] http://www.indy.gov/eGov/City/DMD/Planning/Documents/2017CPSR003-NeighInvestmentStrategy.pdf

Land Use

Figure 2-18 displays various land use categories and Figure 2-19 shows that nearly half of the land in Marion County is classified as residential.

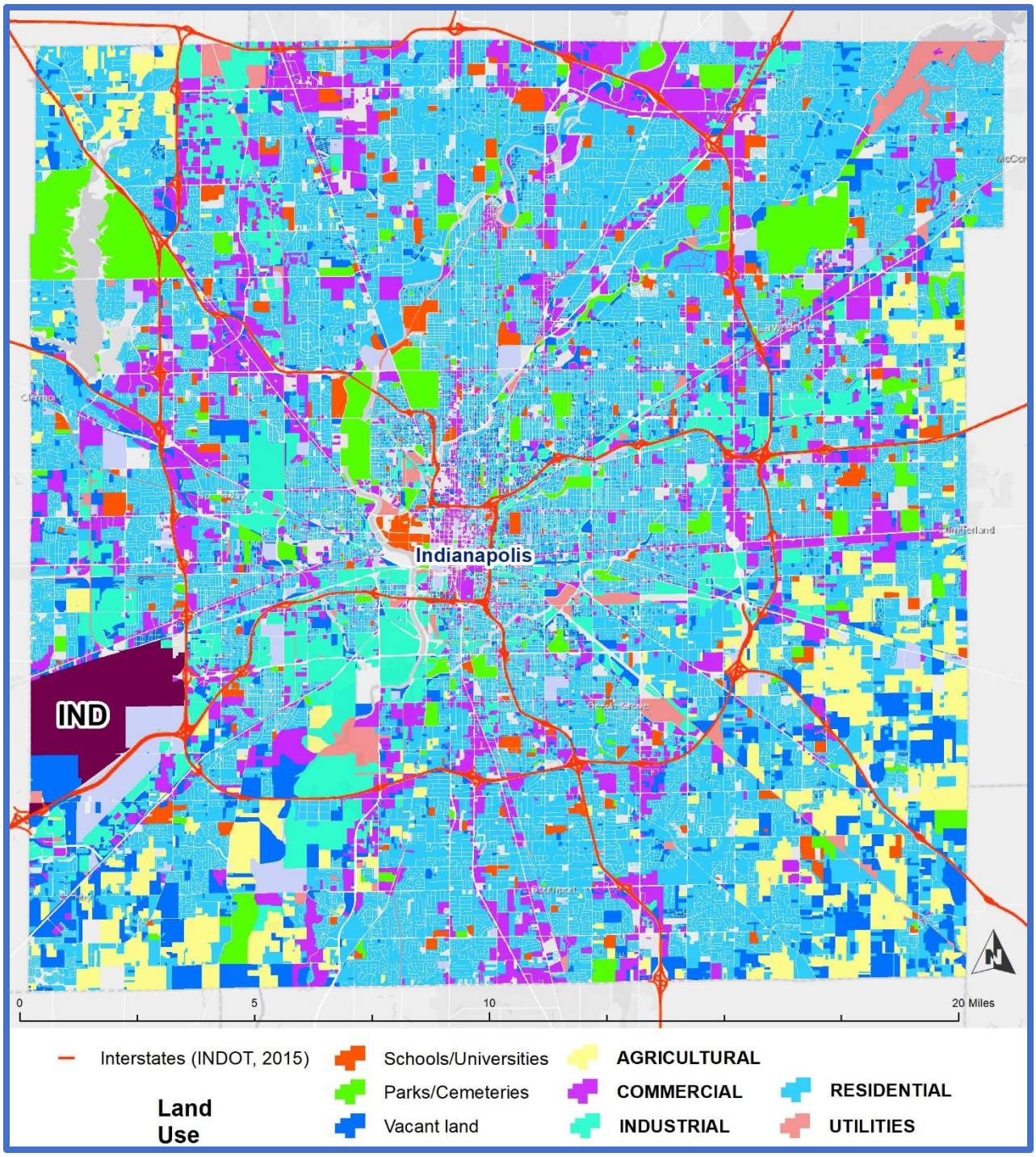


Figure 2-18: 2017 Land Use from Property Values Categories (2017)[8]

[8] https://www.arcgis.com/home/item.html?id=5800e32e9ff649029c915adcd8a080f7

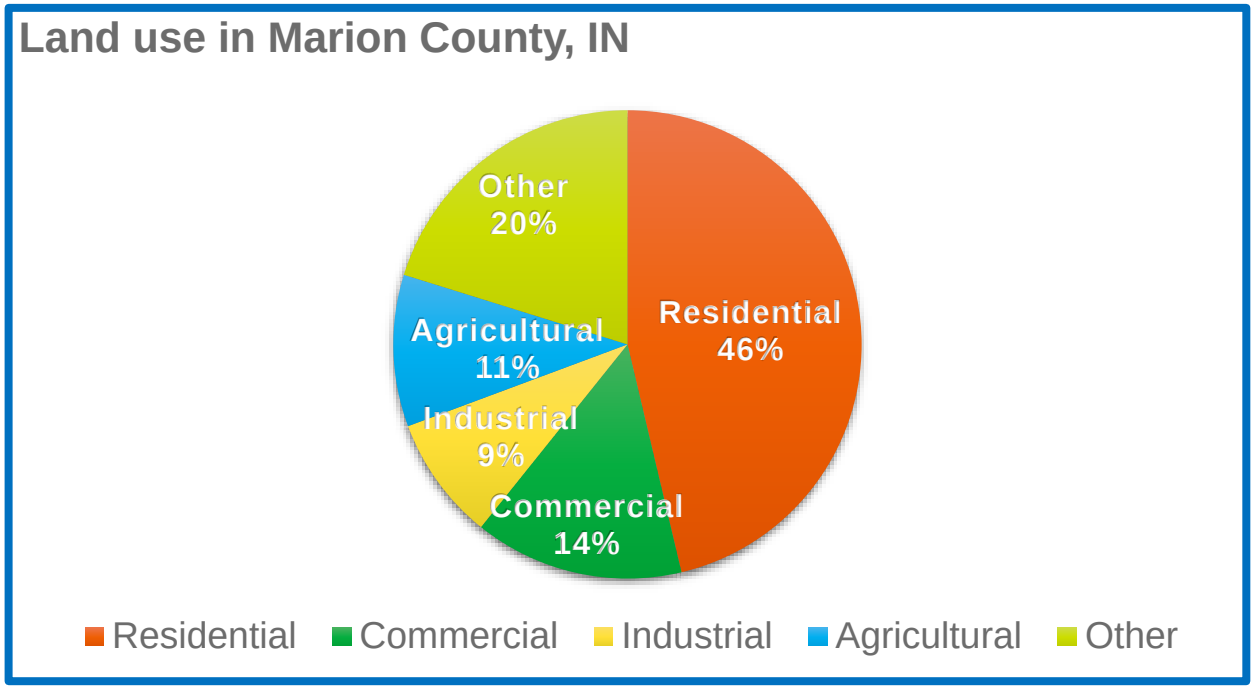


Figure 2-19: Land Use in Marion County, IN[8]

Climate

The Midwestern Regional Climate Center (MRCC) provides climate data collected at a weather station located at the Indianapolis International Airport (station 124259). A comparison of 5-year climate information for precipitation, snowfall and temperature since the last MHMP is provided in Table 2-3. It shows seasonal variations in precipitation, temperature and snowfall, as has been predicted in this area due to climate change effects. In many cases, the uncertainty in the projections results in predictions that indicate a decrease or an increase of precipitation is possible. May and July are typically the wettest months, while February is typically the driest.

Table 2-3: 5-Year Average Climate Comparison (MRCC station 124259)

Parameter	2013-2017	2008-2012
Precipitation, 5-year average (in)	45.8	43.8
Snowfall, 5-year average (in)	25.5	26.4
Temperature, 5-year mean (°F)	53.6	54.6

The highest 24-hour precipitation was recorded on September 1, 2003 with 7.2 inches of rain. The highest monthly snowfall recorded was in January of 1978 with 30.6 inches. These record extremes are discussed further in the Hazard Profiles in Chapter 3.

Looking forward, the climate is projected to change in Indianapolis. As such, the project team worked with partners at the Great Lakes Integrated Sciences + Assessments (GLISA), a partnership between the University of Michigan and Michigan State University and funded by the National Oceanic and Atmospheric Administration to develop local projections of change for Indianapolis/Marion County. Table 2-4 provides a summary of changes experienced to-date and projected changes for Indianapolis/Marion County. These projections are consistent with IN CCIA projections.

Table 2-4: Historic Record and Future Long-Term Climate Projections (GLISA Summary Report Appendix E)

Climate Change in the City of Indianapolis/Marion County					
	Historic (1951-2014)	Mid-Century Projections (High Emissions)	End of Century Projections (High Emissions)	Change Mid-century/ End of century	Percent Change* Mid-century/ End of century
Average Temperature	53.3°F	50.3 to 60.3°F	58.3 to 64.3°F	3 to 7°F / 5 to 11°F	6 to 13%/ 9 to 21%
Winter (1981-2010)	30.7°F	31.7 to 35.7°F	35.7 to 39.7°F	1 to 5°F / 5 to 9°F	3 to 16%/ 16 to 29%
Spring (1981-2010)	52.8°F	53.8 to 59.8°F	55.8 to 63.8°F	1 to 7°F / 3 to 11°F	2 to 13%/ 6 to 21%
Summer (1981-2010)	74.0°F	77.0 to 83.0°F	79.0 to 87.0°F	3 to 9°F / 5 to 13°F	4 to 12%/ 7 to 18%
Fall (1981-2010)	55.3°F	58.3 to 62.3°F	60.3 to 68.3°F	3 to 7°F / 5 to 13°F	5 to 13%/ 9 to 24%
Average Low Temperature	43.9°F	46.9 to 50.9°F	48.9 to 54.9°F	3 to 7ºF / 5 to 11°F	7 to 16%/ 11 to 25%
Average High Temperature[9]	62.7°F	65.7 to 69.7°F	67.7 to 73.7°F	3 to 7°F / 5 to 11°F	5 to 11%/ 8 to 18%
Days/Year Greater than 90°F	13.6 Days	32 to 56 Days	50 to 56 Days	18 to 42 Days / 36 to 42 Days	129 to 300%/ 257 to 300%
Days/Year Greater than 95°F	2-4 Days	10 to 15 Days	76 Days*	8 to 11 Days	300 to 400%

[9] *Percent change is calculated as the difference between the projected values and the historic average, divided by the observation and multiplied by 100.*

Data provided in this table is described in the "About the Data" section for "GHCN", "CMIP3", and "Dynamically Downscaling for the Midwest and Great Lakes Basin."

Additional details are provided in the full GLISA report included in Appendix E.

Climate Change in the City of Indianapolis/Marion County					
	Historic (1951-2014)	Mid-Century Projections (High Emissions)	End of Century Projections (High Emissions)	Change Mid-century/ End of century	Percent Change* Mid-century/ End of century
Days/Year Less than 32°F	100.4 Days	76 to 78 Days	60 Days*	-24 to -22 Days	-24 to -22%
Total Annual Precipitation	42.2 in.	40.2 to 47.2 in.	39.2 to 49.2 in.	-2 to 5 in. / -3 to 7 in.	-5 to 12%/ -7 to 17%
Winter (1981-2010)	8.2 in.	7.2 to 12.2 in.	7.2 to 12.2 in.	-1 to 4 in. / -1 to 4 in.	-12 to 49%/ -12 to 49%
Spring (1981-2010)	12.4 in.	9.4 to 15.4 in.	11.4 to 5.4 in.	-3 to 3 in. / -1 to 5 in.	-24 to 24% / 8 to 40%
Summer (1981-2010)	11.9 in.	9.9 to 13.9 in.	9.9 to 14.9 in.	-2 to 2 in. / -2 to 3 in.	-17 to 17%/ -17 to 25%
Fall (1981-2010)	9.9 in.	7.9 to 11.9 in.	7.9 to 11.9 in.	-2 to 2 in. / -2 to 2 in.	-20 to 20%/ -20 to 20%
Heavy Precipitation Days (>1.25")	6.6 Days/ Year	7.0 to 9.4 Days/Year	7.4 to 9.4 Days/Year	0.4 to 2.8 Days/Year / 0.8 to 2.8 Days/Year	6 to 42%/ 12 to 42%

* Projections from the IN CCIA.

The U.S. Climate Resilience Toolkit's Climate Explorer shows projected conditions for temperature, precipitation, and related variables from 1950 to the early 2000s for two possible futures: one in which humans continue conducting business as usual and its resulting emissions, and one in which humans make a "moderate attempt" to reduce global emissions.

The projections for Marion County indicate that even in a relatively lower emission scenario, the mean daily maximum temperature is expected to increase in decades to come (Figure 2-20). Mean daily maximum temperature stands as one measure of comfort, safety, and health due to its impact on illness, transportation and energy infrastructure stress when it exceeds certain thresholds.

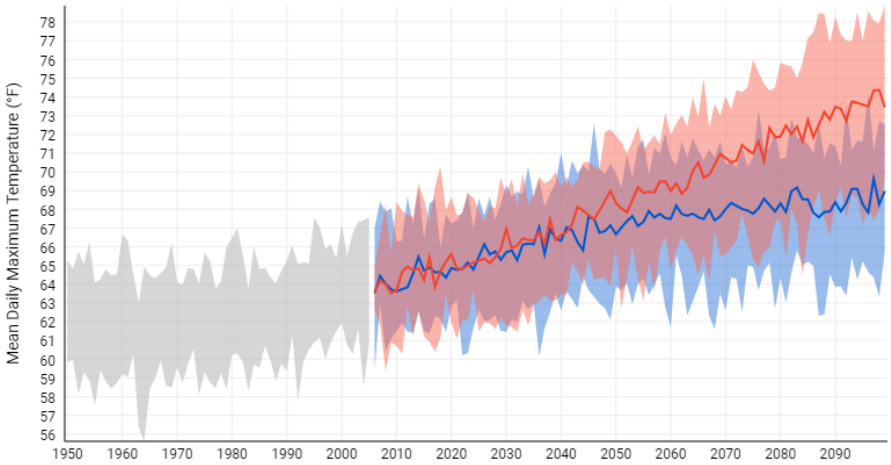


Figure 2-20: Mean Daily Maximum Temperature – Marion County[8]

A similar trend is found in the mean daily minimum temperature, as both emission scenarios result in higher mean temperatures in the coming decades (Figure 2-21). Plants, animals, and people recover from daytime heat when temperatures lower at night. With minimum temperatures on the rise in Marion County, adverse impacts to human health and ecosystems could be triggered. Cold weather also kills pests, preventing their spread. Increases in energy demand can also stress energy infrastructure.

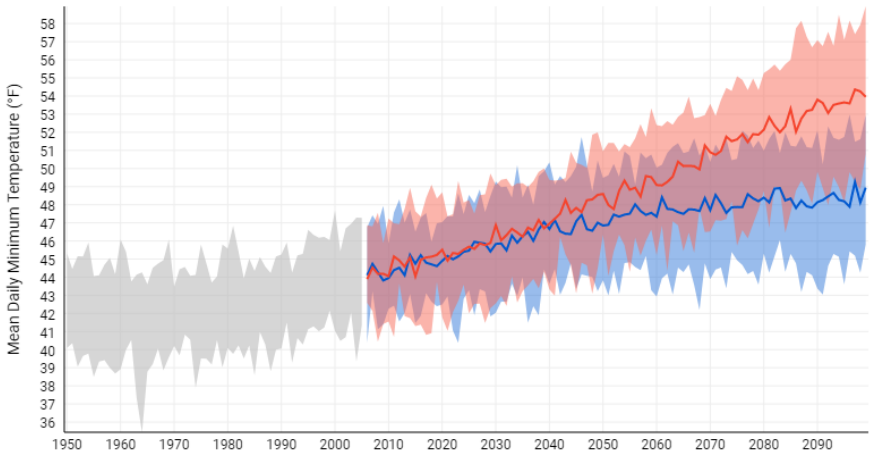


Figure 2-21: Mean Daily Minimum Temperature – Marion County[8]

The annual number of days with a temperature maximum above 95°F is indicative of how often very hot days occur. In such conditions, humans can experience heat stress or even illness depending on humidity, wind, and access to air conditioning. Plants, animals, and infrastructure are also stressed, while energy infrastructure can be stressed due to increased demand for cooling. In both emission scenarios, Marion County will experience an increase in the number of hot days (Figure 2-22).

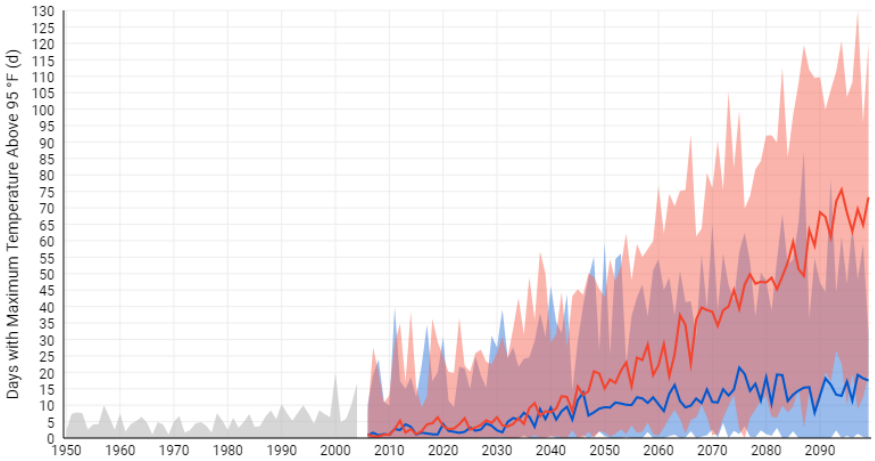


Figure 2-22: Days With a Maximum Temperature Above 95 Degrees – Marion County[8]

The total number of days per year with a minimum temperature below freezing 32°F can indicate how often cold days occur. Marion County will experience fewer days that reach below-freezing temperatures in the coming decades, under both emission scenarios, which is indicative of a trend in which cold days occur less often over the course of the year (Figure 2-23). Temperatures below freezing can present driving hazards, aircraft icing, and even directly damage infrastructure. However, certain industries such as winter recreation businesses, as well as plants, require low temperatures to maintain snowpack and spur budding or blooming, respectively.

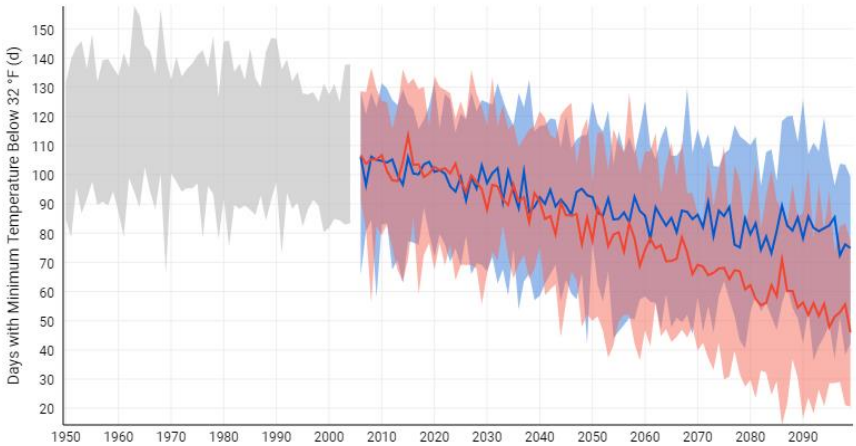


Figure 2-23: Days With a Minimum Temperature Below 32°F – Marion County[7]

While these graphs provide extreme weather data trends in coming decades under multiple emissions scenarios, extreme weather is covered more in depth in the hazard profiles in Section 3, as each is considered in the context of future climate change.

Indianapolis/Marion County Summary

- Average air temperature in Indianapolis has increased by 2.2°F since the 1950s.
- Average air temperature is expected to rise 3°F to 7°F by 2050.
- Total annual precipitation has increased by 16.1% since 1950.
- The total volume of rainfall in extreme events has increased 4% since 1981.
- Total annual precipitation will likely increase in the future, though types of precipitation will vary (i.e., more winter precipitation in the form of rain).

Major Waterways, Watersheds, and Natural Areas

Most waterways in Marion County are part of the Upper White River Watershed (8-digit Hydrologic Unit Code (HUC): 05120201), which encompasses a 2,720 square mile area (approximately 1.7 million acres) within central Indiana. The **Upper White River Watershed** is broken down in Marion County into the following smaller sub-watersheds: Eagle Creek, Lower Fall Creek, Upper Fall Creek/Geist Reservoir, Pleasant Run – White River, White Lick Creek, Goose Creek–White River, Crooked Creek-White River, and Clear Creek-White River.

The extreme eastern and southeastern corner of Marion County is in the **Driftwood River Watershed** (8-digit HUC: 05120204), which is broken down into the Grassy Creek, Buck Creek, and the Little Sugar Creek sub-watersheds. Watersheds are also known by their Hydrologic Unit Code or HUC.[10] The two watersheds can be seen in Figure 2-24.

[10] http://marionswcd.org/water-sheds/

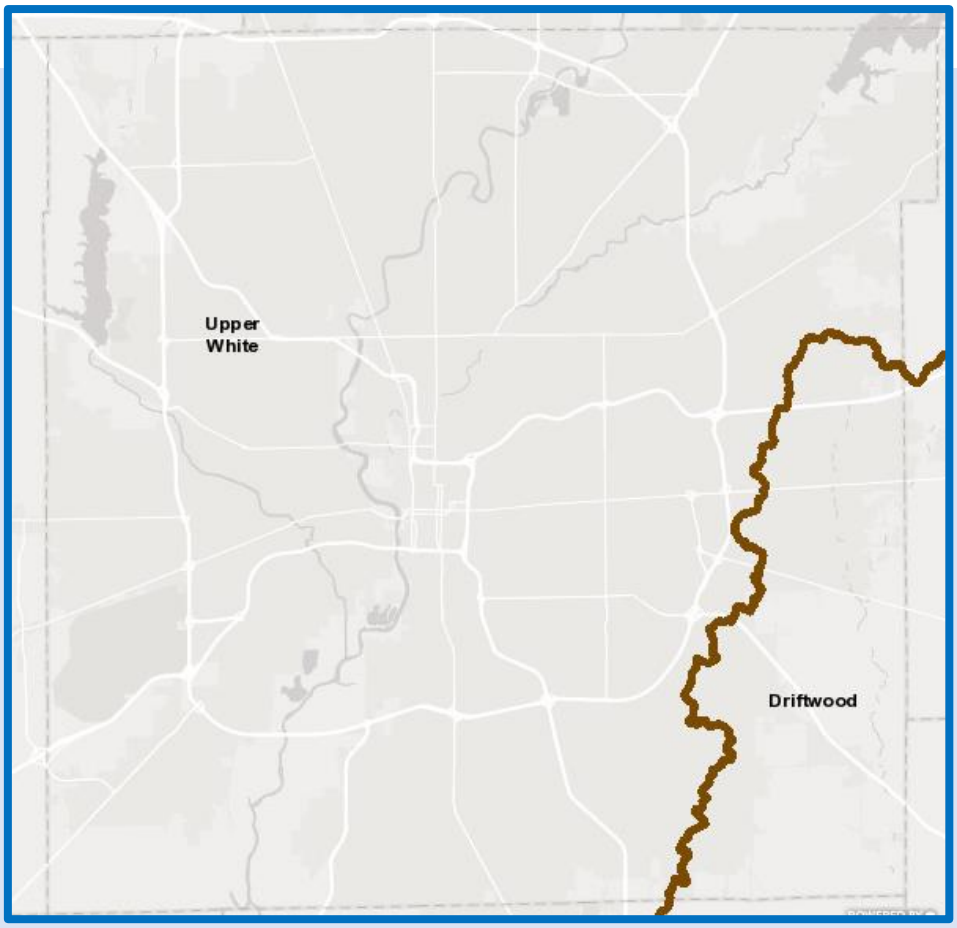


Figure 2-24: Marion County HUC 8 Map with Brown Line Separating the two Watersheds

Tree Canopy

Each year, Keep Indianapolis Beautiful (KIB) supports an average of 500 community improvement projects with more than 30,000 volunteers. For the past four decades, KIB has partnered with neighborhoods, the public sector, and Indianapolis community groups and businesses to achieve this vision for a beautiful city: *Keep Indianapolis Beautiful, Inc. sees a vibrant city, with every neighborhood landscape thriving and well, and its people empowered, mobilized, and devoted toward that vision. The result: a city defined by strong neighborhoods; inspired places; and a clean, flourishing environment.*

KIB has recently completed an assessment showing that Marion County has 33% tree canopy cover. A map of tree cover is shown on Figure 2-25. KIB has a Tree Canopy Planner and Mapping Tool[11] which enables users

[11] https://pg-cloud.com/KIB/

to view, plan, and grow the region's urban forest. KIB has many other projects, described on their website, www.KIBI.org.

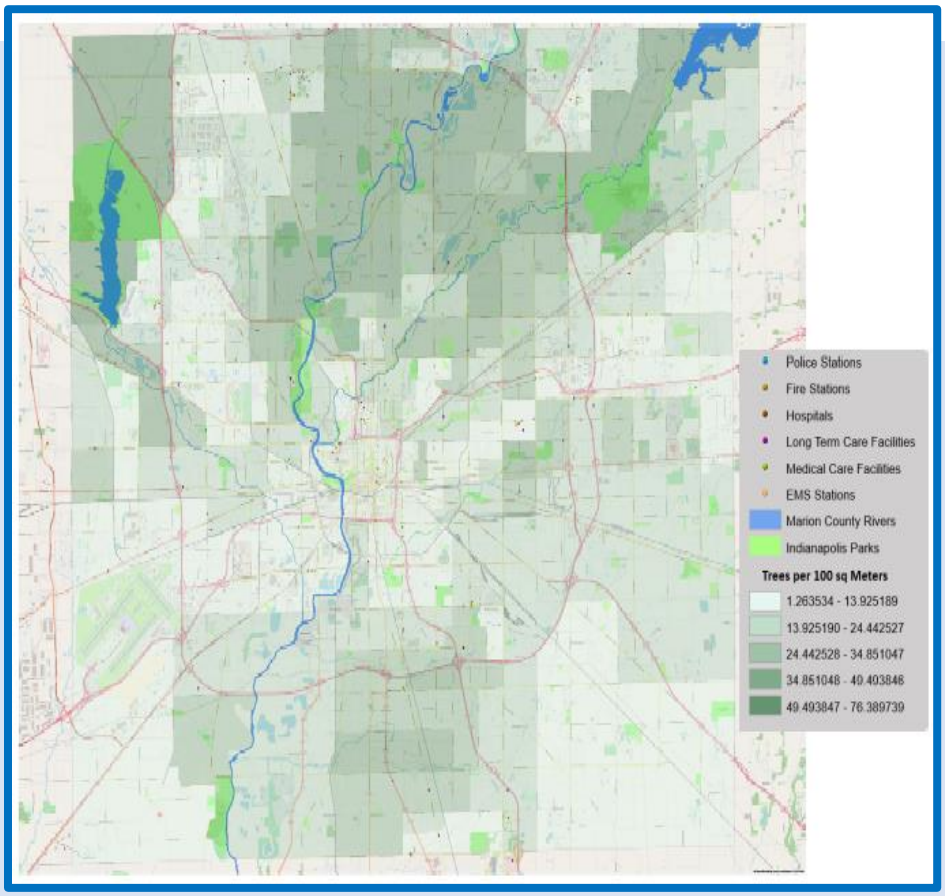


Figure 2-25: Marion County Tree Canopy (map credit: Yi Wang, Indiana University)

Water Features

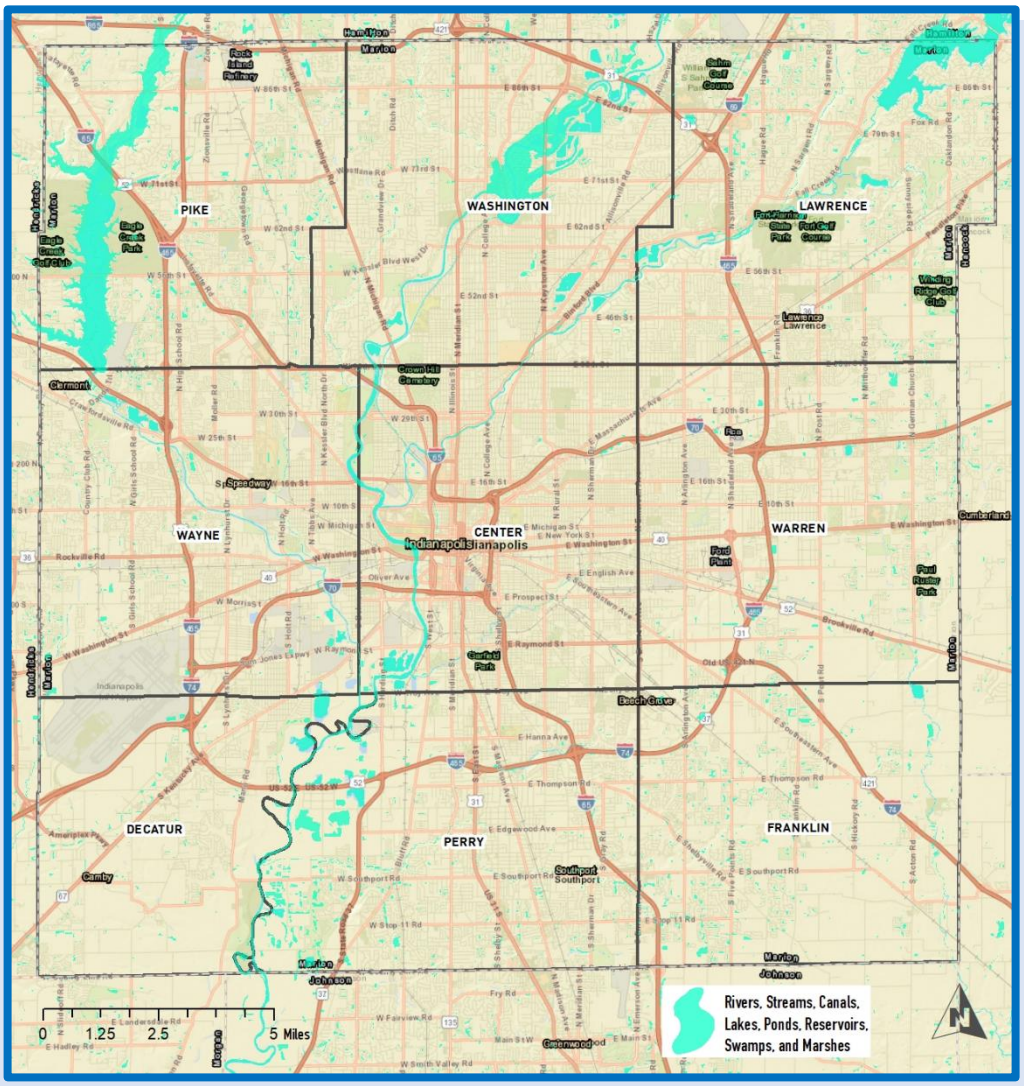


Figure 2-26: Marion County Water Features

Marion County houses the following water features (mapped in Figure 2-26):[12]

- Canals – 47
- Lakes – 7
- Reservoirs – 7
- Springs – 1
- Streams – 235

[12] http://in.gov/idem/cleanwater/pages/huc/

Topography

Marion County is relatively flat with the lowest area in the County falling along the White River as can be seen in the LiDAR data map in Figure 2-27 below. The flood zones and repetitive loss areas are also depicted in the map. The proximity of flood risk to water bodies and low-lying areas is clear. These will be discussed further in the Hazard Profile for Flooding in Chapter 3. LiDAR colorizes digital elevation model (DEM), hillshade, and slope data to form an elevation map which is more accurate than a topographical map.

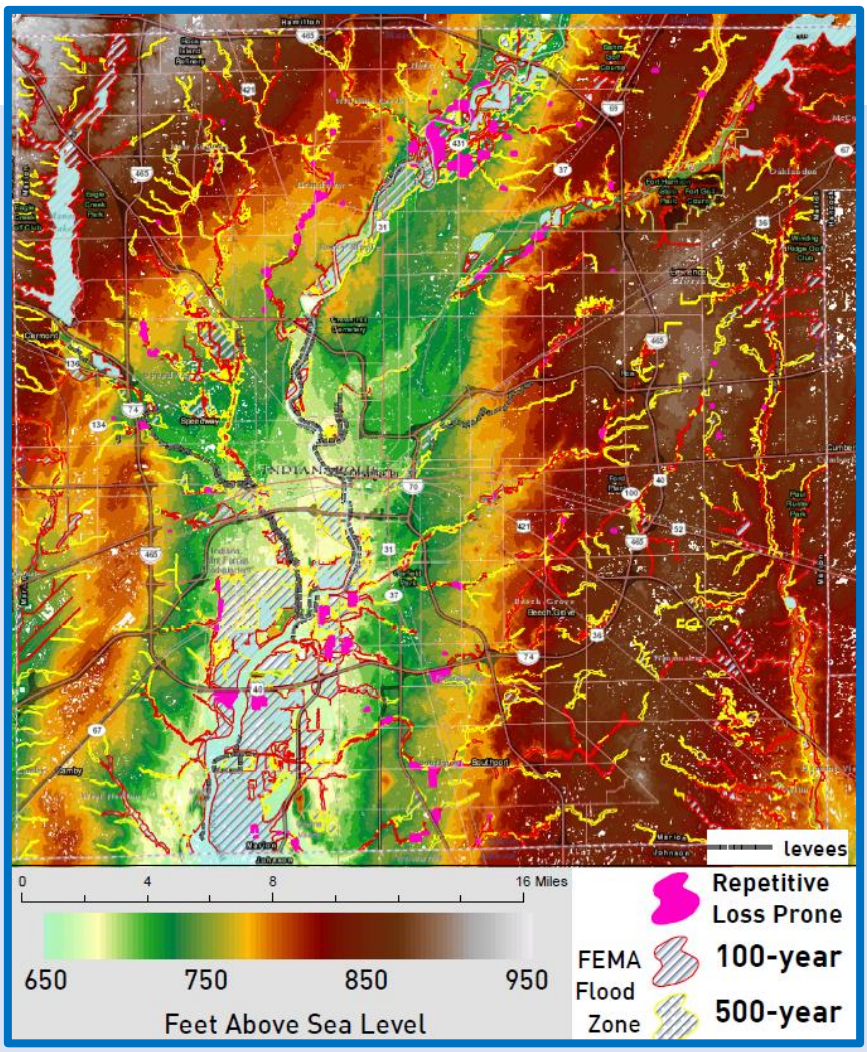


Figure 2-27: Elevation Map of Marion County

Critical Infrastructure & Non-Critical Structures

44 CFR 201.6(c)(2)(ii)(A)

The plan should describe vulnerability in terms of the types and number of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas.

According to the Critical Infrastructure Protection Act of 2001, critical infrastructure is defined as "systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters."

The operation of critical facilities becomes especially important following a hazard event since they are vital to the community's response and recovery activities. There are 16 critical infrastructure sectors, with a specific number of assets in Marion County within each sector, as defined in the Presidential Policy Directive 21 (PPD-21):

Chemical – 22 Assets – Includes basic chemicals, specialty chemicals, agricultural chemicals, pharmaceuticals, and consumer products.

Commercial – 17 Assets – Includes a diverse range of sites that draw large crowds of people for shopping, business, entertainment, or lodging.

Communication – 20 Assets – Includes terrestrial, satellite, and wireless transmission systems that enable operation of all businesses, public safety organizations, and government.

Critical Manufacturing – 3 Assets – Includes primary metals manufacturing, machinery manufacturing, electrical equipment, appliance, and component manufacturing, and transportation equipment manufacturing.

Dams/Levees – 2 Assets – Includes dam projects, navigation locks, levees, hurricane barriers, mine tailings impoundments, and other similar water retention and/or control facilities.

Defense Industrial Bases – 1 Asset – Includes resources that enable research, development, design, production, delivery, and maintenance of military weapons systems, subsystems, and components or parts to meet U.S. military requirements.

Emergency Services – 81 Assets – Includes a wide range of prevention, preparedness, response, and recovery services during both day-to-day operations and incident response.

Energy – 22 Assets – Includes the infrastructure and resources related to electricity, oil, and natural gas.

Financial Services Sector – 2 Assets – Includes thousands of depository institutions, providers of investment products, insurance companies, other credit and financing organizations, and the providers of the critical financial utilities and services that support these functions.

Food and Agriculture – 7 Assets – Includes facilities that produce products to feed and clothe people.

Government Facilities – 20 Assets – Includes facilities that may or may not be open to the public and includes general-use office buildings and special-use military installations, embassies, courthouses, national laboratories, and structures that may house critical equipment and systems, networks, and functions. It also includes cyber elements that contribute to the protection of sector assets as well as individuals who perform essential functions or possess tactical, operational, or strategic knowledge.

Healthcare and Public Health – 16 Assets – Includes resources which are critical in the response and recovery across all other sectors in the event of a natural or human made disaster.

Information Technology – 387 Assets – Includes virtual and distributed functions used to produce and provide hardware, software, and IT systems and services, and the Internet.

Nuclear Reactors, Materials, and Waste Sector – 0 Assets – Includes reactors, power plants, research facilities, testing and training facilities, and the transportation, storage, and disposal of nuclear material or waste.

Transportation Systems – 107 Assets – Includes assets related to aviation, highway and motor carriers, maritime transportation systems, mass transit and passenger rail, pipeline systems, freight rail, and postal and shipping.

Water and Wastewater Systems – 41 Assets – Includes assets needed to provide safe drinking water and properly treat wastewater in order to protect public health, prevent disease, and protect the environment.

Indiana DHS maintains a record with specific locations of critical infrastructure assets in Marion County, however that level of detail is not provided in this report in order to better protect those assets. More specific information can be obtained through communication with the Indiana DHS.

03 RISK ASSESSMENT

44 CFR 201.6(c)(ii)

The risk assessment shall provide the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessment must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

A risk assessment measures the potential loss from a hazard incident by assessing the vulnerability of the built and natural environment, as well as the community. It identifies the characteristics and potential consequences of hazards, how much of the community will be affected by a hazard, and the impact on community assets. The risk assessment conducted for Marion County and the NFIP communities is based on methodologies described in a series of guidance documents published by FEMA, including the 2013 Local Multi-Hazard Mitigation Planning Handbook. Best available data, technology, and resources were used to ensure that the risk assessment is **accurate, current, and relevant.**

The two cross-cutting themes are addressed in the following ways:

- A **Social Vulnerability Index** is presented in the first section of Chapter 3. It discusses the index methodology and presents the results as a series of maps. The results should be considered in terms of all 15 hazards in order to identify areas and populations with less resources or abilities to recover from shocks and stressors. In most hazard profiles, the *direct/indirect effects tables* in each hazard profile specifies vulnerable populations which will be potentially more at risk. Direct effects include those impacts immediately caused by the hazard while indirect effects could be due to a long-term consequences or chain reactions.
- A **Climate Change Considerations** section is included in most profiles to present data on past changes and future projections.

Each of the 15 hazard profiles consists of the following sections:

- **Hazard Identification** lists the 15 hazards selected as having the greatest direct and indirect impacts, as well as the systems used to rank and prioritize the hazards (these are covered in the greatest detail in *Appendix A - Public Outreach*).
- **Hazard Profile** for each hazard, discusses:
  - **Recent Occurrences:** Historic data relevant to the County where applicable;

- **Assessing Vulnerability:** In terms of number and types of structures, repetitive loss properties (flood only), estimation of potential losses, and impacts;
- Future considerations with respect to cross-cutting themes, as they relate to the hazards and the themes below.

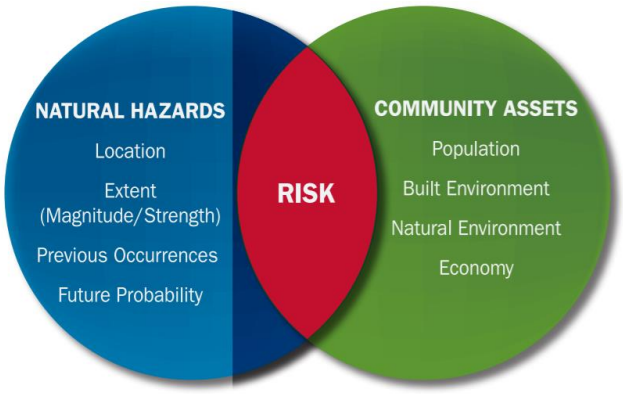
- **Hazard Summary** provides an overview of the risk assessment process and a table summarizing the relationship of the hazards.

Community risk from natural hazards

The risk assessment provides the foundation for the rest of the mitigation planning process, which is focused on identifying and prioritizing actions to reduce risk to hazards.

Risk is the potential for impacts created by the **interaction of natural hazards with community assets**. The **exposure** of people, property, and other assets can result in disasters depending on the impacts. **Impacts** are the consequences of the hazard on the community and its assets.

- 2013 Local Mitigation Handbook



Note: Modified from U.S. Geological Survey and Oregon Partnership for Disaster Resilience Models.

HAZARD SELECTION

The MHMP project team reviewed the list of human-caused, natural, and technological hazards from the 2013 Marion County MHMP. Next, the team discussed recent occurrences of the hazards and the potential for these hazards to occur in the future. The project team identified those hazards that either affect or have the potential to affect Marion County and NFIP communities and selected the hazards to study in detail as part of this planning effort. As shown in Table 3-1 these hazards include the 10 hazards assessed in the previous plan (drought, earthquake, extreme temperatures, flooding, winter storm and ice, tornado, dam & levee failure, hazardous material incident, structural fire, and civil disturbance) as well as five additional hazards including:

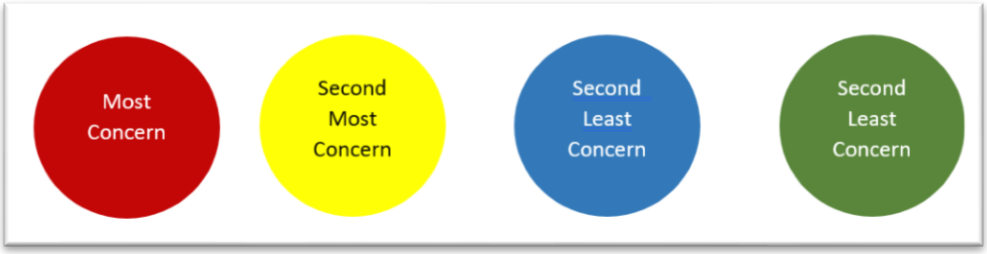
- Increased heat waves
- Increased precipitation
- Air quality
- Urban heat island
- Regional and national displacement of people and animals

These hazards were added because of recent history and predictions indicate they should be considered a possible hazard for Marion County in an effort to address chronic stressors on people and communities and the impacts from climate change.

It is understood that not every hazard can be mitigated individually. This plan operates under the assumption that most minor hazards or hazard components (i.e. hail, lighting, thunderstorms, erosion, sinkholes) can be addressed by the larger hazard categories expounded in this plan. For example, mitigating for the tornado, flooding, or increased precipitation hazards would mitigate the precursor hazard components such as thunderstorms or erosion. Other hazards, such as landslides are deemed to be isolated and minor due to the topography of the area, whereas mitigation strategies would need to be site specific rather than overarching.

During the March 27, 2018 meeting, participants marked the hazards that they identified as being of the most and least concern. Hazards marked with red are those of most concern, with yellow are second most concern, then blue, and then green as posing the least concern.

Participants were given one each of red, yellow, blue and green stickers that represented the following, regarding the hazards:



Participants were then instructed to place each sticker on the poster next to the hazard that was relevant to the color of the sticker, when asked:

Which hazards most concern you?

Which hazards are of least concern to you?

Table 3-1 tabulates the results by hazard. Most hazards that were prioritized as top concerns aligned with results from the 2013 MHMP update, but there was a heightened concern for **Winter storm & ice** and **Hazardous materials incident.**

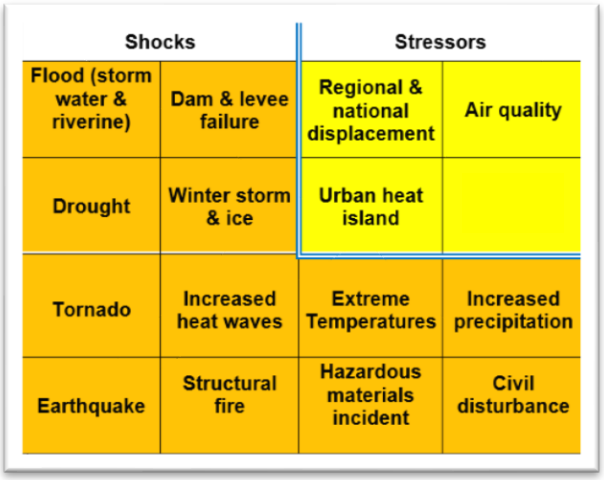
Table 3-1: Stakeholder Hazards of Most Concern

Hazard	Most concern (red)	Second most concern (yellow)	Second least concern (blue)	Least concern (green)
Flood (stormwater & riverine)	11	3		1
Dam & levee failure	3	2	2	1
Increased precipitation	1			
Drought		1	2	5
Winter storm & ice	5	4	1	1

Continuation of Table 3-1

Hazard	Most concern (red)	Second most concern (yellow)	Second least concern (blue)	Least concern (green)
Tornado		9		
Extreme temperatures		1	1	1
Increased heat waves		1		1
Urban heat island			1	3
Air quality		1	5	
Earthquake	1		2	3
Structural fire	2		1	5
Hazardous materials incident	3	4	3	1
Civil disturbance			7	3
Regional & national displacement	1		1	

During the April 26, 2018 meeting, participants were divided into groups of up to five people and sent to five stations, each with a facilitator who guided them through a "shocks and stressors" type exercise. The figures to the right show the printed 16 cards with Shocks (orange) and Stressors (yellow) and the "coordinate plane" of likelihood of occurrence and magnitude of impact. The participants were instructed to discuss the differences between the cards (particularly with respect to shocks versus stressors) and to identify linkages between seemingly unrelated ones. Each group deliberated on how the hazards ranked in frequency and severity, and which were most significant in those respects. Timeframes were also discussed, as participants placed the cards on the frequency/severity quadrants. Results are described more thoroughly in *Appendix A - Public Outreach*. It is important to note that each of the



five arrangements of cards varied dramatically within each table. There were several general overarching concerns and themes. For example, **power outages** related to several hazards, in terms of what causes them and potential impacts. During a heat wave, overuse of air conditioning can

cause power losses, which places severe stress on hospitals. The County-City has measures to identify backup generators and is looking for more solutions.

The Vulnerability Matrix below summarizes the results from aggregating how the five task force teams prioritized the 15 hazards in terms of frequency (risk) and impact severity (consequence).

Vulnerability Matrix

		Consequence			
		Low	Moderate	High	Very High
Risk	Low	-	Civil disturbance	Earthquake	Dam & levee failure
	Moderate	Drought	Increased precipitation	Extreme temperatures	Hazardous materials incident
	High	Regional & national displacement	Urban heat island	Air quality	Tornado
	Very High	Increased heat waves	Structural fire	Flood	Winter storm & ice

INTRODUCING SHOCKS AND STRESSORS

Marion County has unique risks and vulnerabilities that impact its ability to sustain and strengthen its resilience. In terms of resilience, shocks are sudden or acute events that threaten or impact immediate well-being. These can include earthquakes, extreme weather events, infrastructure failures, or civil disturbance.

Stressors are daily or chronic challenges that weaken the communities' natural, built, or human resources. Examples include climate change, aging infrastructure, inequity, and homelessness. Stressors can amplify the effects of shocks when they occur, particularly for vulnerable populations.

Shocks and stressors are interrelated. For example, increasing number of heat days is technically a hazard but may lead to longer term chronic stress on a community.

SOCIAL VULNERABILITY INDEX

Two main perspectives have emerged in terms of the meaning of vulnerability. The first is to look at vulnerability as a pre-existing condition and to focus on the likelihood of general exposure to risk. The next perspective considers the consequence of this exposure based on an individual's lack of resilience. Resilience is defined as the ability to recover from losses quickly. When resilience is considered along with resistance, which is the ability to absorb damaging impact of a hazard, they contribute to overall vulnerability.

Socioeconomic vulnerability to environmental hazards has been measured via a Social Vulnerability Index using a framework that integrates social and geographic context to frame/place vulnerability for Marion County, at the census tract level. By accounting for social vulnerability, the project team added a new dimension that can assist planners and decision-makers to evaluate areas of the City-County according to the selection of hazards.

SUB-INDEX COMPONENTS

For this index, six variables were used to evaluate vulnerability by census tract:

- Limited English proficiency
- People of color (Percent non-white)
- Population density
- Percent over age 65
- Households with no vehicles
- Percent of households below poverty

After a brief description of the methodology, the rationale for using these six indicators, the results, and other important factors will be discussed. An expanded evaluation of vulnerable populations and the impacts of hazards on them will be done in the *Thrive Indianapolis* project.

The index was developed by first identifying data for each vulnerable population per capita for each census tract, and then normalizing the data to create comparable sub-indices which assessed the population's vulnerability on a scale of 0 to 1. The average of all six sub-indices was calculated to create the aggregate Social Vulnerability Index by census tract, which gives equal weight to each of the six factors.

Social Vulnerability

Social vulnerability is defined as the disproportionate susceptibility of some social groups to the impacts of hazards. These impacts could include death, injury, loss, or disruption of life or livelihood. Social vulnerability also affects a population's resilience: the ability to adequately recover from or avoid impacts. Vulnerability is a function of demographic characteristics of the population, as well as environmental and community conditions such as healthcare provision, social capital, access to social networks, and social isolation.

There are many ways to develop a composite Social Vulnerability Index. The most common is simply aggregating a multitude of selected indicators into a single index. This can be taken a step further by defining geographical groupings within the index. It is difficult to objectively justify why one variable carries more weight than another, particularly when they include race and ethnicity. Hence, most studies use many variables and give them all equal weight.

The six indicators were normalized in order combine them. This required a statistical and mathematical analysis. The singular vulnerability index (I_n) for most social indicators is the ratio of the value for each census tract (V_n) to the maximum value for all tracts within Marion County (V_{max}) (Equation 1).

Equation 1: $I_n = \frac{V_n}{V_{max}}$

Each of Marion County's 224 census tracts was assigned a value between 0 and 1 for each indicator based on its rank in comparison to other tracts in the County. The six ranking values were averaged for each block group to give an overall social vulnerability rating to inform the potential neighborhood consequences for a variety of hazards.

RATIONALE FOR INDICATORS, SUB-INDEX RESULTS, AND MARGINS OF ERROR

The following pages present the maps with the sub-index results for the six indicators and explain why these indicators are relevant in the context of this plan. It is important to view these maps with the understanding that census data at the tract level has a significant margin of error (MOE)[13]. ACS estimates are based on a sample of the population, and this creates uncertainty in the data. At a given confidence level, the estimate and the actual population value will differ by no more than the value of the MOE. The Census Bureau Standard is to achieve 90% confidence level. For the ranges of values within the maps, MOE should be considered, in that these minimum and maximum values have a quantified level of uncertainty. MOE's are available for all census data and can be viewed at www.census.gov/programs-surveys/acs/data/data-tables-and-tools/more-acs-data-tools.html.

CLIMATE CHANGE

The Indiana Climate Change Impacts Assessment (IN CCIA), led by the Purdue Climate Change Research Center (PCCRC), contains a series of reports that explain the effects climate change is having on the state of Indiana. These reports assist in understanding the climate change-related risks and how to better plan communities to account for climate change. This may include how the state invests in infrastructure, manages agriculture, moves water, uses energy, and plans communities. The first reports of the IN CCIA were published in March 2018. The key findings of this report include projected increases in temperatures, precipitation, and

[13] www.census.gov/content/dam/Census/programs-surveys/acs/guidance/training-presentations/20180418_MOE.pdf

number of extreme weather events. These events will impact all aspects of society in Indiana including human health, public infrastructure, water resources, agriculture, energy use, urban environments, and ecosystems. The IN CCIA includes detailed evaluations of the impacts of climate change on each of these areas. The IN CCIA is the most comprehensive evaluation of the impacts of climate change ever completed for the State of Indiana.

The GLISA data and IN CCIA data are consistent.

PEOPLE WITH LIMITED ENGLISH PROFICIENCY

Residents with a limited English proficiency can miss crucial information on how to prepare for hazards. For some groups of people, cultural practices for information sharing may focus on word-of-mouth communication. During response and recovery operations in the wake of an event, residents can also face challenges communicating with emergency response personnel. If residents are more socially isolated, they may be less likely to hear about upcoming events. Finally, immigrants, especially ones who are undocumented, may be reluctant to use government services out of fear of deportation or general distrust of the government or emergency personnel.

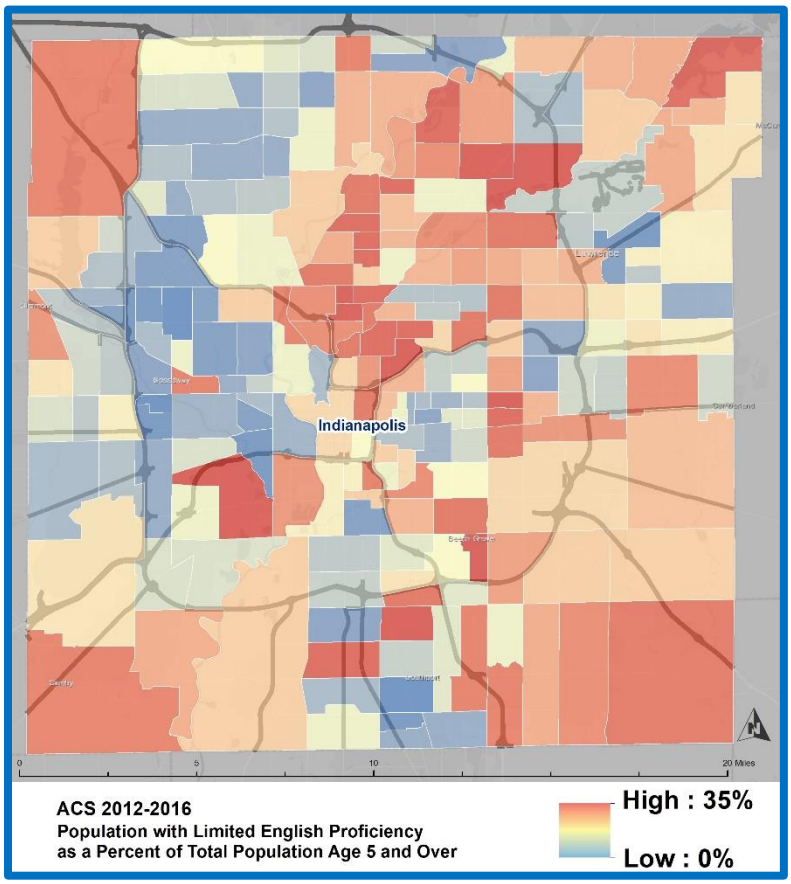


Figure 3-1: Population with Limited English Proficiency (ACS 2012-2016)

PEOPLE OF COLOR

People of color are more likely to fall into multiple vulnerable groups, as they statistically have lower levels of income and higher levels of poverty than the population at large. Non-white residents may not have ready access in their primary language to information about available resources to mitigate the impacts of hazards. Specific to extreme heat related hazards, they can be compounded by the fact that people of color often live in more densely populated urban areas that are at higher risk for heat exposure due to the urban heat island effect and poor-quality housing.

HIGH POPULATION DENSITY

Increased population density and urbanization is an indicator of vulnerability, and it has distinct value in balancing the index to be unbiased and solution-oriented. Denser populations are associated with congestion, limited escape routes, dense infrastructure, and poverty. These factors increase vulnerability to hazards.[14] Vulnerability of large rural areas can be exaggerated when mapping results. On a map, the large size of the tract makes it disproportionately stand out as a hotspot. While rural populations have fewer opportunities in some respects, the analysis must consider the applicability of solutions. When adaptation resources are limited by extent of the area, an effective strategy would be to protect the largest number of people within the smallest space, while also making sure that these are the people who need help the most. When planning and prioritizing for mitigation actions, an important

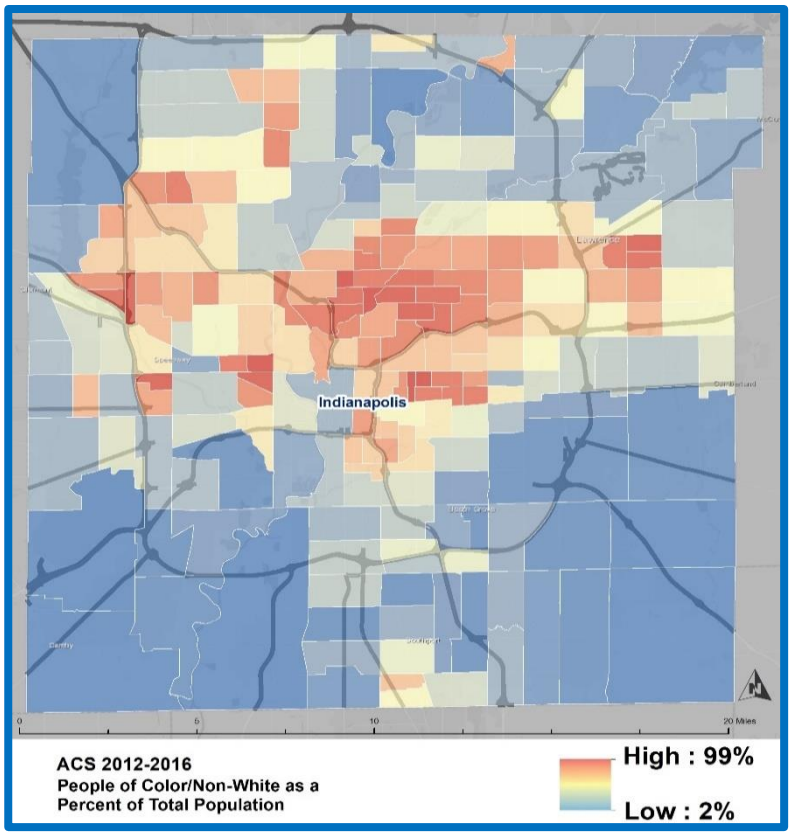


Figure 3-2: People of Color Distribution (ACS 2012-2016)

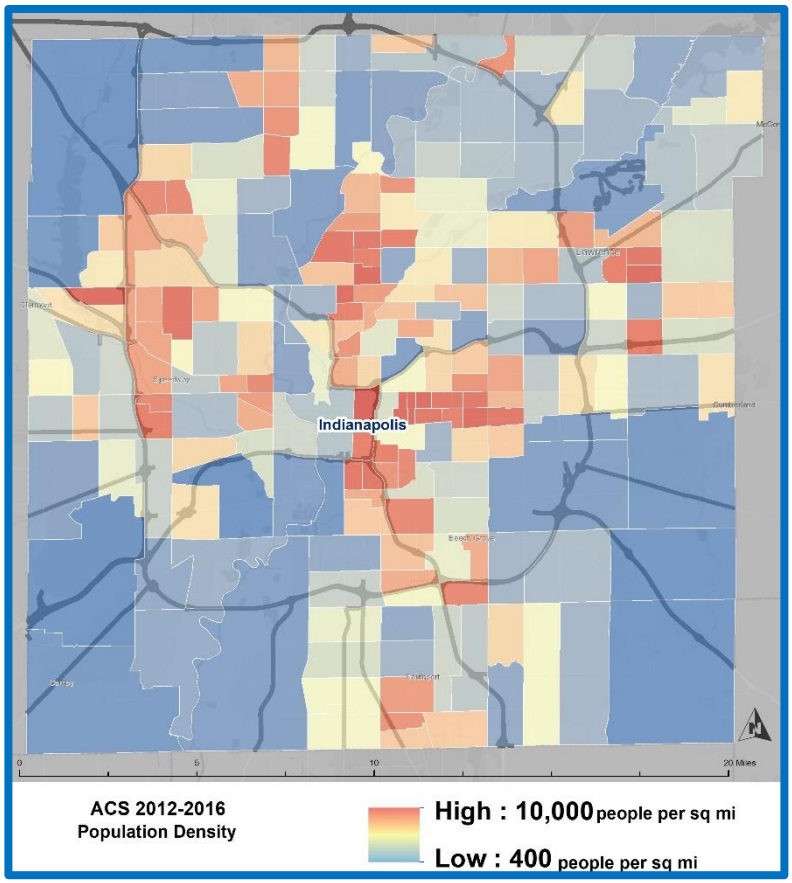


Figure 3-3: Population Density (ACS 2012-2016)

[14] https://www.prb.org/disaster-risk/

criterion is the number of additional people being protected as a result of that action.

PEOPLE WITH NO ACCESS TO A VEHICLE

Access to a vehicle influences mobility and creates further dependence on public transportation and emergency services in the event of a disaster.

PERCENT OVER AGE 65

Older adults (those over age 65) are more physically vulnerable in an emergency situation. They also suffer from higher rates of medical illness than the rest of the population and can have some functional limitations in an evacuation scenario, as well as when preparing for and recovering from a disaster. Furthermore, older adults are physically more vulnerable to the impacts of extreme heat. Beyond the physical risk, older adults are more likely to be socially isolated. Without an appropriate support network, an initially small risk could be exacerbated if an older adult is not able to get help.

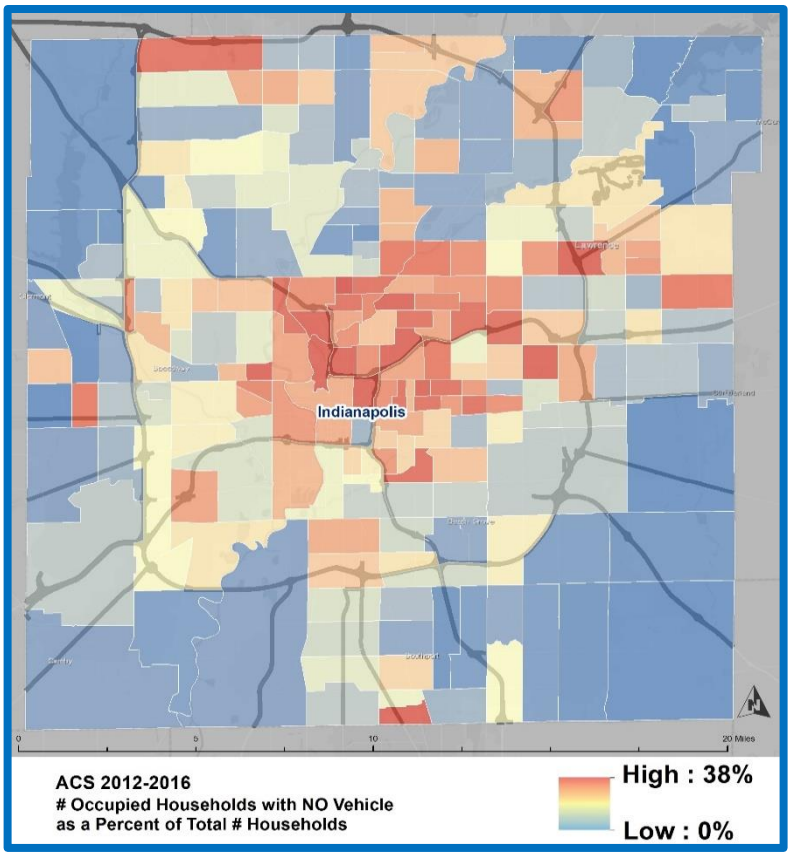


Figure 3-4: Population with No Vehicle (ACS 2012-2016)

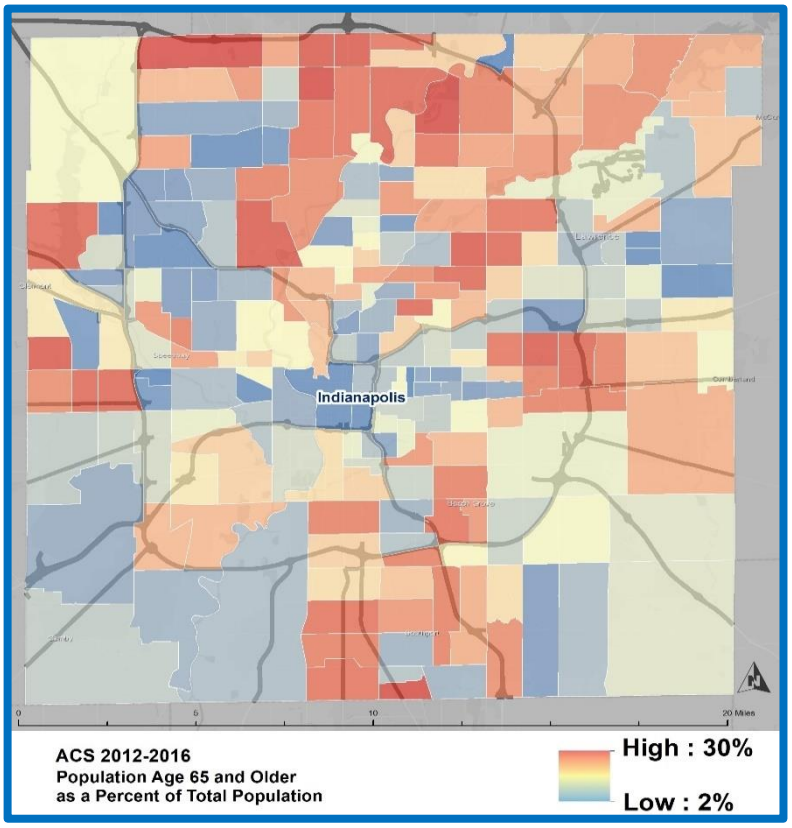


Figure 3-5: Population Percentage Over Age 65 (ACS 2012-2016)

PEOPLE WITH LOW-TO NO-INCOME

A lack of financial resources impacts a household's ability to prepare for and recover from a disaster event. It also impacts their ability to provide support to family, friends, and neighbors. For example, residents without televisions, computers, or data-driven mobile phones may face challenges getting news about hazards or recovery resources. Renters may have trouble finding and paying deposits for replacement housing if their residence is impacted by flooding. Homeowners may be less able to afford insurance that will cover flood damage. Having low or no income can create difficulty evacuating in a disaster event because of a higher reliance on public transportation and emergency services. If unable to evacuate, residents may be more at risk without supplies to stay in their homes for an extended period of time. Low- and no-income residents can also be more vulnerable to hot weather if running air conditioning or fans puts utility costs out of reach.

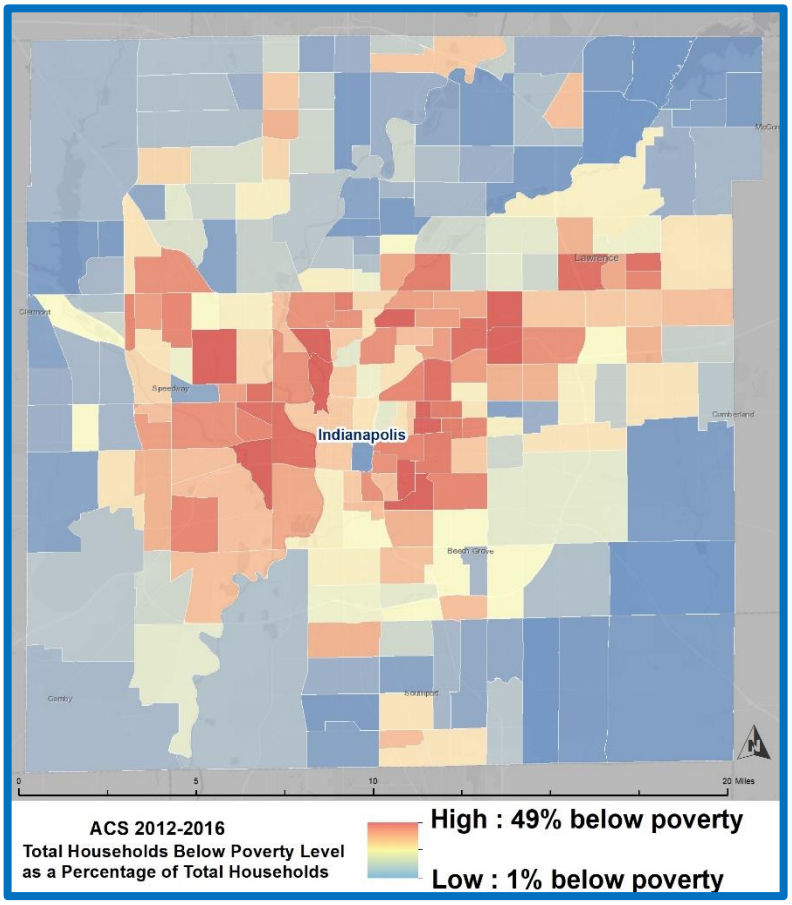


Figure 3-6: Households with Low- to No- Income (ACS 2012-2016)

AGGREGATED INDEX – An average per tract of their rankings for the six sub-indices

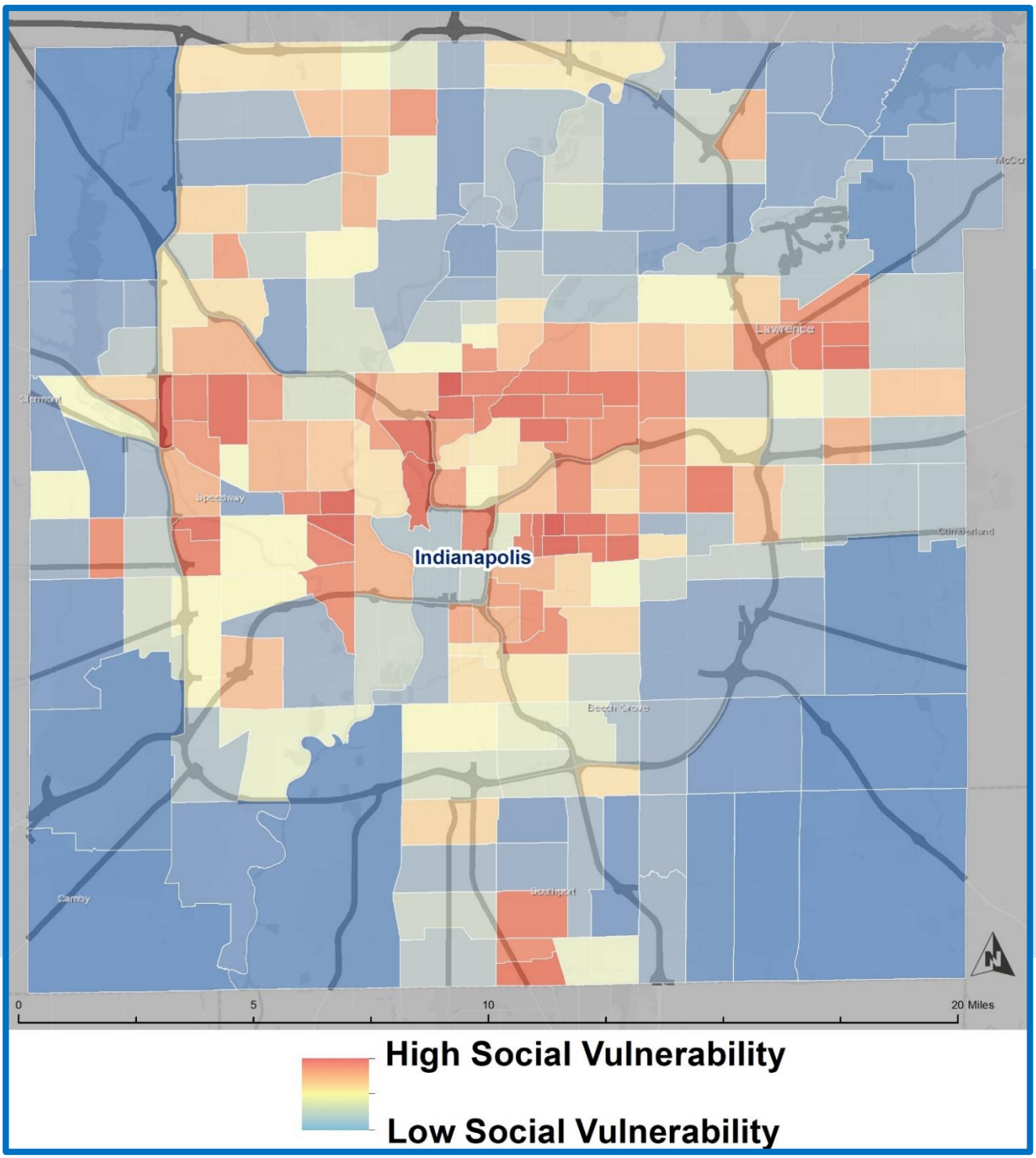


Figure 3-7: Aggregated Social Vulnerability Distribution

The largest clusters of high social vulnerability are in the northern ring around downtown. Hotspots are west of I-65 and south of I-70 to the east. However, when these tracts are overlaid with residential areas, social trends become more apparent.

The following map shows the aggregated index results overlaid with land-use to allow residential areas in tracts to be considered with respect to the results. Industrial areas are also highlighted to allow for consideration of how high social vulnerability can potentially be correlated with proximity to industrial areas and other land-uses.

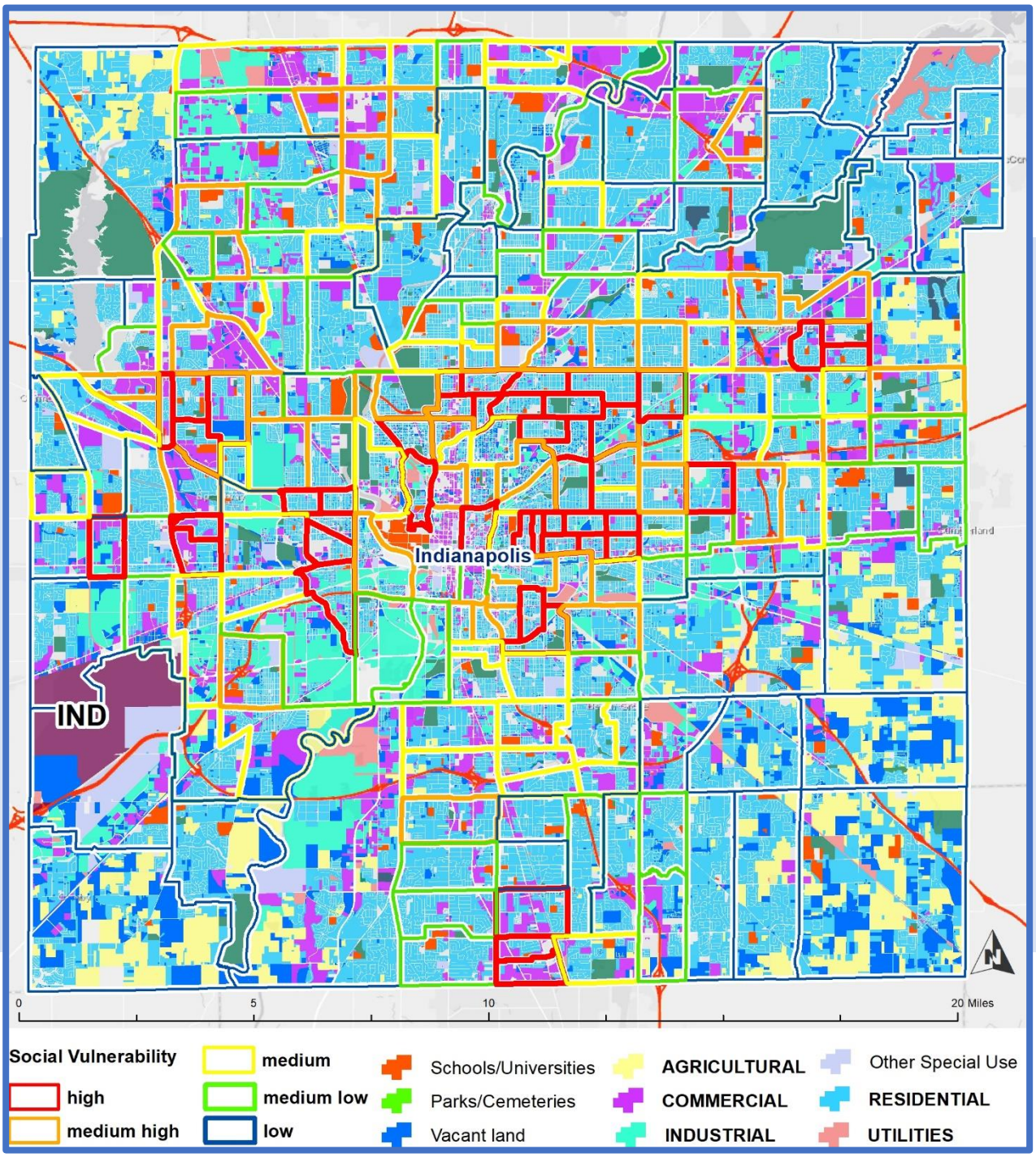


Figure 3-8: Aggregated Social Vulnerability Distribution and Land Use

ADDITIONAL SOCIALLY VULNERABLE GROUPS

CHILDREN

Families with children require additional resources in an emergency. When school is cancelled (e.g. for cold weather event), parents need alternative childcare options, which can mean missing work. Children are especially vulnerable to extreme heat and stress following a natural disaster.

PEOPLE WITH DISABILITIES

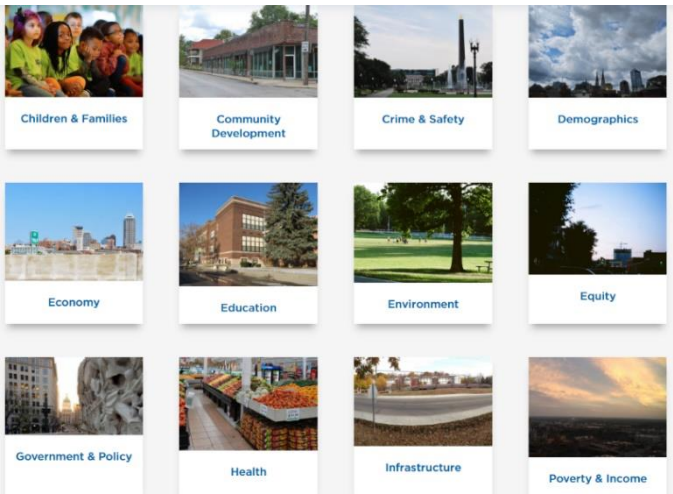
People with disabilities are among the most vulnerable in an emergency; they sustain disproportionate rates of illness, injury, and death in disaster events. People with disabilities may find it difficult to adequately prepare for a disaster event, including moving to a safer place. They are more likely to be left behind or abandoned during evacuations. Rescue and relief resources—like emergency transportation or shelters, for example—may not be universally accessible. Research has revealed a historic pattern of discrimination against people with disabilities in times of resource scarcity, like after a major storm and flood.

CASES OF MEDICAL ILLNESS

Symptoms of existing medical illnesses are often exacerbated by hot temperatures. For example, heat can trigger asthma attacks or increase already high blood pressure due to the stress of high temperatures put on the body. Disaster events can interrupt access to normal sources of healthcare and even life-sustaining medication. Special planning is required for people experiencing medical illness. For example, people dependent on dialysis will have different evacuation, shelter-in-place, or care needs than other Marion County residents in a climate event.

Other Local Indices from SAVI.org

SAVI is a program from The Polis Center at IUPUI in partnership with United Way of Central Indiana. The website offers a series of services, including web-based decision support tools. Tools provide data viewing and analysis for a wide variety of topics, including the 12 icons pictured here in a screenshot from the website.



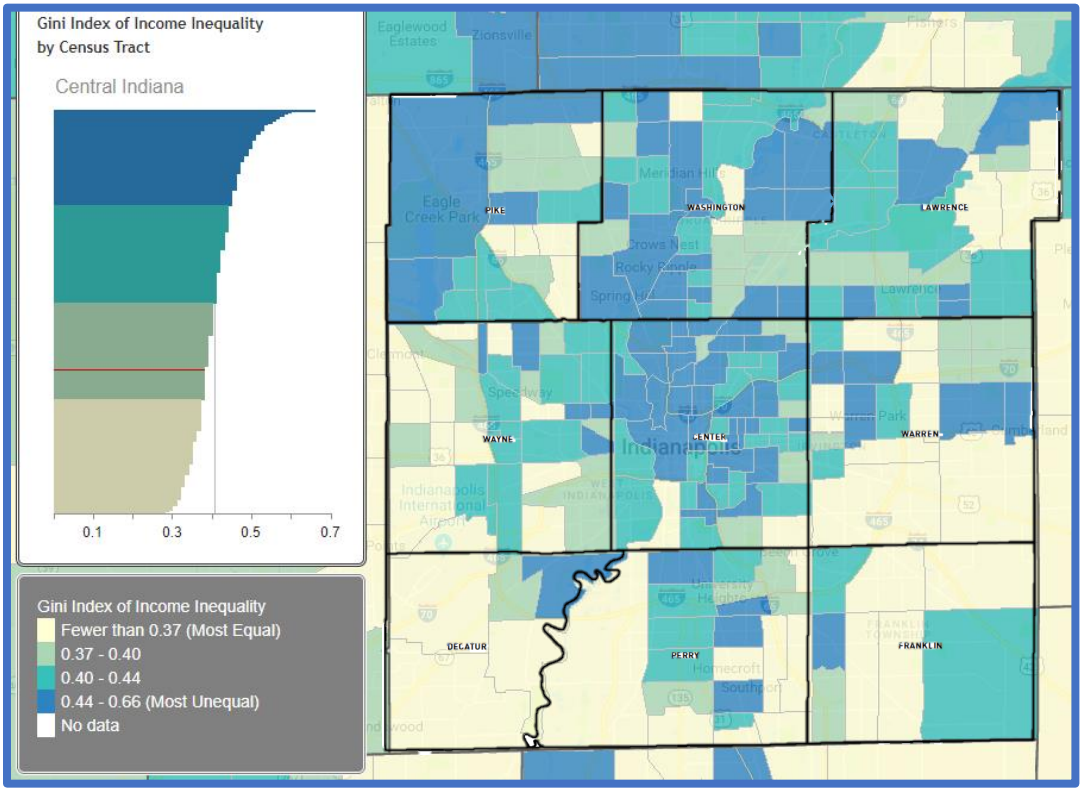
INDY VITALS

SAVI

One tool, **IndyVitals.org** is a new digital neighborhood monitoring tool for Marion County to measure progress towards the **Plan 2020** goals. IndyVitals and other interactive tools are geared toward supporting communities as they build capacity to withstand the impacts of disaster events. **SAVI.org** has compiled three state-wide indices which aggregate indicators of social vulnerability. These indices generally align with the index presented in this plan. The overarching trend that is prevalent in all indices is the **ring of poverty** around Indianapolis' downtown. The results from the indices are summarized below.

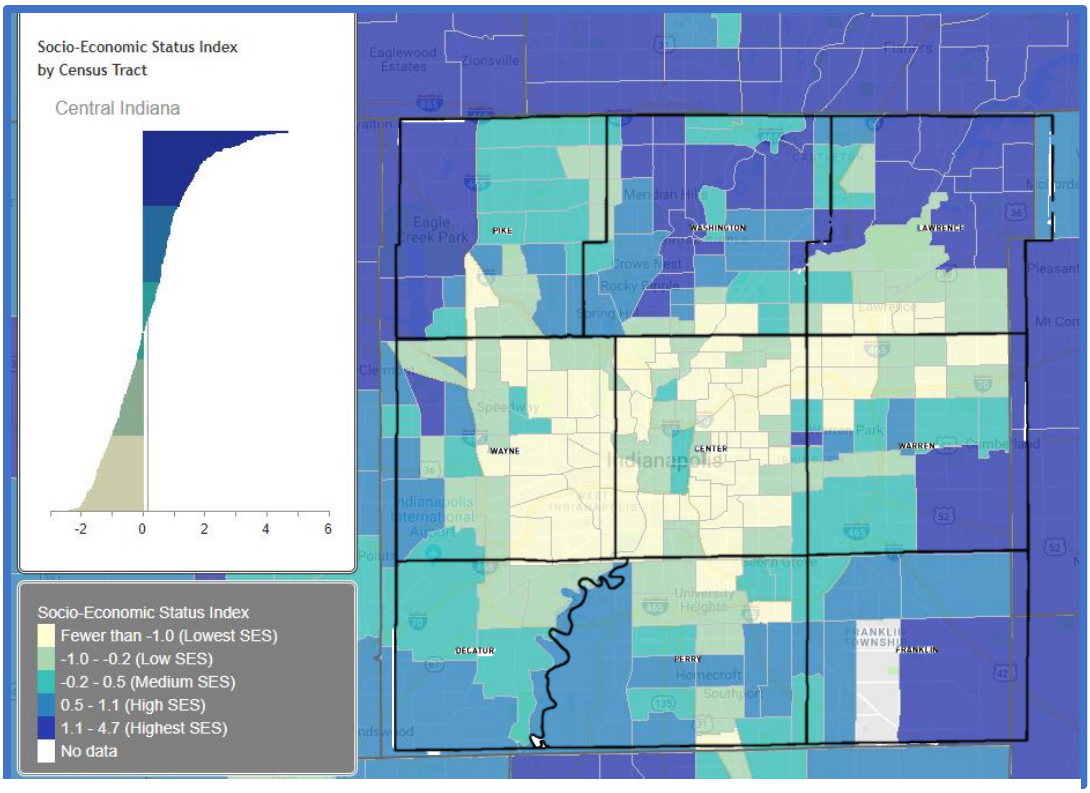
- The **Gini Index of Income Inequality** is focused on income inequality among residents WITHIN a tract, rather than comparing the County's tracts to each other. The map shows that the greatest income inequality is around the Center Township and in large parts of Pike and Washington Townships. It is also interesting to note the elevated income inequality prevails north of the urban center toward Carmel and Zionsville.
- **The Gini Index of Socio-Economic Status (SES) Index** shows a dramatically lower socio-economic status within the Center Township.
- **The Area Deprivation Index** describes the relative socio-economic deprivation of areas based on income, education, cost-of-living, employment, and domestic disadvantage/stressors. In this map, the Center Township has the most prevalent deprivation.

These indices can also be generated by township. Zooming out shows that the northern townships have higher socio-economic status and lower socio-economic deprivation.



Gini Index of Income Inequality: The Gini Index is a summary measure of income inequality. The Gini Index varies from 0 to 1. A value of 0 indicates perfect equality, where there is a proportional distribution of income, and a value of 1 indicating perfect inequality, where one person has all the income and no one else has any. (U.S. Census Bureau).

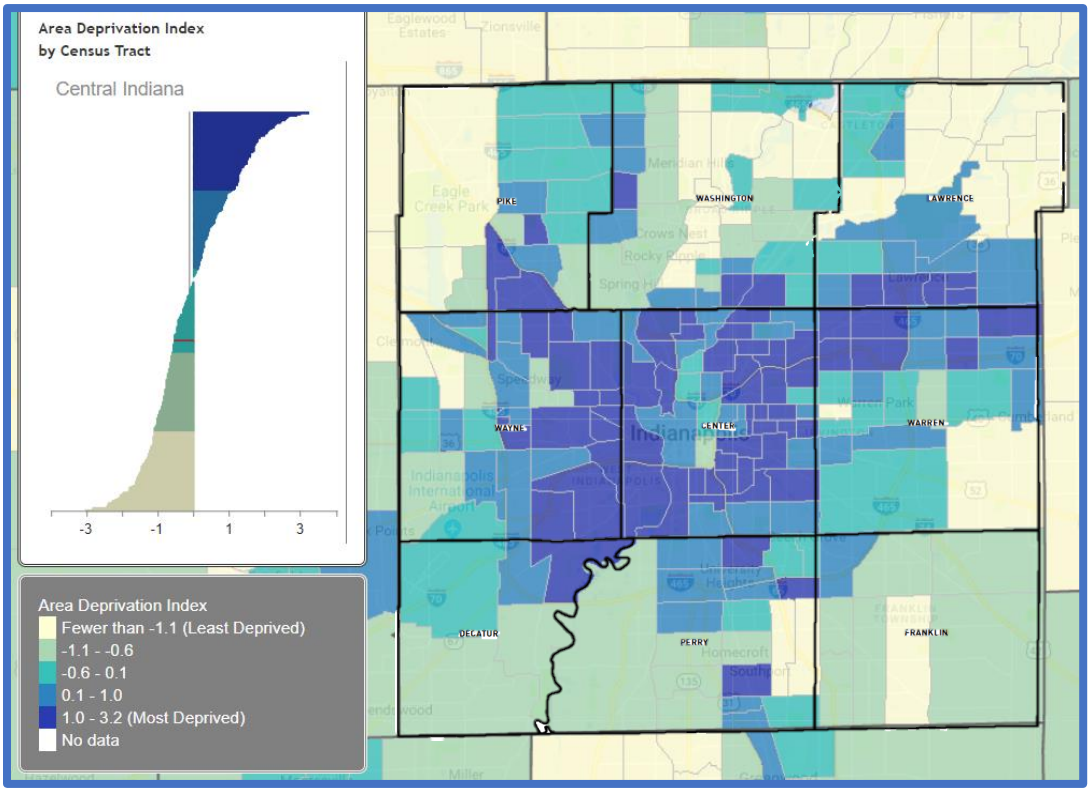
Figure 3-9: Gini Index of Income Inequality (U.S. Census Bureau)



Gini Index of Socio-Economic Status (SES) Index:

This index describes the socio-economic status of a community based on income, education, occupation, employment and other social environmental factors. A higher value on the index means a community has a higher socio-economic status.

Figure 3-10: Gini Index of Socio-Economic Statue



Area Deprivation Index:

Describes the relative socio-economic deprivation of areas based on income, education, cost-of-living, employment and domestic disadvantage/stressor (e.g., single-parent families). Higher values indicate higher levels of socio-economic deprivation while lower values indicate lower levels of socio-economic deprivation.

Figure 3-11: Area Deprivation Index

HAZARD ANALYSIS

HAZARD PROFILE 1: FLOOD

This hazard profile describes the type, location, and extent of flood hazards that affect Marion County. Those who participated in the stakeholder engagement surveys and task force prioritization exercises ranked flooding as the top concern and indicated the urgency associated with flooding potential and dangers. Information on previous occurrences of hazard events and on the probability of future hazard events is also included. The flood hazard profile has been updated to address climate change by including a discussion of how climate change can increase the frequency and severity of flooding in the community, increasing exposure to properties which are located outside of the **Special Flood Hazard Area**. While it is challenging to factor climate change into probability calculations for future hazards, several governmental and academic institutions have developed predictive models to estimate future conditions. When available, overviews are presented to describe the impacts of projected increases in extreme weather events on the frequency, severity, and duration of flood events. **National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI)** documents severe flooding events which have occurred in recent years.[15] Future increases in extreme precipitation events will directly correlate to increases in flooding, but other factors such as infrastructure and drainage can influence the damage. The **Recent Occurrences** and **Assessing Vulnerability** sections address NFIP insured structures that have been repetitively damaged by floods.

The **Assessing Vulnerability** section describes the vulnerability in terms of:

- The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;
- An estimate of the potential dollar losses to vulnerable structures and a description of the methodology used to prepare the estimate;
- A general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions;
- Delineation of each jurisdiction's risks where they vary from the risks facing the entire planning area.

WHAT IS A FLOOD?

A flood is "A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties from:

[15] https://statesummaries.ncics.org/sites/default/files/downloads/IN-screen-hi.pdf

- Overflow of inland or tidal waters;
- Unusual and rapid accumulation or runoff of surface waters from any source;
- Mudflow or collapse or subsidence of land along the shore of a lake or similar body of water due to erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood as defined above."

HAZARD OVERVIEW

FEMA describes flooding as being among the most common hazards in the United States, and flooding is considered a major hazard for Marion County.[16] Since it is a sudden event, it is a shock. Floods occur in some part of Indiana nearly every year and have occurred in every month of the year. The months of greatest flood frequency are December through April. The primary cause of floods is prolonged periods of heavy rains, although rain falling on snow or frozen ground can be a contributing factor.[17]

When do floods occur and why are they a major hazard in Marion County?

Floods occur when water recharge to an area exceeds the amount of discharge. As the most prevalent natural disaster that exists, flooding can lead to disruption losses, property damage, and loss of life, as well as accidents and injuries.[18] In the U.S. floods kill more people each year than tornadoes, hurricanes or lightning.[19] Flooding can occur any time of year, but it is most common in the spring, when heavy rains and winter snow melts occur. However, intense rainfall coupled with insufficient drainage and impermeable surfaces can cause damaging flash floods during the summer and year-round.

The traditional benchmark for riverine or coastal flooding is a 1% annual chance of flooding, or the 100-year flood. This is a benchmark used by FEMA to establish a standard of flood protection in communities throughout the country. The 1% annual chance flood is referred to as the "regulatory" or "base" flood. Another term commonly used, the "100-year flood," is often incorrectly used and can be misleading. It does not mean that only one flood of that size will occur every 100 years. What it actually means is that there is a 1% chance of a flood of that intensity and elevation happening in any given year. In other words, the regulatory flood elevation has a 1% chance of being equaled, or exceeded, in any given year and it could occur more than once in a relatively short time period.

What is a flash flood?

Flash floods are the most dangerous kind of floods, because they combine the destructive power of a flood with incredible speed and unpredictability. Flash floods occur when excessive water fills normally dry creeks or river beds along with currently flowing creeks and rivers, causing rapid rises of water in a short amount of time. Similar

[17] https://www.nssl.noaa.gov/education/svrwx101/floods/
[18] https://www.ncdc.noaa.gov/climatenormals/clim60/states/Clim_IN_01.pdf
[19] https://www.nssl.noaa.gov/education/svrwx101/floods/

flooding can also occur when water flow exceeds the capacity of drainage infrastructure. They can happen with little or no warning.

Why did the Great Flood of 1913 occur and what were the impacts?

Indiana has a dramatic history of intense flooding. In March 1913, a devastating 2-day flood event spanned 15 states along the Ohio and Mississippi Rivers. Impacts of the heavy rainfall on saturated ground in Indianapolis included:

- Six square miles inundated
- 4,000 families displaced
- Four bridges destroyed
- Levee protecting West Indianapolis was breached
- Five deaths recorded (although likely more)

The flood hazard was a unique concurrence of hazards leading to compounding effects. The late spring thaw that year meant that the ground was mostly frozen. In this condition, a series of storms brought tornadoes and two to three months equivalent of rain in the two-day span. The precipitation could not be absorbed into the frozen ground and thus became overwhelming floodwaters, with more than 90% of the rain water becoming runoff. The White River crest (feet above gauge datum) was recorded at an unparalleled 30 feet. West Indianapolis was hit the hardest in the City, with five known fatalities and 7.76-inches of rainfall in the two-day span. Fortunately, most citizens heeded the warnings and had evacuated to higher ground, reducing the loss of life. In total, there were an estimated 650 deaths in Ohio, Indiana, and eleven other states and the damage was estimated to be in the hundreds of millions of dollars. This event led to the birth of modern flood control engineering.[20]

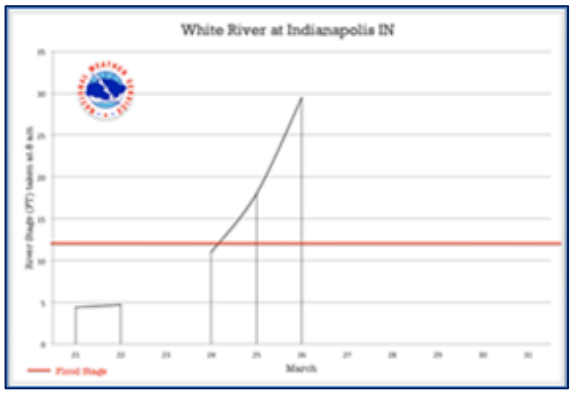


Figure 3-12: White River Stage

Figure 3-13: Impacts of the Great Flood of 1913

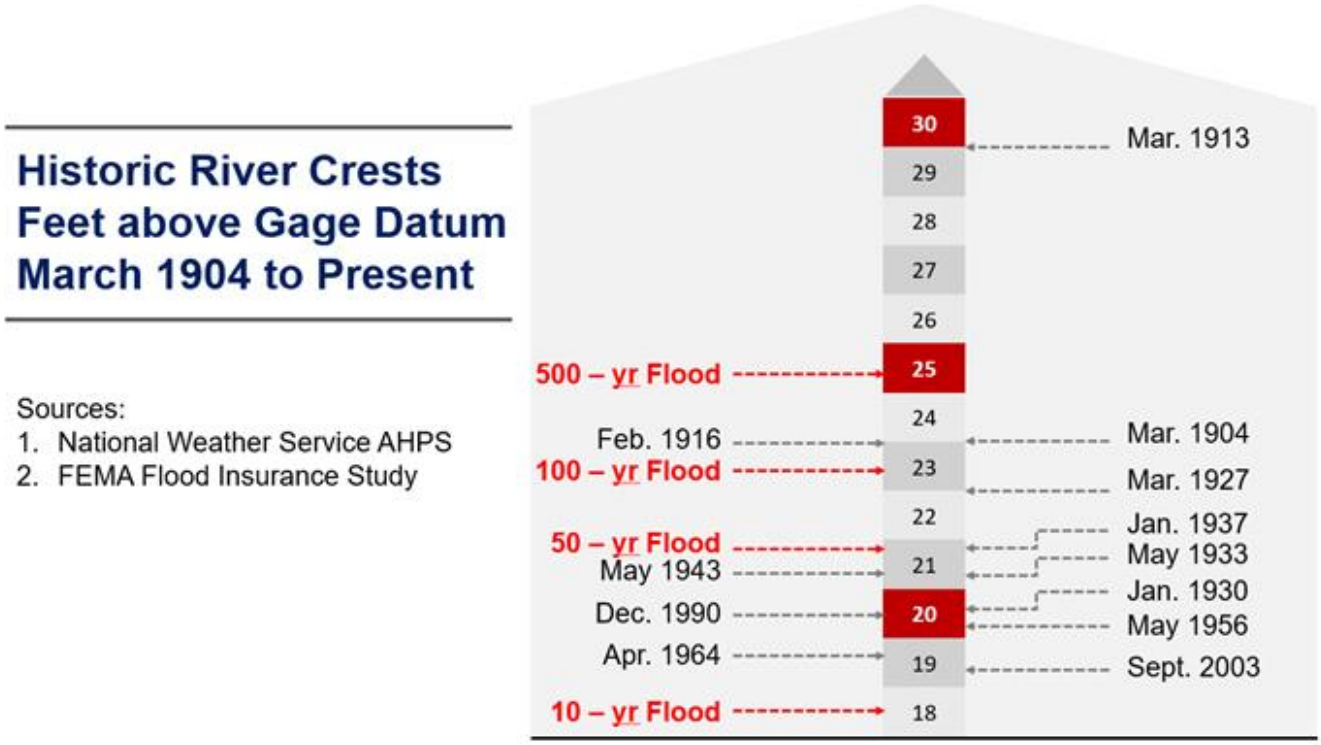
[20] References

Trudy E. Bell (Spring 2006). "Forgotten Waters: Indiana's Great Easter Flood of 1913". *Traces of Indiana and Midwestern History*. Indianapolis: Indiana Historical Society. 18(2): 15.

"Other Weather Events in 1913". The Great Flood of 1913, 100 Years Later. Silver Jackets. 2013. Retrieved 19 September 2013.

J. David Rogers. "The 1913 Dayton Flood and the Birth of Modern Flood Control Engineering in the United States" (pdf). University of Missouri-Rolla. Retrieved 23 September 2013.

Indiana Underwater: The Flood of 1913 http://www.in.gov/dnr/historic/files/hp-1913_flood.pdf



What kind of flood-related alerts are important for citizens to know about?

- **Flood Watch**: Flooding is possible. Tune in to NOAA Weather Radio, commercial radio, or television for information.
- **Flash Flood Watch**: Flash flooding is possible. Be prepared to move to higher ground; listen to NOAA Weather Radio, commercial radio, or television for information.
- **Flood Warning**: Flooding is occurring or will occur soon; if advised to evacuate, do so immediately.
- **Flash Flood Warning**: A flash flood is occurring; seek higher ground on foot immediately.

https://www.weather.gov/ind/dec2015rain

Figure 3-14: Flood Related Alerts

How are floods measured and monitored? When is a warning issued?

Flash floods tend to be associated with many types of storms, all capable of producing excessive rainfall over a particular area, so detection remains a challenge. Sometimes a flash flood threat is overshadowed by other severe weather events happening at the same time. The main tools used to detect heavy rainfall associated with flash floods are satellite, lightning observing systems, radar, and rain gauges.[21]

[21] https://www.nssl.noaa.gov/education/svrwx101/floods/detection/

Stream gauges are used to monitor surface water elevations and/or discharges at key locations and time periods. Some such gauges are further equipped with National Weather Service's (NWS) Advanced Hydrologic Prediction Service (AHPS) capabilities. These gauges have the potential to provide valuable information regarding historical high and low water stages, hydrographs representing current and forecasted stages, and a map of the surrounding areas likely to be flooded. Within Marion County, there are 22 active United States Geological Survey (USGS) stream gauges equipped with the AHPS capabilities. In addition to stream gauges, the City of Indianapolis has placed warning signs (as pictured in Figure 3-15) in flood prone areas. It is important to note that storm water and flooding do not adhere to jurisdictional, political, or neighborhood boundaries. Funding of mitigation measures and management efforts including policies, regulations, and infrastructure must be coordinated with inclusive stakeholder groups, including, technical, political, regulatory, and community members.

Figure 3-15: Warning Sign

RECENT OCCURRENCES

Where is a good place to find flood related information?

The NCEI is responsible for preserving, monitoring, assessing, and providing public access to the Nation's archive of climate and historical weather data and information. NCEI is formerly the National Climatic Data Center (NCDC). NCEI has a wide range of climate datasets and mapping tools.

The NCEI reports that between February 2013 and February 2018, there were 37 flood events (15 floods and 22 flash floods) that resulted in approximately $382,300 in property damages and an additional $11,000 in crop damages in Marion County. Only $10,750 of property damages were a result of flooding, while $367,000 was from flash floods. While no loss estimates were provided for many of the events, reports do indicate that roads were flooded, neighborhoods were affected, and damages occurred in agricultural areas.

How does flood damage for the period of this plan differ from results presented in the previous plan?

Table 3-2: Comparison of Recorded 2006-2013 to 2013-2018 Flooding Damages

2006-2013					2013-2018				
Floods	Flash floods	**Total**	Property damages	Crop damages	Floods	Flash floods	**Total**	Property damages	Crop damages
17	16	**33**	$382,300	$11,000	15	22	**37**	$377,800	$75,000

WHICH FLOODING EVENT OCCURRING BEWTEEN 2013-2018 CAUSED THE MOST DAMAGE?

- In the summer of 2015, central Indiana experienced historic levels of rainfall resulting in the wettest July on record in Indianapolis (8.6 inches above normal). Flooding in June and July exceeded flood control capacity in three reservoirs for the first time since they were built in the late 1960s. The extremity of this event rivals in magnitude the exceptional drought that impacted the state in 2012, highlighting the increasing extremes in weather that the state has experienced in recent years.
- On August 26, 2016 severe flooding came less than 48 hours after a series of tornadoes tore through the state, with impacts all over Marion County, including:
  - More than 15,000 Indianapolis Power & Light customers were without power. In a 3½-hour period, Indianapolis Fire Department (IFD) dispatchers received 102 calls for emergency medical services, 15 calls for high water and 25 calls for downed power lines, according to IFD spokesperson Rita Reith.[22] In Broad Ripple, many without power had severe basement flooding. On Winthrop Avenue, the sewers backed up, creating a lake in the middle of the road for hours. One car was inundated in water.[23] In some areas, the water was high enough to reach the headlights of cars attempting to traverse washed-out streets. Public service announcements were broadcast, “Turn Around! Don't Drown!”

Impacts of Recent Floods

Today, destruction due to flooding in the United States may cost billions of dollars per event. Due to several natural and manmade factors, Texas has been largely affected by catastrophic flooding over the past few years and in 2016 in particular.

In March 2016, over a span of just a few days, the rainfall total ranged from 15 to 20 inches, leading to massive flooding along the Sabine River basin on the Texas and Louisiana border. Five people were killed, over 1,000 homes and businesses were damaged or destroyed, and the estimated recovery costs were approximately $2.8 billion.

One month later, in April 2016, a period of extreme rainfall of up to 17 inches in just 24 hours created widespread urban flooding in Houston and surrounding areas. A local flood control district declared it a one-in-10,000-year rainfall event. Eight people were killed, thousands of homes and businesses were damaged, and roads and schools were forced to close. The total estimated costs were $2.4 billion.

https://www.ncdc.noaa.gov/billions/events.pdf

[22] https://twitter.com/Waynetwpfire/status/769318197099106304/photo/1?ref_src=twsrc%5Etfw&ref_url=http%3A%2F%2Ffox59.com%2F2016%2F08%2F26%2Fflash-flooding-causes-problems-in-indianapolis-friday-night%2F

[23] http://fox59.com/2016/08/26/flash-flooding-causes-problems-in-indianapolis-friday-night/

The Indianapolis Indians baseball game was postponed. As the scheduled game time neared, water covered the field at Victory Field. Pitcher Trevor Williams tweeted a picture and video, showing the high water wasn't limited to the diamond."
https://www.wthr.com/article/many-indianapolis-streets-heavily-flooded-after-storms-move-through

"*Any time we get a big rain like it does, it completely floods out to the point where this car was completely under water. The water was about three feet higher than what it is right now," said a resident. The resident added, "unfortunately, in some of these houses, literally the back doors are underwater and their basements are completely flooded*." (Washington Street and Tibbs Avenue, Wayne Township)

https://twitter.com/Waynetwpfire/status/769318197099106304/photo/1?ref_src=twsrc%5Etfw&ref_url=http%3A%2F%2Ffox59.com%2F2016%2F08%2F26%2Fflash-flooding-causes-problems-in-indianapolis-friday-night%2F

Central Indiana also experienced damaging floods in April 2013. Heavy rains, in some areas 5 to 10-inches of rain, on top of saturated soils caused several local water courses to crest well above flood stage and cause localized flooding. Much of the damage to structures and property was experienced in Howard and Tipton Counties to the north of Marion County.

ASSESSING VULNERABILITY

What areas are at risk from flash floods?[24]

Vulnerable areas have less capacity for storage and drainage, and are characterized by impermeable surface areas, low soil infiltration, and other factors. Flood hazards can affect many geographic settings but are especially probable in low-lying areas located near water bodies. Even very small streams, gullies, creeks, culverts, dry streambeds, or low-lying terrains that appear safe in dry weather can quickly flood and become unsafe.

Densely populated areas are at a greater risk for flash floods. The construction of impermeable infrastructure like buildings, highways, driveways, and parking lots decreases the permeability of the land cover and increases runoff. This runoff increases the potential for flash flooding.

- Sometimes, streams through cities and towns are routed underground through **storm drains**. During heavy rain, the storm drains can become overwhelmed and flood roads and buildings due to the flow constriction. Low spots, such as **underpasses, underground parking garages, and basements** are especially vulnerable.
- **Areas near rivers** are also at risk from flash floods. Embankments, also known as levees, are often built along rivers and are used to prevent high water from flooding bordering land. In 1993, many levees failed along the Mississippi River, resulting in devastating floods. The city of New Orleans experienced devastating flooding days after Hurricane Katrina came onshore in 2005 due to the failure of levees designed to protect the city.
- **Ice jams and snowmelt** can help cause flash floods. A deep snowpack increases runoff produced by melting snow. Heavy spring rains falling on melting snowpack can produce flash flooding. Melting snowpack may also contribute to flash floods produced by ice jams on creeks and rivers. Thick layers of ice often form on streams and rivers during the winter. Melting snow and/or warm rain running into the streams may lift and break this ice, allowing large chunks of ice to jam against low head dams, bridges, or other structures. This causes the water to rapidly rise behind the ice jam. If the water is suddenly released, serious flash flooding could occur downstream. Huge chunks of ice can be pushed onto the shore and through houses and buildings.
- Areas damaged by wildfires are known as **burn scars** and are particularly susceptible to flash floods and **debris flows** during rainstorms. Rainfall that is normally slowed down and/or absorbed by vegetation can

[24] https://www.nssl.noaa.gov/education/svrwx101/floods/

run off almost instantly, causing creeks and drainage areas to flood much earlier and with higher magnitude than normal.

Some populations are particularly vulnerable to flood hazards due to their inability to prepare for, respond to, and recover from these events. These groups include people with who have such things as greater social vulnerability, limited adaptive capacity, and hindered risk perception. Factors contributing to these vulnerable populations include population density, age, demographics, poverty level, literacy rate, economic diversification, as well as environmental issues. Flood-affected communities and populations are vulnerable to such things as adverse health effects, displacement, unemployment, water-borne diseases, and injury due to flooding.

How are flood events categorized?

Flood events can be categorized according to four levels of severity or extent; minor, moderate, major, and record. Minor flooding entails minimal or no property damage, but possibly some public threat. Moderate flooding involves some inundation of structures and roads near the water source requiring some evacuations of people and/or transfer of property to higher elevations. Major flooding includes extensive inundation of structures and roads requiring significant evacuations of people and/or transfer of property to higher elevations. Record flooding equals or exceeds the highest stage or discharge at a given site during the period of record keeping.

WHAT ARE DIRECT AND INDIRECT EFFECTS OF FLOOD EVENTS?

Flood events may affect large portions of Marion County at one time. Large river systems and areas with poor drainage cover much of the County and several communities. Within Marion County, direct and indirect effects of a flood event may include:

Table 3-3: Effects of Flood Events

Direct Effects:	Indirect Effects:
• Loss of life, injuries and health impacts associated with people who are unable to evacuate a flooding area in time • Property damages and/or loss of revenue for properties affected by increased water • Increased costs associated with additional response personnel, evacuations, and sheltering needs • Lower air quality and worsened respiratory symptoms • Building mold and cleanup costs These effects may be exacerbated among socially vulnerable populations who may not have insurance or resources to aid recovery; especially those who are institutionalized (in a hospital,	• Increased response times for emergency personnel if roads are impassable • Increased costs associated with personnel to carry out evacuations • Increased risk of explosions, fire, and other hazards associated with hazardous materials or other debris • Losses associated with missed work or school due to closures or recovery activities • Cancellations of special events in impacted areas due to hazardous conditions • Public health impacts of increased mold and potential for more disease vectors (e.g. mosquitoes) from standing water • Impacts during flood events may exacerbate inequities in risk and damage surrounding

Direct Effects:	Indirect Effects:
prison, foster care, nursing home, long term care) with limited mobility and access to safety. Those populations who do not have the resources to repair damaged property or replace what they have lost.	facilities and protective measures at landfills, superfund sites, combined sewer overflow locations, wastewater treatment plants, and CERCLIS sites not on the NPL and expose the environment and various populations to harmful chemicals • Food deserts are particularly vulnerable if flooding impacts local grocery stores and/or restaurants, leaving people without a way to purchase food

Flooding of structures like homes and business can degrade indoor air quality and worsen asthma symptoms. On average, people spend at least 90 percent of their time indoors. Thus, the quality of indoor air heavily affects the health status of the population. Moisture, increased air humidity, and damp building materials can significantly impact indoor air quality. Any residential or commercial structures that experience flooding will face potential long-term challenges related to mold growth and resulting respiratory problems. This risk is exacerbated in buildings that are adjacent to poorly drained soils, have poorly sealed exterior windows and roofs, or use forced hot air, which can become a conveyor of air from damp basement areas.

The presence of residential buildings in flood prone areas likely means that nuisance flooding occurs in that area. Nuisance flooding, minor, recurrent flooding that takes place during smaller rain events, rarely damages property, but impacts road access and mobility. Nuisance flooding affects quality of life for people in general, with a higher probability of impacting socially vulnerable populations. Flooded sidewalks, for example, can impact someone in a wheelchair or has difficulty walking, making it more difficult to complete a daily task. Flooded roads and sidewalks also disrupt neighborhood connectivity and isolate residents from one another, contributing to social isolation. For populations burdened with significant stressors and fewer resources, this hazard will cause disproportionate impacts.

Marion County is considered at high risk of flooding by MHMP Task Force based on numerous surface water features and historical occurrence. Flood effects can be local, impacting a neighborhood or community, or very large, affecting entire river basins. Impacts from flooding may include erosion, loss of potable water supplies, drowning, collapse of or damage to structures, undermined structural integrity of roads, bridges, and other critical infrastructure. Buildings are vulnerable to inundation which may damage or destroy them, and riverine erosion may compromise the integrity of structures. Additionally, there can be loss of service if a road is washed out impacting the ability and efficiency of emergency response services. Other impacts include possible loss of water services, and based upon historical accounts, there can be economic impacts as well.

WHAT IS A REPETITIVE LOSS PROPERTY AND HOW DOES IT RELATE TO FLOOD INSURANCE REQUIREMENTS?

Any property having received two insurance claim payments for flood damages totaling at least $1,000, paid by the NFIP within any 10-year period since 1978, is defined as a repetitive loss property. These properties are important to the NFIP because they account for approximately one-third of the country's flood insurance payments. According to the Indiana Department of Natural Resources (DNR), Division of Water, there are 171 properties within the City of Indianapolis that are considered to be repetitive loss properties. Further, within the City of Lawrence, there is one additional repetitive loss property. As a part of the Marion County's mitigation efforts, the County has purchased one property in a repetitive loss area in the City of Lawrence.

There have been numerous claims made for damages associated with flooding in Marion County. Within the Town of Speedway, there have been two claims and more than $2,000 in payments. In addition, there have been 2,091 claims within the City of Indianapolis resulting in approximately $16,500,000 in payments. Approximately $13,400,000 of payments were made in 2013 and an additional $3,100,000 were made since then. Tables 3-4 through 3-8 present various flood-related damage data. Table 3-4 specifically identifies the number of claims per NFIP community as well as payments made. Mandatory flood insurance purchase requirements apply to structures in 1% annual chance of flooding delineated areas. Total flood insurance premiums for Marion County and the NFIP communities is approximately $4,900,000. Of that total, $17,000 is flood insurance coverage for the City of Beech Grove. Premiums have decreased from their peak in 2013, when they were $5,800,000.

Table 3-4: NFIP summaries for Marion County

Source: Federal Emergency Management Agency NFIP Insurance Report Indiana

Community Name	Total Premium	A-Zone	No. Policies	Total Coverage	Total Claims Since 1987	Total Paid Since 1978
MARION COUNTY						
CITY OF INDIANAPOLIS	$ 4,755,752	2,896	4,214	$ 837,784,300	2,091	$ 16,488,435
CITY OF BEECH GROVE	$ 17,078	7	18	$ 5,943,400	0	$ 0
CITY OF LAWRENCE	$ 13,696	7	20	$ 4,221,900	2	$ 10,389
TOWN OF SPEEDWAY	$ 94,712	52	73	$ 11,153,200	2	$ 2,098
County Total	**$ 4,881,238**	**2,962**	**4,325**	**$ 859,102,800**	**2,095**	**$ 16,500,922**

The following sections discuss each jurisdiction's risk and vulnerability to flooding. Flood hazard areas identified on the Flood Insurance Rate Map (FIRM) are identified as a Special Flood Hazard Area (SFHA). SFHAs are defined as the area that will be inundated by the flood event having a 1% chance of being equaled or exceeded in any given year. The 1% annual chance flood is also referred to as the base flood or 100-year flood. SFHAs are labeled as Zone A, Zone AE, and Zone VE. Zone VE is also referred to as the Coastal High Hazard Area (CHHA), as it is along waterways. Tables 3-7 and 3-8 below provide a summary of the parcels located within the SFHA and the 500-year flood hazard area which are vulnerable to flooding and its impacts for unincorporated Marion County and each jurisdiction. Of the 341,923 parcels in the County, 45,461 are either within or touching the SFHA.

Critical Facilities

"Critical facilities" are defined as those structures from which essential services and functions for survival, continuation of public safety actions, and disaster recovery are performed or provided. Shelters, emergency operation centers, public health, public drinking water, sewer and wastewater facilities are examples of critical facilities. Though not explicitly included in the definition, supporting life-line infrastructure essential to the mission of critical facilities must also be included in the inventory when appropriate. These facilities should be given special consideration when formulating regulatory alternatives and floodplain management plans. A critical facility should not be located in a floodplain if at all possible. If a critical facility must be located in a floodplain it should be provided a higher level of protection so that it can continue to function and provide services after the flood. Communities should develop emergency plans to continue to provide these services during a flood.

There are 109 critical facilities located in Marion County's Floodway, as shown in Table 3-5. It is important to note that official floodplain designations take a considerable amount of time to change and may not always represent changing conditions.

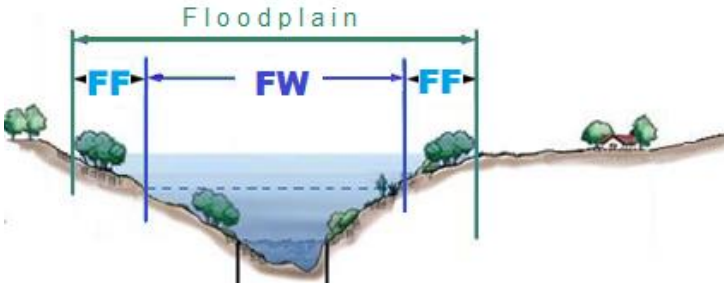
Amendment to the Floodplain Maps and Zoning Ordinance

Floodway (FW) district:

- Passive uses only
- Structures less than 400sf (basically no build)

Floodway Fringe (FF) district:

- Critical facilities prohibited
- Build if elevated 2' above base flood elevation



Source: Indianapolis Department of Business and Neighborhood Services

Figure 3-16: Amendment to the Floodplain Maps and Zoning Ordinance

Table 3-5: NFIP Community Summaries

NFIP Community	Floodway	1%	0.2%
Indianapolis	12 School 1 Chemical 1 Hospital 3 Emergency Response 1 Commercial 79 Bridge 3 Water 2 Dam	17 School 4 Chemical 4 Emergency Response 4 Bridge 1 Energy 3 Water 1 Communication	11 School 1 Heliport 1 Chemical 2 Hospital 1 Electric Substation 4 Emergency Response 3 Government 1 Commercial 1 Railroad 1 Manufacturing 2 Water
Beech Grove	1 Emergency Response		1 School 1 Natural Gas
Lawrence	2 Bridge 1 Water	1 Emergency Response	
Southport			
Speedway	2 Bridge 1 Water	1 Commercial	1 Chemical 1 Energy

In terms of classifying all structures and their location within or overlapping the SFHA, Table 3-6 quantifies the number of structures based on the building data layer. The table has distinctions to classify buildings based on square footage (less or more than 400 square feet, and whether they are in the 1% chance flood zone or the SFHA (which is both 1% and 0.2%). These buildings are shown in Figures 3-17 and 3-18.

Table 3-6: Structures in SFHA by NFIP Community

Total Structures >400sq ft	Structures >400 sq. ft completely within SFHA	Structures >400 sq. ft within or partially within SFHA	Structures <400 sq. ft completely within SFHA	Structures within or partially within 1% chance flood zone	Structures completely within 1% chance flood zone
400,752	23,681	32,397	9,473	21,515	17,049

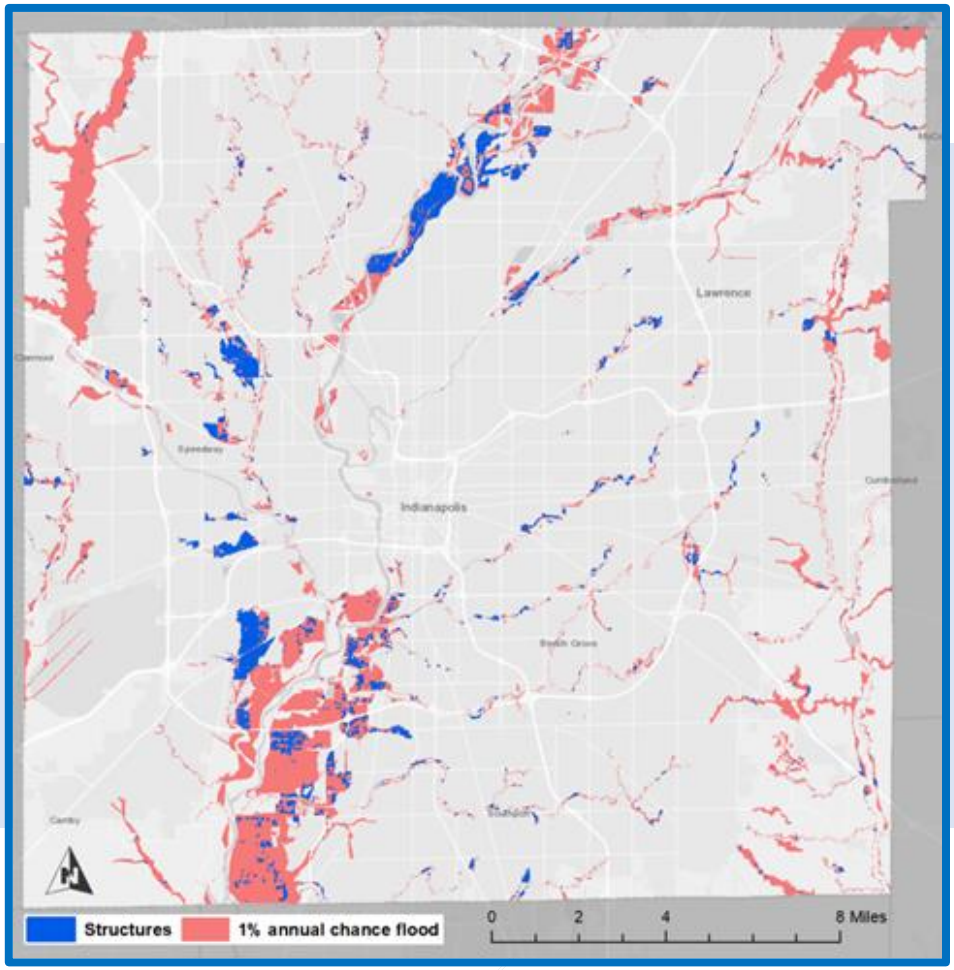


Figure 3-17: Structures Less Than 400 sq ft in 1% Chance Flood Zone

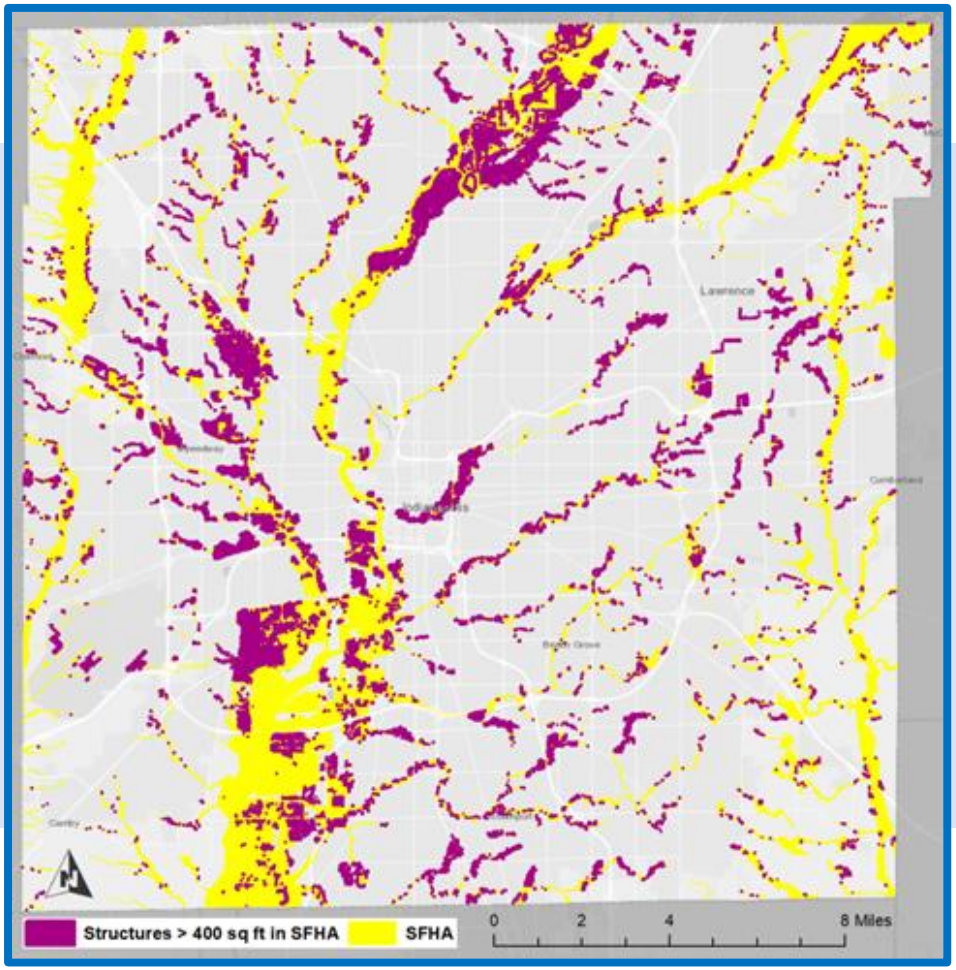


Figure 3-18: Structures Greater Than 400 sq ft in SFHA 1% and 0.2% Chance Flood Zone

Figure 3-17 shows the location of structures that are less than 400 square feet in a 1% chance flood zone, an area with a 1% chance of a flood occurring in any given year. Figure 3-18 shows structures larger than 400 square feet in SFHA 1% and 0.2% flood zones, areas with a 1% and 0.2% chance of a flood occurring in any given year.

2016: New Flood Maps

The City of Indianapolis has been working to comply with FEMA and to support the updating of the FIRMs. These efforts include:

- Funding improvements incrementally since 1999
- Partnering with DNR and FEMA to use federal grants, not just local funds
- Studying over 183 miles of streams (out of the 400 total in the County)[25]
    - FEMA funded: 93 miles of stream studies
    - Indianapolis funded: 90 miles of stream studies
- Pushing for improvements to the floodplain mapping based on:
    - Redelineation of floodplains using 2009 or more recent topography
    - Updated computer modeling methods, flow amounts, bridges / culverts, and cross section data
    - Multiple reviews of preliminary maps to make sure correct data was added
    - Reviewed preliminary maps to remove obvious high ground that was inadvertently included

The final FIRMs were approved March 2016. The updated maps ensure that, for current conditions:

- Flood risk is more accurately shown for the whole County
- Flood elevations are more realistic for 183 miles of stream
- There is identification of more floodways and DNR jurisdiction, so individuals do not have to hire an engineer to make determinations
- There is a more accurate base flood elevation so that first floor elevation requirements yield improved flood protection

ESTIMATING POTENTIAL LOSSES

Critical and non-critical structures located in regulated floodplains, poorly drained areas, or low-lying areas are most at risk for damages associated with flooding. For this planning effort, a Geographic Information System (GIS) Desktop Analysis methodology was utilized to estimate flood damages.

For the GIS Desktop Analysis method, an analysis was completed utilizing the effective Digital FIRMs (DFIRMs) overlaid upon the 2017 Taxroll Property Assessments provided by Marion County and structures located within each flood zone were tallied using GIS analysis techniques.

[25] All information is from Donna Price from the Indianapolis Department of Business and Neighborhood Services (See Table 1-1)

The resulting Modified Parcel Inventory was used in the GIS analyses.

Tables 3-7 & 3-8 summarize the manual GIS analysis utilizing most recent FIRM data and the Marion County parcel value inventory to evaluate the both the land use and the total assessed value of parcels within the 100 and 500-year floodplains within each jurisdiction. Figures 3-19, 3-20, and 3-21 show the locations of repetitive loss areas, flood zones, ground elevation, and other infrastructure.

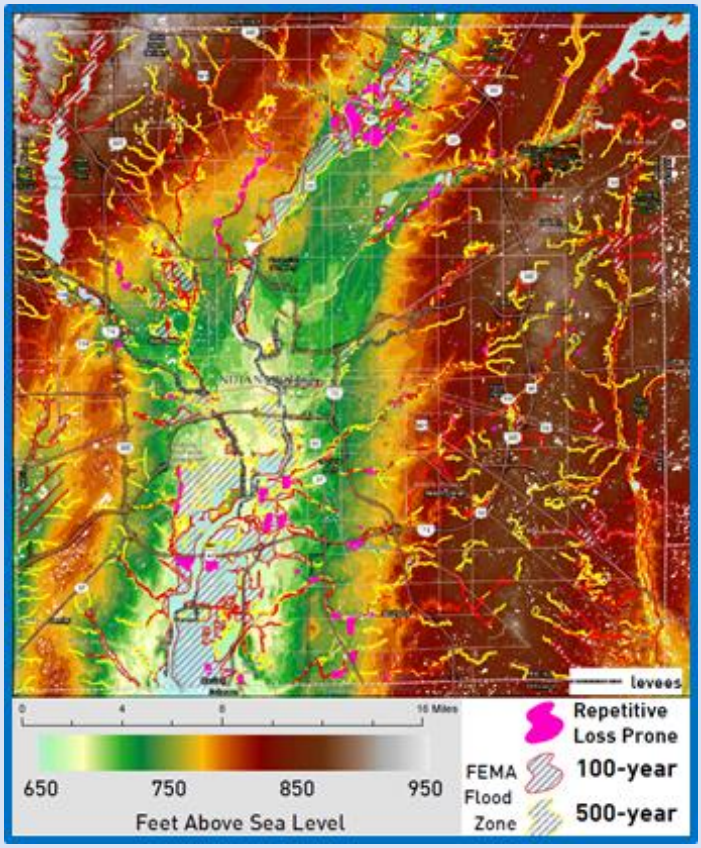


Figure 3-19: Flood Zones in Relation to Elevation

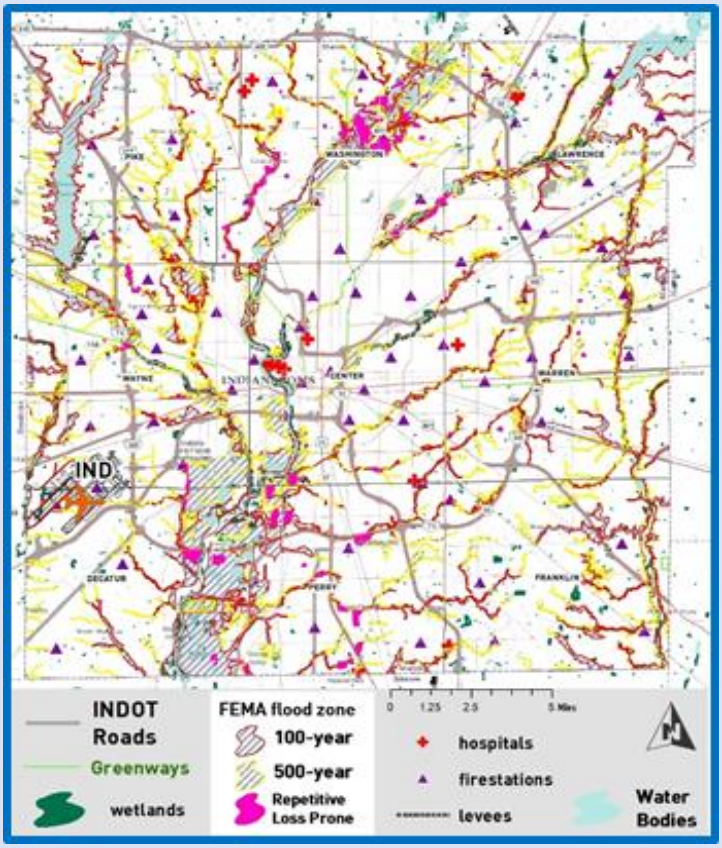


Figure 3-20: Infrastructure in Flood Zones

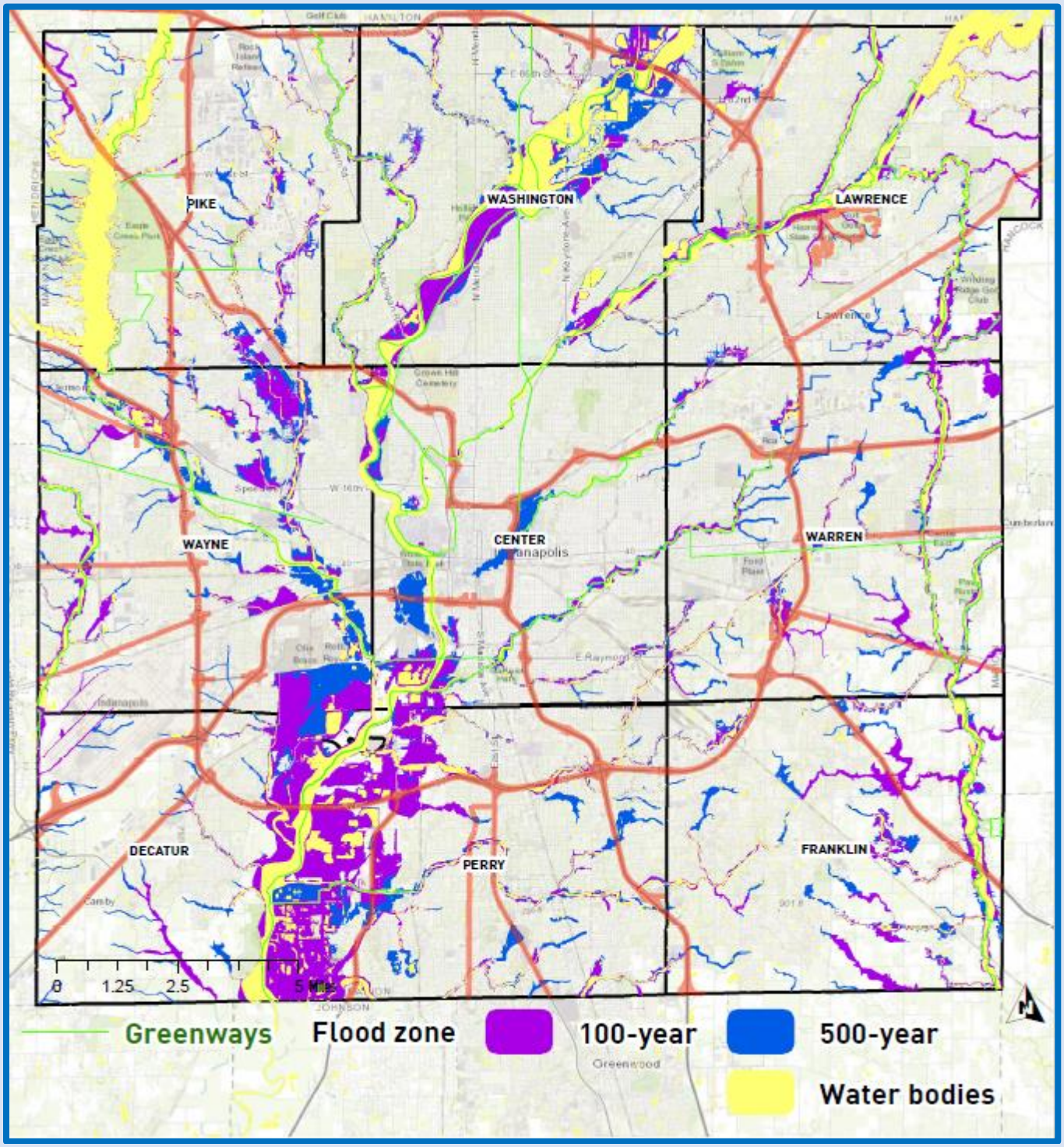


Figure 3-21: Greenways in Flood Zones

Table 3-7: Parcels by Land Use Located Within the 1% Annual Chance Floodplain

Total Number of Parcels in Floodplain by Land Use Category										
	Land Area	Total Number of Parcels in Jurisdiction	Residential	Commercial	Industrial	Agriculture	Other	Total # of Parcels in Floodplain (all land uses)	% of Parcels in Floodplain	Total Value of Parcels in Floodplain by Jurisdiction
Indianapolis	368 sq mi	312,905	21,239	1,577	341	386	867	24,410	7.8%	$ 6,416,822,700
Lawrence	20.2 sq mi	15,126	672	34	0	7	42	755	5.0%	$ 224,911,700
Speedway	4.8 sq mi	3,852	306	20	52	0	13	391	10.2%	$ 193,266,500
Beech Grove	4.4 sq mi	5,082	155	27	19	0	34	235	4.6%	$ 90,663,900
Southport	0.6 sq mi	776	28	12	0	0	4	44	5.7%	$ 5,366,900
Other	5 sq mi	4,182	517	15	0	2	121	655	15.7%	$ 8,916,600
Marion County	403 sq mi	341,923	22,917	1,685	412	395	1,081	26,490	7.7%	$ 6,939,948,300

Table 3-8: Parcels by Land Use Within the 0.2% Annual Chance Floodplain

Total Number of Parcels in Floodplain by Land Use Category										
	Land Area	Total Number of Parcels in Jurisdiction	Residential	Commercial	Industrial	Agriculture	Other	Total # of Parcels in Floodplain (all land uses)	% of Parcels in Floodplain	Total Value of Parcels in Floodplain by Jurisdiction
Indianapolis	368 sq mi	312,905	15,118	1,303	412	122	689	17,644	5.6%	$ 4,796,314,100
Lawrence	20.2 sq mi	15,126	269	17	7	4	15	312	2.1%	$ 114,696,400
Speedway	4.8 sq mi	3,852	373	5	6	0	14	398	10.3%	$ 49,078,600
Beech Grove	4.4 sq mi	5,082	84	9	0	0	4	97	1.9%	$ 21,471,300
Southport	0.6 sq mi	776	69	12	0	0	5	86	11.1%	$ 8,782,300
Other	5 sq mi	4,182	378	13	6	4	558	434	10.4%	$ 1,031,100
Marion County	403 sq mi	341,923	16,291	1,359	431	130	1,285	18,971	5.5%	$ 4,991,373,800

CLIMATE CHANGE CONSIDERATIONS

As the population of Marion County continues to grow, it is anticipated that the number of critical and non-critical infrastructure will also increase accordingly. Locations of these new facilities should be carefully considered. Precautions should be encouraged to ensure that school, medical facilities, community centers, municipal buildings, and other critical infrastructure are located outside the 0.2% annual chance (500-year) floodplain. These facilities should also be protected to that level along with a flood-free access to reduce the risk of damages caused by flooding and to ensure that critical infrastructure will be able to continue functioning during major flood events.

It is also important to ensure that owners and occupants of residences and businesses within the known hazard areas are well informed about the potential impacts from flooding incidents as well as proper methods to protect themselves and their property. There are several resources to increase public awareness on flood risk and climate change. NOAA[26] and FEMA[27] have tools for viewing flood zones and understanding local impacts. As new FIRMs have been developed throughout Marion County, residents within these areas are being notified that they may be subject to an increased risk of damages associated with flooding. Additionally, several individual stream studies are being completed in order to revise the Unnumbered Zone A areas, or to provide detailed delineations for the SFHA.

Despite these efforts, the overall vulnerability and monitory value of damages is expected to increase in the area unless additional measures, such as those discussed later in Chapter 4 of this report, are implemented.

The Climate Change-Induced Flood Hazard Index (CCFHI) refers to the potential for increased flooding compared to baseline conditions. This model is based on the concept that warmer temperatures will reduce flooding due to drier conditions, while increased precipitation intensity will increase flooding. Flooding potential is defined as the probability of daily streamflow volume exceeding maximum holding capacity. Daily stream flow volume was simulated using the Soil and Water Assessment Tool (SWAT). SWAT is designed to simulate water balance and stream flows at the watershed scale. Baseline conditions taken over a three-year period, along with climate change impacts from mean temperature and precipitation variation inputs were incorporated into the SWAT model.

RELATIONSHIP TO OTHER HAZARDS

While flooding creates social, physical, and economic losses, it may also cause other hazards to occur. For example, flooding may increase the potential for a hazardous materials incident to occur. Above ground storage facilities may be toppled or become loosened and migrate from the original location releasing the stored chemicals. In less severe situations, the materials commonly stored in homes and garages such as oils, cleaners, and de-greasers, may be mobilized by flood waters. Should access roads to hazardous materials incidents

[26] https://www.ncdc.noaa.gov/customer-support/tools
[27] https://toolkit.climate.gov/tool/fema-flood-map-service-center

become flooded, or if bridges are damaged by flood waters, response times to more significant incidents may be increased, potentially increasing the damages associated with the release.

Increased volumes of water during a flood event may also lead to a dam and/or levee failure. As the water levels rise in areas protected by dams and levees, and the flood water exceeds the design threshold, these structures will over-top or will breach leading to more water released into previously protected areas. These two hazards, flood and dam/levee failure, when combined, may result in much greater damages.

In a similar fashion, a snow storm or ice storm can also lead to flooding on either a localized or regional scale. When a large amount of snow or ice accumulates, the potential for a flood is increased. As the snow or ice melts, and the ground becomes saturated or remains frozen, downstream flooding may occur. Ice jams near bridges and culverts may also result in flooding of localized areas and potentially damage the bridge or culvert itself.

Flooding in known hazard areas may also be caused by dams and levees that experience structural damages or failures not related to increased volumes or velocities of water. These failures while not typical, may occur wherever these structures exist.

HAZARD PROFILE 2: DAM & LEVEE FAILURE

HAZARD OVERVIEW

Within the National Inventory of Dams, each dam is assigned a downstream hazard classification based on the potential loss of life and damage to property should the dam fail. The three classifications are high, significant, and low. With changing demographics and land development in downstream areas, hazard classifications are regularly updated by Indiana DNR. The following definitions of hazard classification currently apply to dams in Indiana:

- High Hazard Dam: a structure the failure of which may cause the loss of life and serious damage to homes, industrial and commercial buildings, public utilities, major highways, or railroads.
- Significant Hazard Dam: a structure the failure of which may damage isolated homes and highways or cause the temporary interruption of public utility services.
- Low Hazard Dam: a structure the failure of which may damage farm buildings, agricultural land, or local roads.

Figure 3-22: An example of a levee EC-09(b) protecting households from rising water levels in Eagle Creek in Speedway. (Source – Indianapolis/Marion County Levee System Operations & Maintenance Program Preliminary Assessment, Christopher B. Burke Engineering (CBBEL), 2017)

What is a Levee?

A levee is a flood control structure designed to hold water away from a buildings, infrastructure, or other structures. Levees protect buildings from flooding as well as from the force of water, from scour at the foundation, and from impacts of floating debris.

The principle causes of levee failure are similar to those associated with dam failure and include overtopping, surface erosion, internal erosion, and slides within the levee embankment or the foundation walls. Levees are

designed to protect against a particular flood level and they may be overtopped in a more severe event. When a levee system fails or is overtopped, the result can be catastrophic and often times more damaging than if the levee were not there, due to increased elevation differences and water velocity. The water flowing through the breach continues to erode the levee and increase the size of the breach until it is repaired or water levels on the two sides of the levee have equalized.

RECENT OCCURRENCES

Within Marion County, there are 20 Indiana DNR regulated dams: five high hazard dams, two significant hazard dams, and 13 low hazard dams as shown on Figure 3-23. High Hazard dams include: Castlebrook Dam, College Park Dam, Eagle Creek Reservoir Dam, Geist Reservoir Dam, and Pogue's Run Dam. Because of this, many people also identified dam and levee failure as a primary concern for their communities. However, there have been no recorded dam failures in Marion County. This failure is an acute event and therefore classified as a shock.

There are nine levees considered to be consequential in terms of buildings identified as in or out of the 100-year floodplain. While there are an additional 35 levees located within Marion County, they are not providing protection for the 100- year flood and as such, not included within this planning effort.

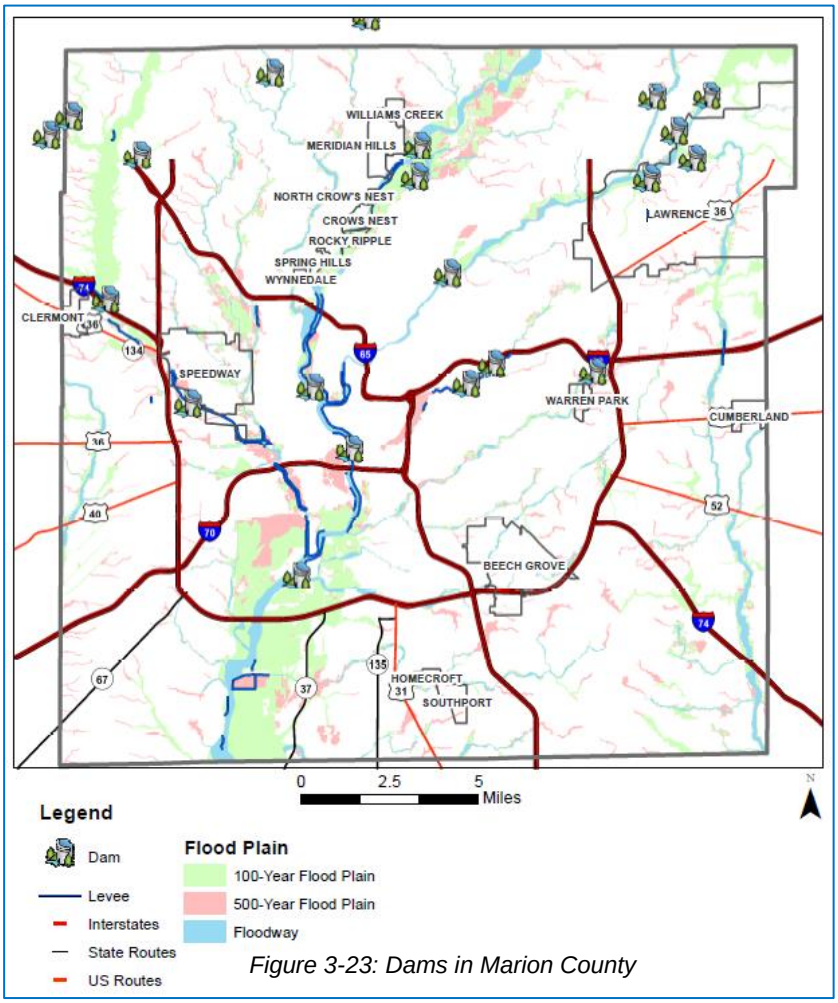


Figure 3-23: Dams in Marion County

Figure 3-23: Dams within Marion County

ASSESSING VULNERABILITY

Dam and levee failure can cause adverse effects on whole communities and populations including threats to health and safety. Potential flooding can destroy neighborhoods, buildings, and infrastructure and have negative effects on drinking water quality. Also, negative social effects include, psychosocial, demographic, economic, and political impacts. Dam and levee failure response and recovery planning must account for the needs of vulnerable populations.

WHAT ARE DIRECT AND INDIRECT EFFECTS OF DAM & LEVEE FAILURE?

Table 3-9: Effects of Dam & Levee Failure

Direct Effects:	Indirect Effects:
• Loss of life, injury, and serious damage to downstream homes, industrial and commercial buildings, public utilities, major highways, or railroads These effects may be exacerbated among socially vulnerable populations who may not have access to resources to offset the effects of this infrastructure failure.	• Loss of land in the immediate scour area • Increased response times due to damaged or re-routed transportation routes and/or bridges • Re-routed transportation routes and/or road and bridge closings due to damage may result in loss of job and thus loss of income, home and other belongings • Negative impacts on subsistence fishing populations possible

Due to the conditions beyond the control of the dam owner or engineer, there may be unforeseen structural problems, natural forces, mistakes in operation, negligence, or vandalism that may cause a dam to fail. Two of the high hazard dams in Marion County, Eagle Creek Reservoir Dam and Pogue's Run Dam have an Incident and Emergency Action Plan (IEAP), both updated in 2012 by CBBEL, with a detailed dam failure inundation area identified. Citizens Energy Group also has IEAPs for the Morse and Geist Reservoir Dams and they complete regular reviews and training and exercising of those plans. IEAPs should be reviewed at least once a year and updated as needed, however Indiana is one of the many states which does not have a dam owner produced IEAP requirement. Dam owners and operators also may not be responsible for developing an evacuation plan, however other parties responsible are.

Recent Levee Evaluation

In June of 2017, a study of operation and maintenance of levees in Marion County was completed by City of Indianapolis Public Works. The report by CBBEL evaluated current Operations and Maintenance (O&M) of levees within Marion County and compared them to recommended best practices. The report found that the overall O&M of the levees in Marion County is considered to be "minimally acceptable" to "unacceptable." The report found that some levees are not maintained consistently or according to recommended best practices. As a result, risk to nearby risk to nearby properties and public safety is increased. The report found that only 23% of the levees in Marion County are FEMA accredited. For a levee to be FEMA accredited, it must meet Federal design, construction, maintenance and operation standards to adequately reduce the risk of flooding from a major flood. There must be evidence that the levee provides this standard risk reduction such as a signed statement by a licensed professional engineer or other Federal agency responsible for the design of the levee.

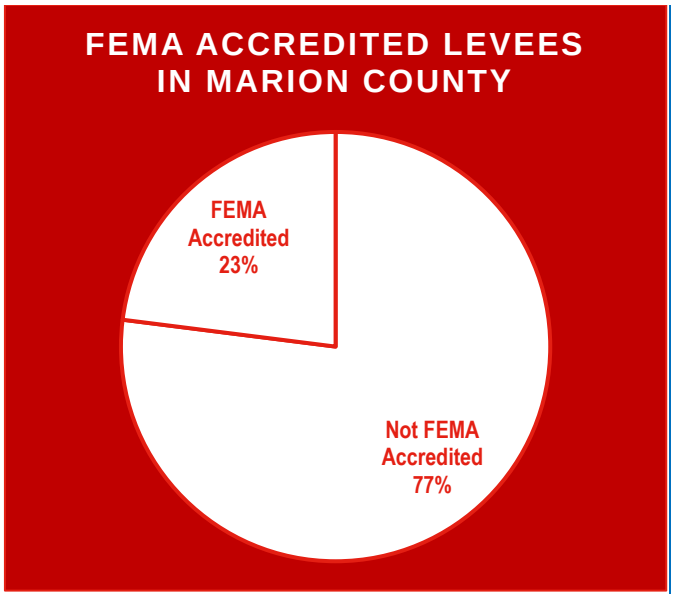


Figure 3-24: FEMA Accredited Levees in Marion County

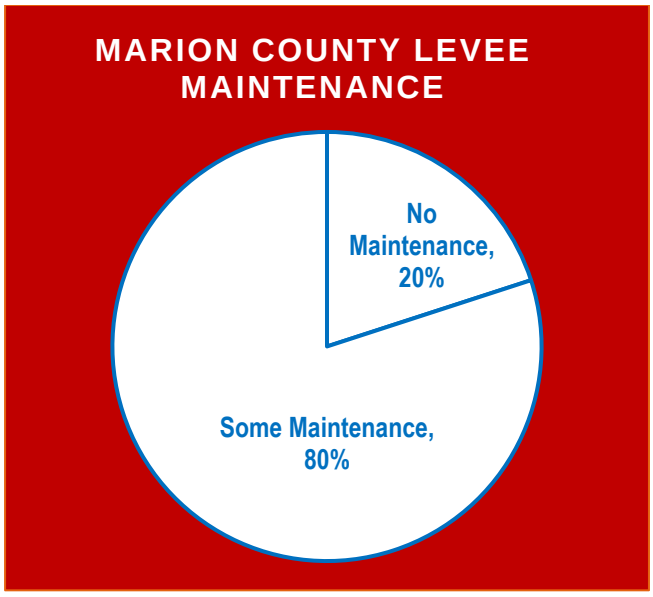


Figure 3-25: Marion County Levee Maintenance

ESTIMATING POTENTIAL LOSSES

The potential dam failure inundation areas for the Eagle Creek Reservoir Dam and the Morse Reservoir Dam were overlaid onto recent aerial photography to estimate the number of critical and non-critical structures that may be affected by a dam failure. The Eagle Creek Reservoir Dam was selected as a worst-case scenario with a very large potential impact area, including downtown Indianapolis. The Morse Reservoir Dam, while located within Hamilton County, was selected to indicate that impacts to Marion County may originate in areas outside of the County.

The actual magnitude and extent of damage depend on the type of dam break, volume of water that is released, and the width of the floodplain valley to accommodate the dam break flood wave. The anticipated damages to the structures and contents located within Marion County are summarized in Table 3-10.

Table 3-10: Anticipated Damages to Structures and Outbuildings Damaged

	Eagle Creek Reservoir	Morse Reservoir
Structures (>400 sq. ft.)	31,916	9,642
Outbuildings (<400 sq. ft.)	8,315	1,973
TOTAL Structures	**40,231**	**11,615**

There are several critical structures located within the delineated dam failure inundation area for the Eagle Creek Reservoir Dam and the Morse Reservoir Dam. Table 3-11 identifies the number and type of critical facilities within each potential inundation area. The number and type of critical facilities located behind consequential levees is provided in Table 3-12.

Table 3-11: Critical Structures in the Potential Dam Inundation Area

	Eagle Creek Reservoir	Morse Reservoir
Indianapolis	1 Ag/Food 49 Bridge 5 Chemical 2 Commercial 1 Communication 1 Dam 1 Emergency Response 2 Energy 1 Government 3 Hospital 1 Manufacturing 1 Petroleum 28 School 1 Transportation 8 Water	50 Bridge 1 Chemical 1 Communication 4 Emergency Response 1 Energy 12 School 4 Water
Speedway	2 Bridge 1 Chemical 1 Commercial 1 Energy 1 Government 1 Manufacturing 1 School 1 Water	
TOTAL	**122**	**73**

Table 3-12: Structures Located Behind Consequential Levees in Marion County

Levee Segment	Number/Type of Structure
WR-16	**614**: 493 Residential; 63 Commercial; 39 Industrial; 19
WR-20(a)/FC-02(a)	**12**: 3 University; 9 Commercial
LEC-01	**105** Mobile homes
EC-09(b)	**11** Multifamily Residential
EC-12(c)	**150:** 14 Multifamily, 11 Duplex, 125 Single Family Residential
WR-20(b)	**2:** 1 Park Building; 1 Golf Course
HD-C1/WR-C1	**455:** 1 School; 16 Commercial; 46 Multifamily, 287 Single Family
LEC-04	**27:** 26 Residential, 1 Commercial
WR-17/WR-18	0

CLIMATE CHANGE CONSIDERATIONS

As areas near existing dams or levees continue to grow in population, it is anticipated that the number of critical and non-critical structures will also increase accordingly. Location of these new facilities should be carefully considered and precautions should be taken to ensure that schools, medical facilities, municipal buildings, and

other critical infrastructure are located outside of the delineated or estimated dam failure inundation areas and outside the levee-protected areas. Also, flood-free access should be provided for these facilities.

It is also very important to all downstream communities and property owners that all IEAPs are kept up-to-date as well as routinely exercised to ensure the greatest safety to those within the hazard area. It is also important to note that, due to their relatively low design standard, the levees are vulnerable to overtopping and failure. Detailed flood response and evacuation plans are being prepared for these areas and will be exercised routinely. There is also a growing level of public education for these areas.

Climate change has the potential to increase the intensity, duration, and frequency of rain events in Marion County. This will directly impact all of the dams and levees in the area, increasing risk to properties downstream of dams and adjacent to levees.

RELATIONSHIP TO OTHER HAZARDS

With the potentially large volumes and velocities of water released during a dam breach, it can be expected that a dam failure would lead to flooding and within the inundation areas downstream of the dam. Similarly, if levee systems are located within the dam failure inundation area, increased stress may be applied to these systems leading to a potential levee failure as well.

Downstream bridges and roads are also in danger of being destroyed or damaged due to a dam failure. Bridges may become unstable, portions of road surfaces may be washed away, or road integrity may be undermined. Other infrastructure such as utility poles and lines may be damaged as the water flows along the surface or pipes may become exposed due to scouring; all of which may lead to utility failures within the area downstream of the dam failure.

Several other independent hazards may also lead to a dam failure. Hazards such as flooding, the melting of snow or ice, or rapid precipitation associated with thunderstorms, may all lead to increased pressure on the dam structures or overtopping of the structures, leading to failure. Additionally, earthquakes or tornadoes may cause damage to the structures or earthen components of the dam resulting in irreparable damages or failure.

HAZARD PROFILE 3: INCREASED PRECIPITATION

HAZARD OVERVIEW

This hazard profile describes the potential impacts that increased precipitation will have on Marion County. While this hazard was not identified as a concern by MHMP task force members, increased precipitation does pose a risk to Marion County and these risks are expected to increase. The increased precipitation hazard profile has been added to address climate change and includes a discussion of how climate change can increase the frequency and severity of extreme precipitation in the community, increasing exposure to the population, infrastructure, and properties. While it is challenging to factor climate change into probability calculations for future hazards, overviews are presented which describe the impacts of projected increases in extreme weather events. These weather events are a classified as shocks because of how abruptly the event starts and ends.

The **Recent Occurrences** and **Assessing Vulnerability** sections address issues which were covered in the flood hazard profile but focus more on climatic implications. The **Assessing Vulnerability** section describes the vulnerability in terms of increasing exposure and addressing uncertainty in a way that allows for best adaptation practice options. Adaptive management and scenario planning enables the selection of strategies in which risk reduction and cost effectiveness are maximized in the widest range of scenarios.

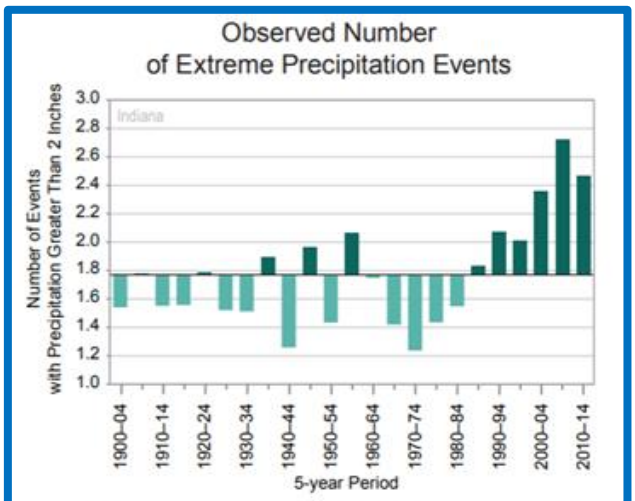
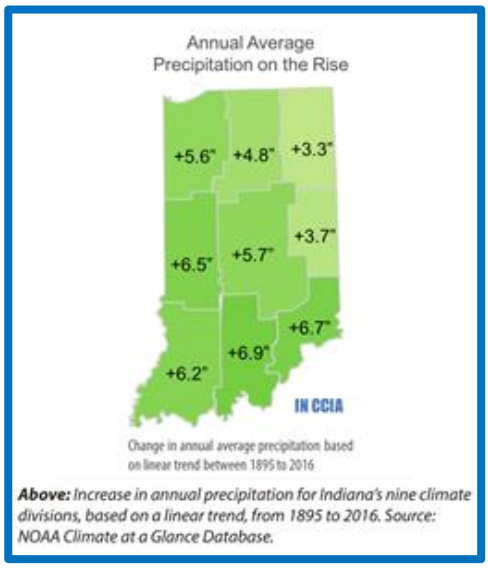


Figure 5: The observed number of days with extreme precipitation events (annual number of days with precipitation above 2 inches) for 1900–2014, averaged over 5-year periods; these values are averages from 21 available long-term reporting stations. The dark horizontal line represents the long-term average. A typical station experiences between 1 and 2 such events per year. The number of extreme precipitation events has been above average since the late 1980s. Between 2005 and 2009, Indiana experienced a record high number of events when stations averaged almost 3 events annually. Source: CICS-NC and NOAA NCEI.

Figure 3-26: Observed Number of Extreme Precipitation Events



***Above:** Increase in annual precipitation for Indiana's nine climate divisions, based on a linear trend, from 1895 to 2016. Source: NOAA Climate at a Glance Database.*

Figure 3-27: Annual Average Precipitation on the Rise

Increased Precipitation

RECENT OCCURRENCES

May 3-5, 2017

A heavy storm system brought 8.5 inches of rain in less than 24 hours. Some areas saw the highest river crests since April 2013. The significant river flooding led to multiple road closures due to high water. Flooding also impacted farm fields and residential areas.

December 2015

A persistent storm system dropped rain on the Indianapolis area between December 26 and 28. Areas in Marion County received between 2 and 6 inches of rainfall during this time. Some roads were closed due to high water. Streams, creeks, and low-lying areas experienced flooding for over a week. Flooding impacted multiple roads, farm fields, and residential areas.

ASSESSING VULNERABILITY

Similar populations, as with dam and levee failures and flooding, are particularly vulnerable when considering the effects of increased precipitation. People with greater social vulnerability must be considered when planning for the impending possibility of flooding due to increased precipitation.

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF INCREASED PRECIPITATION?

Table 3-13: Effects of Increased Precipitation

Direct Effects:	Indirect Effects:
• Loss of life and serious injury possible • Increased property damages and/or loss of revenue due for properties affected by increased water • Increased erosion • Possibility of dam and levee failure and flooding events • Socially vulnerable populations may be particularly sensitive due to lack of resources to recover from these impacts	• Reduced crop yields due to shifted distribution of rainfall throughout the year • Decreased receiving water quality due to increased combined sewer overflow events • Human health impacts due to increased combined sewer overflow events include exposure to disease-causing pathogens and other pollutants and illness due to contact with water or shellfish that have been contaminated with microbial pathogens or toxics • Increased response times for emergency personnel if roads are impassable • Contaminants and pollutants, potentially from brownfields, may be mobilized. There are public health impacts related to compromised water quality • Negative impacts on subsistence fishing populations due to flooding

Increased precipitation has already been experienced in the Midwest and Marion County. Total annual precipitation has increased 17.8% from 1951-2014, with heavy precipitation events occurring more often in

shorter time periods. As the climate changes, winter precipitation is also expected to change. With warmer temperatures, it is more likely that rain will fall in place of snow, and mixed winter precipitation (such as freezing rain) will become more likely.

How will Agriculture be Affected?

Agriculture is an important sector of Indiana's economy and is particularly vulnerable to a variety of extreme weather conditions. Although rainfall is anticipated to increase, which can be beneficial to crops, the distribution of rainfall is expected to shift, as noted by a report by the Purdue Climate Change Research Center.

"*…the distribution of precipitation across the year is expected to shift, leading to* ***wetter winters*** *and* ***dryer summers****. In addition, the inability of rainfall to compensate for increased heat may lead to more drying. This is likely to be most pronounced in summer, leading to dryer soils and more drought-like conditions. To the extent the agricultural industry is unable to compensate through the development of improved genetic varieties that exhibit drought tolerance, productivity will decline. Although one might expect irrigation to fill water needs, given current crop genetics, and associated rates of crop evapotranspiration, investments in irrigation infrastructure are not likely to compensate for the combined forces of greater heat and less moisture. As a result, the key adaptation mechanisms for farmers will be to shift planting dates and adopt crop varieties with shorter growing seasons so as to avoid the hottest parts of the growing season. Farmers will have to avoid the deleterious effects of climate change and take advantage of climate conditions that are more conducive to crop growth.* ***Heavier rainfall and periodic flooding during planting and harvest periods may lead to crop losses****.*"

-Impacts of Climate Change for the State of Indiana, Purdue Climate Change Research Center, pg. 11

Significant shifts in climate and rainfall can make current agricultural practices ineffective or obsolete. The existing genetics and farming practices used in corn and soybean production may not yield as highly in future conditions.

What is a Combined Sewer Overflow (CSO)?

A CSO is a designed measure to prevent combined sewers (sewers that collect both stormwater from streets and sewage from residential and commercial buildings) from backing up into basements, toilets, and even streets. When the Marion County sewers experience a higher rate of flow during rain events with ¼-inch of rainfall or more, the excess water is discharged into rivers and streams. This overflow is often a mix of raw sewage and stormwater, which is a significant cause for concern regarding public health. CSO events are common in older neighborhoods in Marion County. Many parts of Marion County are particularly vulnerable due to high amounts of impervious area (roads, parking lots, roofs). In sections of Indianapolis, rainfall of more than ¼ of an inch can overwhelm the combined sewer system and cause a CSO event to occur.

ESTIMATING POTENTIAL LOSSES

Rain events that contribute to or cause flooding will share the same potential losses discussed in the Flood Hazard Profile section of this report. Potential losses attributed to increased precipitation, but not directly to flooding, include:

- Loss of income to farmers due to reduced crop yields. In the growing season of 2015, Purdue University agricultural experts estimated that farmers throughout the entire state of Indiana lost $486,000,000 in corn and soybean production during a record rainfall in June. Precipitation intensity and distribution during each growing season is difficult to predict, however as precipitation increases in the spring, it can be expected that proportional losses will occur unless agricultural practices are adapted.
- Reduced water quality and wildlife health in streams and rivers in Marion County due to increased CSO events

CLIMATE CHANGE CONSIDERATIONS

Precipitation is projected to increase in Indiana, with increases most likely during the winter and spring (Figure 3-28). Extreme precipitation is also projected to increase, potentially increasing the frequency and intensity of floods. Heavier precipitation not only increases the risk of springtime flooding, but also poses a threat to Indiana's important agricultural economy by delaying planting and resulting in loss of yield.

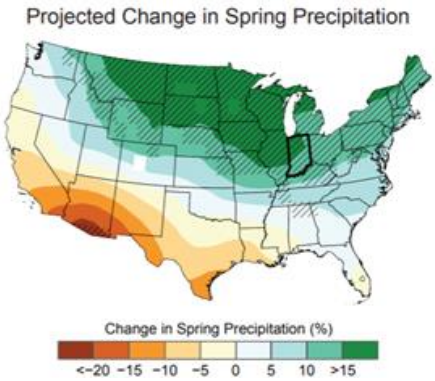


Figure 3-28: Projected Change in Spring Precipitation by Mid-21st Century
Source: CICS-NC, NOAA NCEI, and NEMAC

The Climate Science Special Report, produced by the US Global Change Research Program, gives a thorough assessment of the science of climate change. The report states the importance of changing precipitation patterns and its effect on existing economies and ecosystems.

"***Changes in precipitation are one of the most important potential outcomes of a warming world*** *because precipitation is integral to the very nature of society and ecosystems. These systems have developed and adapted to the past envelope of precipitation variations. Any large changes beyond the historical envelope may have profound societal and ecological impacts.*

Increased Precipitation

Projected changes are examined using the Coupled Model Intercomparison Project Phase 5 (CMIP5) suite of model simulations. They establish the likelihood of distinct regional and seasonal patterns of change." – Climate Science Special Report, Chapter 7

While precipitation is likely to increase on an annual average basis, there is also likely to be an important shift in the seasonality of that precipitation, with **winter and spring precipitation increasing by 21 and 30% by the end of the century, and summer precipitation declining by up to 9%**. Such a shift may result in the increased precipitation being of minimal use to crops but of significant concern for flooding. Wetter winters, the product of more precipitation and warmer air temperatures, may result in an increased runoff and frequency of floods.

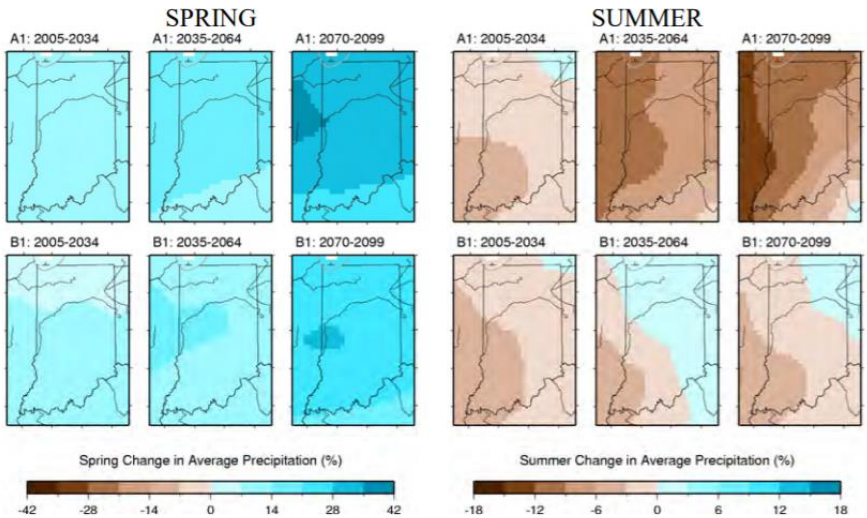


Figure B1. Projected changes in annual average spring and summer precipitation (in units of percentage change relative to 1961-1990 averages) as simulated by the VIC hydrological model under the higher (A1fi) and lower (B1) emissions scenarios. Results shown are the average of VIC model simulations driven by downscaled output from the GFDL, HadCM3 and PCM climate models.

Figure 3-29: Changes in Annual Spring and Summer Precipitation

Heavy downpours are increasing nationally, especially over the last three to five decades, with the largest increases in the Midwest and Northeast. Increases in extreme precipitation are projected for all U.S. regions. Future developments will need to be constructed with this in mind and implement stormwater Best Management Practices (BMPs) and Low Impact Development (LID) strategies. BMPs and LID strategies involve thoughtful site planning and stormwater mitigation strategies such as onsite detention to prevent new stormwater runoff from being created when a site is developed. Examples of this are permeable pavement, rain gardens, and retention ponds.

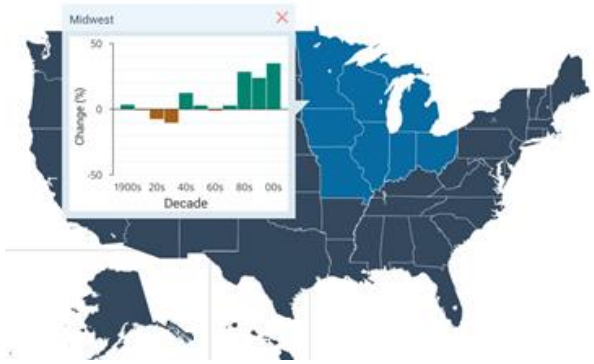


Figure 3-30: Percent changes in the annual amount of precipitation falling in very heavy events, defined as the heaviest 1% of all daily events from 1901 to 2012 for each region. The far-right bar is for 2001-2012.

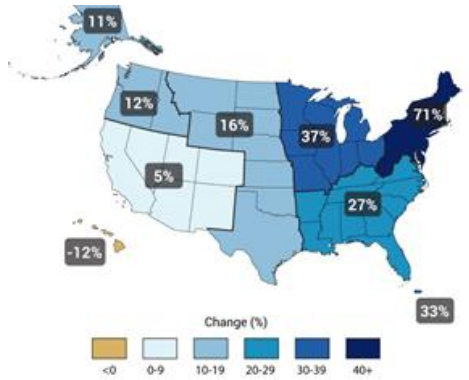


Figure 3-31: Percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2012 for each region of the continental United States. These trends are larger than natural variations for the Midwest.

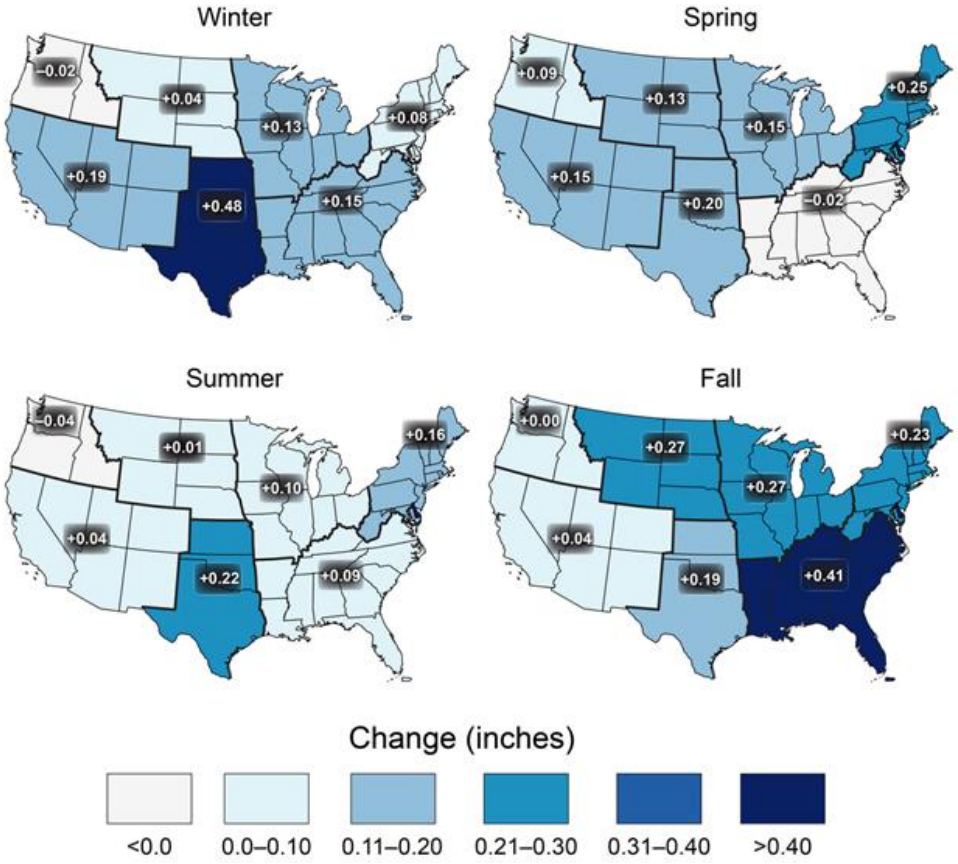


Figure 3-32: Observed changes in the 20-year return value of the seasonal daily precipitation totals for the contiguous United States over the period 1948 to 2015 using data from the Global Historical Climatology Network (GHCN) dataset. (Figure source: adapted from Kunkel et al. 2013; © American Meteorological Society. Used with permission.)

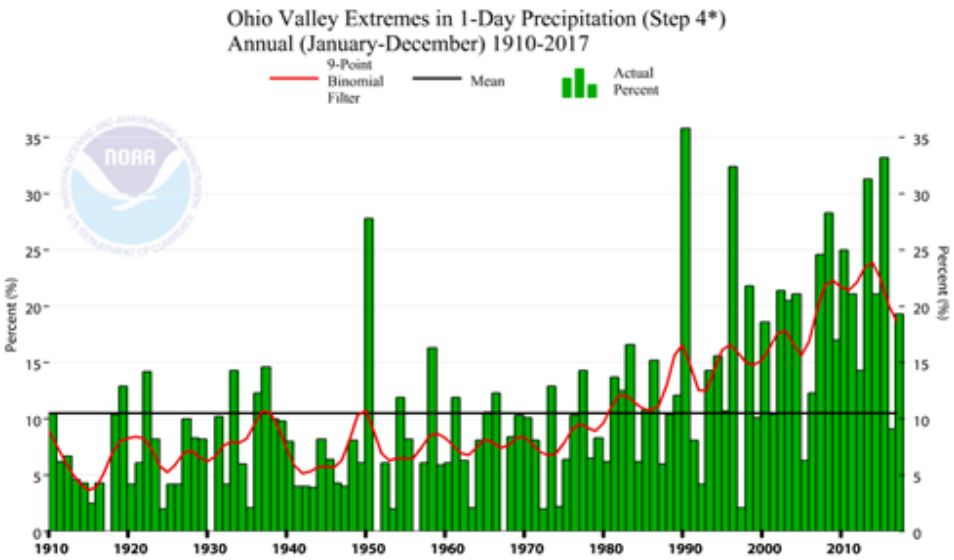


Figure 3-33: Ohio Valley Extreme One-Day Precipitation Events from 1910-2017

Future conditions are difficult to predict, and there is a known uncertainty associated with climate projections and models. Uncertainty differs for hazards; for instance, temperature models are considered more certain than precipitation models.

On average, Indiana has experienced wet springs and summers over the past two decades. While precipitation during these critical growth months is important for adequate soil moisture, it can also make it difficult for farmers to plant crops. Indiana has also experienced an increase in the number of heavy precipitation events (greater than 2-inches of precipitation), which can cause severe flooding.

Average Precipitation

The amount of total annual precipitation has increased by 17.8% (7.0 inches) from 1951 through 2014. An increase in precipitation was observed in all seasons, however, the winter shows the smallest change of -0.9% (-0.1 inch), while the fall shows the greatest change of 19.8% (1.6 inches). Average precipitation in Indianapolis is projected to change -2.0 to 5.0 inches per year by mid-21st century (2041-2070).

Heavy Precipitation

The frequency and intensity of severe storms has increased. This trend will likely continue as the effects of climate change become more pronounced. The amount of precipitation falling in the heaviest 1% of storms increased by 37% in the Midwest from 1958 to 2012 (Walsh et al. 2014). The central part of Indiana is projected to experience one to three more days of heavy precipitation (events greater than 1.25 inches) per year compared to current trends.

Increased Precipitation

Heavy Rain (1-Hour events)

The number of hours per year experiencing heavy rain over 0.3 inches per hour has substantially increased since 2004 compared to earlier years when such events stayed fairly constant in their occurrence.

Heavy Rain (35-Hour events)

The number of events per year resulting in greater than 1 inch of rain in 35 hours has risen gradually since 1975 with strong year-to-year variability and a record high in 2011 (since 1975). By mid-century, models project up to two more days per year receiving over 1 inch of rain, and up to one more day per year receiving over 2 inches of rain.

Heavy Rain (2-week events)

Periods of two weeks receiving greater than three inches of rain have not had any clear trends since 1975. The year of 2015 was an anomalous year with significantly more of these 2-week heavy rain events than normal.

RELATIONSHIP TO OTHER HAZARDS

Increased precipitation is related to other water-related hazards including flooding, dam and levee failure, and winter storm and ice. As the intensity of precipitation events increases, this may lead to additional localized or wide-spread flooding. This may also result in dam or levee breach. Larger precipitation events during cold weather may result in large snow falls or freezing rain events, reducing people's mobility and/or causing damage to trees and power lines.

HAZARD PROFILE 4: DROUGHT

This hazard profile provides a description of the type, location, and extent of drought hazards that affect Marion County. An explanation of the various types of drought, information on previous occurrences and an investigation on the probability of future drought events are also included. The **Recent Occurrences** section addresses all recorded impacts of droughts in Marion County since 2013, as noted in the **U.S. Drought Monitor** and the **NCDC Storm Events Database**. While drought is not a frequent occurrence in Marion County, the hazard is unpredictable and can impact the entire region. This profile also discusses how climate change can increase the frequency, severity, and impacts of drought in the County and provides an overview which describes the impacts of these increased extreme weather events and other resulting hazards. Drought can severely impact a whole community, especially those who are socially vulnerable. The **Assessing Vulnerability** section describes the vulnerability in terms of:

- The geographic extent of previous drought hazard events in Marion County;
- Drought impacts as assessed by the Drought Impact Reporter;
- An estimate of the potential dollar losses to Marion County's primary agricultural crops and a description of the methodology used to prepare the estimate;
- The potential impacts on urban trees; and
- The projected change in the number of consecutive dry days.
- Fire risk

As a reference for the community on the nature and impacts of this hazard, additional sources containing drought related information have also been provided.

HAZARD OVERVIEW

What is a drought?

Drought is a naturally occurring hazard that can happen year-round. It is the consequence of a reduced amount of precipitation over a period of time (typically a growing season or more). Drought can also be caused by excessive heat which can lead to increased evaporation, further enhancing drought conditions. The severity of a drought depends on the duration, location, and geographical extent. Additionally, the magnitude of the impacts depends on the available water supply, usage demands from human activities, vegetation, and agricultural operations.

Drought is classified as a shock since it threatens the immediate well-being of both humans and ecosystems. However, a drought can become extensive enough to have social, environmental, or economic effects that last for months to years, thus becoming a stressor.

Table 3-14: Types of Drought[28]

Type	Definition
Meteorological	The degree of dryness, expressed as a departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales.
Hydrological	The effects of precipitation shortfalls on streamflows and reservoir, lake, and groundwater levels.
Agricultural	Soil moisture deficiencies relative to water demands of plant life, usually crops.
Socioeconomic	The effects of meteorologic, hydrologic, and agricultural drought on the supply and demand of economic goods or services.
Ecological	A prolonged and widespread deficit in naturally available water supplies — including changes in natural and managed hydrology — that create multiple stressors across ecosystems.

The U.S. Drought Monitor categorizes drought severity on a scale from D0 to D4 as outlined in Table 3-15.[29]

Table 3-15: U.S. Drought Monitor - Drought Categories

Category	Description	Possible Impacts
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested.
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed.
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions.
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies.

[28] http://drought.unl.edu/DroughtBasics/TypesofDrought.aspx
[29] http://drought.unl.edu/ranchplan/DroughtBasics/WeatherDrought/MonitoringForecastingDrought.aspx

RECENT OCCURRENCES

The NCDC Storm Events Database does not list any drought events in Marion County since 2013. The only six events listed in the database, which has records dating back to 1950, all occurred in 2010 and 2012. No injuries, deaths, property or crop damage have been documented in Marion County specific to the six events.[30]

Marion County data gathered from the U.S. Drought Monitor indicated that between September 2013, and March 2018, drought impacted agriculture, plants and wildlife, and water supply and quality. One example is in August 2016 when Indiana crops were stressed from lack of rain.

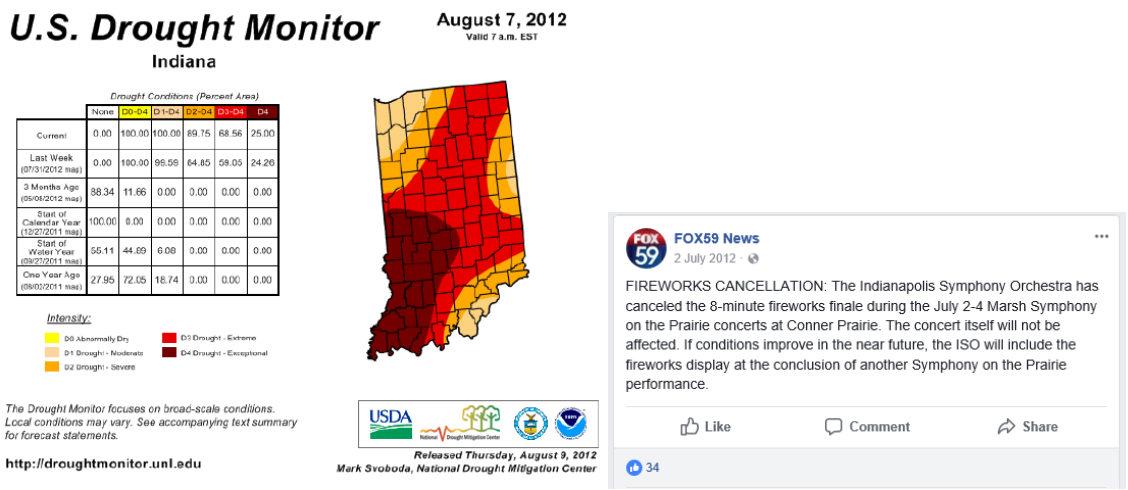
[30] Smith, T. R. (1988). Economic Development In The Nation's Heartland: Issues And. *Economic Review-Federal Reserve Bank of Kansas City*, *73*(5), 3.

The Drought of 2012

"Indianapolis hasn't seen significant rainfall in 45 days, tying the Indiana city's record for its longest dry spell in more than 100 years." http://www.croplife.com/management/drought-2012-about-20-of-corn-crop-could-be-lost/

The impacts of the 2012 drought were felt not only in Marion County, but also throughout the entire state of Indiana and across the Midwest. In August 2012, the entire state of Indiana was experiencing drought conditions ranging from "D0-Abnormally Dry" to "D4-Exceptional Drought." Figure 3-34 identifies those areas and categories of drought throughout Indiana for August 7, 2012. Marion County is primarily located in the "D3-Extreme" with the far southwestern border located in the "D4-Exceptional Drought" zone. Due to the shortage of water and the dry environment, the Mayor of Indianapolis canceled a fireworks display as a precaution, which brought further public awareness to the severity of the drought conditions.

The August 21, 2012 report shows that the northern reaches of Marion County were declassified to a "D2-Severe Drought" and by the September 4, 2012 report, the entire County was considered within the "D2-Severe Drought" severity. It wasn't until the October 30, 2012 report that the entire County was considered out of drought condition status.



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	89.75	68.56	25.00
Last Week (07/31/2012 map)	0.00	100.00	99.59	84.85	59.05	24.26
3 Months Ago (05/08/2012 map)	88.34	11.66	0.00	0.00	0.00	0.00
Start of Calendar Year (12/27/2011 map)	100.00	0.00	0.00	0.00	0.00	0.00
Start of Water Year (09/27/2011 map)	55.11	44.89	6.08	0.00	0.00	0.00
One Year Ago (08/02/2011 map)	27.95	72.05	18.74	0.00	0.00	0.00

Figure 3-34: U.S. Drought Monitor - August 7, 2012

Purdue Agriculture News reports that as of March 2013, Indiana producers received more than $1.0 billion in crop insurance payments for 2012 corn, soybean, and wheat losses. This amount is nearly double that of the previous record, $522 million following 2008 losses, also due to drought. https://www.cnbc.com/id/100408319

How is drought measured and monitored? Where is a good place to get drought related information?

The United States Drought Monitor (http://droughtmonitor.unl.edu/)

Established in 1999, this website provides a weekly map of drought conditions based on measurements of climatic, hydrologic and soil conditions, as well as reported impacts and observations from over 350 contributors nationwide.

Summary of Drought for Indiana (https://www.drought.gov/drought/states/indiana)

This website displays the percent area affected by the drought conditions from D0 to D4 (for current conditions, last week, three months ago, at the start of the calendar year and one year ago) and a map of the current drought extent across the state.

Central Indiana Drought Information (http://w2.weather.gov/ind/drought)

The website provides regional drought information. This includes the Drought Information Statement, as well as current conditions and 8-14 day, 30 day and 90 day precipitation forecasts.

The National Integrated Drought Information System's U.S. Drought Portal (https://www.drought.gov/drought/data-maps-tools)

The website offers a comprehensive database of data, maps and tools on current conditions, outlooks and forecasts, impacts, soil moisture, vegetation, fire, temperature and precipitation, agriculture, water supply and paleoclimate. In addition, users can enter in their location to learn about how drought is currently affecting their neighborhood.

ASSESSING VULNERABILITY

Marion County is increasingly vulnerable to drought hazards due to growth and shifts in population and land use changes, which can result in water shortages and degrade water quality. The County is also vulnerable since climate change is expected to increase the frequency, severity, and duration of drought events.

Drought increases the vulnerability of many different groups of people. Those who are heavily reliant on agriculture for income and/or their food supply are particularly at risk. Also, those who live in food deserts could find an even more substantial increase in food prices due to lack of supply. Preparing drought-prone areas for negative impacts on markets, creating coping strategies, and building resilience of affected populations is crucial.

What areas are at risk from drought?

Droughts have far-reaching impacts. The hazard extent for a drought is County-wide, as droughts will generally affect entire counties and even multi-county regions at one time. Since the last plan update in 2013, Marion County has not experienced a significant drought, but the probability of a drought occurring in the future is unknown. Due to the regional scale of this hazard, both rural and urban areas are at risk.

According to the National Drought Mitigation Center, scientists have difficultly predicting droughts more than one month in advance due to the numerous variables such as precipitation, temperature, soil moisture, topography, and air-sea interactions.[31] Further factors may also contribute to create more dramatic droughts or lessen the severity of droughts.

WHAT ARE DIRECT AND INDIRECT EFFECTS OF DROUGHT EVENTS?

Droughts generally have regional impacts. As Marion County has both urban and rural areas, the County will experience a wide range of direct and indirect effects at different scales, across the social, environmental and economic spheres.

Table 3-16: Effects of Drought Events

Direct Effects:	Indirect Effects:
• Urban areas may experience revenue losses landscaping companies, golf courses, water use restrictions on industry impacting cooling and processing demands, businesses dependent on crop yields; and increased potential for fires • Rural areas within the County may experience revenue losses from reductions in livestock and crop yields as well as increased field wild fires • Citizens served by drinking water wells may be impacted during low water periods and may require drilling of deeper wells or loss of water service for a period of time • Increased air pollution through entrainment of dust in the atmosphere	• Loss of income of employees from businesses and industry affected; loss of revenue to support services (food service, suppliers, etc.) • Loss of revenue from recreational or tourism sectors associated with reservoirs, streams, and other open water venues • Increased demand on emergency responders and firefighting resources • Potential increases in food prices and loss of domestic gardens may affect disadvantaged communities • Food deserts are particularly vulnerable if agricultural drought impacts production • Damage to private and public green spaces

In urban environments, the effect of drought on water supplies including streamflows, reservoirs, wetlands, and groundwater can contribute to significant impacts to a variety of non-agricultural sectors. Economic impacts can

[31] http://drought.unl.edu/DroughtBasics/PredictingDrought.aspx

extend to tourism and recreation, public utilities, horticulture and landscaping services, navigation, and other industries and businesses that rely on the substantial consumption of water, among other sectors.[32]

Table 3-17 Impacts Produced by Water Shortage in Urban Areas[33]

Social Impacts
• Physical and mental stress of the population (anxiety, depression, safety loss) • Hygienic safety problems connected to the scarce flows (diminution of the flow in sewerage, increase of the concentration of the pollutants) and to the use of the water • Reduced firefighting capabilities • Alimentary restrictions (increase of the cost, diminution of the production of some foods) • Increase of respiratory ailments • Increase of political and legal conflicts on the management and use of the water • Inequity in distribution of assistance for drought • Reduction or modification of recreational activities • Reduction of quality of life • Loss of human life • Loss of aesthetic values of natural systems and assets
Environmental Impacts
• Reduction of the water resources, levels in reservoirs and lakes, flow from springs • Decrease of the levels of groundwater, land subsidence • Reduced flow of springs • Effects on water quality • Air quality effects • Increased mortality of vegetation • Increased prevalence of invasive species • Increased change for wildfires

[32] https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1198&context=natrespapers

[33] https://books.google.com/books?id=jKSKciYdhOgC&pg=PA382&lpg=PA382&dq=vulnerability+%22urban+drought%22&source=bl&ots=Qz1esd_vfN&sig=oMOjUFt7RW6NmgoRGUu5KSW0ZhU&hl=en&sa=X&ved=0ahUKEwjAyry3o9PZAhVIGt8KHZTeCmMQ6AEIUDAG#v=onepage&q=vulnerability%20%22urban%20drought%22&f=false Pg. 392; Table 6

Economic Impacts
• Losses in tourism and recreation • Increase of the cost of water resources • Increase of the cost of food • Increase in energy demand • Revenue losses to water utilities from reduced tax base • Cost of increased groundwater depletion, land subsidence • Cost of new or supplemental water resource development • General reduction of economic development

ESTIMATING POTENTIAL LOSSES

It is difficult to estimate the potential losses associated with a drought for Marion County because of the nature and complexity of this hazard and the limited data on past occurrences.

However, for the purpose of this MHMP update, a scenario was used to estimate the potential crop loss and associated revenue lost due to a drought similar to that experienced during the drought of record from 1988. In 2012, Marion County produced crops with a total market value of $27.25 million (Table 3-18). Using the range of crop yield decreases reported in 1988 and 1989, just after the 1988 drought period (50%-86%) and assuming a typical year, economic losses could range between $13.6 million-$23.4 million; depending on the crop produced and the market demand.

Table 3-18: Agricultural Data Related to Drought Vulnerability from the USDA Census of Agriculture

	2002		2007		2012	
	Total Harvested Cropland (acres)	Market Value of Crops ($1,000)	Total Harvested Cropland (acres)	Market Value of Crops ($1,000)	Total Harvested Cropland (acres)	Market Value of Crops ($1,000)
Marion County	17,203	33,435	13,224	22,509	15,130	27,256

Additional losses associated with a prolonged drought are more difficult to assess. The impacts of droughts in non-agricultural sectors and the urban environment are not often quantified, though the effect that drought conditions have in such settings are well understood. Drought in Marion County could impact the public water supply system's ability to deliver clean water by causing water scarcity, deteriorated water quality, and interruptions of supply. Citizens Energy Group, which supplies water to approximately 800,000 people and thousands of businesses in the Indianapolis area draws from both groundwater and surface water sources,

including Morse Reservoir, Geist Reservoir, and Eagle Creek Reservoir.[34] Though the reservoirs are not subject to the effects of short-term precipitation variations, the water supply to both urban and rural populations would be threatened in the occurrence of severe and sustained drought.[35]

Drought has lasting impacts on the urban landscape and urban trees: death to all or portions of a tree, reduction in the tree's ability to withstand insects and diseases, and interruption of normal growth patterns. Such effects on trees, especially urban trees can lead to additional impacts, both environmentally and monetarily. The spread of Emerald Ash Borer insect and the weakening of tree limbs and trunks, for example, may lead to increased damages during other hazard events such as wind and ice storms.

CLIMATE CHANGE CONSIDERATIONS

Though there are many types of droughts, all originate from a deficiency of precipitation or meteorological drought, as seen in Figure 3-35. NOAA National Centers for Environmental Information describes how increases in evaporation rates in recent years may increase the intensity of naturally occurring droughts. By affecting the natural climate variability in this manner, deficiencies in precipitation patterns can create meteorological drought conditions and other types of drought and impacts which cascade as a result.

Summer drought and the number of consecutive dry days may increase in the future. Not only are droughts projected to be more frequent events, but their intensity is also projected to increase. "Even if precipitation increases in the future, increases in temperature will increase evaporation rates and the rate of loss of soil moisture. Thus, future summer droughts, a natural part of the Indiana climate, are likely to be more intense." [36]

[34] http://www.citizensenergygroup.com/Our-Company/About-Citizens
http://www.citizensenergygroup.com/My-Home/Utility-Services/Water/Supply-and-Sources
[35] https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1198&context=natrespapers
[36] https://statesummaries.ncics.org/in

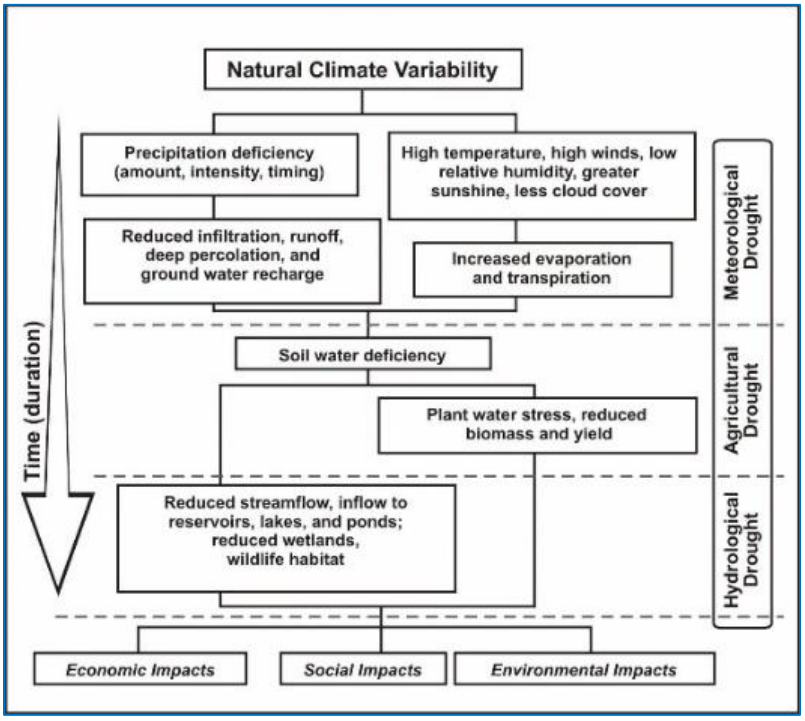


Figure 3-35: Natural Climate Variability

GLISA mapped projected changes in the average number of consecutive dry days per year experiencing no measurable precipitation by 2041-2070 as compared to the 1971-2000 period, assuming emissions of greenhouse gases continue to rise under the A2 Scenario[37] as characterized by the Intergovernmental Panel on Climate Change (Figure 3-36). Marion County is expected to experience a change in the number of consecutive dry days per year in the range from 0-1. Though the trend is counterintuitive, the number of consecutive dry days per year could increase in the areas expected to experience the largest increases in precipitation. Many models project that wet and dry periods of the year will become more polarized, as the fall, winter and spring get wetter as summers become drier. Furthermore, a greater proportion of precipitation may fall in heavy precipitation events, which would leave more days per year with little to no

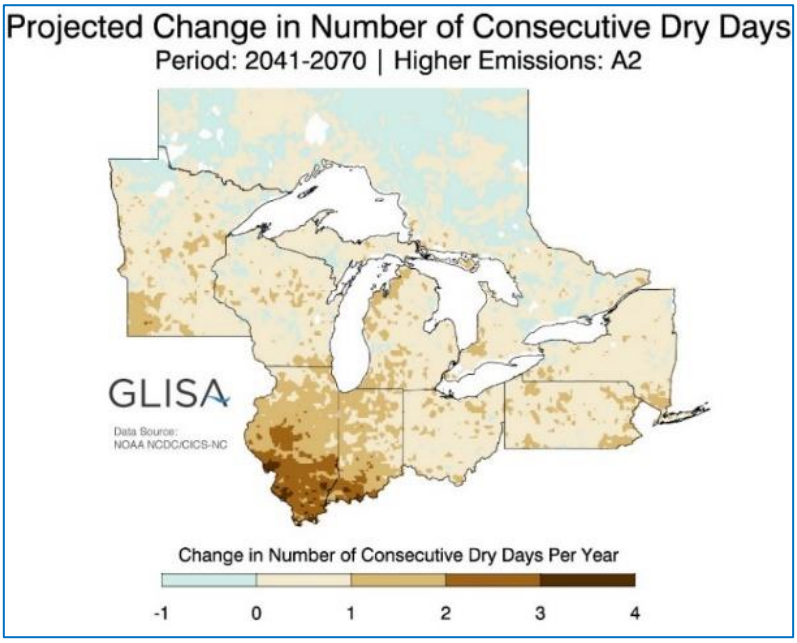


Figure 3-36: Greenhouse Gas Emissions A2 Scenario (GLISA)

[37] The IPCC released emission scenarios to be used to develop climate change scenarios, where the A2 Scenario describes a heterogenous world with an increasing global population, regional economic development and fragmented technological change.

precipitation.[38] Changes in precipitation patterns will have a significant impact on the future prospects of agriculture in Marion County. Advancements in plant hybrids and development have eased the impacts from short duration droughts. Seeds and plants may be more tolerant of dryer seasons and therefore fewer crop losses may be experienced.

As the more urban areas of the County continue to grow and expand, protocols may need to be developed which create a consistency throughout the communities and the unincorporated portions of the County for such things as burn bans and water usage advisories or restrictions. There is also evidence that air quality is directly correlated to drought because as drought disturbs the water cycle, it will directly affect atmospheric composition.

RELATIONSHIP TO OTHER HAZARDS

Droughts are related to increases in heat waves, as heat can exacerbate drought and both hazards are closely connected to the hydrologic cycle. Across the country, the concurrence of meteorological droughts and heat waves shows statistically significant increases, as longer and hotter heat waves are more often coinciding with drought conditions.[39] Furthermore, it is anticipated that areas of the County may be more susceptible to fires during a drought and this may lead to increased losses associated with a structural fire.

[38] http://glisa.umich.edu/resources/great-lakes-regional-climate-change-maps
[39] http://www.pnas.org/content/early/2015/08/27/1422945112

HAZARD PROFILE 5: WINTER STORM & ICE

HAZARD OVERVIEW

A winter storm can range from moderate snow over a few hours to blizzard conditions with high winds, ice storms, freezing rain or sleet, heavy snowfall with blinding wind-driven snow, and extremely cold temperatures that can last for several days. Some winter storms may be large enough to affect several states while others may affect only a single community. Winter storms are accompanied by cold temperatures and blowing snow, which can severely reduce visibility.

- A **winter storm** is one that drops four or more inches of snow during a 12-hour period, or six or more inches during a 24-hour span.
- An **ice storm** occurs when freezing rain falls from clouds and freezes immediately on impact. Ice can accumulate on roadways, creating a sheet of ice. Ice can also accumulate on power lines, roofs, cars, and sidewalks, making travel more hazardous.
- A **blizzard**, as defined by the NOAA, is a "storm which contains large amounts of snow OR blowing snow, with winds in excess of 35 mph and visibilities of less than 1/4 mile for an extended period of time (at least three hours)."

Winter storms make driving and walking extremely hazardous. The aftermath of a winter storm can affect a community or region for days, weeks, and even months. A significant amount of MHMP task force meeting participants indicated that winter storms are a hazard they are especially concerned about.

Storm effects such as extreme cold, flooding, and snow and ice accumulation (Figure 3-37) can cause hazardous conditions and hidden problems for people in the affected area. People can become stranded on the road or trapped at home, without utilities or other services, including food, water, and fuel supplies. The conditions may overwhelm the capabilities of a local jurisdiction. Winter storms are considered deceptive killers as they may indirectly cause transportation accidents, and injury and death resulting from exhaustion/overexertion, hypothermia and frostbite from wind chill, and asphyxiation; and house fires occur more frequently in the winter due to lack of proper safety precautions. This hazard is classified as a shock because of the suddenness that accompanies extreme weather events.

Figure 3-37: Freezing Rain Coating a Power Line with Ice

A winter storm watch indicates that severe winter weather may affect your area. A winter storm warning indicates that severe winter weather conditions are on the way. A blizzard warning means that large amounts of falling or blowing snow and sustained winds of at least 35 mph are expected for several hours. Winter storms are common in Marion County. Such conditions can result in substantial personal and property damage, even death.

RECENT OCCURRENCES

March 2013

On March 24, 2013, a winter storm dropped 6 to 10-inches of snow in the Indianapolis area, which set a new record. It was only the third time since the 1880s that snowfall of 4-inches or more occurred so late in the season. The storm rapidly created slick and dangerous roads with low visibility.

January 2014

The blizzard in Marion County with the second largest daily snowfall on record, followed by extreme low temperatures, hit the region in January 2014. Over 11-inches of snow fell at Indianapolis International Airport. Those impacted by pronounced poverty were particularly vulnerable during this event as their access to reliable shelter, transportation, and food significantly decreased.

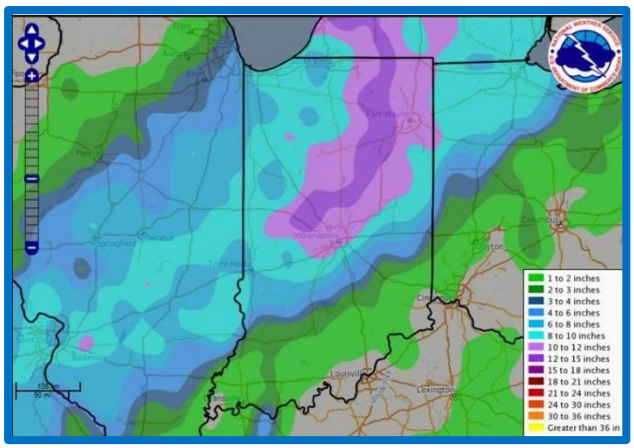


Figure 3-38: January 5th, 2014 Snow Coverage Map

Four hundred residents were transported to shelters by emergency crews and 30,000 homes lost power. The 211 lifeline system was down for 12 hours. City buses did not run for one week. The City did not have the resources to plow the streets, and a travel ban was issued for the first time in 36 years. Terms such as “polar vortex” and “snowmageddon” were used frequently in the media.

March 2018

Indianapolis received a record amount of snow at 10.2 inches, the second snowiest day in March since 1884. A large portion of the heavy and sticky snow fell in only three hours, causing many problems, particularly with driving conditions. This resulted in many crashes and injuries, as well as some fatalities.

ASSESSING VULNERABILITY

Some type of severe winter weather is expected every winter. The severity, frequency and duration of the winter weather events each year varies and is difficult to predict. These events affect everyone but are particularly harsh on populations like the homeless. Those who are unable to afford housing, heat, or any type of shelter are at extreme risk, as long exposure to the cold, snow, and ice experience harmful

health repercussions. Also, those dependent of public transportation, roads, etc. to get to work and make a living are also at risk as these are very dangerous and unreliable during storms. As noted above, Marion County emergency services personnel have capabilities and plans in place to help vulnerable populations during severe winter weather events. Historically, this has included efforts such as directly engaging homeless people to move to shelters and transporting people with underlying health issues to receive care.

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF EXTREME TEMPERATURES?

Table 3-19: Extreme Temperature Effects

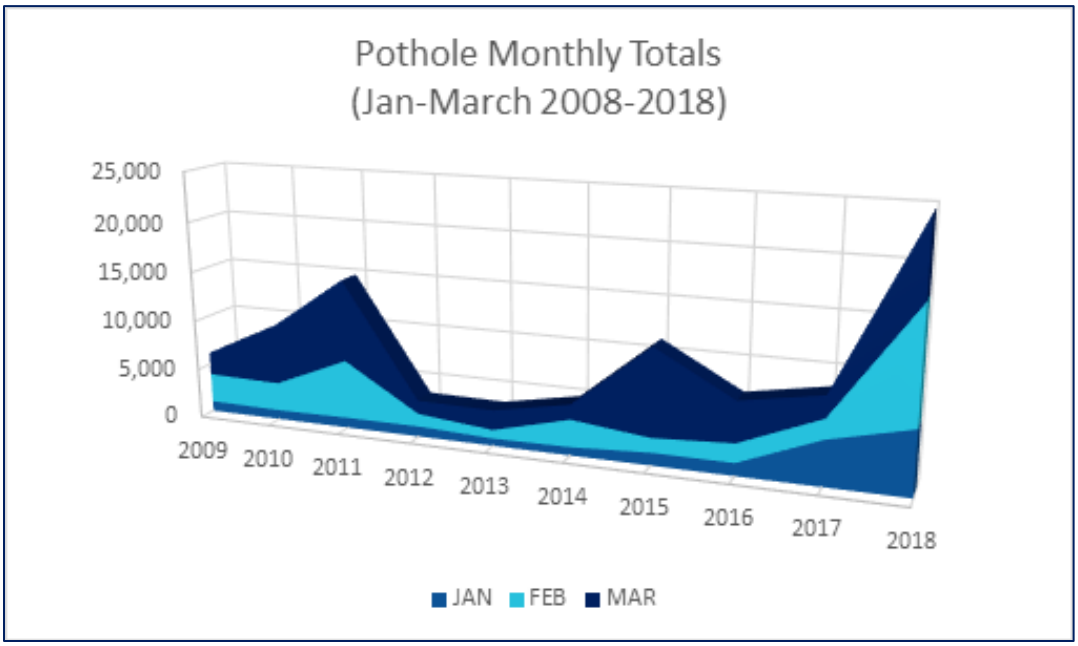
Direct Effects:	Indirect Effects:
• Employers may experience loss of production as employees may not be able to get to work • Roads may be impassable • Expenses related to snow removal or brine applications • Traffic incidents will occur • Exposure danger, including hypothermia and frostbite, particularly for homeless populations • Damage to power lines	• Loss of revenue as businesses are closed • Increased emergency response times based on safety of roads • Loss of income if unable to get to place of employment • Increase in potholes in roadway • Salt degradation of infrastructure • Public health impacts: excessive use of electricity for heating/cooling can cause power outages. Power lines may also be damaged. This can be a life/death situation for individuals who depend on life support devices • Decreased access to food because of store closings, danger or lack of transportation, etc.

Winter Weather and Potholes

Potholes are formed from a process driven by both weather and motorists:

1. Over time, traffic deteriorates roads through normal use resulting in deformation and cracks, which allows water to seep into and beneath the pavement.
2. When temperatures drop below freezing, the water freezes and expands, forcing the pavement to rise and separate
3. Further wear and tear by traffic on these raised sections and temperatures above freezing create a shallow depression in the road and the start of a pothole.

To link potholes to extreme temperatures and rainfall, historic data can be correlated to peak pothole years. The following graphs overlay pothole counts with weather data recorded at the Indianapolis Airport Station to examine possible trends.



ESTIMATING POTENTIAL LOSSES

Given the nature and complexity of a regional hazard such as a winter storm, it is difficult to quantify potential losses to property and infrastructure.

For planning purposes, information collected on winter storms impacting other communities around the nation is useful in assessing the potential social, physical, and economic impacts that a winter storm could have on the Marion County communities. For example, the Denver, Colorado area experienced severe snowstorms from December 2006 through January 2007. In snow removal costs alone, it is estimated that over $19 million was spent throughout the area, with approximately $6.4 million of that allocated to clearing Denver International Airport. Indirect economic impacts were realized when the large storm closed local businesses and the Denver International Airport for nearly 48 hours.

Figure 3-39: Travel Impacted During Snow Storm

While the above examples indicate the wide-ranging and large-scale impact that winter storms can have on a community or region, in general, winter storms tend to result in less direct economic impacts than many other natural hazards. According to the Workshop on the Social and Economic Impacts of Weather, which was sponsored by the U.S. Weather Research Program, the American Meteorological Society, the White House Subcommittee on Natural Disaster Relief, and others, winter storms resulted in an average of 47 deaths and more than $1 billion in economic losses per year between 1988 and 1995. However, these totals account for only 3% of the total weather-related economic loss and only 9% of fatalities associated with all weather-related hazards over the same period.[40]

Winter storms can also result in substantial indirect costs. Increased emergency response times, loss of work or the inability to get to work, as well as business interruption, are possible indirect effects of a winter storm. According to a report by the National Center for Environmental Predictions, the cold and snowy winter in late 1977 and early 1978, which impacted several heavily populated regions of the country, was partially responsible for reducing the nation's Gross Domestic Product (GDP) from an estimated growth rate of between 6% and 7% during the first 3 quarters of 1977 to approximately -1% in the last quarter of 1977 and 3% during the first quarter of 1978.

[40] http://sciencepolicy.colorado.edu/socasp/weather1/index.html

CLIMATE CHANGE CONSIDERATIONS

As populations increase and communities continue to grow, the need to respond to winter storms or ice storms will remain an important municipal effort. As new construction and re-development occurs, especially regarding critical infrastructure, it is important to ensure that these new structures are equipped to deal with the potential risks associated with winter storms. Those may include lengthy power outages and potentially impassable transportation routes, making it difficult to obtain supplies or for passage of response vehicles.

The need to address the aging infrastructure has never been more imminent. The inability of the City's aging infrastructure to deal with a winter weather related event like that experienced in early 2018 exposed gaps in the City's ability to address large-scale shocks and the impact aging infrastructure can have in inhibiting the City's ability to return to business as usual.

As climate changes, occurrence of rain during the winter and early spring is expected to increase. This rain may fall on frozen ground, snow, and ice, creasing the chances of flooding. This will put more pressure on drainage features and dams in Marion County.

RELATIONSHIP TO OTHER HAZARDS

Winter storms and ice storms can lead to flooding as the precipitation melts and enters local receiving water bodies. This increased volume of water on already saturated, or still frozen ground can quickly result in flooding related damages to structures and properties (Figure 3-40), as well as within the stream or river channel. The increased flooding may then lead to a dam or levee failure within the same area, further exacerbating the damages.

Figure 3-40: Flooding Caused by Snow Melt

Hazardous materials incidents may be caused by poor road conditions during winter storms or ice storms. Many hazardous materials are transported by rail or by tanker over highways and interstates. In the more suburban/rural areas of Marion County, or where open areas are more susceptible to drifted roads, the possibility of a traffic-related hazardous materials incident may increase.

Power outages and other infrastructure failures may also occur during a winter storm. Weight from snow and ice accumulations can directly or indirectly cause power lines to fail. During periods of extreme cold, power outages may prove deadly for certain populations such as the elderly or ill.

HAZARD PROFILE 6: TORNADO

This hazard profile provides a description of the extent to which tornado hazards affect Marion County. Tornadoes can be devastating due to the suddenness of the storm, unpredictability of its path, and level damage it may cause to the entire region. This profile will outline how tornadoes are categorized and the respective damage that may occur. The **Recent Occurrences** section addresses all tornadoes that have affected Marion County since 2013 and the destruction that occurred as a result. This profile will also discuss the probability of future hazard events, the potential areas and vulnerable populations at risk, as well as the effects climate change will have on the frequency and severity of tornadoes in the community.

HAZARD OVERVIEW

What is a tornado?

Tornadoes are defined as violent cyclonic wind storms that often develop around major thunderstorms. A tornado is generated when conditions in a strong storm cell are produced that exhibit a mass of cool air that overrides a layer of warm air. The underlying layer of warm air rapidly rises, while the layer of cool air drops – sparking the swirling action.

A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 300 mph. The average forward speed of a tornado is 30 mph, but may vary from stationary to 70 mph. Some tornadoes are clearly visible, while rain or nearby low-hanging clouds obscure others.

Tornadoes can strike quickly, with little or no warning, and cause fatalities and devastate a neighborhood within only seconds, and damage paths can be in excess of one mile wide and 50 miles long. Every state in the U.S. is at some level of risk from tornadoes. Because of the suddenness, it is classified as a shock.

Before a tornado strikes, the wind may die down and the air may become very still. The damage from a tornado is a result of the high wind velocity and flying debris. A cloud of debris can mark the location of a tornado even if a funnel is not visible. Tornadoes generally occur near the trailing edge of a thunderstorm. It is not uncommon to see clear, sunlit skies behind a tornado.

When do tornadoes occur and why are they a major hazard in Marion County?

The Indiana State Climate Office estimates that throughout Indiana there is an average of 20 tornado touchdowns per year. Tornado season is generally April through June in Indiana, although tornadoes can occur at any time of year. Tornadoes tend to occur in the afternoons and evenings; over 80% of all tornadoes strike between 3:00pm and 9:00pm, but can occur at any time of day or night. In Marion County, the predominant tornado path is from the southwest to the northeast.

Due to the unpredictability of this hazard, all critical and non-critical structures within the County are at risk of future damage or loss of function. Because of the unpredictability of tornadoes, all structures and facilities throughout the County are uniformly exposed to this hazard and potentially could be impacted.

How are tornadoes categorized?

The Enhanced Fujita Scale (EF) has been used in the United States since 2007 to rate the intensity of tornadoes based on the damage caused. It replaced the Fujita Scale with revised wind speeds that more closely align with the damage done by the tornado. The EF scale rates tornadoes based on estimated wind speed and the degree of damage. The damage is assessed in order to approximate wind speed and from that, a rating is assigned. The EF scale was formulated as a result of research that suggested wind speeds for strong tornadoes on the Fujita Scale (F) were greatly overestimated. However, being determined by a synthesis of opinions of top engineers and meteorologists, the EF scale wind speeds remain as estimates, not measurements, and are also biased to United States construction practices.

Table 3-20: Fujita/Enhanced Fujita Scale Rankings

Scale	Wind Speed	Potential Damage Impacts	Approximate Relative Frequency
F0/ EF0	<73 mph/ 65-85 mph	**Light** – damage to protruding structures such as chimneys, antennas, satellite dishes, signs, balcony railings; windows shattered by debris; broken tree limbs; uprooted trees	29%
F1/ EF1	73-112 mph/ 86-110 mph	**Moderate** – roofing material stripped; mobile homes shifted from foundations or overturned; moving vehicles blown off roads	40%
F2/ EF2	113-157 mph/ 111-135 mph	**Considerable** – roof trusses torn from wall frames; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light- to moderate- weight debris projected at high velocity; vehicles lifted off ground	24%
F3/ EF3	158-206 mph/ 136-165 mph	**Severe** – roof trusses and wall framing dismantled; trains overturned; many trees uprooted; heavy vehicles lifted off ground and projected	6%
F4/ EF4	207-260 mph/ 166-200 mph	**Devastating** – well-constructed structures leveled; structures with weak foundations blown away at some distance; heavy objects projected at high velocity	2%

Scale	Wind Speed	Potential Damage Impacts	Approximate Relative Frequency
F5/ EF5	261-318 mph/ >200 mph	**Incredible** – strong framing leveled off foundations and scattered; large and heavy objects projected at high velocity in excess of 300 feet; bark and limbs stripped from trees	<1%

While most tornadoes (69%) have winds of less than 100 mph, they can be much stronger. Although violent tornadoes (winds greater than 205 mph) account for only 2% of all tornadoes, they cause 70% of all tornado deaths.

The impacts of a tornado vary based upon the wind speed. The table above describes the six categories of tornadoes using the EF scale, as well as possible damage impacts. Because the path of a tornado is unpredictable, all assets throughout the County are vulnerable to the impacts of tornadoes. Based upon the historical occurrences described below, wind damage is the most common impact of tornadoes and related property damage could be as great as $5 million. Additionally, another impact of historical tornado occurrences include injury and loss of life. Critical infrastructure could be impacted resulting in road and power outages which can affect emergency response services.

RECENT OCCURRENCES

According to the NCDC, Marion County experienced three tornadoes between 2013 and 2018. Tornadoes recorded for Marion County include 1 – EF0 and 2 – EF1. The following exhibit illustrates one tornado event in Marion County.

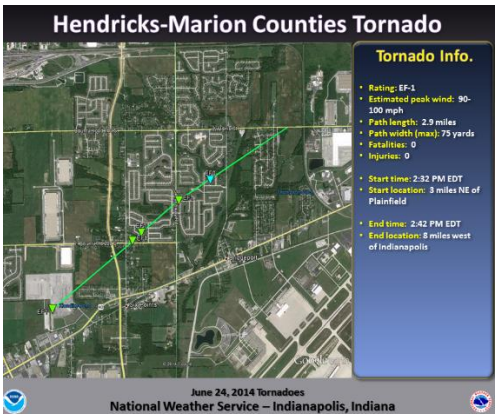
Table 3-21: Tornado Occurrences (NCEI)

Location	Date (only tornadoes causing damage since 2013)	Magnitude	Deaths	Injuries	Property Damage ($1,000)	Crop Damage
Six Pts	06/24/2014	EF1	0	0	$500	$0
Beech Grove	5/30/2015	EF1	0	0	$49	$0
Woodruff Place	8/24/2016	EF0	0	0	$15	$0
Totals (total for all events in the County)			0	18	$29,664	$0

EF-1 Tornado in 2014

In the afternoon of June 24, 2014, thunderstorms developed ahead of a cold front and area of low pressure, which ultimately produced three tornadoes in central Indiana over the course of an hour and a half. Two of the tornadoes were rated EF-1, while the third was EF-0.

A tornado touched down in Marion County along an approximately three-mile path in Indianapolis and Plainfield, with winds estimated from 90 to 100 mph. A vehicle auction facility sustained the first significant damage, with one building heavily damaged and over 200 cars impacted by flying debris. Traveling northeast, the tornado damaged nearly two dozen homes in Hendricks County, where a camping trailer was lofted into the air and tossed approximately 175 feet east onto a house, where it removed a substantial portion of the roof.



In the last few minutes of the tornado's landfall, the most significant damage occurred as it moved into Marion County and Indianapolis. Several homes along Raceway Road near Blue Pine Drive were stripped of portions of their roofs. The tornado lifted, however intermittent straight-line wind damage to trees occurred from northeast of the subdivision to near Rockville Road and I-465 all the way to the town of Speedway. Officials estimated that 75 to 100 homes sustained minor damage in Indianapolis, while over 200 vehicles in total sustained varying degrees of damage.[41]

What kind of tornado-related alerts are important for citizens to know about?

Within Marion County, there are numerous events each year that draw many thousands of Indiana residents as well as international guests. Due to this, it is imperative that the DHS place continued importance on the need to maintain and, as necessary, upgrade the outdoor warning siren coverage. Currently, approximately 97% of Marion County is covered by an outdoor warning siren.[42] The existing siren locations and effective areas are shown on Figure 3-41.

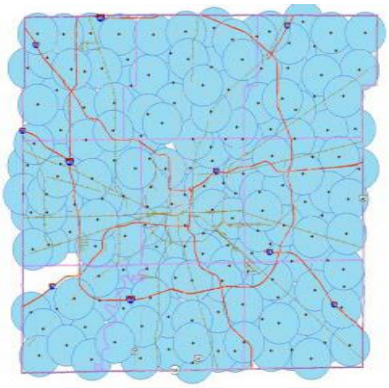


Figure 3-41: Coverage Area for Outdoor Warning Sirens

[41] https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=530627, https://www.indystar.com/story/news/2014/06/24/tornado-reported-plainfield/11316435/

[42] http://www.indy.gov/eGov/City/DPS/DHS/Documents/Copy%20of%20Siren%20Protocol070111.pdf

ASSESSING VULNERABILITY

Ever community is vulnerable to a tornado. Tornadoes have the possibility to destroy homes, infrastructure, buildings, businesses and agriculture, and cause injury and death. Those populations who do not have quick access to shelter, the institutionalized (in a hospital, prison, foster care, nursing home, long term care), or to no shelter at all (e.g. the homeless) are particularly at risk. Also, those who cannot afford to repair the damage caused to their homes may find themselves homeless while those who can't afford to repair their businesses may become unemployed. Public health is also at risk due to tornadoes.

What areas are at risk from tornadoes?

All of Marion County may be impacted by tornado. It is not possible to predict where a tornado may touch down and its path. Based on historical data, there is a high probability a tornado will occur in Marion County.

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF TORNADOS?

As noted above, any location in Marion County may be impacted by a tornado. Therefore, it is difficult to isolate specific critical infrastructure and non-critical structures or areas of Marion County. Direct and indirect effects from a tornado may include:

Table 3-22: Tornado Effects

Direct Effects:	Indirect Effects:
• Loss of life, for people, livestock and pets • Property damage • Significantly greater damages to older structures, mobile homes, and outbuilding structures (pole barns, sheds, etc.) • Damage to above ground utility lines and structures • Disabled and institutionalized populations are particularly vulnerable because of their lack of mobility and ability to seek shelter quickly	• Expenses related to debris clean-up and/or reconstruction • Loss of revenue for affected businesses • Loss of work if employers are affected • Vulnerable populations may experience health impacts and may lack resources for recovery and expenses

ESTIMATING POTENTIAL LOSSES

Tornadoes can cause damage to structures, trees, power lines, mobile homes, and vehicles and threaten the safety of life. Impacts include roof damage, power outages, blown down signage, debris, uprooted trees, debris missile launching, and in some cases, buildings can be completely destroyed. Tornadoes can propel objects such as vehicles, homes, people, trees, and other debris. Damage is primarily to the roofs of structures and tree debris impacting transportation and power services. Residents are vulnerable to injury if proper protection measures are not taken. Down power lines can increase risk of electrocution, and loss of power can lead to other health safety issues for those outside the areas directly impacted. Mobile homes are most vulnerable to the impacts of tornadoes because they are often not designed on anchored property to withstand the wind speeds

associated with tornadoes. Documented losses due to tornado events in Marion County are presented in Table 3-21. As shown in Table 3-21, losses can range widely depending on where a tornado touched down. For example, losses would be minimal in a fallow field while losses in a highly populated area of the County would be significant.

CLIMATE CHANGE CONSIDERATIONS

As tornado records in the U.S. only date back to 1950, long-term trends in tornadoes are difficult to identify. Indiana has about 15 tornadoes a year, usually occurring between April and June, however, there is significant variation year to year and no trend in tornado activity.[43] It is even more difficult to interpret the link between tornadoes and climate change. Certain future conditions, such as a warmer, more heavily moisture-laden world, could allow for more frequent atmospheric conditions associated with tornado formation.[44] Conversely, a warmer atmosphere could also lessen chances for wind shear, another condition supportive of tornado formation. Until climate models develop greater sensitivity to the relatively geographically small extent of tornadoes and the complex physical processes that cause the hazards are better understood, it will remain challenging to estimate how climate change may influence tornado frequency and severity.[45]

RELATIONSHIP TO OTHER HAZARDS

Tornadoes may result in a hazardous materials incident. Material storage containers can become damaged by high winds and debris can result in a spill or release of hazardous materials. As wind speeds increase, the potential for damages to above ground storage containers also increases. Tankers and other transportation vehicles carrying hazardous materials are also at an increased risk while on the road or rail. Tornadoes may also result in a dam or levee failure. The increased wind speeds and debris caused by the tornado, may directly impact the dam or levee, or cause indirect damages through large debris or downed trees on a natural levee. In addition, tornadoes may lead to structural fire damage to buildings and exposing electrical transmission assets.

[43] https://ag.purdue.edu/indianaclimate/indiana-climate-report/

[44] https://www.c2es.org/content/tornadoes-and-climate-change/

[45] https://www.c2es.org/content/tornadoes-and-climate-change/

HAZARD PROFILE 7: EXTREME TEMPERATURES

This hazard profile provides a description of the type, location, and extent of extreme temperature hazards that affect Marion County. Extreme temperatures include both heat and cold. These temperatures are relative to the average temperatures within a specific region and are classified according to the heat index values or Wind Chill Temperature Index. Extreme temperatures impact put the whole region, especially vulnerable populations. Because extreme temperatures affect people and ecosystems more than infrastructure, it is more difficult to quantify the monetary effects this hazard can have on the County. However, the risks for those exposed to extreme temperatures at length are discussed. Recent occurrences in Marion County have been documented and are associated with the increasing prevalence of climate change. This profile has been modified to address climate change by including a discussion of how climate change is increasing the frequency and severity of extreme temperatures in the community.

HAZARD OVERVIEW

What are extreme temperatures?

Weather conditions described as extreme hot or cold temperatures vary across different areas and are relative to the range of average temperatures within a region. For example, in areas unaccustomed to winter weather, near freezing temperatures are considered “extreme cold”, while elsewhere, an 80 degree day could be “extreme heat.”

An extreme heat event is characterized by average daily temperatures that hover 10 degrees or more above the average high temperature for a region for the duration of several weeks. An extended period of extreme heat of three or more consecutive days is typically referred to as a heat wave. Humid or muggy conditions increase the heat index and add to the discomfort of high temperatures. This occurs when a dome of high atmospheric pressure traps water-laden air near the ground.

Extreme cold temperatures are typically characterized by the ambient air temperature dropping to approximately 0 degrees Fahrenheit (F) or below. Extremely low temperatures can occur in winter months when continental surface temperatures are at their lowest point and the North American Jet Stream pulls arctic air down into the continental United States. The jet stream is a current of fast moving air found in the upper levels of the atmosphere. This rapid current is typically thousands of kilometers long, a few hundred kilometers wide, and only a few kilometers thick. Jet streams are usually found somewhere between 10-15 km (6-9 miles) above the Earth’s surface. The position of this upper-level jet stream denotes the location of the strongest surface temperature contrast over the continent. The jet stream winds are strongest during the winter months when continental temperature extremes are greatest. When the jet stream pulls arctic cold air masses over portions of the United States, temperatures can drop below 0° F for one week or more. Sustained extreme cold poses a physical danger to all individuals in a community and can affect infrastructure function as well. Because these

extreme temperatures typically only last for a short duration of time, they are classified as an acute event or a shock.

How are extreme temperatures categorized?

Heat alert procedures are based primarily on heat index values. A heat index, given in degrees F, is often referred to as the apparent temperature and is an accurate measure of how hot it really feels when the relative humidity is factored into the air temperature. To find the heat index temperature, refer to the NWS heat index chart in Figure 3-42. As an example, if the air temperature is 96°F and the relative humidity is 65%, the heat index – how hot it feels – is 121°F. The National Weather Service will initiate alert procedures when the heat index is expected to exceed 105°-110°F for at least two consecutive days.

It is important to also note that these heat index values were devised for shady, light wind conditions. Exposure to full sunshine may increase heat index values by up to 15°F. Further, strong winds, coupled with either very hot or very cold air, can also be extremely hazardous.

NWS Heat Index — Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Figure 3-42: Heat Index (NOAA)

The magnitude of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that is felt when outside and is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body is cooled at a faster rate, causing a person's skin temperature to drop. The Wind Chill Chart, shown in Figure 3-43, identifies how a given ambient temperature may feel vastly different in varying wind speeds. The chart also includes a frostbite indicator, showing points where temperature, wind speed, and exposure time will produce frostbite for humans.

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

Figure 3-43: Wind Chill Chart (NOAA)

http://www.nws.noaa.gov/om/cold/wind_chill.shtml

RECENT OCCURRENCES

The effects of extreme temperatures extend across large regions, typically affecting several counties, or states, during a single event. According to the NCDC, between January 2013 and July 2018, there have not been any extreme heat events that have lasted for the duration of several weeks. While there have been approximately 322 days where the hot temperatures were considered extreme, the number of consecutive days of elevated

temperatures were limited. Also, there have been approximately 30 days where the temperature has dropped to below 0°F and thus, classified as extreme cold.

The blizzard and extreme cold snap of January 2014 greatly strained the City's already limited fiscal resources. An estimated $13.4 million was immediately spent addressing hazardous road conditions. An additional $24 million was appropriated to address the damage caused by this extreme weather event. In a city that holds 18% of all Indiana's jobs, and 24% of the wages, the blizzard's impact to infrastructure and people led to impacts on the State's economy. [46]

What kind of extreme temperature-related alerts are important for citizens to know about?

Temperature-related alerts are classified based on the severity of the risks they pose. These classifications are shown in Table 3-23.

Table 3-23: Heat Index Effects on Population

Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

https://www.weather.gov/ama/heatindex

[46] http://www.hoosierdata.in.gov/articles.asp?article_id=all

The Record Setting Winter of 2017 - 2018

The last week of 2017 and the first week of 2018 brought some of the coldest temperatures experienced in the past four years as artic air flowed into Marion County and across central Indiana. Air temperatures in the Indianapolis area dipped well below zero, with even more extreme wind chills which made for record setting conditions. The daily high of 11°F on December 31 tied the record for the coolest maximum temperature for the date; January 2, 2018 had a daily low of -12°F, which tied the record low temperature for the date, originally set in 1887.

https://www.indystar.com/story/news/2018/02/20/indiana-winter-indianapolis-sets-new-high-temperature-february/356625002/

Less than two months later, Indianapolis was breaking temperature records at the other extreme, when it reached 77°F degrees at the Indianapolis Airport on February 20, 2018. The previous record of 76 degrees was set on 2/25/2000. With a low of -12°F and a high of 77°F, Indianapolis faced a historic 89 degree swing in temperature from early January to late February.

https://www.indystar.com/story/news/2018/01/02/indiana-weather-sets-record-breaking-hazardously-cold-temperatures/995124001/

https://www.weather.gov/ind/DecJan1718coldspell

ASSESSING VULNERABILITY

As climate change is becoming more prevalent, extreme temperatures are becoming more apparent. Whether it is extreme cold or extreme heat, many adverse health effects are possible. These include hypothermia and frostbite due to the cold or heat stroke, sunburn, sun poisoning, and heat exhaustion due to the heat. These usually occur to long exposure, making the homeless extremely vulnerable. Also, those without access to air conditioning or heat during these extreme temperatures are also at risk.

The inability of the City's aging infrastructure to deal with a sporadic winter weather event exposed the numerous gaps in the City's ability to address large-scale shocks and the impact aging infrastructure can have in inhibiting the City's recovery from these shocks. The shutdown of basic services, streets and schools, and the fiscal aftermath of repairing the damage demonstrated the need for new plans, flexibility, and refreshed attention to refortify and secure infrastructure-based system.

What areas are at risk from extreme temperatures?

As extreme temperatures are typically regional, the hazard extent of extreme temperatures in Marion County is County-wide. It is difficult to predict the probability that an extreme temperature event will affect Marion County residents within any given year. In the past, extreme heat events, where the daytime high temperature exceeds 95°F, were limited to five days a year on average. However, by mid-century, it is projected that Indiana will experience dozens of extreme heat days per year.[47]

As noted above, this type of hazard will generally affect the entire County; however, certain portions of the population are more vulnerable to extreme temperatures. For example, outdoor laborers, very young and very old populations, low income populations, and those in poor physical condition are at an increased risk to be impacted during these conditions.

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF EXTREME TEMPERATURES?

Within Marion County, direct and indirect effects from a long period of extreme temperature may include:

Table 3-24: Extreme Temperature Effects

Direct Effects:	Indirect Effects:
• Health risks to the elderly, infants, people with chronic medical disorders, lower income families, outdoor workers, and athletes • Health impacts to animals • The homeless population is especially vulnerable because of their need to seek shelter in extreme cold or heat • Those without access to shelter or medical care could experience severe injury or death due to long exposures of extreme temperatures	• Increased need for cooling or warming shelters • Increased medical emergency response efforts • Increased energy demands for heating or cooling • Aging and unstable infrastructure could experience long term damage and prevent usage of the roads, bridges, railroads, etc. resulting in loss of jobs • Food deserts are particularly vulnerable if agriculture destruction due to extreme temperatures occurs or people are unable to leave their homes to buy food • Air pollution (ozone)

ESTIMATING POTENTIAL LOSSES

Extreme temperatures generally impact people more than infrastructure. This hazard is not typically as damaging to structures or critical infrastructure as it is to populations so monetary damages associated with the direct effects of the extreme temperature are not possible to estimate. However, extreme temperatures put strain on the natural and built environment, including through increased energy demands and damage caused by heat

[47] https://ag.purdue.edu/indianaclimate/hoosier-health-report/

expansion in building and road materials. These impacts to people take the form of decreased physical and mental health, resulting in increased healthcare or emergency services expenses. Extreme heat can affect the proper function of organ and brain systems by elevating core body temperatures above normal levels. Elevated core body temperatures, usually in excess of 104°F are often exhibited as heat stroke. For weaker individuals, an overheated core body temperature places additional stress on the body, and without proper hydration, the normal mechanisms for dealing with heat, such as sweating in order to cool down, are ineffective. Examples of danger levels associated with prolonged heat exposure are identified in Table 3-23.

Extreme cold may result in similar situations as body functions are impacted as the temperature of the body is reduced. Prolonged exposure to cold may result in hypothermia, frostbite, and even death if the body is not warmed.

Manufacturing facilities where temperatures are normally elevated may need to alter work hours or experience loss of revenue if forced to limit production during the heat of the day. Energy suppliers may experience demand peaks during the hottest and/or coldest portions of the day. Requiring equipment and facilities to perform at maximum output while environmental conditions are outside of the recommended conditions for that equipment. Power failures are more likely during extreme heat due to the increased demand for electric power for air conditioning, adding stress on mechanical and electrical assets. At the same time, air conditioning and heat provide important protection from exposure to extreme temperatures, especially for those who are most vulnerable.

Extreme temperature events often lead to severe short and long-term health conditions, or even death, particularly for special needs populations and the elderly. A particularly vulnerable population to extreme temperatures are the homeless populations who often must obtain shelter or risk being admitted to a hospital due to temperature related conditions (i.e. heat stroke or hypothermia). Hospitals may be required to retain patients longer than necessary if the patient does not have a safe, healthy residence to be released to.

As more and more citizens are experiencing economic difficulties, local power suppliers along with charitable organizations have implemented programs to provide cooling and heating mechanisms to residents in need. Often, these programs are donation-driven and the need for such assistance must be demonstrated. As susceptible populations increase, or as local economies are stressed, such programs may become more necessary to protect Marion County's at-risk populations.

CLIMATE CHANGE CONSIDERATIONS

The number of extremely hot days, those over 95°F and 100°F, will likely increase. Overnight lows have warmed faster than daytime highs, which may lessen opportunities for relief during heat waves. Summers in Indiana by the end of this century could feel like a present-day typical summer in Oklahoma.[48]

While the number of extremely cold days is expected to decrease, winter's will likely become wetter. Coupled with more winter precipitation falling as rain and temperature swings like those experienced in 2018, impacts to both people and infrastructure are expected to increase.

Figure 3-44 shows an increase in temperature and the variability of the data is consistent.

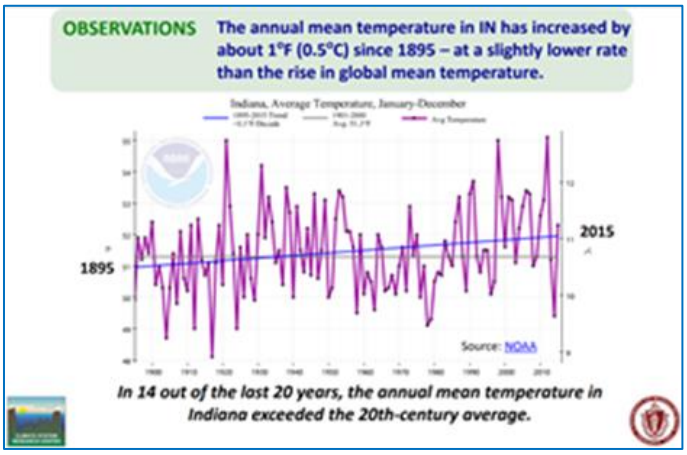


Figure 3-44: Annual Mean Temperature Variability

Figure 3-45 gives a projection for what the climate in winter and summer months in Indiana may be in coming years, indicating an increase in temperatures year-round.

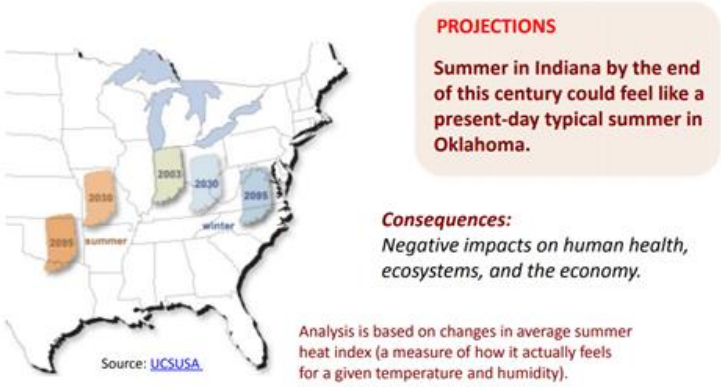


Figure 3-45: Summer Temperature Projections (UCSUSA)

[48] https://www.geo.umass.edu/climate/stateClimateReports/IN_ClimateReport_CSRC.pdf

Figure 3-46 also projects a significant increase in temperatures in the future for Indianapolis. However, it is important to note that predictions are not exact. Although this is what current data suggests, it is only a model for the data and the further out predictions reach, the less accurate they become.

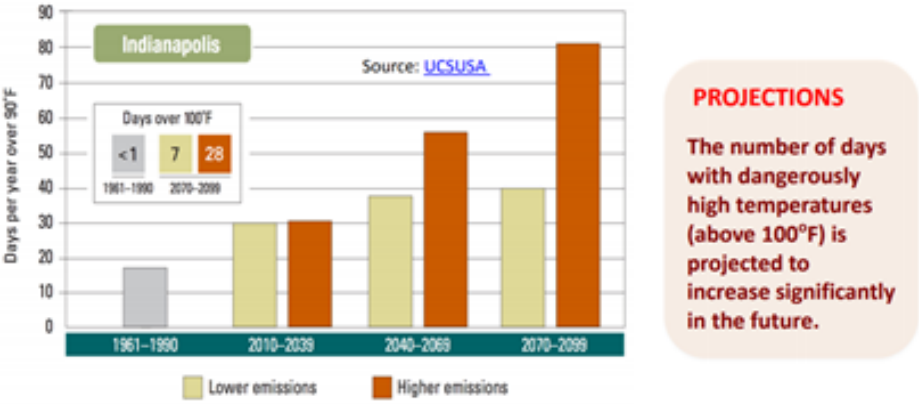


Figure 3-46: Days per Year with High Temperatures (UCSUSA)

RELATIONSHIP TO OTHER HAZARDS

This hazard is closely linked with the two following hazards, increased heat waves and urban heat island. Extreme temperatures could also potentially increase the occurrence of civil disturbances due to prolonged periods of high temperatures, citizens may become increasingly agitated and irritable, leading to disturbances requiring emergency response and/or law enforcement intervention. If civil disturbances requiring response efforts occur more often, these changes should be incorporated into City plans to better inform future budgeting.

One of the cascading events of extreme cold temperatures over a long period of time is the formation of ice dams resulting in damage to bridges and other infrastructure. Extreme low temperatures may also exacerbate risks associated with flooding.

Urban populations are particularly vulnerable because of the urban heat island effect.

HAZARD PROFILE 8: INCREASED HEAT WAVES

This hazard profile provides a description of the effects heat wave hazards have on Marion County. Heave waves are very dangerous and can have serious repercussions on people's health, especially regarding vulnerable populations. These hazards can also be damaging to aging and unstable infrastructure as well as agriculture. The National Weather Service categorizes heat waves and issues warnings based on the severity of the temperature combined with the relative humidity. Information on previous hazard events since 2013 and on the probability of future hazard events is also included. The hazard profile discusses how climate change can increase the frequency and severity of heat waves in the County and provides an overview regarding the impacts of these projected increases. Temperatures year round are rising in Marion County and are predicted to do so well into the future. This hazard is closely linked with drought, extreme temperatures, and urban heat islands and may exacerbate the impacts of each.

The Recent Occurrences section addresses all of the recorded impacts of heat waves in Marion County as assessed by the NCDC Storm Events Database. The Assessing Vulnerability section describes the County's vulnerability to heat waves in terms of:

- The geographic extent of previous heat wave events in Marion County;
- The most vulnerable populations;
- An estimation of potential losses; and
- The projected change in numbers of days over 90°F and 95°F.

HAZARD OVERVIEW

What is a heat wave?

A heat wave is a period of abnormally and uncomfortably hot and unusually humid weather, which is characterized by three or more consecutive days with temperatures at 90°F or higher.[49] Because of this short duration, it is classified as a shock. Though heat can damage infrastructure and pose a considerable threat to property and crops, its most significant threat is to the safety and welfare of humans. As humid conditions decrease the rate of perspiration, the human body feels warmer in humid conditions. Physically, heat waves can induce heat cramps, sunburn, dehydration, fatigue, heat exhaustion, and even heat stroke. Heat waves can also cause mental stress as people are less comfortable for long periods of time.

How are heat waves categorized?

Heat waves are not typically categorized, though the extreme temperatures associated with the hazard are classified by their effect on the body and relationship with heat disorders. The NWS developed a "Heat Index"

[49] http://w1.weather.gov/glossary/index.php?letter=h

(HI) as a measure of how hot it really feels when the effects of relative humidity are factored in with the actual air temperature (Figure 3-47).[50] The NWS Heat Index uses categories ranging from Caution to Extreme Danger to assess the likelihood of heat disorders with prolonged exposure or strenuous activity. As heat index values were created for shady and light wind conditions, full sunshine exposure can increase heat index values by up to 15°F.

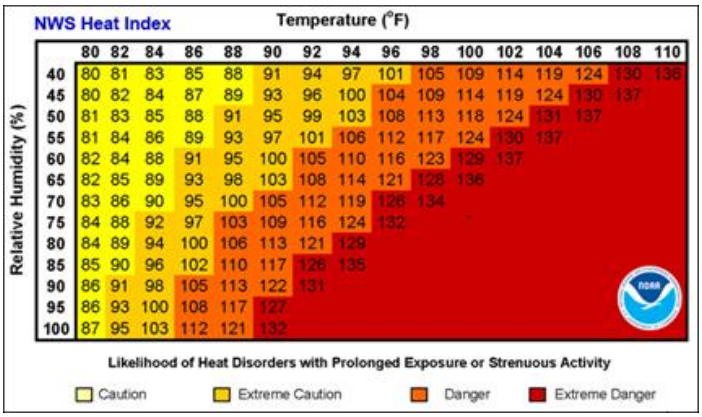


Figure 3-47: NWS Heat Index

The classifications used in the Heat Index are related to their effects on the body in Table 3-25.

Table 3-25: Effects of Heat on the Body

Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

When do heat waves occur and why are they a major hazard in Marion County?

Heat waves are most common during the hottest months of the year but can occur hear the beginning or end of the summer as well. Heat waves are a major hazard in Marion County due to the significant health impacts that are accompanied by elevated heat index values; mortality rates rise as mean temperatures increase (Figure 3-48). Heat is especially dangerous to those young and old with health challenges and is one of the top deadliest weather-related hazards. Heat puts strain on the natural and built environment, including through energy demands and damage caused by heat expansion in building and road materials.

[50] http://www.nws.noaa.gov/om/heat/heat-images/heatindexchart.png

Even a single day of high temperatures may increase death rates, but a sequence of hot days, as in the case of a heat wave, increases risks. Morbidity and mortality effects of heat may be especially severe if the power goes out during an extreme heat event. Power failures are more likely during heat waves due to the increased demand for electric power for air conditioning, as well as the added stress of the heat on mechanical and electrical assets. At the same time, air conditioning provides important protection from exposure to extreme heat and air pollution, especially for those who are most vulnerable.

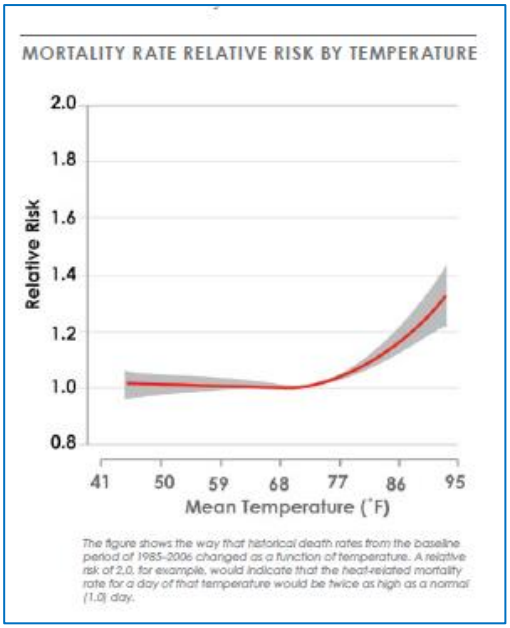


Figure 3-48: Mortality Rate Relative Risk by Temperature

RECENT OCCURRENCES

There are only two heat events listed in NOAA's National Centers for Environmental Information's Storm Events Database, neither of which occurred since the last plan update in 2013. To provide the historical context of heat wave hazards, the first event was in July 1997, and did not result in any deaths, injuries, property damage, or crop damage. The second was in June 2000, and did not result in any injuries, property damage or crop damage, though it did result in one death.

What kind of heat wave-related alerts are important for citizens to know about?

The NWS Forecast Office for Indianapolis may issue the following heat-related products in the table below, as conditions warrant.

Table 3-26 Excessive Heat Products (NWS)

Excessive Heat Products	Description
Excessive Heat Outlooks	Excessive Heat Outlooks are issued when the potential exists for an excessive heat event in the next three to seven days. An Outlook provides information to those who need considerable lead-time to prepare for the event.
Heat Advisory—Take Action!	A Heat Advisory is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Advisory is when the maximum heat index temperature is expected to be 100° or higher for at least two days, and night time air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas that are not used to dangerous heat conditions.
Excessive Heat Watches—Be Prepared!	Heat watches are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. A Watch is used when the risk of a heat wave has increased but its occurrence and timing is still uncertain.

Excessive Heat Products	Description
Excessive Heat Warning—Take Action!	An Excessive Heat Warning is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Warning is when the maximum heat index temperature is expected to be 105° or higher for at least 2 days and night time air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas not used to extreme heat conditions.

http://www.nws.noaa.gov/om/heat/ww.shtml

Where is a good place to get heat wave related information?

The NWS provides a comprehensive overview of heat safety, the distinction between different heat products (such as Heat Watch vs. Warning), the heat index, common heat related illnesses, and what to do during a heat wave.

How are heat waves measured and monitored?

There are many different indices for measuring heat waves. The NWS's Heat Index can measure the extreme temperatures of heat waves. The NWS Forecast Office for Indianapolis measures and monitors heat waves, and can correspondingly issue Excessive Heat Warnings, Excessive Heat Watches, Heat Advisories, and Excessive Heat Outlooks.

ASSESSING VULNERABILITY

Heat waves are becoming more severe and occurring more frequently as climate change is becoming more prevalent. These hazards can be detrimental to health and cause heat stroke, sunburn, sun poisoning, heat exhaustion, heat cramps, headache, nausea, dizziness, weakness, irritability, thirst, and heavy sweating. These usually occur due to long exposure, making the homeless extremely vulnerable. Children and elderly are also at risk and are particularly vulnerable. Also, those without access to air-conditioning or shelter are at a greater risk.

Heat waves put strain on the natural and built environment. This includes an increase in energy demand, agriculture, ecosystems, and infrastructure where damage can occur due to heat expansion in buildings and road materials.

What areas are at risk from heat waves? What populations are at risk?

Since heat waves are regional events, an event can impact the whole County. Heat hazard vulnerability refers to impacts on populations and energy infrastructure as well as public and other facilities without air conditioning or that may house vulnerable populations (such as nursing homes or public housing) across the County. Not all residents are equally able to prepare for, adapt to, and recover from temperature hazards. Groups who tend to be especially vulnerable to heat waves include:

- Older adults (65+)
- Children
- People with mobility issues, disabilities, and chronic and acute medical illness
- People in heavily urbanized areas and in the top floors of tall buildings[51]
- Homeless people without access to air conditioning

2017 Midwest Heat Wave

A heat wave in mid-July 2017 resulted in some form of heat advisory or warning in over a dozen states in the Midwest. Central Indiana had dangerous heat indices of approximately 100 degrees, the highest experienced since 2013. Marion County had a "hot dome" overhead, where air was sinking and compressing, therefore heightening the effects of the hot weather pattern in the region. July's record heat wave brought a cluster of thunderstorms.

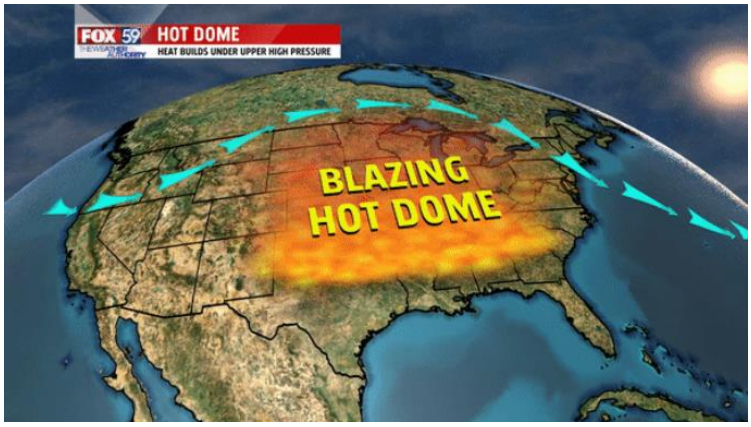


Figure 3-49: Hot Dome[52]

These groups are not necessarily independent. Also, these socio-economic characteristics may correlate with other socioeconomic characteristics like people with low to no income.

[51] http://www.noaa.gov/stories/excessive-heat-silent-killer
[52] http://fox59.com/2017/07/19/heat-wave-to-take-hold-hottest-in-four-years-with-dangerous-afternoon-heat-index/

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF HEAT WAVES?

There are many direct and indirect effects of heat waves, though the most significant effects surround the impact that heat waves have on human health.

Table 3-27: Effects of Heat Waves

Direct Effects:	Indirect Effects:
• Heat mortality and increased morbidity – heat can trigger asthma attacks or increase already high blood pressure due to the stress of high temperatures put on the body; increases in respiratory and cardiovascular disease; decreased mental health • Health risks to the elderly, infants, people with chronic medical disorders, lower income families, outdoor workers, and athletes • The homeless population is especially vulnerable because of their inability to seek shelter in extreme heat • Those without access to medical care could experience severe injury or death due to long exposures of extreme heat because of their inability to seek medical attention • Increased energy use and environmental impacts • Many agricultural products exhibit direct temperature threshold responses[53] • Stress and health impacts to animals and plants • Transportation infrastructure – high temperature can cause stress to railroad ties, ballasts and rail anchors, while thermal expansion can also occur in asphalt and concrete roads. The required repairs can be negatively impacted by construction crews' ability to work safely outdoors in the hotter summer months	• Emergency room visits, and hospital admissions increase • Increased medical emergency response efforts • Increased need for cooling shelters • Agricultural products can be affected through threshold responses of agricultural pests[54] • Resulting economic loss from agricultural losses • Food deserts are particularly vulnerable if agriculture destruction due to increased heat waves occurs • Increased risk of loss of power • Air pollution • Aging and unstable infrastructure could experience long term damage and prevent usage of the roads, bridges, railroads, etc. resulting in loss of jobs

[53] https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-12-00066.1
[54] https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-12-00066.1

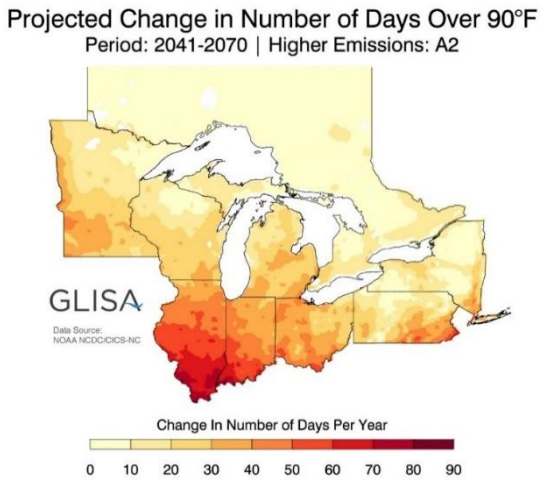


Figure 3-50: Projected Change in Number of Days per Year Exceeding 90°F by 2041-2070

Source: http://glisa.umich.edu/media/images/NCA2014-GL-16_2_b_branded.jpg

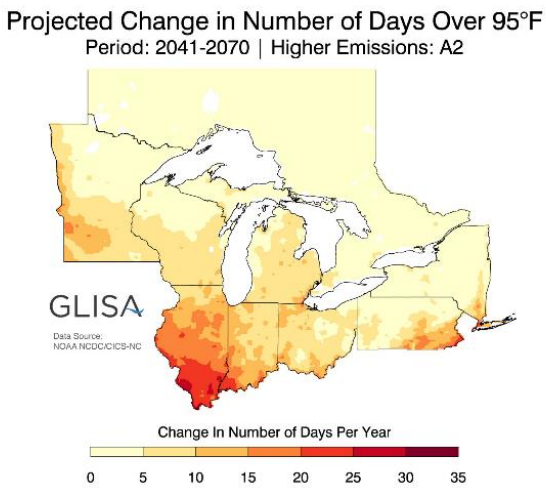


Figure 3-51: Projected Change in Number of Days per Year Exceeding 95°F by 2041-2070

Source: http://glisa.umich.edu/media/images/NCA2014-GL-17_4_b_branded.jpg

CLIMATE CHANGE CONSIDERATIONS

Temperatures in Indiana have risen approximately 1°F since the beginning of the 20th century and are projected to continue to rise. The extent to which the temperatures continue to change in Marion County based on the actual greenhouse gas emissions and the resulting severity of the local impacts.

GLISA projected changes in the number of days per year that exceed 90°F by 2041-2070 as compared to the 1971-2000 period, assuming emissions of greenhouse gases continue to rise under the A2 Scenario as characterized by the Intergovernmental Panel on Climate Change (Figure 3-50). Marion County is expected to experience 40 to 50 more days per year over 90°F.[55]

The second GLISA map shows projected changes in the number of days per year that exceed 95°F by 2041-2070 as compared to the 1971-2000 period, assuming emissions of greenhouse gases continue to rise under the A2 Scenario as characterized by the Intergovernmental Panel on Climate Change (Figure 3-51). Marion County is expected to experience 5 to fifteen more days per year over 95°F.[56] In the recent past, there have only been an average of two extremely hot days per year statewide. If these projections are correct, future heat waves are likely to be more common and intense.[57]

[55] http://glisa.umich.edu/resources/great-lakes-regional-climate-change-maps
[56] http://glisa.umich.edu/resources/great-lakes-regional-climate-change-maps
[57] https://statesummaries.ncics.org/sites/default/files/downloads/IN-screen-hi.pdf

RELATIONSHIP TO OTHER HAZARDS

Heat waves are closely related to other hazards that are associated with extreme heat. In recent years, a substantial increase in concurrent droughts and heat waves has been identified, along with a statistically significant shift in the distribution of concurrent extremes.[58] If there are an excessive amount of heat waves, drought may be possible. Extreme heat is particularly a concern in urban areas, since it combines with high humidity to produce dangerous heat index values, and urban heat island effects.[59] Extreme heat events are also worsened by urban heat islands.[60] Heat waves can create drier conditions that are more conducive to structural fires. Air pollution and heat waves are related since a lack of wind and rain reduces dilution of air contaminants. Heat is worsening ozone air pollution and air pollution is exacerbating the heat.

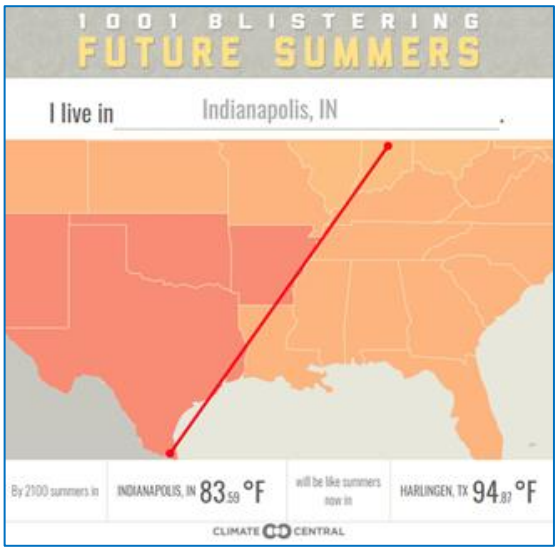


Figure 3-52: Future Summer Conditions
Source: http://www.climatecentral.org/news/summer-temperatures-co2-emissions-1001-cities-16583

[58] http://www.pnas.org/content/early/2015/08/27/1422945112
[59] https://statesummaries.ncics.org/sites/default/files/downloads/IN-screen-hi.pdf
[60] https://www.epa.gov/heat-islands/heat-island-impacts

HAZARD PROFILE 9: URBAN HEAT ISLAND

This hazard profile outlines the urban heat island effects on Marion County. Urban heat islands occur in urban areas, such as Indianapolis, due to a substantial amount of concrete and other structures, as well as an absence of vegetation. Therefore, Marion County has the potential to experience these effects. Research has been gathered from models in order to prepare for the impacts of an urban heat island. The increased temperatures can impact vulnerable populations, specifically those without access to shelter or with health conditions sensitive to heat. This hazard can also negatively impact the environment, increase air pollution, and decrease water quality. With increasing temperatures in Marion County due to climate change, urban heat islands may become increasingly prevalent. Urban heat islands are closely related to other hazards such as extreme temperatures and heat waves.

HAZARD OVERVIEW

What is the urban heat island effect?

The term "heat island" is defined as areas that are hotter than surrounding areas. These tend to occur in urban areas due to "a combination of dark pavement and roofs that absorb heat, heat-generating activities such as engines and generators, and the absence of vegetation that provides evaporative cooling."[61]

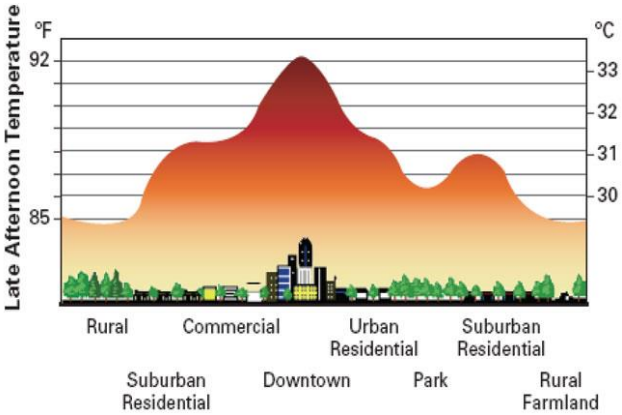


Figure 3-53: Urban Heat Island Effect

These higher temperatures are particularly hazardous at *nighttime*, when it is important for the body to cool off. Elevated concentrations of heat in urban areas can lead to heat exposure and its accompanying health risks. It can also lead to increases in air pollution, such as ground-level ozone. To decrease the impact of heat on people, additional air conditioning is needed, which increase energy consumption.[62]

When do urban heat islands occur and why are they a major hazard in Marion County?

Heat islands occur year-round during the day or night, though the effect's temperature difference is typically larger at night, during the winter and under conditions with weak winds.[63] A 2015 study by the California Environmental Protection Agency found that hotter areas do not necessarily have the most intense urban heat islands, and that the effect is influenced by wind and topography. The study also found that heat island effects are related to the size of the urban area.[64] While Marion County does not have a nearby mountain range that could potentially trap heated urban air, it is a large urban area with large areas of impermeable groundcover.

[61] https://calepa.ca.gov/2015/09/16/urbanheat/
[62] http://www.southwesturbanhydrology.com/urbanization-concerns/urban-heat-island-effect/
[63] https://scied.ucar.edu/longcontent/urban-heat-islands
[64] https://calepa.ca.gov/2015/09/16/urbanheat/

Large urban areas, such as downtown Indianapolis, can experience a greater temperature increase than that which townships around the outskirts of the County can expect. Urban heat islands are classified as a stressor. Stressors can amplify the effects of shocks when they occur, particularly for vulnerable populations.

How are urban heat islands measured and monitored?

In 2015, the California Environmental Protection Agency established a first-of-its-kind index that quantifies the extent and severity of the heat island effect for individual cities across the state.[65] The index assigns a score based on hour-by-hour atmospheric modeling from 2006 and 2013, for each census tract in and adjacent to most urban areas across the state.[66]

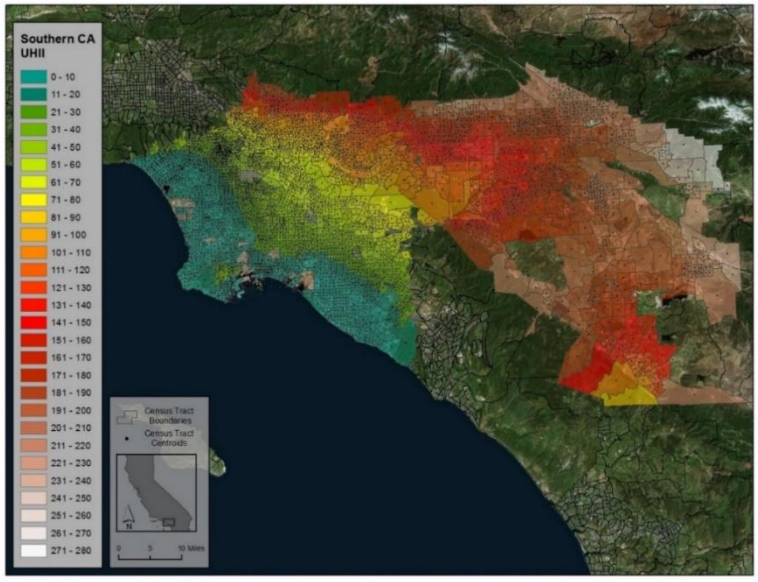


Figure 3-54: Urban Heat Island Index

An urban heat island index can help "communities target outreach and education to protect against heat illness in vulnerable populations such as children and the elderly".[67] Though this index has only been calculated for areas across California, the model can be applied in other states, to identify priority areas for local mitigation measures and aid in future planning efforts.

RECENT OCCURRENCES

As noted above, the urban heat island effect can occur at any time of the year. Therefore, it is observed by the relatively high temperatures measured In Indianapolis compared to the surrounding areas.

What kind of urban heat island-related alerts are important for citizens to know about?

There are no urban heat island specific alerts in Marion County, though there are important alerts which pertain to the drivers behind the urban heat island effect, such as extreme heat, as well as alerts which are aimed at bringing awareness to the outcomes of the urban heat island effect, such as increased ozone conditions. The NWS issues Heat Watches and Warnings on collaboration with local partners to advise the public about dangerous or potentially dangerous heat conditions (see Increased Heat Waves and Extreme Temperature hazard profiles for more information). The City of Indianapolis' Office of Sustainability Knozone initiative works

[65] https://calepa.ca.gov/2015/09/16/urbanheat/
[66] http://climatechange.ca.gov/climate_action_team/urban_heat_island/Data_13-001/ALL_DATA_DH_Day_2/
[67] https://calepa.ca.gov/2015/09/16/urbanheat/

to improve the region's air quality in part through declaring Knozone Action Days in Central Indiana when factors likely to produce high levels of ozone and PM2.5 (particulate matter) align.[68]

Where is a good place to get urban heat island-related information?

The EPA maintains an information portal on the Heat Island Effect (https://www.epa.gov/heat-islands), where users can learn about heat islands and strategies to reduce the risks.

ASSESSING VULNERABILITY

Populations who live in developed urban areas with limited tree cover and an excess of concrete are particularly at risk. The homeless population in areas like this are at risk of heat related health problems including heat stroke and nausea. More energy is required to keep buildings in the area cool. Also, impacts on urban infrastructure may be greater than in the surrounding rural areas.

What areas are at risk from the urban heat island effect?

Developed areas experience greater heat island effects than their rural surroundings due to their reduced vegetation, the properties of urban construction materials, urban geometry, anthropogenic heat, and additional factors.[69] Anthropogenic heat from population concentration and additional factors such as weather and geographic location influence the heat island effect. In addition, socially vulnerable populations who live in urban environments experience a heightened risk from the urban heat island effect.

Trees and vegetation which typically dominate the landscape in rural areas provide shade and help lower surface temperatures, while reducing air temperatures through evapotranspiration and dissipating ambient heat. By contrast, the conventional roofs, sidewalks, roads, and parking lots which primarily comprise the impervious surfaces of urban areas result in a reduction of shade and moisture, resulting in reductions in evaporation, and elevated surface and air temperatures.[70]

As Marion County develops, the urban heat island effect will exacerbate the effects of heat waves, which will put a greater population at greater risk. More uniformly developed cities, such as New York and Chicago, which are laid out on a precise grid, have a far greater buildup of heat compared to cities such as Boston or London which are arranged more chaotically.[71] This is due to the close proximity of the buildings. As Indianapolis is laid out on a more consistent grid pattern, the City is more predisposed to heat buildup and the resulting heat island effect.

What are effects of urban heat islands?

Surface heat islands, where roof and pavement surface temperatures in urban areas can climb to 50-90°F (27–50°C) hotter than the air on a hot and sunny summer day, contribute to atmospheric urban heat islands. Nearby

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[68] http://knozone.com/
[69] https://www.epa.gov/sites/production/files/2014-06/documents/basicscompendium.pdf
[70] https://www.epa.gov/sites/production/files/2014-06/documents/basicscompendium.pdf
[71] http://news.mit.edu/2018/urban-heat-island-effects-depend-city-layout-0222

shaded and moist surfaces, often in rural surroundings, remain close to ambient air temperatures.[72] These elevated temperatures can have a positive effect, such as extending the plant-growing season, and even reducing energy use in colder cities.[73] However, negative impacts often outweigh the benefits, and include:

Increased Energy Consumption

- Elevated summertime temperatures in cities increase energy demand for cooling. Research shows that electricity demand for cooling increases 1.5–2.0% for every 1°F (0.6°C) increase in air temperatures, starting from 68 to 77°F (20 to 25°C), suggesting that 5–10% of community-wide demand for electricity is used to compensate for the heat island effect.[74]
- Urban heat islands increase overall electricity demand, as well as peak demand, which generally occurs on hot summer weekday afternoons, when offices and homes are simultaneously running cooling systems, lights, and appliances. During extreme heat events, which are exacerbated by urban heat islands, the resulting demand for cooling can overload systems and require a utility to institute controlled, rolling brownouts or blackouts to avoid damages to their generating and transmission infrastructure. There has been no evidence of an epidemic of rolling blackouts in the United States in recent years. In 2011, only 5% of all power outages in the US might have been rolling blackouts.[75]

Elevated Emissions of Air Pollutants and Greenhouse Gases

- As described above, urban heat islands raise demand for electrical energy in summer. Companies that supply electricity typically rely on fossil fuel power plants to meet much of this demand, which in turn leads to an increase in air pollutant and greenhouse gas emissions. The primary pollutants from power plants include:
  - Sulfur dioxide (SO2);
  - Nitrogen oxides (NOx);
  - Particulate matter (PM);
  - Carbon monoxide (CO); and,
  - Mercury (Hg).
- These pollutants are harmful to human health and also contribute to complex air quality problems such as the formation of ground-level ozone (smog), fine particulate matter, and acid rain. Increased use of fossil-fuel-powered plants also increases emissions of greenhouse gases, such as carbon dioxide (CO2), which contribute to global climate change.

[72] https://www.epa.gov/heat-islands/heat-island-impacts
[73] https://www.sciencedirect.com/science/article/abs/pii/S0195925515001043
[74] https://www.epa.gov/heat-islands/heat-island-impacts
[75] http://www.politifact.com

- In addition to their impact on energy-related emissions, elevated temperatures can directly increase the rate of ground-level ozone formation. Ground-level ozone is formed when NOx and volatile organic compounds (VOCs) react in the presence of sunlight and hot weather. If all other variables are equal, such as the level of precursor emissions in the air and wind speed and direction, more ground-level ozone will form as the environment becomes sunnier and hotter.

Compromised Human Health and Comfort

- Increased daytime temperatures, reduced nighttime cooling, and higher air pollution levels associated with urban heat islands can affect human health by contributing to general discomfort, respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality.
- Heat islands can also intensify the impact of heat waves, which are periods of abnormally hot, and often humid, weather. Sensitive populations, such as children, older adults, and those with existing health conditions, are at particular risk from these events. Increased loss of life and illness from lower air quality are also possible.
- Excessive heat events, or abrupt and dramatic temperature increases, are particularly dangerous and can result in above-average rates of mortality. The Centers for Disease Control and Prevention estimates that from 1979–2003, excessive heat exposure contributed to more than 8,000 premature deaths in the United States. This figure exceeds the number of mortalities resulting from hurricanes, lightning, tornadoes, floods, and earthquakes combined.

Impaired Water Quality

- High pavement and rooftop surface temperatures can heat stormwater runoff. Tests have shown that pavements that are 100ºF (38°C) can elevate initial rainwater temperature from roughly 70ºF (21ºC) to over 95ºF (35ºC). This heated stormwater generally becomes runoff, which drains into storm sewers and raises water temperatures as it is released into streams, rivers, ponds, and lakes.
- Water temperature affects all aspects of aquatic life, especially the metabolism and reproduction of many aquatic species. Rapid temperature changes in aquatic ecosystems resulting from warm stormwater runoff can be particularly stressful, even fatal to aquatic life.

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF THE URBAN HEAD ISLAND EFFECT?

There are many direct and indirect effects of an urban heat island, though the most significant effects surround the impacts on human health and the environment.

Table 3-28 Effects of an Urban Heat Island

Direct Effects:	Indirect Effects:
• Health risks to the elderly, infants, people with chronic medical disorders, lower income families, outdoor workers, and athletes • The homeless population is especially vulnerable because of their inability to seek shelter in extreme heat • Those without access to medical care could experience severe injury or death due to long exposures of extreme heat because of their inability to seek medical attention • Increased energy use and environmental impacts • Transportation infrastructure – high temperature can cause stress to railroad ties, ballasts and rail anchors, while thermal expansion can also occur in asphalt and concrete roads. The resulting repairs necessitated can be negatively impacted by construction crews' ability to work safely outdoors to maintain roads in the hotter summer months	• Emergency room visits, and hospital admissions increase • Increased medical emergency response efforts • Increased need for cooling shelters • Food deserts are particularly vulnerable if agriculture destruction due to increased heat waves occurs • Air pollution • Aging and unstable infrastructure could experience long term damage and prevent usage of the roads, bridges, railroads, etc. resulting in loss of jobs

ESTIMATING POTENTIAL LOSSES

As two of the most cited detrimental impacts of the urban heat island are increased summer energy use and increased summer heat related mortality, aspects of each impact have been assessed to estimate the potential losses due to the urban heat island effect in Marion County.[76] Increased summer energy use is just one aspect that contributes to the full economic impact of the urban heat island effect; air pollution, decreased water quality and less productive workers due to health risks and discomfort, among others, all reduce economic productivity.

[76] https://www.sciencedirect.com/science/article/abs/pii/S0195925515001043

CLIMATE CHANGE CONSIDERATIONS

The total economic costs of climate change for cities with VHI effects in this century could be 2.6 times those without urban heat island effects. The most impacted cities could experience losses up to 10.9% GDP by 2100.[77]

It is worth noting that a recent study found that in the north of the U.S. there was a net decrease in energy use from the urban heat island effect, due to a relatively larger heating energy reduction in colder months, as compared to the increase in cooling energy during the warmer months. Therefore, the total economic costs of climate change for Marion County could still be higher due to the urban heat island effect, though not as a result of the increased summer energy use.

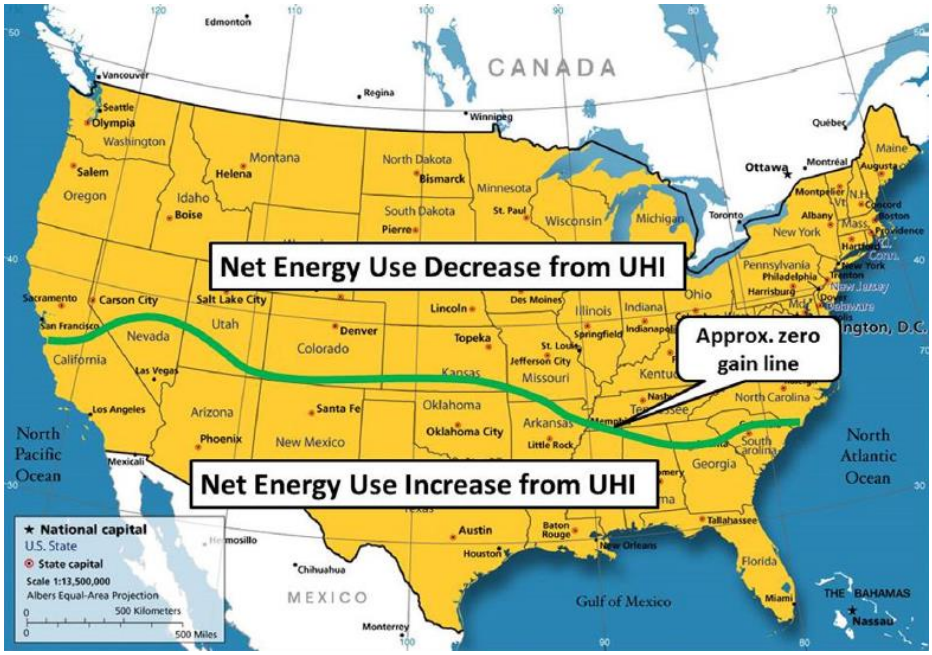

Figure 3-55: Energy Flux from Urban Heat Islands

Urban heat islands may cause an increase in heat related mortality of approximately one death per million people. As the population of Marion County nears one million, the urban heat island effect could potentially cause an increase in heat related mortality of one death per million. However, in winter, the urban heat island may decrease cold related mortality by an estimated four deaths per million, resulting in a net decrease of deaths for residents.[78] As of 2016, there are roughly 1,700-1,800 total heat-attributable deaths per summer in the United States.[79]

The EPA notes two important interactions between climate change and heat islands. First, that the warming climate will increase already elevated temperatures in heat island areas, and second, that cooling strategies implemented by communities to reduce heat islands can not only help climate change adaptation, but also lower

[77] http://www.nature.com.libproxy.berkeley.edu/articles/nclimate3301.pdf
[78] https://linkinghub.elsevier.com/retrieve/pii/S0195925515001043
[79] https://www.epa.gov/sites/production/files/2016-03/documents/eheguide_final.pdf

the greenhouse gas emissions which cause climate change.[80] Another important interaction to note is that the urban heat island effect is projected to increase with climate change.[81] "The researchers concluded urban heat island effects could add 2 Celsius to warming for the most populated cities by 2050."[82]

RELATIONSHIP TO OTHER HAZARDS

Urban heat islands are related to other heat-related hazards. Drought, heat waves and extreme temperatures contribute to dry conditions and extended periods of excessively hot weather, exacerbating the effects of urban heat islands. Urban areas already impacted by the heat island effect will suffer from more severe and more frequent heat waves. Furthermore, the combination of these heat events, rising temperatures, and the heat island effect will create conditions that are increasingly harmful to human health, and air and water quality.[83] Air pollution and unusually high temperatures, such as those found in urban heat islands are directly correlated with a lack of wind and rain to dilute contaminants in the atmosphere. Air pollution also destroys the ozone, causing an increase in temperatures. Heat is worsening ozone air pollution and air pollution is exacerbating the heat.

[80] https://www.epa.gov/heat-islands/climate-change-and-heat-islands
[81] https://calepa.ca.gov/2015/09/16/urbanheat/
[82] https://linkinghub.elsevier.com/retrieve/pii/S0195925515001043
[83] https://www.epa.gov/heat-islands/climate-change-and-heat-islands

HAZARD PROFILE 10: AIR QUALITY

This hazard profile describes the potential impacts that decreasing air quality will have on Marion County. Information on what pollutants can threaten air quality, recent occurrences of poor air quality and the risks it poses are also included. The hazard profile has been modified to address climate change by including a discussion of how climate change can increase the amount of contaminants in the air. Air quality can also be closely linked to other hazards including increased heat waves, drought and structural fires.

HAZARD OVERVIEW

What is Air Quality?

Air quality refers to the degree to which the air is free of contaminants. It often takes many sources of contamination into consideration. A lower amount of contaminants in the air leads to higher air quality.

What Pollutants May Impact Air Quality?

Many pollutants can enter the air and degrade its quality. The Healthy Environment and Community Assessment Partnership (HECAP) is a collaborative group that collects and shares data related to air quality in Indiana. It takes in to account five major air contaminant sources, which are defined by HECAP below.

Sulfur Dioxide (SO2)

Sulfur Dioxide is a very harmful pollutant. This class of chemicals affects human health by causing respiratory problems and harms the environment by contributing to acid rain that damages trees and other ecosystems buildings and property.

Particulate Matter (PM2.5)

Particulate matter, or PM2.5, is a class of particles in air 2.5 micrometers (approximately 1 ten-thousandth of an inch) or less in diameter. This is less than the thickness of a human hair. Particulate matter is a mixture that can include organic chemicals, dust, soot and metals. These particles can come from cars and trucks, factories, wood burning, and other activities. When these particles react with sunlight, they form haze, which can remain suspended in the air and travel for hundreds of miles. Particulate matter also negatively affects the nutrient and chemical balances of soil and water. Rivers may become acidic when exposed to particulate matter and soil nutrients may be depleted, damaging crops and forests.

Diesel Particulate Matter (PM)

Exhaust from trucks, buses, trains, ships, and other equipment with diesel engines contains a mixture of gases and solid particles. The solid particles are known as diesel particulate matter (diesel PM). Diesel PM contains hundreds of different chemicals. Many of these are harmful to health. The highest levels of diesel PM are near ports, rail yards, freeways, and other heavily used roadways. People are exposed to diesel PM from breathing

air containing diesel exhaust. Diesel PM have a large surface area, which makes it very easy for various compounds to become adsorbed to various surfaces which may cause adverse health and environmental effects.

Ozone

Ozone is a naturally occurring component of the atmosphere. It is a critical component of the Earth's upper atmosphere, protecting the planet from harmful radiation. When ozone is present in the air people breathe, it can harm their health, even at relatively low concentrations.[84] Additional details on ozone are in the Urban Heat Island Hazard Profile.

SOURCES OF AIR POLLUTANTS

Traffic

Indiana is known as the "Crossroads of America" due to the several interstates which intersect in the City of Indianapolis, resulting in heavy traffic in and around the area. Traffic density is a measure of the number of vehicles on the roads in an area. Since traffic is a large source of air contaminants, traffic density is an important metric to understand the potential for air quality problems.

Industrial Releases

Facilities that make or use toxic chemicals can have permitted or unpermitted release of these chemicals into the air. Information is available on the amount of chemicals released for over 500 chemicals for large facilities in the United States. This information can be found in the Toxics Release Inventory (TRI), a resource for learning about and preventing toxic chemical releases and pollution activities by industrial and federal facilities.

RECENT OCCURRENCES

Acute air quality events are rare. More common air quality events impact a wide area and may last for a few hours to several days or weeks. Air quality is classified as a stressor. Figure 3-56, created by HECAP, combines the six pollution indicators listed above to create an overall air pollution indicator score. This map helps identify regions of Marion County that often experience higher air pollutant levels and/or exposure time. As shown in the graphic, central Marion County and western regions tend to experience lower quality air.

ASSESSING RISK

In February 2010, the Indiana Department of Environmental Management (IDEM) released a report covering a study conducted between 2006 and 2009 by IDEM, the U.S. EPA, the City of Indianapolis, and other stakeholders regarding hazardous air pollutants and other air toxics in southwestern Indianapolis. The study involved air monitoring and air modeling within the limits shown in Figure 3-57.

[84] https://www.epa.gov/ozone-pollution

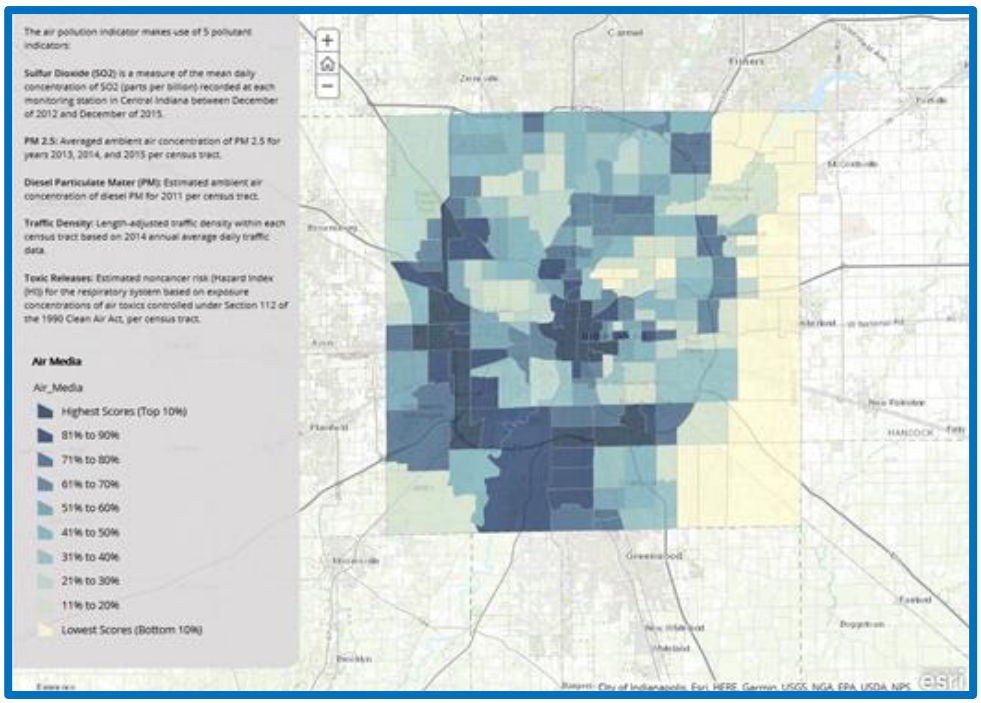

Figure 3-56: HECAP Air Pollution Map

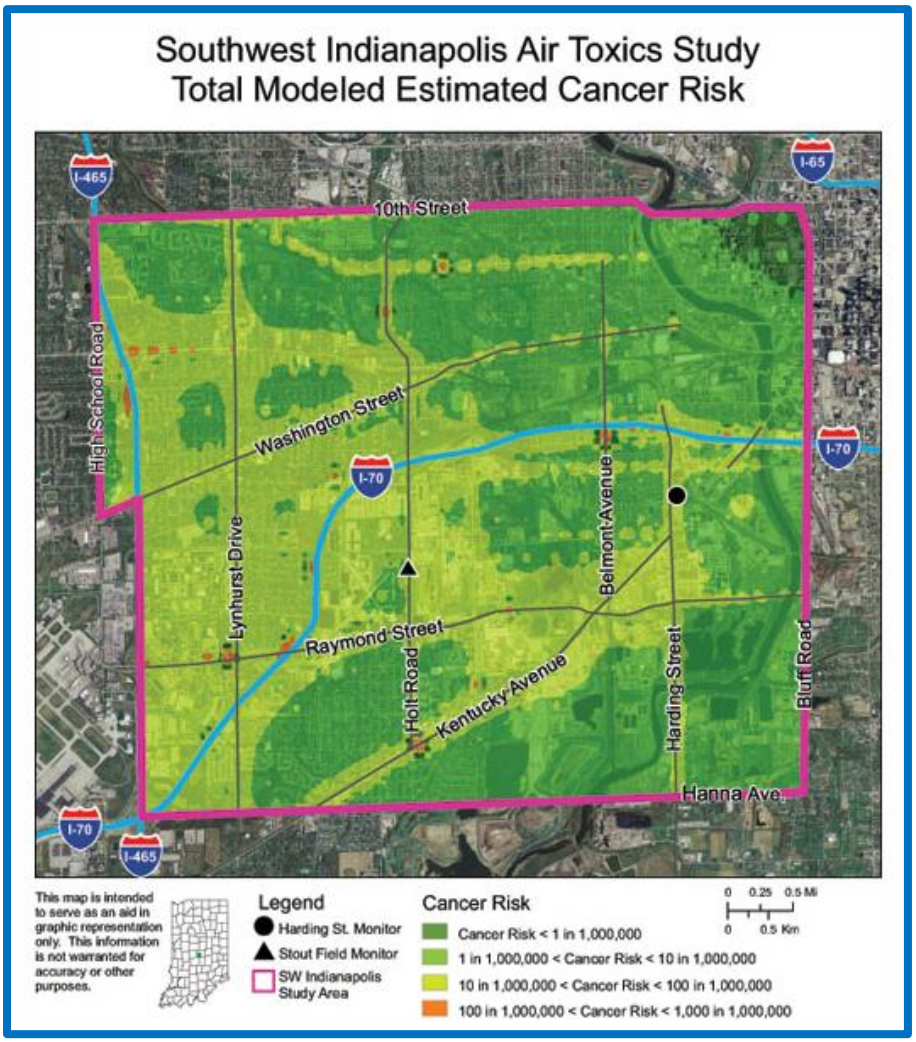

Figure 3-57: Southwest Indianapolis Air Toxics Study Total Modeled Estimated Cancer Risk

Source: www.in.gov

The report indicated:

"IDEM found the air toxics concentrations measured in the area to be similar to those found throughout Indiana and other Midwestern cities. No pollutants were found to be at concentrations which required immediate or emergency action. IDEM's analysis shows that air toxics concentrations, and therefore potential health risks, are lower than predicted by the U.S. EPA in the 1999 and 2002 National Air Toxics Assessment (NATA) reports.

During the course of the study, IDEM looked at all potential sources of air toxics in the area and found the largest contributor to be mobile sources (i.e., cars and trucks). Industrial sources were evaluated closely. The risks contributed by industry in the area were small when compared to the risk from mobile sources. Many of the major industrial sources within the study area are active partners of the State Partners for Pollution Prevention program. For those sources that are not, IDEM will be exploring partnership opportunities."

The main conclusions of the study are as follows:

- No pollutants were observed at concentrations that warranted immediate or drastic action.
- Air toxics concentrations in Southwest Indianapolis are similar to concentrations observed in other Indiana cities.
- Motor vehicles are the largest contributor of air toxics within the study area, as shown in Figure 3-58.

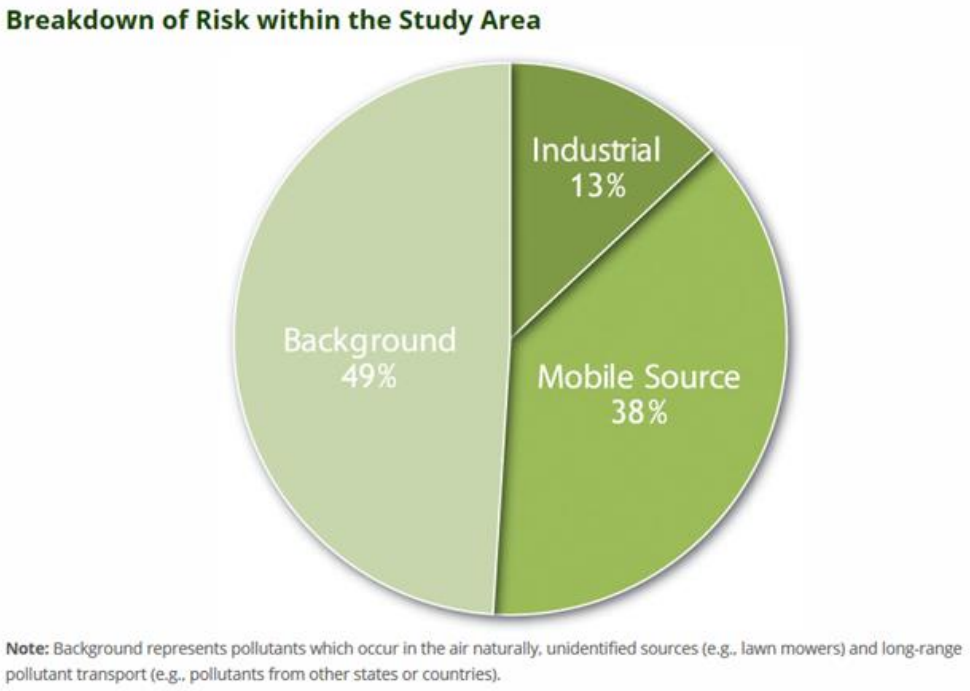

Figure 3-58: Pie Chart of Pollutant Sources from IDEM

Source: www.in.gov

The findings of this report are further supported by data from the U.S. Energy Administration. Figure 3-59 shows how emissions of carbon dioxide from transportation (cars, trucks, etc.) has begun to surpass emissions from electric power plants. Similarly, the local initiative, Knozone, reports that transportation is a major contributor to ozone pollution. Figure 3-60 indicates that 12% of ozone causing pollution can be attributed to local powerplants and large factories, whereas transportation contributes to 45% of ozone causing pollution. This indicates transportation generates three to four times as much ozone pollution as power plants and large factories located within Marion County.

Figure 3-59: Climate Central Infographic

Figure 3-60: Knozone Infographic (Source: Knozone.com)

"Knozone is an initiative to make Central Indiana one of the Midwest's most sustainable, livable regions. Through education, resources and guidance for taking action, Knozone works with residents and businesses to improve our region's air quality, making Central Indiana a great place to live, work and visit." (Source: Knozone.com)

ESTIMATING POTENTIAL LOSSES

Poor air quality can negatively affect people's health, ecosystems, agriculture, and the environment. Losses due to poor air quality could include:

- Decreased health (higher risk of lung disease, cancer)
- Decreased quality of life
- Increased health costs
- Lost work productivity and/or wages

ASSESSING VULNERABILITY

People who have respiratory issues, allergies, or other forms of compromised health are vulnerable. Populations who live in large cities frequently exposed to vehicles emissions and are at risk for experiencing the adverse effects of poor air quality.

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF POOR AIR QUALITY?

There are many direct and indirect effects of air quality, both on the environment and human health.

Table 3-29: Effects of Air Quality

Direct Effects:	Indirect Effects:
• Adverse health effects due to low levels of ozone, particularly to vulnerable populations such as the homeless • Populations without access to medical care could experience injury or death due to poor air quality • Increased mortality and morbidity of both rural and urban vegetation • Acid rain may cause damage to infrastructure, buildings and the environment	• Surface water quality impacts • Reduced effectiveness of urban vegetation to absorb air impacts

CLIMATE CHANGE CONSIDERATIONS

Climate change can affect average temperatures, wind patterns, and a variety of other atmospheric factors that in turn can affect how a pollutant will behave when airborne. The **Hazard Overview** and **Assessing Risk** sections address specifics on how air quality affects climate change.

RELATIONSHIP TO OTHER HAZARDS

Hazardous material incidents and structural fires can directly impact air quality by causing acute air quality hazards. Environmental factors such as air temperature, humidity, wind patterns and other factors play a large role in air quality, so increased heat waves and drought can also affect air quality.

HAZARD PROFILE 11: EARTHQUAKE

Earthquakes may affect Marion County and can cause catastrophic damages to buildings, infrastructure and entire communities. They may occur any time of the year and with little to no warning. This hazard profile includes information on previous occurrences of hazard events as well as on the probability of future hazard events. It also includes information on how earthquakes are categorized, how vulnerable populations are particularly affected by the hazard and their relation other hazards as well. Although climate change is affecting Marion County, there has been minimal evidence that the severity and frequency of earthquakes are directly correlated with climate change.

HAZARD OVERVIEW

What is an earthquake?

An earthquake is a sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface. It is classified as a shock. The forces of plate tectonics shape the earth as the huge plates that form the earth's surface move slowly over, under, and past each other. Sometimes the movement is gradual. At other times, the plates are locked together, unable to release the accumulating energy. When this accumulated energy grows strong enough, the plates break free, causing the ground to shake. Most earthquakes occur at the boundaries where the plates meet; however, some earthquakes occur in the middle of the plates. Earthquakes strike suddenly, without warning. Earthquakes can occur at any time of the year and at any time of the day or night.

Ground shaking from earthquakes can collapse buildings and bridges; disrupt gas, electric, and phone service; and sometimes trigger landslides, avalanches, flash floods, fires, and huge destructive ocean waves (tsunamis). Buildings with foundations resting on unconsolidated landfill and other unstable soil, and trailers and homes not tied to their foundations are at risk because they can move off their mountings during an earthquake. When an earthquake occurs in a populated area, it may cause deaths, injuries, and extensive property damage.

According to the U.S. Geological Survey's 2014 update of the United States' National Seismic Hazard Maps, there are 42 states and territories in the United States at moderate to very high risk from earthquakes, and they are located in every region of the country (Figure 3-61). California experiences the most frequent damaging earthquakes; however, Alaska experiences the greatest number of large earthquakes- most located in uninhabited or lightly inhabited areas. The largest earthquakes felt in the United States were along the New Madrid Fault in Missouri, where a three-month long series of quakes

from 1811 to 1812 occurred over the entire Eastern United States, with Missouri, Tennessee, Kentucky, Indiana, Illinois, Ohio, Alabama, Arkansas, and Mississippi experiencing the strongest ground shaking.[85]

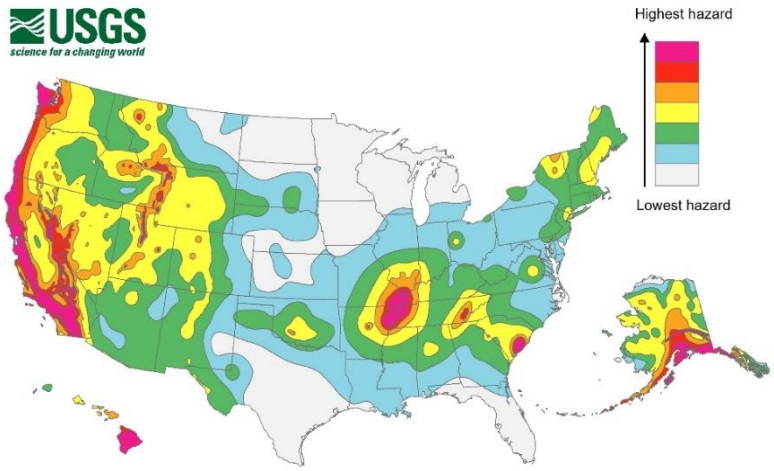

Figure 3-61: Simplified 2014 Seismic Hazard Map (PGA, 2% in 50 Years)

The majority of Marion County is in the 8-10%g[86] hazard zone, while the southwest corner is in the 10-14%g hazard zone.

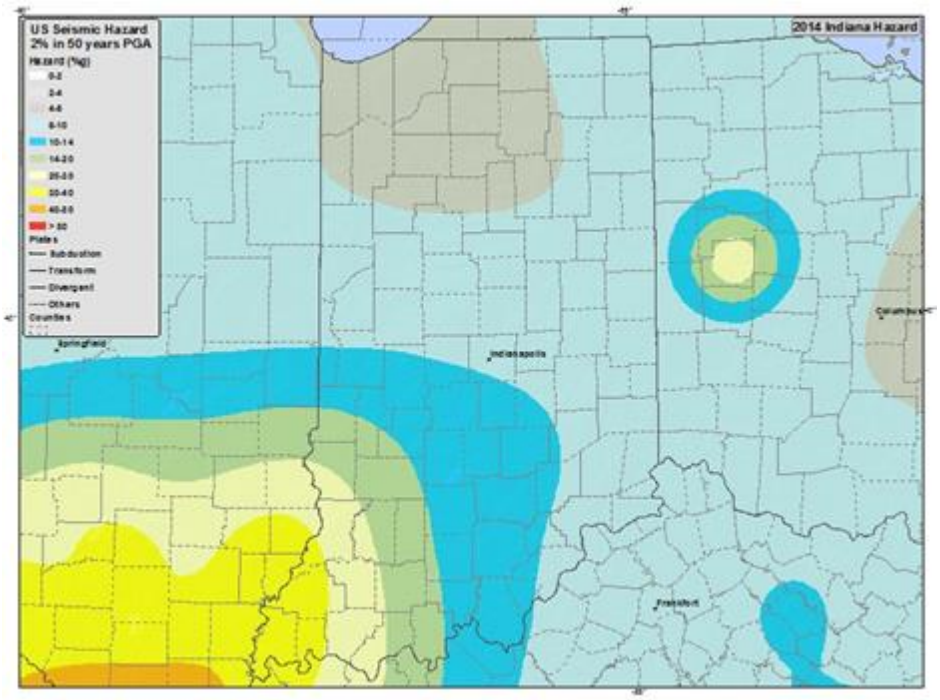

Figure 3-62: Seismic Hazard Map

Sources:

Above

2014 Seismic Hazard Map - https://earthquake.usgs.gov/earthquakes/byregion/indiana-haz.php

Left https://pubs.usgs.gov/of/2014/1091/pdf/ofr2014-1091.pdf

[85] Coppola, Damon P. Introduction to International Disaster Management. Elsevier/Butterworth-Hein, 2011.
[86] Shaking is expressed as a percentage of g (g is the acceleration of a falling object due to gravity)

How are earthquakes categorized?

Earthquake magnitude, which is determined from measurements on seismographs, measures the energy released at the source of the earthquake. Intensity measures the strength of shaking produced by the earthquake at a certain location and is determined from effects of people, human structures, and the natural environment.

The Richter Scale determines the magnitude of earthquakes through the logarithm of the amplitude of waves as recorded by seismographs, making adjustments for the distance between the recording seismographs and earthquake's epicenter. Magnitude is expressed in whole numbers and decimal fractions in a logarithmic scale, in which a whole number increase in magnitude represents a tenfold increase in measured amplitude, and a release of approximately 31 times more energy than the preceding whole number value. [87]

The intensity of an earthquake, or the effect that the magnitude has on the Earth's surface, is measured by the Modified Mercalli (MM) Intensity scale. As opposed to the Richter Scale, the MM Intensity Scale is not mathematically based, but is instead based on observed effects to produce an arbitrary ranking system. The key responses captured in the MM Intensity Scale—such as people awakened, movement of furniture, damage to chimneys, and total destruction—represent a more meaningful measure of severity to the general public than the magnitude due to the effects experienced in a given location. [88]

Tables 3-30 and 3-31 define earthquake magnitudes and their corresponding intensities.

Table 3-30: Abbreviated Mercalli Intensity Scale[89]

Intensity	Shaking	Description
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very Strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.

[87] https://earthquake.usgs.gov/learn/glossary/?term=Richter%20scale
[88] https://earthquake.usgs.gov/learn/glossary/?term=Richter%20scale
[89] https://earthquake.usgs.gov/learn/topics/mercalli.php

Intensity	Shaking	Description
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Table 3-31: Earthquake Magnitude vs. Modified Mercalli Intensity (MMI) Scale

Earthquake Magnitude	Typical Maximum MMI
1.0 - 3.0	I
3.0-3.9	II-III
4.0-4.9	IV-V
5.0-5.9	VI-VII
6.0-6.9	VII-IX
7.0 and higher	VIII or higher

Earthquakes, Indiana Style – Frost Quakes in Recent Winters

Although earthquakes are infrequent occurrences in Marion County, Cryoseism, also known as an ice or frost quakes, have been experienced as recently as the winter of 2017/2018.

100-foot ice crack in a rural driveway in Wapun, Wisconsin:

Sources: http://archive.jsonline.com/weather/ice-quake-leaves-100-foot-crack-in-waupun-familys-driveway-b99182994z1-239936381.html

https://weather.com/news/news/2018-01-15-indiana-frost-quakes-cryoseisms

RECENT OCCURRENCES

Indiana, as well as several other Midwestern states, lies in the most seismically active region east of the Rocky Mountains. Marion County is located in close proximity to the Sharpsville Fault, which runs through southeastern Howard County and northern Tipton County. Marion County is located in a zone which will experience damage and injuries in the event of a Richter 7.0+ earthquake with an epicenter located in the New Madrid fault which will have the effect of a Richter 5.5-6.1 earthquake in Indianapolis. While the last major earthquake in the New Madrid fault was in 1811 there were smaller earthquakes affecting Marion County in 1895 on the New Madrid fault, and in 1899 and 1987 in the Wabash Valley fault.

In the New Madrid fault area, scientists estimate a 25-40% chance of a magnitude 6.0 or greater earthquake and approximately a 7-10% probability of an earthquake of the scale of the 1811-1812 earthquakes within the next 50 years. Depending on the magnitude and the location of the epicenter, future earthquakes could cause considerable damage in Marion County. [90] The best estimates of the Central United States Earthquake Consortium indicated a Richter 7.0+ New Madrid earthquake would result in 157 fatalities, 787 serious causalities, and over 78,000 displaced persons in Marion County.[91]

ASSESSING VULNERABILITY

Earthquakes generally affect broad regional areas and potentially many counties at one time. All of Marion County is at risk from earthquake hazards. Particularly vulnerable populations include those with a limited ability to seek shelter from an earthquake included the disabled and institutionalized (in a hospital, prison, foster care, nursing home, long term care). Those who live closest to fault lines are also extremely vulnerable because they will experience the most destruction. People with physical and mental health limitations are more affected in and after a disaster response.

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF EARTHQUAKES?

Within Marion County, direct and indirect effects from an earthquake may include:

Table 3-32 Effects of Earthquakes

Direct Effects:	Indirect Effects:
• High density urban areas may experience more damages due to the number of structures and critical infrastructure located in these areas • Rural areas may experience losses associated with agricultural structures such as barns and silos	• Reduced ability for emergency response personnel to assist affected people • Temporary shelter may need to be provided for residents of areas with more damage • Delays in delivery of goods or services to or from affected areas

[90] https://earthquake.usgs.gov/learn/topics/nmsz/faq.php
[91] http://www.indy.gov/eGov/City/DPS/DHS/Hazards/Pages/earthquakes.aspx

Direct Effects:	Indirect Effects:
• Bridges, buried utilities, and other infrastructure may be affected throughout the County and municipalities • Vulnerable populations with limited ability, including the disabled or those institutionalized, are particularly at risk if they cannot seek safety	

ESTIMATING POTENTIAL LOSSES

Types of loss caused by an earthquake could be physical, economic, or social in nature. Due to the unpredictability and broad impact regions associated with an earthquake, all critical and non-critical infrastructure are at risk of experiencing earthquake related damages. Damages to structures, infrastructure, and even business interruptions can be expected following an earthquake.

FUTURE CONSIDERATIONS

While the occurrence of an earthquake in or near to Marion County may not be the highest priority hazard evaluated in this MHMP, it is possible that residents, business owners, and visitors may be affected should an earthquake occur. For that reason, Marion County should continue to provide education and outreach regarding earthquakes and even earthquake insurance along with education and outreach for other hazards. As Marion County continues to grow and develop, the proper considerations for the potential of an earthquake to occur may help to mitigate against social, physical, or economic losses in the future. Preparing for an earthquake includes constructing critical structures such as schools, hospitals, dams, and bridges so that they are able to survive possible earthquakes. Marion County officials and inspectors should take precautions to lessen the risk of earthquakes to people, buildings, and infrastructure.

CLIMATE CHANGE CONSIDERATIONS

A correlation between earthquakes and climate change has not yet been identified.

RELATIONSHIP TO OTHER HAZARDS

Earthquakes may cause other hazards like hazardous materials incidents, dam and levee failures, and structural fires. Hazardous materials incidents may occur as a result of damage to material storage containers or transportation vehicles involved in road crashes or train derailments. Dam and levee failures may occur following an earthquake or associated aftershocks due to the shifting of the soils and/or structural damage. Structural fires may occur due to damage to electrical infrastructure, while firefighters may not be able to quickly respond, allowing it to spread further than normal. These types of related hazards may have greater impacts on Marion County communities than the earthquake itself. It is not expected that earthquakes will be caused by other hazards studied within this plan.

HAZARD PROFILE 12: STRUCTURAL FIRE

Structural fires can be unexpected and even fatal if the correct preventative measures are not in place. Structural fires can damage homes, buildings, utilities, and other structures. This hazard profile outlines all of the dangers associated with fires and provides information on previous occurrences in Marion County. It also provides sources for more information regarding the hazard. The profile describes areas and populations who are at risk of structural fires. Structural fires can be directly correlated to other hazards as well. The structural fire hazard profile has been modified to address climate change by including a discussion of how climate change can increase the frequency and severity of structural fires in the Marion County.

HAZARD OVERVIEW

What is a structural fire?

Structural fires are uncontrolled fires in populated areas that threaten life and property. Structural fires can be caused by smoking, industrial incidents, damage to utility lines, laboratory accidents, lightning, electrical shorts, carelessness with ignition sources, arson, and explosive or combustible materials. Structural fires occur in virtually every community and are the most common hazard facing most communities in Indiana and across the country. Because fires occur quickly and for a fixed amount of time, it is considered a shock.

According to the Federal Emergency Management Agency's National Fire Data Center, residential fires represent 78% of all structural fires and cause 80% of all fire fatalities. Tragically, over 40% of residential fires and 60% of residential facilities occur in homes with no smoke alarms.

Fires can be deadly if no warning or prevention measures are present. The most dangerous aspect of structural fires is the production of toxic gases and fumes that can quickly accumulate in enclosed areas of structures and asphyxiate those who might be in the structure. Thus, early warning of a structural fire is critical for survival of any person inside the structure.

Problems associated with structural fires are compounded when high-rise buildings catch fire. High-rise fires hinder the ability of rescue workers to fight the fire, reach impacted building occupants, and to evacuate impacted occupants. Rescue efforts also become more complicated when handicapped or disabled persons are involved. Complications associated with high-rise fires typically increase as the height and occupancy levels of the buildings increase. Structural collapse is another concern associated with high-rise fires. Structural collapse often results in persons becoming trapped and severely injured. However, it is important to note that the concern associated with structural collapse is not limited to high-rise buildings. The collapse of smaller residential buildings can also lead to severe injury and death.

RECENT OCCURRENCES

Beilouny Building Fire in Downtown Indianapolis – December 8, 2017

Damage Set at $750,000

A rooftop fire broke out in the early morning on a five-story Massachusetts Avenue condominium building. Though firefighters responded in three minutes and the fire was contained within 30 minutes, the building had already sustained an estimated $750,000 in damage.

The Indianapolis Fire Department sounded two alarms and sent 35 units to the fire, blocking off multiple intersections for hours. The fire never spread beyond the roof, though water damage was sustained on floors below. Power was out on the block for several hours, and multiple businesses were delayed in opening. The cause of the fire was later ruled as an accident that started in the area of a gas grill.

http://fox59.com/2017/12/08/crews-respond-to-large-building-fire-in-downtown-indianapolis/
https://www.indystar.com/story/news/crime/2017/12/08/firefighters-battling-mass-ave-blaze/933807001/

https://www.indystar.com/story/news/crime/2017/12/20/heres-what-caused-mass-ave-building-fire/965050001/

Belmont Ave Fire 2013

In June of 2013 the Nationwide Recycling Center on the west side of Indianapolis caught fire. Although the local and federal agencies were unable to determine the cause of the fire, the fire caused an estimated $10 million in damages. In addition, cause for concern was raised for the neighbors of the warehouse when asbestos was found in some of the fire debris.

Where is a good place to get structural fire-related information?

Dozens of safety tips on topics pertaining to structural fires, such as candle safety, carbon monoxide safety, family escape planning, high rise safety, and smoke alarms are located at:

National Fire Protection Association Safety Tips[92]

Keep it Safe Indy[93]

[92] https://www.nfpa.org/Public-Education/By-topic

[93] http://www.indy.gov/eGov/City/DPS/IFD/Pages/Keep%20it%20Safe%20Indy.aspx

ASSESSING VULNERABILITY

Populations with limited mobility include the disabled and institutionalized (in a hospital, prison, foster care, nursing home, long term care) because it is more challenging to seek safety. People who live in areas where arson is frequent are also at risk as well as those who live in homes or buildings that are not adequately built or maintained to detect, prevent and withstand structural fires.

What areas are at risk from structural fires?

Vulnerable structures may be found in all land use classes throughout Marion County and include all critical infrastructure and non-critical structures. Older buildings and high-rise buildings are at greater risk to structural fire. Marion County has a significant number of multiple story structures which present special problems during a fire or other emergency on the premises. "High-rise" fires are defined as occurring in structures four or more stories tall.

The U.S. Fire Administration identifies multiple factors that affect the risk for structural fires, including the building age of housing units, structures which contain 50 or more units, overcrowded housing units and population demographics.

The U.S. Fire Administration report Socioeconomic Factors and the Incidence of Fire found evidence to suggest that there is a relationship between the age of housing units and increased fire risk.[94] Factors in old, poorly maintained homes and housing units that can contribute to fire risk include older heating, plumbing, and electrical systems which have not received proper maintenance and therefore are at increased risk of mechanical malfunction and fire. [95]

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF STRUCTURAL FIRES?

Table 3-33: Effects of Structural Fires

Direct Effects:	Indirect Effects:
• Loss of structure and contents • Emergency response dependent on nature and magnitude of the fire • Potential for loss of life or injury • Damages to adjacent properties or structures, potentially increasing the magnitude of the fire as well as increasing the response needed	• Loss of revenue for affected businesses or properties involved • Potential need for temporary housing/shelter for residents involved • Expenditures related to debris removal and/or demolition of structures involved

[94] https://www.usfa.fema.gov/downloads/pdf/statistics/socio.pdf
[95] Federal Emergency Management Association. (1997). Socioeconomic Factors and the Incidence of Fire. United States Fire Administration, National FireData Center.

Direct Effects:	Indirect Effects:
• Vulnerable populations with limited ability, including the disabled or institutionalized, are at risk if they cannot seek safety and escape the fire • Those unable to afford to repair what was damaged in the fire are particularly at risk	

ESTIMATING POTENTIAL LOSSES

Due to the associated population density, high-rise fires are likely to result in the greatest social and economic losses of all fire hazards. In the event of a significant high-rise fire involving a residential complex, early detection and evacuation along with shelters and safe havens would help reduce injuries and deaths. Temporary and permanent housing would be needed for displaced people. A significant high-rise fire involving a commercial structure would likely displace people, several businesses and their employees, and losses could include injuries, death, structural damages and business interruptions.

According to the National Fire Protection Association, there were 1.3 million fires reported throughout the United States in 2016. Of that total, nearly 475,000 fires were structural fires resulting in 2,950 deaths, 12,775 injuries, and $7.9 billion in property damages. One structure fire was reported every 66 seconds in the United States. In 2016, 358 fires were investigated by the Fire Investigation Section (FIS) in Indianapolis.

CLIMATE CHANGE CONSIDERATIONS

As the number of structures within the County increases through development, the risk of a structure fire will also likely increase. Within Marion County, high-rise commercial structures are numerous within Indianapolis, and all communities have large multi-family, multi-structure apartment complexes that would result in a great number of displaced residents as well as a great impact on the businesses present.

As climate change impacts Marion County, summer drought and the number of consecutive dry days may increase in the future, despite more precipitation annually, potentially increasing the risk of structural fires. Structures within the wildland/urban interface (WUI), defined as areas where homes are built adjacent to or even on lands prone to wildland fire, will be impacted by these changes. [96] Homes and communities located in these natural landscapes are increasingly at risk to warmer, drier and windier conditions which are conducive to structural fires. [97]

[96] http://www.wildlandfirersg.org/About/Wildland-Urban-Interface
[97] https://www.nfpa.org/News-and-Research/Publications/NFPA-Journal/2016/March-April-2016/Columns/Wildfire-Watch

RELATIONSHIP TO OTHER HAZARDS

Droughts can create conditions which are more conducive to starting structural fires. Heat waves and extreme temperatures can create dry conditions, potentially causing more intense structural fires. Fires routinely lead to hazardous materials releases, especially when the fires are located in storage or manufacturing areas. It is not anticipated that a structural fire will lead to other hazards such as weather-related hazards, or other technological hazards.

HAZARD PROFILE 13: HAZARDOUS MATERIALS INCIDENT

Hazardous materials incidents are dangerous to both the environment and people. Despite preventative measures in place, these incidents can occur due to accidents and therefore are unexpected. This hazard profiles recounts many previous incidents that have affected Marion County and the negative repercussions that came from each incident. The profile also describes populations who are particularly vulnerable toward hazardous materials incidents. Potential losses and future considerations concerning these incidents are also described. Climate change plays a large roll in this hazard. Preventing incidents will aid in preventing climate change and is extremely important in keeping the environment clean. Lastly, the relationship between other hazards and hazardous materials incidents is discussed.

HAZARD OVERVIEW

What are Hazardous Materials?

Hazardous materials are substances that pose a potential threat to life, health, property, and the environment if they are released. Examples of hazardous materials include corrosives, explosives, flammable materials, radioactive materials, poisons, oxidizers, and dangerous gases. Despite precautions taken to ensure careful handling during manufacture, transport, storage, use, and disposal, accidental releases do occur. These releases create a serious hazard for workers, neighbors, and emergency response personnel. Emergency response may require fire, safety/law enforcement, search and rescue, and hazardous materials response units.

As materials are mobilized for treatment, disposal, or transport to another facility, all infrastructure, facilities, and residences in close proximity to the transportation routes are at an elevated risk of being affected by a hazardous materials release. These releases can cause serious harm to Marion County and its residents if proper and immediate actions are not taken. Most releases are the result of human error or improper storage. Corrective actions to prevent or stabilize incidents may not always be feasible or practical in nature.

Railways often transport materials that are classified as hazardous and preparations need to be made and exercised for situations such as derailments, train/vehicle crashes, and/or general leaks and spills from transport cars. Since these events occur suddenly, hazardous materials are classified as shocks.

RECENT OCCURRENCES

Several incidents involving manufacturing facilities and transportation routes occur each year in Marion County. The number of facilities using, storing, and/or manufacturing chemicals and the number of high volume transportation routes increase the likelihood of an incident.

- In June 2017, emergency crews were called to the Vertellus Specialties plant in Indianapolis regarding a spill of approximately 1,500 pounds of pyridine. Emergency crews were able to contain the spill within

the plant property. Workers reported hearing a popping sound in the plant early Tuesday morning. Warning alarms at the plant went off to indicate the spill. There were no injuries reported.

- In August 2017, a forklift at the Indianapolis FedEx Facility spilled a bag of chemical sealant. The spill was cleaned up, but workers began experiencing symptoms including nausea and vomiting. Five employees were sent to the hospital for evaluation. The workers made a full recovery.
- In January 2017, an accident on I-465 caused a tanker truck to strike a guardrail and release 2,000 gallons of lubricating oil onto the ground adjacent to the road. Multiple lanes were closed for six hours. No injuries were reported.
- In May 2013, 230 barrels of diesel fuel leaked from a Marathon Petroleum underground pipeline in Pike Township. Emergency crews were called to block off a half-square mile area until the source of the leak was discovered.

Figure 3-63: CSX Railcars

Figure 3-64: CSX Railcar

- In 2017, CSX railcars derailed and an estimated 75,000 gallons of Motiva Star 6 oil were leaked and 100 cubic yards of soybeans were released. Approximately 3,000 gallons of oil/water mixture recovered from various sumps and storm sewers and approximately 800 cubic yards of railroad ballast, soil, and fill had to be removed.
- On June 28, 1994, 1,660 gallons of hexane leaked into the air and then exploded at the Central Soya plant. Two soybean oil tanks were damaged, soybean oil and fire-fighting water was released into CSO, which then entered the White River. 6,000 gallons of soybean oil entered river and was cleaned up. Additionally, 25,400 gallons of soybean oil went to treatment plant. No liquid hexane made it in to the sewer or white river. However, Central Soya did NOT notify emergency services immediately and as a result, 15 people were injured. Also, IDEM was only notified about 2.5 hours after it happened (15 minutes is expected) so asbestos made it in to the water.

Figure 3-65: Contaminated Water[98]

- In 2008, a CSX spill leaked 22,000 gallons petroleum. Some train cars were slowly leaking diesel but didn't travel very far. However, sodium carbonate, styrene pellets, other dry goods spilled, and 10,000 gallons of liquid fertilizer were leaked.

ASSESSING VULNERABILITY

The environment is particularly vulnerable to hazardous material incidents. Humans may also be affected by consuming contaminated drinking water or coming in contact with toxic chemicals. Hazardous materials can negatively affect air quality, water supplies, agriculture, ecosystems, etc.

Relatively small hazardous materials incidents have occurred throughout Marion County in the past and are highly likely to occur again. If the number of hazardous materials producers, users, and transporters increase within or surrounding Marion County, it can be anticipated that the likelihood of a future incident will also increase. Incidents can occur from both mobile sources e.g. (trucks, rail) and fixed sources (e.g. factories, etc.).

The Right to Know Network (rtk.net) is a publicly available tool used by the EPA to track the generation, shipment, and receipt of hazardous waste. It also contains incident reports of hazardous material incidents such as spills.

[98] https://indianajones.smugmug.com/Hoosier-History/My-Hazmat-Environmental-and/Marion-County-Hazardous/

According to the RTK Network, Marion County has 431 facilities submitting Tier II reports for storing over 10,000 pounds of a hazardous chemical and 249 facilities submitting Tier II reports for storing an extremely hazardous substance greater than or equal to the established threshold planning quantity.

The RTK Network also states that as of December 2015, Marion County had 25 facilities subject to EPA's Risk Management Plan rule (112r of the Clean Air Act Amendment). The Risk Management Plan (RMP) Rule requires facilities that use large amounts of extremely hazardous substances to file Risk Management Plans with the EPA.

The majority of RMP facilities in Marion County are cold storage facilities using anhydrous ammonia in their refrigeration systems. A typical cold storage facility can have to between 50,000 and 70,000 pounds of anhydrous ammonia. In 2016, the Marion County Local Emergency Planning Committee (LEPC) held a hazardous materials exercise with Crossroad Farms Dairy (the facility makes ice cream and other dairy products for Kroger). During the exercise it was explained that because of the vast amount of piping involved in a typical cold storage facility, it is possible for a facility experiencing a pipe failure to lose several hundred to a few thousand pounds of anhydrous ammonia even after isolating the location of the failure.

As of December 2015, Marion County had 125 companies classified as large quantity generators of hazardous waste. The threshold for this classification is generation of 1,000 kilograms per month or more of hazardous waste or more than one kilogram per month of acutely hazardous waste.

Trucks carrying hazardous materials through Indianapolis that do not have a destination in the city are required to follow the route shown in Figure 3-66. This route has a higher risk of traffic-related hazardous spills.

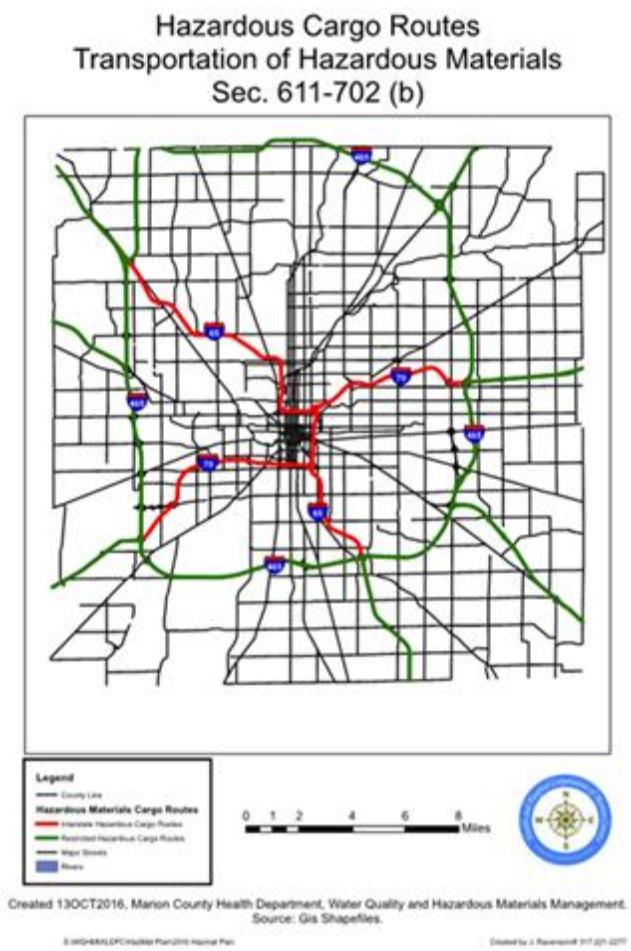

Figure 3-66: Indianapolis Hazardous Cargo Routes

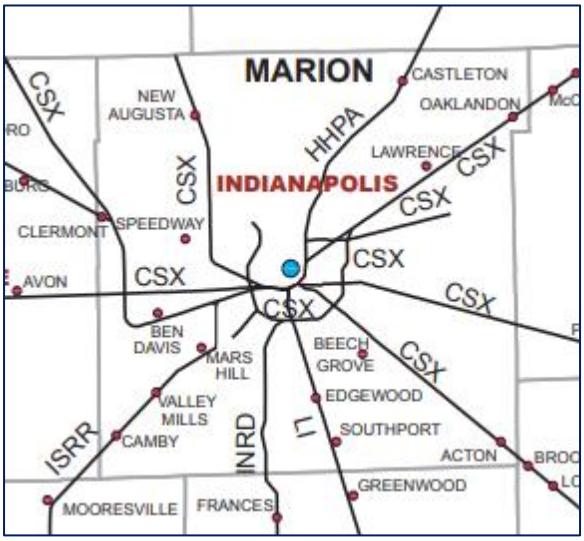

Figure 3-67: Marion County Rail Map

Marion County has a substantial amount of rail assets running through the County which are used to transport both **hazardous** and **non-hazardous** materials. A map of the current rail assets is provided in Figure 3-67.

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF HAZARDOUS MATERIALS INCIDENTS?

Within Marion County, direct and indirect effects from a hazardous materials incident may include:

Table 3-34 Effects of Hazardous Materials

Direct Effects:	Indirect Effects:
• Expense of re-construction of affected structures • Those who are exposed to hazardous materials and without access to medical care are particularly at risk if unable to seek medical attention • Road and bypass closures • Injury or death related to spill • Ecosystem damage and remedial costs	• Loss of revenue or production while recovery and/or reconstruction occurs • Anxiety or stress related to event • Potential displacement of people during evacuation of neighboring structures or facilities

More densely populated areas with a larger number of structures, railroad crossings, and heavily traveled routes are more vulnerable	

While the possibility of an incident occurring may be likely, the vulnerability of Marion County has been lowered due to the enactment of Superfund Amendments and Reauthorization Act (SARA) Title III national, state, and local requirements. SARA Title III, also known as the Emergency Planning and Community Right to Know Act (EPCRA), establishes requirements for planning and training at all levels of government and industry. EPCRA also establishes provisions for citizens to have access to information related to the type and quantity of hazardous materials being utilized, stored, transported, or released within their communities.

One local result of SARA Title III is the formation of the Marion County Local Emergency Planning Committee. This committee has the responsibility for preparing and implementing Marion County's hazardous materials emergency response plans, cataloging Material Safety Data Sheets (MSDS), chemical inventories of local industries and businesses, and reporting materials necessary for compliance.

As of March 1, 2018, 650 facilities in Marion County are subject to SARA Title III provisions due to the presence of listed hazardous materials in quantities at or above the minimum threshold established by the Act. These facilities are also required to create and distribute emergency plans and facility maps to local emergency responders such as the LEPC, and fire departments. With this knowledge on hand, emergency responders and other local government officials can be better prepared to plan for an emergency, the response it would require, and prevent serious effects to the community involved.

ESTIMATING POTENTIAL LOSSES

The very nature of these events makes predicting the extent of their damage very difficult. A small-scale spill or release might have a minor impact and would likely require only minimal response efforts. A slightly larger incident might result in the disruption of business or traffic patterns, and in this situation, might require active control response measures to contain a spill or release. Even small or moderate releases of hazardous materials could potentially grow large enough that mass evacuations or shelter in place techniques are needed, multiple levels of response are utilized, and additional hazards such as structural fires and/or additional hazardous materials releases (or explosions) may occur. Given the unpredictable nature of hazardous materials incident, potential losses were not estimated.

FUTURE CONSIDERATIONS

Additional facilities, both critical and non-critical in nature may be affected if a hazardous materials release were to occur along a transportation route (Figure 3-66). Several routes including railways, Interstate 65, 69, 70, 74, and 465; and numerous segments of US Highways and State Routes are traveled by carriers of hazardous materials.

Figure 3-68: A Burning Tanker Truck on the Interstate

By restricting development within the known hazardous materials facility buffer zones, future losses associated with a hazardous materials release can be reduced. Critical infrastructure especially should be discouraged from being located within these areas. Further, by restricting construction in these zones, the number of potentially impacted residents may also be greatly reduced, lowering the risk for social losses, injuries, and potential deaths. Future construction of hazardous materials facilities should be located away from critical infrastructure such as schools, medical facilities, and municipal buildings. Construction should also be limited near highly populated buildings and potentially populations with specials needs or considerations such as children, elderly, and medically unfit.

CLIMATE CHANGE CONSIDERATIONS

As climate change impacts Marion County, it is important to take extra precaution to prevent avoidable situations, such as hazardous material spills that will further exacerbate the issue. Contaminating the environment has major repercussions on the well-being of nature and of human beings. It is crucial to take extra preventative measures to ensure the conditions of the environment are as clean as possible.

Potentially more dangerous roads due to rain, ice, snow, etc. could cause traffic related spills. Higher flood waters could increase chances of a release due to the flooding of a building or storage facility. Increased storms, high winds, and tornadoes could also result in a release.

RELATIONSHIP TO OTHER HAZARDS

Depending on the nature of the release, conditions may exist where an ignition source such as a fire or spark is in close proximity to a flammable or explosive substance. As the fire spreads throughout the facility or the area, structural and/or property damages will increase. Response times to a hazardous materials incident may be

prolonged until all necessary information is collected detailing the type and amount of chemicals potentially involved in the incident. This may result in greater property losses.

HAZARD PROFILE 14: CIVIL DISTURBANCE

Civil disturbance is a unique hazard that affects the citizens of Marion County. A description about what events are categorized as civil disturbances as well as past occurrences is included in this profile. This profile also includes an in-depth account of what areas and populations are most at risk. The correlation between climate change and the occurrences of civil disturbances is described. Civil disturbances can be associated with other hazards such as structural fires or hazardous materials incidents. This profile is different than the other profiles included in this report but follows a similar structure.

HAZARD OVERVIEW

This hazard profile describes the type, location, and extent of civil disturbance hazards that affect Marion County. Information on previous occurrences of hazard events and on the probability of future hazard events is also included. Research has been gathered from local and national sources on the hazard extent and lists historic occurrences since 2013 and the probability of future incident. The civil disturbance hazard profile has been modified to address climate change by including a discussion of how climate change can increase the frequency and severity of civil disturbances in the community.

What is a civil disturbance?

Civil disturbances typically occur when highly visible and large-scale public events result in rioting, looting*, arson, disruption of essential services and functions, or other unlawful behavior. These are classified as shocks. These disturbances typically occur in association with event and activities with strong public interest and attention. Historically within the United States, civil disturbances have occurred frequently and have had a wide range of physical, social, and economic impacts. Peaceful protest is a protected freedom but may be disruptive, particularly when interventions occur.

**Civil disturbance is a complex multifaced challenge that touches on multiple people in multiple ways. If a family is retrieving resources for survival in any manner, it is clearly a necessity and makes an exception from the implied negative correlations with the term looting.*

When do civil disturbances occur and are they a major hazard in Marion County?

Riots and civil unrest occur when groups or individuals disrupt a community to the degree that intervention is required to protect public safety. They typically occur in more urban areas or where there are dense populations. Common triggers of such events include racial tension, religious conflict, unemployment, and unpopular political actions. In extreme cases, riots and civil unrest can result in injuries, deaths, and property damage. The most common activities associated with this hazard include looting, vandalism, and arson. Violence and tension can be a major source of trauma, particularly to vulnerable communities that are already at risk. Gun violence and discrimination associated with civil disturbance are of extreme concern to disadvantaged communities due to past conflicts or prejudices.

RECENT OCCURRENCES

Civil disturbance is not a common occurrence within Marion County. This is in large part due to the successful partnerships between event and facility planners and the local law enforcement agencies through sound crowd management practices. Law enforcement typically prevent disturbances from reaching a riotous level. Although Marion County does not often experience civil disturbances, citizens have been active in staging sit-ins and protests in recent years. Peaceful assembly is guaranteed by the United States Constitution and only becomes problematic if the peaceful protests turn violent because of conflict or intervention. It is important to focus on prevention and protection for citizens who are involved and affected by a civil disturbance.

While it is arguable that these events are truly civil unrest, there have been a number of protests that have led to arrests. One of the most recent being a protest outside the home of Health and Human Services Secretary, Alex Azar. The protesters were demanding he take action against the use of shock devices on the developmentally disabled patients at the Judge Rotenberg Educational Center in Canton, Massachusetts. However, 26 people were taken custody on suspicion of trespassing.

ASSESSING VULNERABILITY

As a social/political hazard, civil disturbance is generally caused by unique factors when, compared to natural and technological hazards. It is difficult to generalize the characteristics of a potential event in any means. Vulnerable populations may include those who live in areas where rioting, looting*, arson, disruption of essential services and functions, or other unlawful behavior are more likely to occur. People who are directly impacted by racial tensions, religious discrimination, unemployment, or clashes in political believes are more susceptible to the impacts of civil disturbances. This could have negative impacts on physical and mental health. Certain groups of people are more at risk than others including the marginalized and disenfranchised.

What areas are at risk from civil disturbances?

Past civil disturbances across the country have been more likely to occur in downtown or urban areas. Given the large size, strong public interest, and regular frequency associated with events within the County, it was determined that these types of disturbances may occur within any of the individual communities. This is in part due to the interconnectedness of the events, lodging, and other accommodations during such large events.

There are numerous events conducted in Marion County that could potentially result in civil disturbances. Table 3-35 lists facilities and events that frequently attract high public scrutiny and media attention within Marion County.

Table 3-35: Facility or Event Description

Facility or Event	Description
Bankers Life Fieldhouse	Home to the Indiana Pacers and the Indiana Fever this facility also hosts a number of events, concerts, and activities throughout the year.
Government Buildings	Each year, in every community, potentially polarizing decisions are made in these facilities. With State Government Office for several agencies and Congressmen located in Indianapolis, these facilities are also high-profile locations for protests and gatherings.
Indiana Convention Center	The Center hosts several hundred small and large events each year. Attendance at such events may range from 30 people in a small conference room, to over 50,000 for one event. The Convention Center is also connected to Lucas Oil Stadium via tunnel under South Street.
Indiana State Fairgrounds	The State Fair typically draws nearly 1M visitors each year and the grounds are host to many events such as hockey games, trade shows, and other gatherings.
Indianapolis Motor Speedway	Several national and international racing events are held at the speedway each year. The Indianapolis 500, the Brickyard 400, the MotoGP are a just a few of those events drawing several hundred thousand spectators.
Lucas Oil Stadium	Home to the Indianapolis Colts, this facility also hosts several concerts, events, and other sports events throughout the year.
Mini Marathon	The “Mini” typically draws nearly 50,000 people from around the world as competitors, volunteers, and spectators. The path of this race goes through Indianapolis as well as Speedway.

WHAT ARE THE DIRECT AND INDIRECT EFFECTS OF CIVIL DISTURBANCES?

Table 3-36: Effects of Civil Disturbances

Direct Effects:	Indirect Effects:
• Costs associated with the increased number of emergency responders ready for deployment • Increased security efforts for buildings and grounds crews during events • Increased potential for escalating chaos or criminal activity	• Increased perceptions of heightened risk based on historical disturbances • Emotional trauma and mental health are serious concerns for all individuals, but particularly for those who lack a support system or resources to cope during and after a disturbance event

Direct Effects:	Indirect Effects:
• Vulnerable populations with limited representation are particularly at risk if the disturbance affects one group of people specifically, for example gun violence • People born into areas or groups where civil disturbance is a common occurrence, are particularly at risk • Those unable to voice their opinions due to lack of education or representation are also particularly vulnerable • Damages from participants, either to structures, property, or people	• If there were arrests due to the disturbance, this may lead to recidivism (the tendency of one convicted to reoffend) and other cascading impacts from mental stress and psychological impacts. This concern is also heightened for disadvantaged communities 

ESTIMATING POTENTIAL LOSSES

The varied nature of these events makes predicting the extent of their damage difficult. A small-scale disturbance such as a local labor strike might have a minor community impact and would likely require only minimal police oversight or management. A slightly larger disturbance might be associated with a protest growing large enough to begin disrupting businesses or traffic patterns. In this situation police intervention might require active control, but not likely the use of chemical agents or riot gear. On the other hand, civil disturbances could potentially grow large enough and violent enough that rioting, looting*, arson, and other violent acts might occur. Larger disturbances usually require the use of crowd control chemicals, riot gear, and large-scale arrests in order to restore order. The emotional and psychological trauma associated with these events can also have cascading impacts associated with mental health and overall well-being within the community. Potential losses are blurred with survival needs. For example, after a disaster, is taking food from a flooded grocery store looting* and a civil disturbance or a search for life saving resources? Given the unpredictable nature of civil disturbances potential losses associated with a disturbance was not estimated.

CLIMATE CHANGE CONSIDERATIONS

As noted in the discussion of extreme temperatures, stress on people increases as temperatures increase. Therefore, it is anticipated that if temperatures increase as projected, civil disturbances may become a more frequent occurrence in Marion County. Ensuring that residents and visitors are well informed about the potential impacts and threats associated with civil disturbances and the proper methods to protect themselves and their property will help reduce future damages and losses. Education and outreach play roles in helping citizens understand what they can do to protect themselves and feel safe. There should be more engagement to collaborate preventative measures with school representatives, additional hospital representatives, IUPUI and other colleges, transportation sector, and department of corrections.

RELATIONSHIP TO OTHER HAZARDS

Civil disturbances may result a structural fire or hazardous materials releases. Numerous examples of civil disturbances escalating into a potentially riotous situation with ignitions and associated damages exist. Similarly, it is not expected that any other hazards would directly lead to a civil disturbance. However, extended heat waves, extreme heat events, and the urban heat island effect may all contribute to a situation on the brink of a civil disturbance. The correlation of heat and disturbance is based on research showing that throughout history and across the world, higher temperatures, less rainfall, and more drought were consistently linked to increased violence (Figure 3-69).[99] For example, if one U.S. county is three degrees Celsius warmer for three months, statistics reveal an uptick in crime, violence and revolutionary fervor.[100]

[99] http://emiguel.econ.berkeley.edu/research/quantifying-the-influence-of-climate-on-human-conflict
[100] https://www.scientificamerican.com/article/feeling-hot-can-fuel-rage/

The reasons behind the climate-violence link are complex and not fully understood, although anyone who has lived through a heat wave can attest to one simple fact:

"When people are hot, it makes them cranky...It makes people more prone to anger, it makes people more frustrated, and it makes decision making more impulsive. And that can lead to altercations that escalate to more extreme levels of aggression."

Source: Scientific American

https://www.scientificamerican.com/article/feeling-hot-can-fuel-rage/

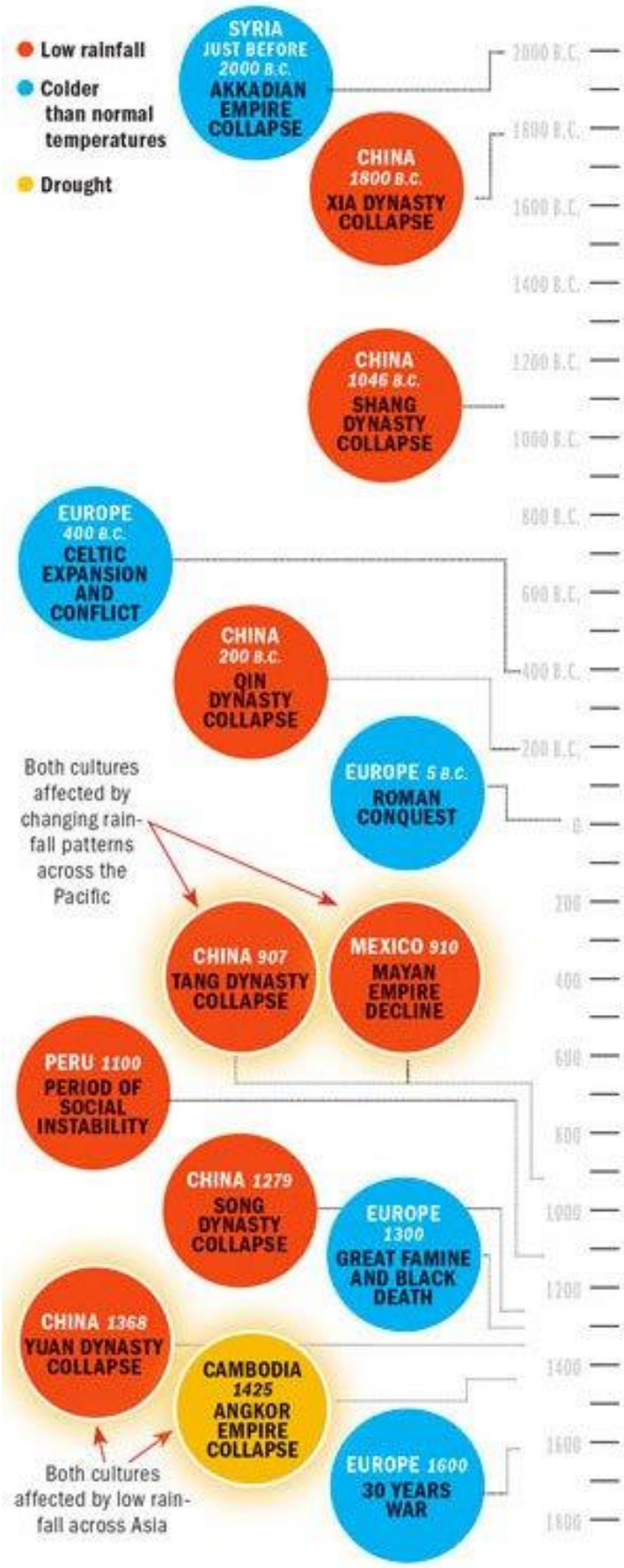

Figure 3-69: Linking Climatic Events to Human Conflict Across History

HAZARD PROFILE 15: REGIONAL & NATIONAL DISPLACEMENT

This is a unique hazard that relates to future changes in the ocean/land interface as well as with climatic changes that influence biological movement and processes. Displacement of people is considered in terms of understanding, coordinating, and planning for climate change-induced migration and planned relocation, where appropriate, at national, regional, and international levels. Because of the long-term and sometimes permanent effects of displacement, it is classified as a stress because of its chronic challenges. The uprooting of coastal communities will have dramatic global impacts.[101] There will be economic, societal, and health implications that inland areas will need to consider. Displacement and relocation of animals is considered here in terms of invasive species and domesticated animals and changes in timing/temperature induced biological processes such as migration and pollination. In many of these processes, various species depend on each other and currently have their timing and seasonality aligned with each other. A good example is the changes in the blooming period of a certain plant, and what interactions might be prevented if it does not overlap with their respective pollinators.

Due to the unique nature of this hazard, the standard profile format is not used. Research on the impacts of climate change on plant and especially animal distributions in Indiana is growing but currently limited. The IN CCIA does indicate that changes in climate will affect distributions and abundances of trees, understory plants and wildlife. However, predicting implications on a complex ecosystem with hundreds of interacting species is challenging, so information is sparse. There are some generic qualitative projections on where populations will migrate to. Given the information deficiency, it is important to monitor changes and prepare for a range of potential scenarios for displacement of people, plants, and animals.

Table 3-37: Key Impacts from Regional and National Displacement

Description	Main Impacts
Displaced populations (potentially from coastal areas due to hurricane/chronic flooding)	Rapid population growth without infrastructure and resources to support needs, mental health issues from refugees.
Invasive Species expanding ranges with increased temperatures	Environmental harm, economic harm, and impacts to human health, displacement of native species. Changes in timing and seasonality of pollination and migration can also threaten the success of native species.

[101] Hauer, M. E. (2017). Migration induced by sea-level rise could reshape the US population landscape. *Nature Climate Change*, *7*(5), 321.

Figure 3-70 shows the potential displacement of coastal populations across the US and figure 3-71 shows potential places where they will go. In terms of international climate refugees, if the US is open to accepting them, there will be a multitude. Globally, there are examples of significant populations displacement due to climate-induced disasters in countries like Bangladesh, India, and the Philippines. Displacement can have adverse effects on communities, governments, economies, agriculture, etc. Figure 3-70 illustrates these projections.

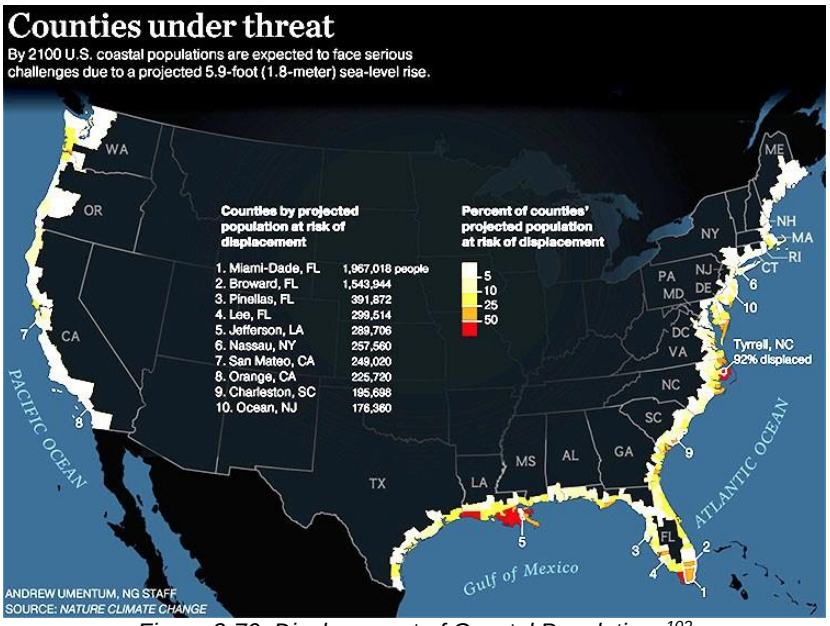

Figure 3-70: Displacement of Coastal Populations[102]

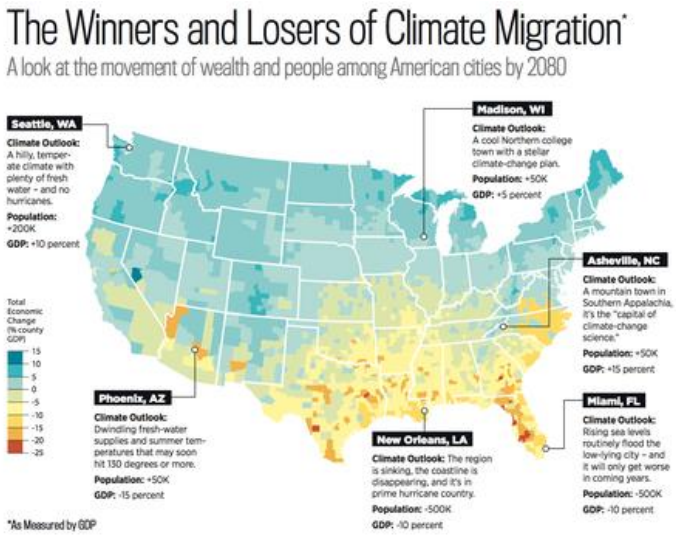

Figure 3-71: Migration from Climate Displacement[103]

[102] https://www.ecowatch.com/13-million-americans-at-risk-from-rising-seas-1882190457.html
[103] https://www.rollingstone.com/politics/news/welcome-to-the-age-of-climate-migration-w516974

The mass displacement of people was evident during Hurricane Katrina in August 2005. The estimates from CPS data indicate that approximately 1.5 million people aged 16 years and older left their homes in Louisiana, Mississippi, and Alabama (Figure 3-72). The people who were displaced fled to all areas of the United States, including Indiana. New Orleans was the most impacted when the levees protecting the city failed and approximately 80 percent of the city was flooded as a result, leading to a mass evacuation.[104] Figure 3-72 displays the number of evacuees by county.

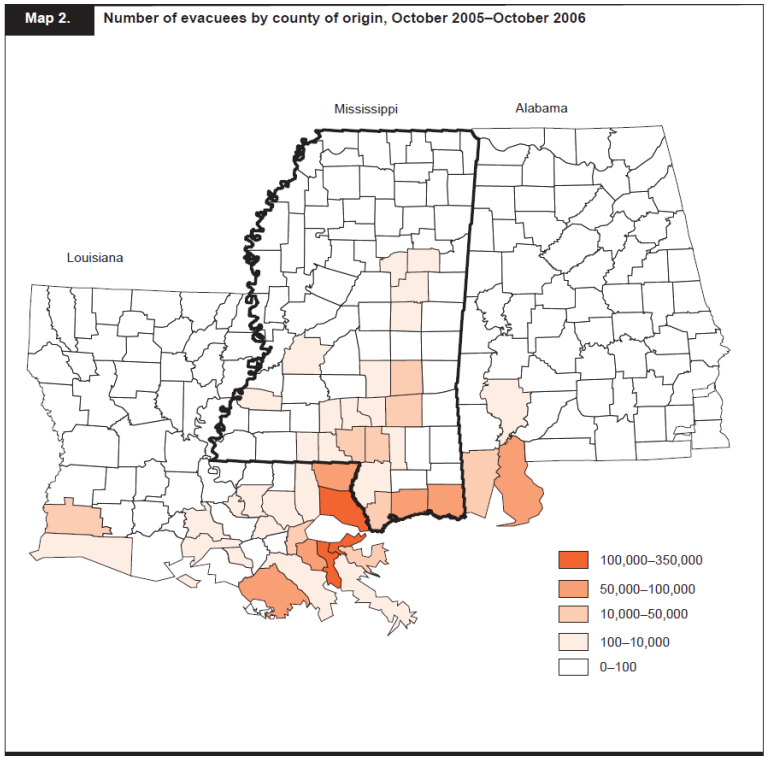

Figure 3-72: Number of Evacuees by County of Origin[104]

Plants and animals are particularly sensitive to climate variability and there are potentially several important species that could be impacted by future climate change in Indiana. In general, threats from climate change are likely to be manifested by declines or changes in behavior of native species, increased incidence of invasive species, and/or increased risks of extinction of endangered/threatened species.

Agricultural Pests

While many beneficial insect species that pollinate crops, increase soil fertility through decomposition, and prey upon crop pests. Many of the most prevalent agricultural pests are also insects. Insect pests reduce US crop production by 13% for an annual loss of $33 billion (USBC 1998). The increase in plant stress predicted with climate change will lead to reduced plant resistance to pests and a subsequent increase in loss. Because different aspects of the climate are not expected to shift in the same way (Williams et al. 2007), the impact on agriculture is not easily forecasted (Paine et al. 1998). For example, increased CO2 levels can increase the losses of soybean to the invasive Japanese beetle (Hamilton et al. 2005). The large majority of crop pest insects are invasive species. The exotic insects such as soybean aphid and the emerald ash borer that successfully

[104] https://www.datacenterresearch.org/data-resources/katrina/facts-for-impact/

invaded the Midwest come from similar climates. An altered climate regime in Indiana could invite an entirely new suite of invasive insects that were previously unknown in the region. Forest insect pests, such as the gypsy moth, defoliate trees during the early summer. When combined with the stress of drought, trees are known to die (Pijanowski 1994). Warmer winter temperatures can also decrease forest pest over-wintering mortality in turn increasing the pest population levels during the summer (Sharov et al. 1999). In Indiana, loss of trees on private forest lands could have a large economic impact as these lands are often harvested for income by the owners.

The Emerald Ash Borer is a species that is of particular concern. This insect hollows out trees, making them more susceptible to downing, especially when they are weighed down with winter ice. Figure 3-73 shows that Indiana has high risk to the Emerald Ash Borer and figure 3-74 shows how the beetle has destroyed tens of millions of ash trees in 18 states and continues to expand to other states.

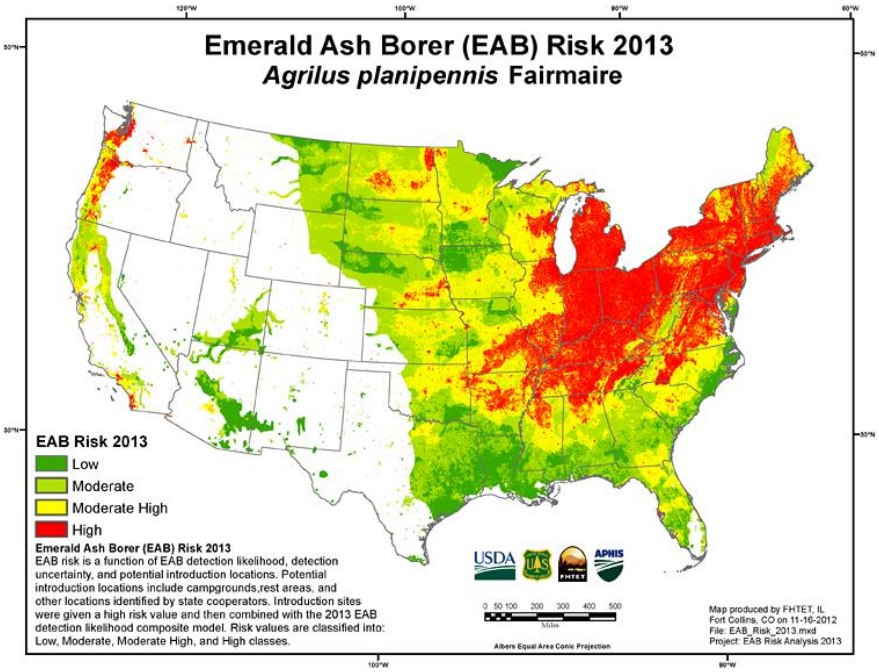

Figure 3-73: Emerald Ash Borer Risk (https://blog.epa.gov/blog/2016/10/page/5/)

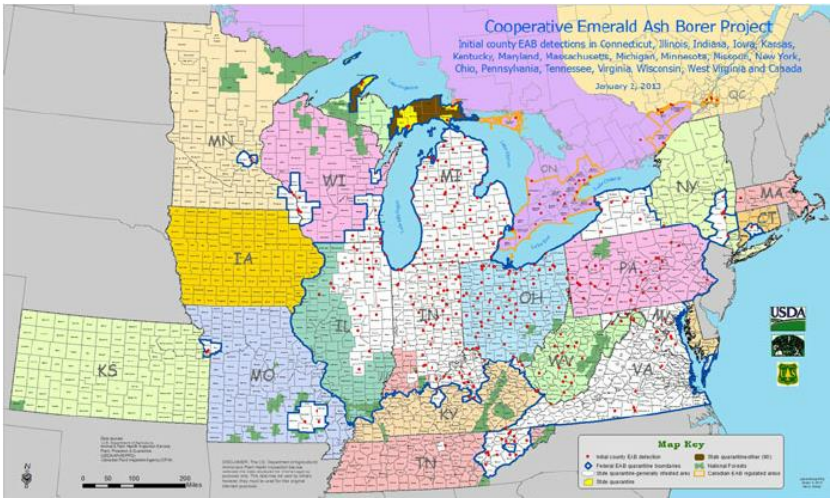

Figure 3-74: Emerald Ash Borer Impacts

https://www.researchgate.net/figure/The-Emerald-Ash-Borer-EAB-beetle-has-destroyed-tens-of-millions-of-ash-trees-in-18_fig1_25

04 MITIGATION GOALS & PRACTICES

This section identifies the updated hazard mitigation goals for the 2018 Marion County MHMP. A summary of select existing mitigation practices and proposed mitigation practices is detailed below.

2018-2022 FEMA Strategic Plan Goals

On March 15, 2018, FEMA issued its 2018-2022 Strategic Plan (https://www.fema.gov/strategic-plan). That document they articulates three strategic goals:

- FEMA Strategic Goal 1 – Build a culture of preparedness
- FEMA Strategic Goal 2 – Ready the nation for catastrophic disasters
- FEMA issued their 2018-2022 Strategic Plan FEMA Strategic Goal 3 – Reduce the complexity of FEMA

Figure 4-1: FEMA 2018-2022 Strategic Plan Infographic[105]

The plan states that "responding to and recovering from any disaster is a whole community effort that relies on the strength of Federal, state, local, tribal, and territorial governments, as well as non-governmental entities and individuals, in addition to FEMA." An infographic summarizing FEMA's vision, Strategic Plan goals and objectives is shown as Figure 4-1.

[105] www.fema.gov/media-library/assets/documents/160940

2018 Mitigation Goals

44 CFR 201.6(c)(3)(i)

[The hazard mitigation strategy should include] a description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

The overall goal of the 2013 Marion County MHMP was to reduce the social, physical, and economic losses associated with hazard incidents through emergency services, natural resource protection, prevention, property protection, public information, and structural control mitigation practices.

A revised vision and more specific goals have been developed for this 2018 MHMP. The revised vision and goals demonstrate the continued evolution of the Marion County's hazard mitigation planning process to consider additional hazards and to account for both climate change and social vulnerabilities. During the March 27, 2018 Task Force Meeting, the group reviewed the draft vision and goals and provided extensive feedback. The goals presented below account for that feedback.

As noted above, FEMA recently issued their **2018-2022 FEMA Strategic Plan**. This vision and goals have been informed by and are consistent with FEMA's Strategic Plan.

Marion County 2018 Proposed Vision: There is a culture of preparedness within the communities of Indianapolis/Marion County, so they are safer, healthier, and better prepared.

Marion County 2018 Proposed Mitigation Goals:

GOAL 1: Enhance public awareness and understanding of risks and foster leadership, partnerships, and actions to mitigate them.

GOAL 2: Increase resilience by ensuring that hazard mitigation and climate change initiatives are prioritized for action, with a focus on the most vulnerable critical facilities, resources, and communities.

GOAL 3: Encourage community, local, regional, and inter-agency coordination of actionable mitigation practices.

GOAL 4: Establish data driven and jurisdiction-specific hazard mitigation and implementation strategies.

GOAL 5: Reinforce local policies and align other plans and standards for hazard mitigation capability.

GOAL 6: Promote compliance with state and federal program requirements.

GOAL 7: In a disaster, Marion County residents are prepared to survive for 72 hours (three days) without assistance.

Mitigation Strategies Background

44 CFR 201.6(c)(3)(ii)

[The hazard mitigation strategy should include] a section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure for each jurisdiction.

An analysis of 23 years of federally-funded mitigation grants was conducted by the National Institute of Building Sciences (NIBS) and released in 2017. Entitled the *Natural Hazard Mitigation Saves: 2017 Interim Report*, the report demonstrates that mitigation funding can save the United States an average of $6 of future disaster costs for every $1 invested in mitigation (NIBS, 2017).

The NIBS team also evaluated how investing in hazard mitigation measures to exceed select requirements in the 2015 International Codes (I-Codes), the model building codes developed by the International Code Council (ICC), can save the nation $4 for every $1 spent (NIBS, 2017).

According to NIBS, continuing to implement hazard mitigation practices and updating the relevant codes would result in the following:

- Prevention of 600 deaths
- Prevention of 1,000,000 nonfatal injuries
- Prevention of 4,000 cases of post-traumatic stress disorder (PTSD)

The long-term impacts of deaths, injuries, and PTSD on the families and communities of Marion County are potentially severe. Implementation of mitigation measures prior to a hazard occurring can dramatically reduce these impacts.

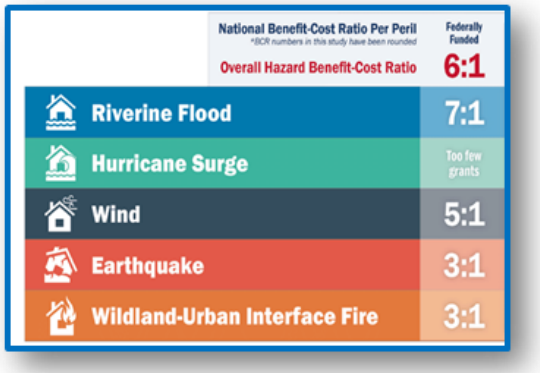

Figure 5-1: NIBS Study Benefit Cost Ratios
www.nibs.org/page/mitigationsaves

Mitigation Action Implementation Success

Marion County and the towns and cities within the County have implemented numerous hazard mitigation measures. The 2013 MHMP documented some of the mitigation measures implemented prior to and during the 2013 MHMP update process. The following sections highlight some of the actions taken to mitigate hazards.

The **DigIndy Tunnel System** is a 28-mile long network of 18-foot diameter deep rock tunnels being built 250-feet beneath the City. The Tunnel System will store more than 250 million gallons of combined sewage during and after wet weather events. Then it will slowly release the sewage to the Southport Advanced Wastewater Treatment Plant, which will discharge clean water back to our waterways. Along with other projects in the combined sewer system and at Citizens two advanced wastewater treatment plants, the $2 billion program is Indy's solution to reducing combined sewer overflows into area waterways by up to 97 percent, greatly improving water quality and reducing localized overflows and backups that adversely affect individual residents and communities.

http://www.citizensenergygroup.com/Our-Company/Our-Projects/Dig-Indy

The **City of Indianapolis Department of Public Works (DPW)** issued the Green Infrastructure Supplemental Document 2016 which is a follow up to the Green Infrastructure Master Plan original issued in 2010. The documents introduce Low Impact Development techniques for implementation by the City and County. A number of the generally accepted benefits from green infrastructure implementation include: cleaner water, enhanced water supplies, cleaner air, reduced urban temperatures, increased energy efficiency, infrastructure cost savings, and community benefits (quality of life). Green infrastructure may be implemented at various scales by both public and private landowners. In recent years, the City has implemented dozens of projects incorporating green infrastructure.

In 2013, **Indianapolis Power and Light (IPL)** began operation of solar farms at the Indianapolis International Airport. Currently, IPL is operating 20 megawatts (MWs) of solar power generating capacity. IPL currently operates 36 solar farms throughout the City.

These solar farms are coupled with the 20 MW-hour capacity lithium-ion battery array at the Harding Street Station. This facility allows for storage of energy for distribution to maintain more safe and reliable service.

Aside from the IPL solar project which benefits the excluded cities and towns, select examples of current and future development in a few excluded jurisdictions is noted below:

- City of Beech Grove – Main Street Reconstruction
- City of Beech Grove – 2.5 mile Greenway Construction
- City of Lawrence – Trades District Development
- Town of Speedway - Main Street Redevelopment and Green Infrastructure Project
- Town of Speedway - The Wilshaw Mixed Use Development Project
- City of Southport - Redevelopment and Mixed Use Development of Downtown Southport

Mitigation Action Identification & Strategy

44 CFR 201.6(c)(3)(iii)

[The hazard mitigation strategy should include] an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

There are six mitigation categories outlined by FEMA for mitigation activities. These categories are:

- **Prevention** – measures designed to keep the problem from occurring or getting worse (i.e., Planning & Zoning, Building Codes, Open Space Preservation, Floodplain Regulations, Stormwater Management, Drainage System Maintenance, Clean-in-place (CIP))
- **Property Protection** – measures to modify buildings subject to hazard damage rather than to keep the hazard away (i.e., Acquisition, Relocation, Elevation, Critical Facilities protection, Retrofitting, Insurance)
- **Natural Resource Protection** – opportunities to preserve and restore natural areas and their function to reduce the impact of hazards (i.e., Floodplain protection, Watershed Management, Riparian Buffers, Erosion/Sediment Control, Wetland preservation)
- **Emergency Services** – measures that protect people during and after a hazard (i.e., Warning systems, Shelter operations, Evacuation Planning, Emergency Response training)
- **Structural Projects** – physical measures used to prevent hazards from reaching a property (i.e., Floodwalls, Stormwater systems, Detention areas)
- **Public Education and Awareness** – activities that advise property owners, potential property owners, and visitors about the hazards, ways to protect themselves and their property from the hazards (i.e., Outreach projects, Hazard Map information, Real Estate Disclosure, School programs)

A wide range of mitigation actions were developed by the Task Force and project team. During the 2018 MHMP plan update, the project team solicited feedback from the MHMP Task Force during the April 27, 2018 meeting and subsequently during the survey that was issued to the MHMP Task Force in early May 2018. Each mitigation action was categorized according to the six categories. These categories are used to classify the existing and proposed mitigation practices presented below.

Mitigation Action Evaluation

Mitigation action prioritization emphasizes the extent to which benefits are maximized, according to a review of the characteristics of the proposed mitigation actions and their associated financial costs. The project team used the prioritization matrix shown as Figure 5-2 to qualitatively evaluate and prioritize the mitigation actions. The greater the action's benefit, and the lower the cost, the more cost beneficial and thus higher priority was assigned to the mitigation action.

Prioritization Matrix				
		Benefit		
		D (Low)	C (Medium)	High
Estimated Cost	High	Low	Low	Medium
	Moderate	Low	Medium	High
	Low	Medium	High	High

Figure 5-2: Mitigation Action Prioritization Matrix

2018 Mitigation Action Plan

The MHMP Task Force and project team worked closely with the *Thrive Indianapolis* project team to document and develop the mitigation plan. The plan includes:

- **Identify Goals** – As documented above in Chapter 4
- **Identify Actions** – As documented through several Task Force and public *Thrive Indianapolis* meetings in addition to the survey submitted to Task Force members.
- **Develop a Mitigation Action Plan** – The mitigation measures and evaluation of these measures for implementation is summarized below.

The project team developed a list of mitigation measures by FEMA mitigation category as shown in Table 5-1. The mitigation measures presented below represent a significant change in the County to recognize how both climate change and social vulnerability impact hazard impacts and preparedness. Mitigation measures from the 2013 MHMP that are ongoing or are not yet implemented are carried forward to this plan.

Table 5-1: Mitigation of Actions Summary

Mitigation Category	Number of Actions
Prevention	19
Emergency Services	12
Natural Resource Protection	4
Property Protection	13
Structural Project	2
Public Education and Awareness	8
Total	**58**

The following key elements are captured within the Mitigation Plan to help the County document and track the proposed actions.

- Action Number
- Action Description
- Hazard(s) Addressed
- Climate Change Value:
  - Mitigation – The action provides climate change mitigation.
  - Adaptation – The action provides climate change adaptation.
  - None – The action provides neither climate change mitigation nor adaptation.
- Impact on Social Vulnerability:
  - Increases – The action increases social vulnerability.
  - Decreases – The action decreases social vulnerability.
  - No impact – The action neither increases nor decreases social vulnerability.
- Co-Benefits – These are defined in broad categories consistent with the core values of the *Thrive Indianapolis* Project:
  - Improves individual and/or community capacity
  - Improves equitable service delivery
  - Reduces poverty
  - Improves fiscal responsibility
- Estimated Financial Cost – Costs are ranked based on the ordinal rankings and associated cost ranges:
  - Low – $0 to $50,000
  - Medium – $50,000 to $500,000
  - High – Greater than $500,000
- Potential Consequences of Inaction – This category summarizes the project team's estimated consequences of inaction, including the following:
  - Injuries/deaths

- Reduced public health
- Reduced mental health
- Reduced public safety
- Built asset damage
- Natural resource damage
- Reduced economic vitality
- Excessive use of emergency medical services (EMS)
- Underfunding of infrastructure
- Enhanced inequalities

- Benefit Cost Ratio (BCR) – Was evaluated qualitatively and ranked low, medium, or high. The qualitative evaluation considered each of the previous categories.
- Priority – Was evaluated qualitatively and ranked low, medium, or high. The qualitative evaluation considered each of the previous categories.
- Potential Funding Source/s – Includes broad categories of potential funding, including:
  - Current Capital Budget
  - Current Operating Budget
  - Increased Capital Budget
  - Increased Operating Budget
  - Grant funding (includes any potential grant funding opportunities)
- Lead Implementer and Key Partner – The lead and key partners for implementation are identified. The primary organizations considered include:
  - City DPW (includes excluded cities and town departments of public works)
  - City Public Safety (includes excluded cities and town departments of departments of public safety)
  - Indianapolis Chamber of Commerce
  - Private Utility/Infrastructure Owners (e.g. IPL)
  - IDNR
  - Other organizations (e.g. the Red Cross, Keep Indianapolis Beautiful)
- Implementation Schedule – Several schedules for implementation are identified, including:
  - Ongoing – This effort is ongoing and should be continued.
  - 2020 – This is an immediate term implementation timeframe.
  - 2025 – This is the short-term implementation timeline as identified in the *Thrive Indianapolis* project.
  - 2050 – This is the long-term implementation timeline as identified in the *Thrive Indianapolis* project.
- Linkage to Other Plans – Other plans that are related to the various mitigation actions are identified for reference.

A select set of these or other mitigation measures will be evaluated in greater detail within the *Thrive Indianapolis* project. Table 5-2 summarizes the mitigation actions documented by the team. Within each category, the actions are listed by priority.

Table 5-2: Mitigation Actions

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
	Prevention												
1	Capture lessons learned on road design from other cities in the US to improve design roads and associated drainage to better manage stormwater, reduce infiltration, and reduce freeze-thaw cycle damage.	☐Flood ☐Dam & Levee Failure ☒Increased Precipitation ☐Drought ☒Winter Storm & Ice ☐Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☒Reduces Poverty ☐Improves Fiscal Responsibility	High	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	High	Very High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☐City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☐Other:	2020	
2	Create jobs and improve workforce skills to enhance economic mobility and reduce unemployment and underemployment.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☒Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☐Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☐Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	High	Very High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☐City DPW ☐City Public Safety ☒**EmployIndy** ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns • Lawrence Economic Development Dept • Speedway Economic Development Commission ☒Other: Economic Development organizations and other related forms of social services	Ongoing through numerous programs under the leadership of City Council and the mayor, as well as coordination with economic development departments in excluded cities and towns	

[106] Includes measures that either directly address climate change or measures that include climate change adaption as a component.
[107] Includes measures that either directly address social vulnerability reduction or include social vulnerability reduction as a component.
[108] Broad categories of co-benefits are based on the Core Values of *Thrive Indianapolis*. Additional details and analysis are provided in the *Thrive Indianapolis* Sustainability and Resilience Action Plan.

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☒Regional & National Displacement											
3	Support existing poverty reduction programs to improve community resilience.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☒Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☐Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☐Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☐City DPW ☐City Public Safety ☒**EmployIndy** ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' boards and commissions • Lawrence • Speedway • Beech Grove • Southport ☒Other: CDCs, numerous non-profit organizations in the city	Ongoing through numerous programs under the leadership of City Council and the mayor, as well as coordination with boards and commissions in excluded cities and towns	
4	Relocate, buyout, or floodproof (non-residential) existing non-critical structures that are subject to repetitive flooding.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	High	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	Low	High	☐Current Capital Budget ☐Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety as well as private utility/inf. owners, and floodplain managers • Lawrence • Speedway • Beech Grove • Southport ☒Other: Private Facility Owners, DMD	2025	2006 Measure
5	Relocate or buyout, residential structures that are	☒Flood ☐Dam & Levee Failure	Adaptation	Decreases	☒Improves Individual and/or Community Capacity	High	☒Injuries/Deaths ☒Reduced Mental Health	High	High	☐Current Capital Budget ☐Current Operating Budget	☒**City DPW** ☒City Public Safety ☐EmployIndy	2025	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
	subject to repetitive flooding.	☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement			☒Improves Equitable Service Delivery ☒Reduces Poverty ☒Improves Fiscal Responsibility		☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities			☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒Private Utility/Inf. Owners ☒ IDNR ☒ Excluded Cities/Towns' private utility/inf. owners • Lawrence • Speedway • Beech Grove • Southport ☐Other:		
6	Update ordinances in cooperation with *Thrive Indianapolis* to reflect current and future climate/weather conditions.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☐Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☒Regional & National Displacement	Mitigation & Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☒Other: DMD, City-County Council	Ongoing, enhance efforts through 2020	
7	Improve levee maintenance to be consistent with other comparable municipalities and meet Army Corps of Engineers standards.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps.	Adaptation	Decreases	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty	High	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☐Other:	2020	Levee Operations & Maintenance Plans

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement			☒Improves Fiscal Responsibility		☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities						
8	Prevent development of new critical infrastructure in the dam break inundation areas and behind levees without flood mitigation measures in place through code revisions.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐Chamber of Commerce ☒Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☒Other: DMD, City BNS	2020	Dam Emergency Action Plans
9	Conduct inspections and maintenance of high hazard dams and private levees regardless of ownership according to industry best practices.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire	Adaptation	Decreases	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☐Other:	2020	Dam Emergency Action Plans

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement					☒Enhanced Inequalities						
10	Implement land use policies to improve neighborhood interconnectedness.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☐Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	Medium	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒City DPW ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: Local Non-Profits, **DMD**	2020	
11	Create systematic improvements in the transportation system using strategies to implement multi-modal transport and "road diets" to improve mobility and optimize current infrastructure layouts.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	Mitigation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	High	☐Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☐Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☐Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: Local Non-Profits, DMD	2025 for significant enhancements	
12	Incorporate hazard information, risk	☒Flood	Adaptation	Decreases	☒Improves Individual and/or	Medium	☒Injuries/Deaths	High	High	☐Current Capital Budget	☒**City DPW** ☒City Public Safety	2020	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
	assessment, and hazard mitigation practices into the Comprehensive Land Use Plan and Development Review to better guide future growth and development.	☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement			Community Capacity ☒Improves Equitable Service Delivery ☒Reduces Poverty ☒Improves Fiscal Responsibility		☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities			☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☒ Other: DMD		
13	Map at risk public and commercial structures (earthquake, unsafe buildings, etc.).	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement	Adaptation	No impact	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☒City DPW ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: **Neighborhood and Business Services**, State Fire Marshall, US Dept of Homeland Security, Indiana National Guard, City BNS	2020	
14	Routinely meet with all transporters of hazmat annually to continue to build and maintain relationships.	☐Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice	No impact	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery	Low	☒Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget	☒City DPW ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns'	Ongoing	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☒Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement			☐Reduces Poverty ☐Improves Fiscal Responsibility		☐Natural Resource Damage ☐Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☐Underfunding of Infrastructure ☐Enhanced Inequalities			☐Grant Funding	departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: **County Health Dept, LEPC**		
15	Capture lessons learned on road design from other cities in the US to improve design quality and safety of transportation infrastructure.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☐Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	No impact	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☐Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☐City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works • Lawrence • Speedway • Beech Grove • Southport ☐Other:	2020	
16	Reduce the carbon footprint to the City to support the City's goal to be carbon neutral by 2050.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☐Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality	Mitigation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	High	☐Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☐Excessive Use of EMS	High	Medium	☒Current Capital Budget ☒Current Operating Budget ☒Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☒Private Utility/Inf. Owners ☒ IDEM ☐ Excluded Cities/Towns ☒Other: Non-profits and philanthropic organizations, Chamber of Commerce, Mayor's Office	2050	

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		☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement					☐Underfunding of Infrastructure ☐Enhanced Inequalities						
17	Continue implementation of mental and physical health outreach program for the homeless.	☐Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	No impact	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☐Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☐Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☐City DPW ☒**City Public Safety** ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☒Other: Local Non-Profits	Ongoing	
18	Turn vacant properties with impermeable surfaces into community operated green space.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	High	☐Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☐Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☐Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: Local Non-Profits, City Parks, DMD, Renew Indy	2025	

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19	Decentralize the electrical power grid and improve resilience through increasing renewable energy usage via implementation of local renewable energy projects.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☐Air Quality ☒Earthquake ☒Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☒Reduces Poverty ☒Improves Fiscal Responsibility	High	☐Injuries/Deaths ☐Reduced Mental Health ☐Reduced Public Safety ☐Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☐Underfunding of Infrastructure ☐Enhanced Inequalities	High	Low	☒Current Capital Budget ☒Current Operating Budget ☒Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☐City DPW ☐City Public Safety ☐EmployIndy ☒**Private Utility/Inf. Owners** ☐ IDNR ☐ Excluded Cities/Towns ☐Other:	2050	
Emergency Services													
20	Update fleet of service vehicles (e.g. snowplows) to improve reliability and efficiency.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☐Drought ☒Winter Storm & Ice ☐Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	No impact	No impact	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	High	☐Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☐Enhanced Inequalities	High	Very High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☐Other:	Significant enhancements in the fleet vehicles and replacement/ renewal procedures by 2025.	
21	Have backup power for facilities providing critical services (e.g. ventilators) in Marion County.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☐Drought	Adaptation	Decreases	☒Improves Individual and/or Community Capacity	High	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety	High	Very High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget	☐City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR	2025	

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		☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement			☒Improves Equitable Service Delivery ☒Reduces Poverty ☒Improves Fiscal Responsibility		☒Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities			☒Increased Operating Budget ☒Grant Funding	☒ Excluded Cities/Towns' departments of public safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: MESH, other local healthcare organizations		
22	Provide shelters that accommodate pets in the event of an emergency.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☐Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☒Reduces Poverty ☒Improves Fiscal Responsibility	High	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	High	Very High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☐City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: MESH, other local healthcare organizations	2025	
23	Obtain grants for and promote utilization of weather radios in all critical infrastructure, as well as residences and businesses.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves	No impact	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☒Grant Funding	☐City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public safety • Lawrence • Speedway • Beech Grove • Southport	Ongoing	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement					☒Excessive Use of EMS ☐Underfunding of Infrastructure ☐Enhanced Inequalities				☐Other:		
24	Maintain and improve procedures to alert and evacuate the populations in known hazard areas.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Medium	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☐Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☐Other:	Ongoing, some plans are in place with enhancements for dam and levee failure evacuation procedures underway by 2020.	
25	Improve disaster preparedness and emergency response through elements of the StormReady Community Program.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Medium	☒Injuries/Deaths ☐Reduced Mental Health ☐Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☐Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☐City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public safety • Lawrence • Speedway • Beech Grove • Southport ☐Other: MCPHD, LEPC	Ongoing, enhancements by 2020.	Comprehensive Emergency Management Plan

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☒Regional & National Displacement											
26	Meet annually with external utilities to continue to improve coordination with municipal agencies.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement	No impact	No impact	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Low	☐Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☐Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ BNS ☐ Excluded Cities/Towns ☐Other:	Ongoing	
27	Provide more command level training to replace retiring experienced responders.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement	No impact	No impact	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☐Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☐City DPW ☒**City Public Safety** ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: MCPHD	Ongoing, more extensive training and exercising by 2020.	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
28	Cross train City departments on public safety and CERT train all City staff.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement	No impact	No impact	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☐Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☐Other:	2025	
29	Establish a consistent meaning for Sirens across multiple counties.	☐Flood ☒Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☒Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☒Earthquake ☐Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	No impact	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☐Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☐City DPW ☒**City Public Safety** ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: Other County staff	2020	
30	Establish warning systems for hearing impaired people to receive public safety alerts.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought	No impact	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery	Medium	☒Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget	☐City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR	2020	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement			☐Reduces Poverty ☐Improves Fiscal Responsibility		☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities			☒Increased Operating Budget ☒Grant Funding	☒ Excluded Cities/Towns' departments of public safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: Local non-profits		
31	Improve communication of hazards and mitigation efforts with all communities throughout all four phases of the Emergency Preparedness Cycle (mitigate, prepare, respond, recover).	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement	No impact	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☐City DPW ☒**City Public Safety** ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public safety • Lawrence • Speedway • Beech Grove • Southport ☐Other: City PIO	2020	
Natural Resource Protection													
32	Improve surface water quality through reducing pollutants in runoff through efforts consistent with the Deep Rock tunnel and CEG consent decree.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves	No impact	No impact	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	High	☒Injuries/Deaths ☐Reduced Mental Health ☐Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒**City DPW** ☐City Public Safety ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☐Other:	Ongoing, enhancements by 2025	Green Infrastructure Plan

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement					☒Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities						
33	Increase tree canopy coverage in conjunction with the Forestry Master Plan to reduce urban heat impacts.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	No impact	No impact	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☐Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒City DPW ☐City Public Safety ☐ EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☐ Indy Urban Forestry ☒ Excluded Cities/Towns' departments of public works • Lawrence • Speedway • Beech Grove • Southport ☒**Other: KIB,** City Parks	Ongoing, enhance by 2025	Forestry Master Plan
34	Support electric vehicles (EV) with infrastructure and explore possibility of EV incentives.	☐Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☒Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☒Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance	Mitigation	No impact	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☐Injuries/Deaths ☐Reduced Mental Health ☐Reduced Public Safety ☐Built Asset Damage ☒Natural Resource Damage ☐Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒**City DPW** ☐City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☒ IDEM ☒ Excluded Cities/Towns' departments of public works • Lawrence • Speedway • Beech Grove • Southport ☒Other: IndyGo	2025	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Regional & National Displacement											
35	Improve education on the risks of poor air quality and actions that citizens can take to mitigate it.	☐Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☒Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	No impact	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	☐Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☒Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☐Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☒Private Utility/Inf. Owners ☒ IDEM ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: Local Non-Profits, MCPHD	2020	
Property Protection													
36	Implement additional green infrastructure with incentives for developers consistent with the Storm Water Credit Manual and Green Infrastructure Supplemental Document.	☒Flood ☐Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	High	☐Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒**City DPW** ☐City Public Safety ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works • Lawrence • Speedway • Beech Grove • Southport ☒Other: DMD, City BNS, DevelopIndy	Ongoing, enhancements by 2025	Storm Water Credit Manual and Green Infrastructure Supplemental Document
37	Develop and implement a surface water management	☒Flood ☒Dam & Levee Failure	Adaptation	Decreases	☒Improves Individual and/or	Medium	☒Injuries/Deaths ☒Reduced Mental Health	High	High	☐Current Capital Budget	☒City DPW ☒City Public Safety ☐EmployIndy	2025	None Captured

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
	strategy that allows for seasonal flooding without causing property loss.	☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement			Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility		☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities			☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: **BNS**		
38	Continue to conduct detailed hydraulic analyses of unstudied, understudied, and unnumbered Zone A streams to determine exact floodplain boundaries, which will accurately reflect the risk.	☒Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	No impact	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Medium	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒City DPW ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☒ IDNR ☐ Excluded Cities/Towns ☒**Other: Floodplain Administrator**	2025	2006 measure
39	Adopt preliminary Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FISs) to maintain current evaluations of flood risk.	☒Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps.	Adaptation	No impact	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty	Medium	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒City DPW ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety	Ongoing, maintain maps with future considerations by 2025.	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement			☐Improves Fiscal Responsibility		☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities				• Lawrence • Speedway • Beech Grove • Southport ☒**Other: FEMA, DMD, and Floodplain Administrator**		
40	Support FEMA approved flood depth mapping (RiskMAP) to better understand the flood risk potential. This should be provided to the public. A process must be in place to ensure regular updates.	☒Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	No impact	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☒**Other: Floodplain Administrator**	Ongoing, maintain maps with future considerations by 2025.	
41	Evaluate and implement recommendations from completed flood protection studies to reduce flood risks.	☒Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☒Other: Floodplain Administrator	2025	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement					☒Enhanced Inequalities						
42	Complete fluvial erosion hazard mapping and monitoring to identify and protect critical infrastructure that may be impacted by natural stream movement.	☒Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	No impact	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☐Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☒Natural Resource Damage ☐Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☐Enhanced Inequalities	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☒ IDNR ☐ Excluded Cities/Towns ☒Other: Floodplain Administrator	2025	
43	Encourage the restoration of the natural stream corridor in new projects and redevelopment projects.	☒Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	No impact	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	High	☐Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☒Natural Resource Damage ☐Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☐Enhanced Inequalities	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒City DPW ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☒ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒**Other: Floodplain Administrator, DMD**	Ongoing, improvements 2025	
44	Discourage development of new	☒Flood	Adaptation	No impact	☐Improves Individual and/or	Medium	☒Injuries/Deaths	High	Medium	☐Current Capital Budget	☒**City DPW** ☒City Public Safety	Ongoing	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
	critical infrastructure in 1% and 0.2% annual chance of flood hazard through increased fees and design requirements.	☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement			Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility		☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities			☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: Floodplain Administrator, **DMD, City BNS**		
45	Encourage new or retrofitted buildings and utilities to incorporate structural bracing, shutters, laminated/impact resistant glass and interlocking roof coverings to minimize damage through code requirements.	☒Flood ☒Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☒Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☒Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	No impact	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	High	☒Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☐Enhanced Inequalities	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒City DPW ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒**Other: Building and zoning code regulators**	2020	
46	Require installation of lightning rods and grounding as well as surge protectors for critical infrastructure.	☐Flood ☐Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice	No impact	No impact	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery	High	☐Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget	☒City DPW ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns'	Ongoing	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☒Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement			☐Reduces Poverty ☒Improves Fiscal Responsibility		☐Natural Resource Damage ☐Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☐Enhanced Inequalities			☐Grant Funding	departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☐Other: **BNS**		
47	Build in-house City staff surface water management capabilities to improve continuity of water management within the County.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	No impact	No impact	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Medium	☐Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☐Reduced Economic Vitality ☐Reduced Public Health ☐Excessive Use of EMS ☒Underfunding of Infrastructure ☐Enhanced Inequalities	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☐Other:	2020	None Captured
48	Improve due diligence during the sale of properties to disclose if the properties are in the floodplain.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS	High	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒City DPW ☒City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport	2020	None Captured

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Earthquake ☐Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement					☒Underfunding of Infrastructure ☒Enhanced Inequalities				☒**Other: Floodplain Administrator,** MYBOR		
Structural Projects													
49	Create a culture of infrastructure planning that accounts for future considerations and emphasizes life-cycle costs.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☐Earthquake ☒Structural Fire ☒Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	High	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	High	Very High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☐City Public Safety ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works • Lawrence • Speedway • Beech Grove • Southport ☒Other: MPO	2020	
50	Designate and design shelter options in areas with large apartment complex.	☐Flood ☒Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☒Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☒Earthquake ☐Structural Fire ☒Hazmat Incident ☒Civil Disturbance	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Medium	☒Injuries/Deaths ☐Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☐Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: DMD, Apartment Association	2020	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Regional & National Displacement											
Public Education/Awareness													
51	Engage the community and second responders in hazmat exercises.	☐Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☒Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement	No impact	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	High	Very High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☒Other: MCPHD, LEPC	Ongoing, enhance by 2025	
52	Improve coordination with community development planning to ensure hazard mitigation goals are met.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☒Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☒Other: Red Cross, LISC, DMD	2020	
53	Continue to educate the public on enhancing safety	☒Flood ☒Dam & Levee Failure	Adaptation	Decreases	☒Improves Individual and/or	Low	☒Injuries/Deaths ☒Reduced Mental Health	High	High	☐Current Capital Budget	☒City DPW ☒**City Public Safety** ☐EmployIndy	Ongoing, enhance efforts by 2020.	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
	measures and insurance options, affordability, and support to ensure that coverage on claims is fully delivered.	☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☐Air Quality ☒Earthquake ☒Structural Fire ☐Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement			Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility		☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities			☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☐Other: Insurance Commission		
54	Continue training people/community on protective actions like shelter in place.	☐Flood ☒Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☒Tornado ☐Extreme Temps. ☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☐Natural Resource Damage ☐Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☐Enhanced Inequalities	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: Chamber of Commerce	Ongoing	
55	Upgrade community-wide alert network to include hazmat incident alerts.	☐Flood ☐Dam & Levee Failure ☐Increased Precipitation ☐Drought ☐Winter Storm & Ice ☐Tornado ☐Extreme Temps.	No impact	Decreases	☐Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☐Natural Resource Damage	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☐City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☐ Excluded Cities/Towns ☐Other:	2020	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☐Increased Heat Waves ☐Urban Heat Island ☐Air Quality ☐Earthquake ☐Structural Fire ☒Hazmat Incident ☐Civil Disturbance ☐Regional & National Displacement			☐Improves Fiscal Responsibility		☐Reduced Economic Vitality ☐Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities						
56	Provide hazard preparedness (warning sirens, radio stations, insurance protection, etc.) literature at public facilities and on agency websites as appropriate.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☒Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☒Underfunding of Infrastructure ☒Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☐Other:	Ongoing, enhance efforts through the annual MHMP maintenance meetings and reporting.	
57	Promote individual and family preparedness for up to 72 hours through public outreach and education.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☒Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☒Other: Private Employers, Chamber of Commerce, MCPHD	2020	

#	Mitigation Action Description	Hazards Addressed	Climate Change Value[106]	Impact on Social Vulnerability [107]	Co-Benefits[108]	Estimated Financial Cost	Potential Consequences of Inaction	Benefit Cost Ratio	Priority	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters	Implementation Schedule	Linkage to Other Plans
		☒Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement					☒Enhanced Inequalities						
58	Work with large employers in the area to promote individual and family preparedness for up to 72 hours.	☒Flood ☒Dam & Levee Failure ☒Increased Precipitation ☐Drought ☒Winter Storm & Ice ☒Tornado ☒Extreme Temps. ☒Increased Heat Waves ☒Urban Heat Island ☒Air Quality ☒Earthquake ☒Structural Fire ☒Hazmat Incident ☒Civil Disturbance ☐Regional & National Displacement	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☒Reduces Poverty ☒Improves Fiscal Responsibility	Low	☒Injuries/Deaths ☒Reduced Mental Health ☒Reduced Public Safety ☐Built Asset Damage ☒Natural Resource Damage ☒Reduced Economic Vitality ☒Reduced Public Health ☒Excessive Use of EMS ☐Underfunding of Infrastructure ☒Enhanced Inequalities	Medium	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☒ Excluded Cities/Towns' departments of public works/safety • Lawrence • Speedway • Beech Grove • Southport ☐Other: Private Employers	2020	

ACTION PRIORITIZATION

To focus mitigation action implementation, the project team identified specific mitigation actions to prioritize for implementation. This prioritization was based on feedback collected from Task Force members during the April 26, 2018 Task Force meeting and from the survey. Ten actions were selected from the 58 mitigation actions presented above in Table 5-2. These actions are summarized on the following pages in Table 5-3. They are not presented in any specific order. It is expected that these actions will be carried forward for further evaluation in the *Thrive Indianapolis* Sustainability and Resilience Action Plan.

Table 5-3: High Priority Mitigation Actions (Actions are ranked as the top 10 and are not listed in any order of priority in respect to each other)

	Mitigation Action Description	Climate Change Value[109]	Impact on Social Vulnerability[110]	Co-Benefits[111]	Estimated Financial Cost	Benefit Cost Ratio	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters
1	**Public Education/ Awareness:** Engage the community and second responders in hazmat exercises	No impact	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒City DPW ☒**City Public Safety** ☐Chamber of Commerce ☒Private Utility/Inf. Owners ☐ IDNR ☐Other:
2	**Prevention:** Conduct inspections and maintenance of high hazard dams and private levees regardless of ownership according to industry best practices	Adaption	Decreases	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	Low	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☒City Public Safety ☐EmployIndy ☒Private Utility/Inf. Owners ☐ IDNR ☐Other:
3	**Prevention:** Capture lessons learned on road design from other cities in the US to improve design roads and associated drainage to better manage stormwater, reduce infiltration, and reduce freeze-thaw cycle damage	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☒Reduces Poverty ☐Improves Fiscal Responsibility	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☐City Public Safety ☐Chamber of Commerce ☐Private Utility/Inf. Owners ☐ IDNR ☐Other:

[109] Includes measures that either directly address climate change or measures that include climate change adaption as a component.
[110] Includes measures that either directly address social vulnerability reduction or include social vulnerability reduction as a component.
[111] Broad categories of co-benefits are based on the Core Values of *Thrive Indianapolis*. Additional details and analysis are provided in the *Thrive Indianapolis* Sustainability and Resilience Action Plan.

	Mitigation Action Description	Climate Change Value[109]	Impact on Social Vulnerability[110]	Co-Benefits[111]	Estimated Financial Cost	Benefit Cost Ratio	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters
4	**Emergency Services:** Cross train City departments on public safety and CERT train all City staff	No impact	No impact	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐EmployIndy ☐Private Utility/Inf. Owners ☐ IDNR ☐Other:
5	**Property Protection:** Implement additional green infrastructure with incentives for developers consistent with the Storm Water Credit Manual and Green Infrastructure Supplemental Document	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	High	High	☒Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒**City DPW** ☒City Public Safety ☐Chamber of Commerce ☒Private Utility/Inf. Owners ☐ IDNR ☐Other:
6	**Public Education/ Awareness:** Improve communication of hazards and mitigation efforts with all communities throughout all four phases of the Emergency Preparedness Cycle (mitigate, prepare, respond, recover)	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☐Increased Operating Budget ☐Grant Funding	☒City DPW ☒**City Public Safety** ☐Chamber of Commerce ☒Private Utility/Inf. Owners ☐ IDNR ☐Other:

	Mitigation Action Description	Climate Change Value[109]	Impact on Social Vulnerability[110]	Co-Benefits[111]	Estimated Financial Cost	Benefit Cost Ratio	Potential Funding Source/s	Lead Implementer (Bold) and Key Supporters
8	**Emergency Services:** Have backup power for facilities providing critical services (e.g. ventilators) in Marion County	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☒Reduces Poverty ☒Improves Fiscal Responsibility	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☐City DPW ☒**City Public Safety** ☐Chamber of Commerce ☒Private Utility/Inf. Owners ☐ IDNR ☒Other: MESH, other local healthcare organizations
9	**Structural Projects:** Create a culture of infrastructure planning that accounts for future considerations and emphasizes life-cycle costs	Adaptation	Decreases	☐Improves Individual and/or Community Capacity ☐Improves Equitable Service Delivery ☐Reduces Poverty ☒Improves Fiscal Responsibility	High	High	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☐Grant Funding	☒**City DPW** ☐City Public Safety ☐Chamber of Commerce ☐Private Utility/Inf. Owners ☐ IDNR ☐Other:
10	**Prevention:** Implement land use policies to improve neighborhood interconnectedness	Adaptation	Decreases	☒Improves Individual and/or Community Capacity ☒Improves Equitable Service Delivery ☐Reduces Poverty ☐Improves Fiscal Responsibility	Low	Medium	☐Current Capital Budget ☒Current Operating Budget ☐Increased Capital Budget ☒Increased Operating Budget ☒Grant Funding	☒City DPW ☒City Public Safety ☐Chamber of Commerce ☐Private Utility/Inf. Owners ☐ IDNR ☒Other: Other: Local Non-Profits, **DMD**

06 PLAN MAINTENANCE

Monitoring, Evaluating, and Updating the Plan

44 CFR 201.6(c)(4)(i)

[The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

To achieve the vision and goals of this plan, it is important that implementation of this MHMP be monitored, evaluated, and updated. The DHS Director is ultimately responsible for the MHMP. Depending on grant opportunities and fiscal resources, mitigation practices may be implemented independently, by individual NFIP communities, or through local partnerships. Therefore, the successful implementation of this MHMP requires the participation and cooperation of the entire MHMP Task Force to successfully monitor, evaluate, and update the Marion County MHMP.

The DHS Director will reconvene the MHMP Task Force on an annual basis and/or following a significant hazard incident to:

- Document if the nature, magnitude, and/or type of hazards have changed
- Determine if the required resources are available for implementation of mitigation measure/s
- Document the cost of inaction if a hazard occurs and relevant mitigation measures were not implemented
- Review if there are problems, such as technical, political, legal, or coordination issues with other agencies preventing the implementation of a mitigation measure
- Evaluate the success of mitigation measure that were implemented
- Engage with newly identified MHMP Task Force member organizations
- Update the plan if a disaster declaration is issued for part or all of Marion County

The findings and recommendations of the MHMP Task Force shall be documented and shared with interested stakeholders, including City Council members, and the public.

The data used to prepare this MHMP was based on “best available data” and data collected during the stakeholder meetings held during development of this MHMP. Therefore, there may be limitations to the data. As more accurate data becomes available, updates should be made to the list of critical infrastructure, the risk assessment and vulnerability analysis.

Five Year Plan Review and Update

DMA 2000 requires local jurisdictions to update and resubmit their MHMP every five to continue to be eligible for mitigation project grant funding. In early 2023, the DHS Director will once again reconvene the MHMP Task Force for a series of meetings designed to replicate the original planning process. Information gathered following individual hazard incidents and annual meetings along with updated vulnerability assessments to assess the risks associated with each hazard common in Marion County. These hazards, and associated mitigation goals and practices will be updated, prioritized, and detailed as discussed in the preceding sections to reflect any practices implemented within the interim as well as any additional practices discussed by the Committee during the update process.

Prior to submission of an updated MHMP, a public meeting will be held to present the information to residents of Marion County and to provide them an opportunity for review and comment of the draft MHMP. A media release will be issued providing information related to the update, the planning process, and details of the public meeting.

Incorporation into Existing Planning Mechanisms

44 CFR 201.6(c)(4)(ii)
[The plan maintenance process shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.

Public and private entities within Marion County are continuously planning for the future and implementing those plans. Therefore, incorporating this plan with the other ongoing planning efforts, most notable, *Thrive Indianapolis*, is critical to the success of the planning effort and mitigation of hazards for the people of Marion County.

Perhaps one of the most important plans to integrate with is the Comprehensive Emergency Management Plan. This plan summarizes the actions during the response and recovery stages of emergency response. In addition, dam and levee Emergency Action Plans are being updated in 2018. Close coordination with these plans is paramount to maintain a safe and resilient Marion County.

Where needed, modifications will be proposed to be made to each NFIP communities' planning documents and ordinances during the regularly scheduled update. Among other things, local planning documents and ordinances may include comprehensive plans, floodplain management plans, zoning ordinances, building codes, site development regulations, or permits. Modifications include discussions related to hazardous material facility buffers, floodplain areas, and discouraging development of new critical infrastructure in known hazard areas.

Based on added language within each of the Comprehensive Plan updates the appropriate Zoning Ordinances and Floodplain Management Ordinances within each community would be updated to reduce the consequences of a hazard occurring.

Similar to Marion County, the excluded jurisdictions intent to intertwine the recommendations of this hazard mitigation plan into existing documents as well as incorporate them in future plans. This process includes reviewing and realigning comprehensive and master plans, ordinances, and other community plans and policies held by the excluded cities and town. Many of the plans authored by Marion County or other entities, cover the excluded jurisdictions outside of plans, ordinance and initiatives which the jurisdictions have developed independently. Discussions were held at the stakeholder meetings with excluded city/town jurisdictions to discuss their existing plans.

Continued Public Involvement

44 CFR 201.6(c)(4)(iii)

[The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.

Public participation is an important part of the component to the local mitigation planning process. Public participation will continue through the *Thrive Indianapolis* Sustainability and Resilience Action Plan development and implementation process. Public involvement was emphasized during the 2018 MHMP and *Thrive Indianapolis* efforts were reviewed as part of the 2017 plan update. A public hearing is required prior to adoption if any significant changes or amendments to the MHMP. In addition, Marion County regularly posts information about hazard and risk assessment on City communication channels (e.g., social media and e-newsletters). This is led by City communications staff working with public safety staff. The City also maintains a hazard mitigation planning website that can be used to provide updates and post the most current version of the plan:

http://www.indy.gov/eGov/City/DPS/DHS/Preparedness/Pages/MultiHazardMitigationPlan.aspx

By making the plan available in the Indianapolis DHS office and on the City's website with an invitation and instructions on providing feedback, public comment opportunities will be continuously available. Other efforts to involve the public in the maintenance, monitoring, evaluation, and revision process will be made as necessary. These efforts may include:

- Notifying and engaging with the public on any maintenance and/or periodic review activities taking place.
- Advertising MHMP update stakeholder meetings on the City website, social media channels, local newspapers, public bulletin boards and/or City office building

LIST OF APPENDICES