PREPARING FOR CLIMATE CHANGE

Goshen
THE MAPLE CITY

CLIMATE CHANGE VULNERABILITY ASSESSMENT FOR STORMWATER

GOSHEN, IN

EXECUTIVE SUMMARY

The climate in this region is changing, and these changes are causing immediate threats to Goshen's citizens, health, economy, and the community's overall vitality. Over the last several years, the region has experienced a 1.4°F increase in average annual temperature, with spring experiencing the greatest amount of warming (a 2.4°F increase). Nighttime temperatures are rising, and the number of cold days (< 32°F) is declining. Annual precipitation is changing too: in the last several decades Goshen has experienced a 10.1% increase in annual precipitation (amounting to 3.9 inches), with the greatest change happening in fall (18% increase, amounting to roughly an extra 1.7 inches). In addition, the frequency and intensity of severe storms are increasing, with the City experiencing a 9% increase in the number of heavy precipitation events (heaviest 1% of storms) annually with a 16% increase in the total volume of rainfall during these events. These are just some of the changes that have led to serious impacts to the community's infrastructure, economy, social networks, cultural identity, and safety. These impacts are likely to be more extreme as the climate continues to change.

In light of this, the City of Goshen has decided to plan for climate change, making sure to consider what changes are projected to take place in the future and integrating that information into how the City operates. Guiding this work is a commitment to ensuring the health, safety, and general welfare of all Goshen's residents—especially the frontline communities that are already experiencing a disproportionate share of the impacts associated with a changing climate. This Stormwater Vulnerability Assessment is one important component of Goshen's efforts to create a more equitable and resilient community for all Goshen residents—ensuring every resident is prepared for the current and future risks associated with a changing climate.

The waterways throughout Goshen are an amenity that have played a major role in how and why historic development occurred, but they also mean the City periodically experiences flooding. Catastrophic flooding in February of 2018 (Figure 1), raised greater awareness about the potential vulnerabilities the City of Goshen faces as it moves towards a future of living with climate change. Flooding in Goshen was not new in 2018, but far more intense in the middle of the City than other events in living memory. Climate change in the region is expected to bring more frequent and more intense storms and thus, when a host of other conditions are also in place, more frequent and more intense flooding. The 2018 event and the understanding that such events could become worse and occur more often prompted conversations, planning efforts, and participation in this assessment.

Managing and planning for more intense storm events will be a significant challenge for all stakeholders in stormwater management. A first step is an understanding of existing and potential stormwater system vulnerabilities. To accomplish this need, the City of Goshen Stormwater Department completed this assessment in partnership with the Great Lakes Integrated Sciences and Assessments (GLISA). The Great Lakes Integrated Sciences and Assessments provided the assessment framework, a fillable template, climate impact data, and base level research into broader trends and considerations. The Stormwater Department added all of the site-specific information including landscape feature analysis, socio-economic vulnerability information, and on-the-ground knowledge of flood-prone areas of the City.

Within the pages of this report, readers will find more information about how changes in weather and long-term climate have already impacted Goshen and details about projected changes in climate relevant to the City. Further, the report provides insights into what those changes might mean in terms of on-the-ground impacts to stormwater systems, an assessment of Goshen's overall stormwater-system vulnerability to these changes, and which segments of the community may be most vulnerable. This assessment does this by considering demographic data, climate projections, features of the City's landscape, and lessons learned during past severe storm and flood events. Finally, the report synthesizes these insights to assess 18 different "system components" for sensitivity to climate impacts and adaptive capacity—a method of qualitatively measuring overall vulnerability.

Figure 1: February 2018 floodwaters impacted businesses in Linway Plaza and along Lincoln Avenue.

At a high level, climate change is anticipated to exacerbate or create the following major impacts to stormwater in Goshen:

- Extreme rain events will drop large amounts of rain in a short amount of time, which could overwhelm existing stormwater infrastructure (e.g. storm structures, storm pipes, and stormwater basins).
- Increased rainfall in the winter and spring could lead to increased runoff and thus more frequent flooding to the already flood-prone areas of the City.
- Rapid urban development has increased impervious surface cover and consequently generated greater stormwater runoff. This factor combined with more intense storms could mean greater peak flows and riverine flooding that threatens developed areas of floodplains within the City.
- The design capacity and condition of the stormwater conveyance system may not be able to accommodate higher system demand and thus necessitate more widespread use of stormwater management practices and increased stormwater capture and controlled release requirements that help reduce peak flows by keeping stormwater in place.
- Tree and native plant species that have typically thrived in the region may no longer do so due to increasing temperatures and invasive insects, which could increase stormwater runoff if the coverage of the urban tree canopy and other beneficial plant life decreases.

Climate change will variably impact each of the 18 different system components evaluated for this report because of their locations, land uses, and existing social and infrastructure vulnerabilities. This report takes a deep dive into these factors and creates a base for identifying priority areas where City efforts can reduce climate change vulnerability as it relates to stormwater—creating a more climate resilient community in the years to come.

CONTENTS

1. WHAT IS A VULNERABILITY ASSESSMENT

As the climate continues to change, communities across the U.S. and the world are asking, "How are these changes already affecting my community?" and "What local impacts might we experience from future changes in climate?" To help answer these questions, communities are using a tool called a vulnerability assessment. A vulnerability assessment helps stakeholders identify:

1. What changes in climate are projected to happen and what those changes could mean in terms of local **impacts**,
2. The level of **exposure** the community has to potential changes,
3. How **sensitive** the various city and community systems are to projected changes in climate, and
4. What **capacity** those systems have to adapt.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC 2014).

Sensitivity: The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC 2014).

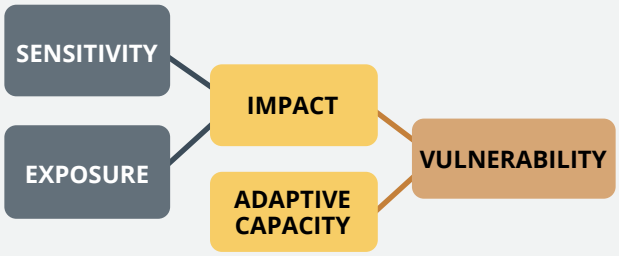
Impact: Effects on natural and human systems such as lives, livelihoods, health, ecosystems, economics, societies, cultures, services, and infrastructure (IPCC 2014).

Adaptive Capacity: The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC 2014).

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC 2014).

Figure 2 provides a graphical depiction of how exposure, sensitivity, impacts, and adaptive capacity all combine to create vulnerability.

Figure 2: Graphical depiction of the various elements of vulnerability

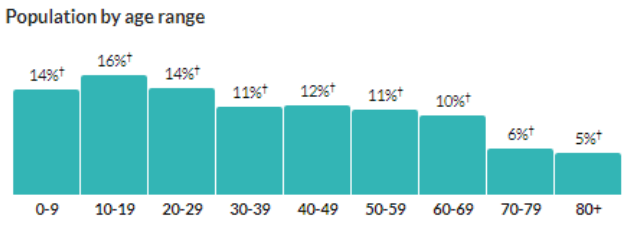


Once completed, the results of a vulnerability assessment can be used to inform the types of actions a community should take to reduce vulnerabilities or seize on potential opportunities.

Currently, most existing vulnerability assessment guidance and tools have either limited or no discussion regarding the important role that a community's social and economic characteristics play in determining local vulnerability. Because of the critical importance social dynamics play in shaping the local community, the City of Goshen partnered with fellow Midwestern cities, the Huron River Watershed Council, the Great Lakes Integrated Sciences and Assessments, and Headwaters Economics to develop a revised vulnerability assessment template that assesses the community's social, physical, cultural, economic, and environmental vulnerability to climate change. The document you are currently reading is a spinoff of this work, focused explicitly on understanding the vulnerability of Goshen's stormwater system to climate change, socio-economic considerations, and local landscape features.

2. SOCIO-ECONOMIC PROFILE OF GOSHEN

Table 1: Section Summary[1]

Population by age range	Age	Income	
	35.4 Median age	$21,603 Per capita income	$48,399 Median household income

Goshen is a unique and diverse city—a multi-generational community home to peoples representing a variety of languages, ethnicities, religious practices, political views, educational achievement, economic situations, and jobs. It is this diversity that makes Goshen great.

Some of the characteristics of the community mark Goshen's strengths in an uncertain climate future while others reveal some of its vulnerabilities—the neighborhoods and peoples that will need additional resources to adapt to this future in an equitable way. To fully understand how the City of Goshen is resilient or vulnerable to climate change, a deeper look at the community's socio-economic (social and economic) characteristics is needed. Using the Neighborhoods at Risk (Data Mapper, compiles 2018 American Community Survey data) tool from Headwaters Economics, nine characteristics were analyzed that help explain local vulnerabilities:

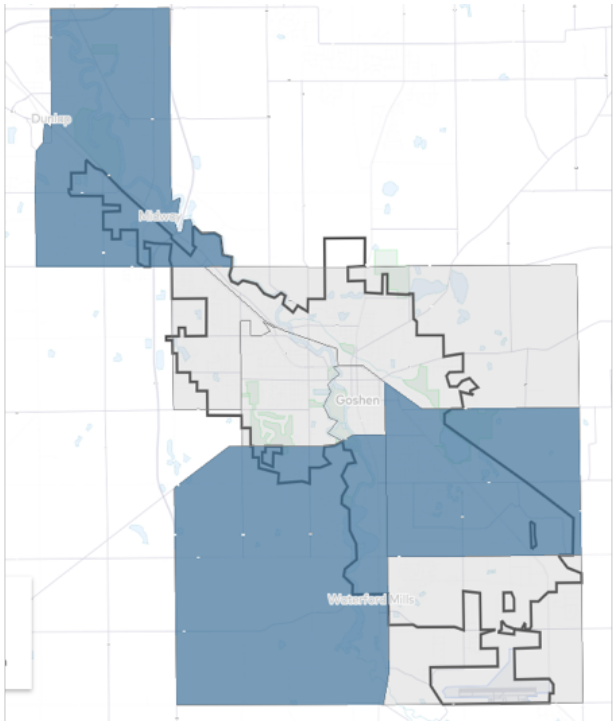


Figure 3: Blue Census Tracts: Tracts in Goshen where the percentage of the population 65 years and older exceeds the national average of 15.2%.

A. Percent of population over 65
B. Percent of population under 5
C. Percent of community in poverty
D. Percent of population with limited English proficiency
E. Percent of population identifying as a Person of Color or Hispanic
F. Percent of households without health insurance
G. Percent of households without a car
H. Percent of population with disabilities
I. Percent of rental and mobile homes
J. Percent of population without a high school diploma

A Note On the Data:

A new census was conducted in the year 2020. At the time of writing, the new numbers were not yet publicly accessible.

The American Community Survey periodically updates demographic data using survey methodology and the 2018 Survey numbers used in the analysis represent the best available data for Goshen.

The size of census tracts in Goshen—the geographic unit available to display demographic data—are too large in area to understand clearly the finer detail of vulnerability distribution amongst distinct neighborhoods in Goshen. Census tracts also do not align with City limits. Thus, the following analysis should be considered as generalizations to guide thinking, but on-the-ground knowledge remains essential to thinking about equity in the vulnerability assessment and ongoing planning efforts.

A. Percent of population over 65

As of 2018, the City of Goshen had 33,915 residents, 16% (5,675) of which were 65 years or older.[2] This is higher than the U.S. national average for residents over 65, which is 15.2%. Of this population, approximately 1,037 (3.1%) are 80 years or older. Goshen is home to many services developed specifically for elderly populations. Notably, Greencroft Communities located along College Avenue is one of the largest elderly residential housing facilities in the region. Several other neighborhoods have been specifically designed with retirement age persons in mind.

This figure is important because elderly populations are at increased risk of compromised health related to environmental hazards and climate change. In fact, age is the single greatest risk factor related to illness and death from extreme heat[3] and the elderly are more likely to have pre-existing medical conditions or compromised mobility, which reduces their ability to respond to extreme heat and extreme weather events[4] (which are both likely to become more frequent due to climate change). Finally, the increased likelihood of chronic disease,[5] combined with the fact that older adults are more susceptible to air pollution, which is expected to become worse due to climate change, makes them a uniquely vulnerable population.[6]

All of these factors combined mean that the elderly require unique and/or additional services compared to younger residents. As such, understanding the community's age profile helps determine the appropriate types of services and resources needed to ensure all of Goshen's residents can survive and thrive in a climate-altered future.

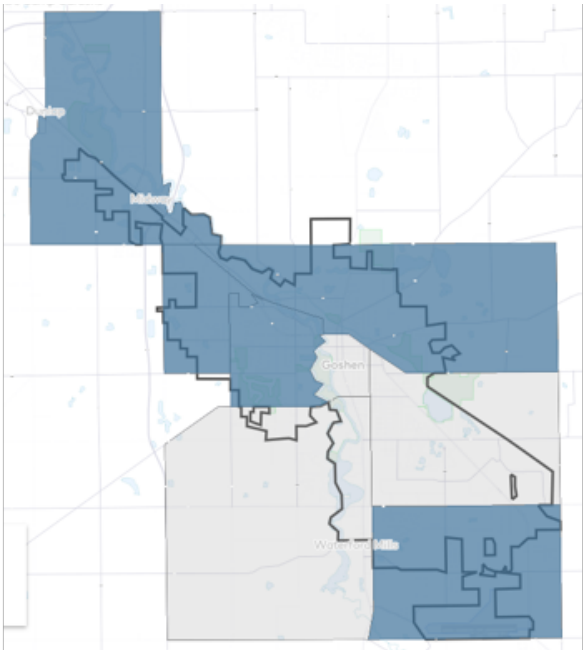


Figure 4: Blue Census Tracts: tracts in Goshen where the population under the age of five exceeds the national average of 6.1%.

B. Percent of population under 5

As of 2018, 6.9% (2,346) of the City of Goshen's population was under five years of age. This is just one-tenth of a percentage point higher than the national average of 6.8%.[7] The areas of Goshen with higher than average populations of children under the age of five are largely concentrated in the northwest section of the City. Note that at least one of these tracts lies mostly outside City limits, but can give a general sense that there may be more family housing units in that region.

Knowing what percentage of residents are under the age of five, and where they reside, is important because children's developing bodies are particularly sensitive to health problems and environmental stresses,[8] including those associated with climate change. Children also spend more time outside and have faster breathing rates than adults, so they are more at risk for respiratory problems related to things such as ground-level ozone, airborne particulates, wildfire smoke, and allergens:[9] all of which can be exacerbated by climate change. Moreover, because their immune systems are not fully developed, children are more susceptible to infectious diseases,[10] including those that spread during natural disasters.

Focusing efforts on reducing youth vulnerability makes

sense for many reasons, including the fact that childhood lays the foundation for lifelong health, meaning that poor health during childhood can significantly increase the likelihood of problems throughout adulthood.[11] With the rising cost of health care in the U.S., ensuring that Goshen has a healthy, productive community is pivotal to not only wellbeing but also social structure and the economy.

As the City seeks to ensure its youth are resilient to climate change, particular attention needs to be paid to youth that are living in poverty. Children living in poverty are less likely to receive high-quality health care, meaning that they may be especially sensitive to changes in climate and the ensuing health impacts.[12] Children living in poverty are also more likely to live in vulnerable areas, including areas that have poor air quality, limited transit options, and homes that are less resilient to changing weather patterns. As the City moves forward with building community-wide resilience, care must be taken to ensure that children, especially those in poverty, are prioritized.

C. Percent of community in poverty

Poverty is typically defined using multiple factors including household income and the number of household members. In 2018, the City of Goshen had 1,197 families living in poverty. The U.S. Department of Commerce Census Bureau calculated a total of 8,264 family units in Goshen for whom they determined poverty status in 2018. That makes the rate of families living in poverty 14.5% in 2018. This number is significantly above the U.S. national average of 10.1%.[13] Looking closer into these groups, data shows that in Goshen 13.1% of families with children live in poverty—well above the national average of 7.5%. Finally, 10.5% of the City's families are both living in poverty and a single mother household. That's more than double the national average of 4.5%.

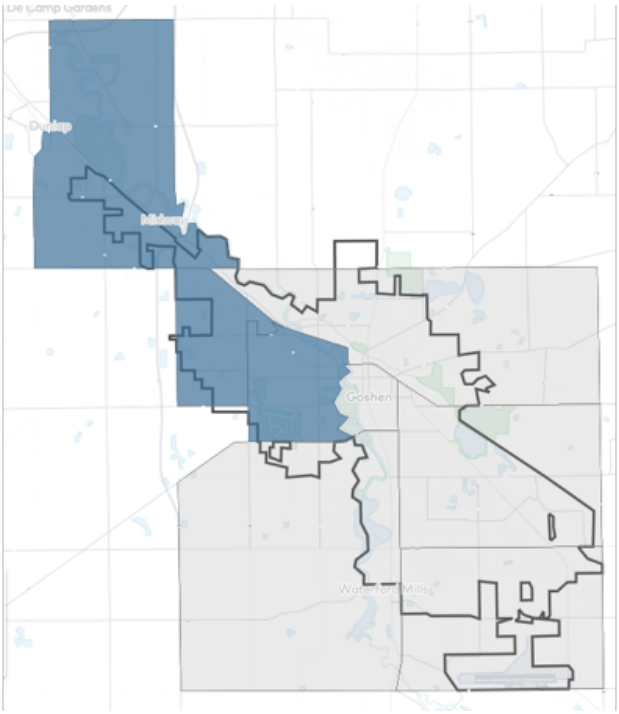


Figure 5: Blue Census Tracts: tracts in Goshen where the percentage of families living in poverty exceeds the national average of 10.1%.

The City will look for updated numbers from the 2020 census as the Global Pandemic and its fallout may have significantly impacted these numbers. National trends could provide some insight on the expected impacts, but Goshen's heavy reliance on manufacturing may make for trends unique to the region. While the raw numbers for rates of poverty may have changed dramatically, the distribution of the populations more likely to be in poverty likely did not. The map of census tracts can thus still give a general sense of where the most economically vulnerable populations may live.

Understanding the percent and location of those living in poverty is critical because low income is one of the strongest predictors of compromised health as well as an individual's ability to recover from disasters.[14] Moreover, natural disasters disproportionately impact the poor because of things such as inadequate housing, social exclusion, a diminished ability to evacuate, lack of property insurance, and more acute emotional stress.[15] In addition, research has shown that low-income people are more likely to be overlooked during the emergency response period following a disaster.[16] Low-income populations are also more likely to live or work in areas with greater exposure to environmental hazards, including working in jobs that require outdoor labor.[17]

Income inequality within a community is also associated with poor health outcomes: residents in low-income neighborhoods tend to have higher incidences of asthma, depression, diabetes, heart conditions, and emotional stress compared to higher-income neighborhoods.[18] Low-income households also have to make lifestyle compromises to make ends meet, such as choosing unhealthy foods, less food, substandard housing, or delayed medical care.[19] Having limited income may also mean that it is simply too expensive to run fans, air conditioners, or heaters to manage indoor living temperatures, not to mention that many low-income

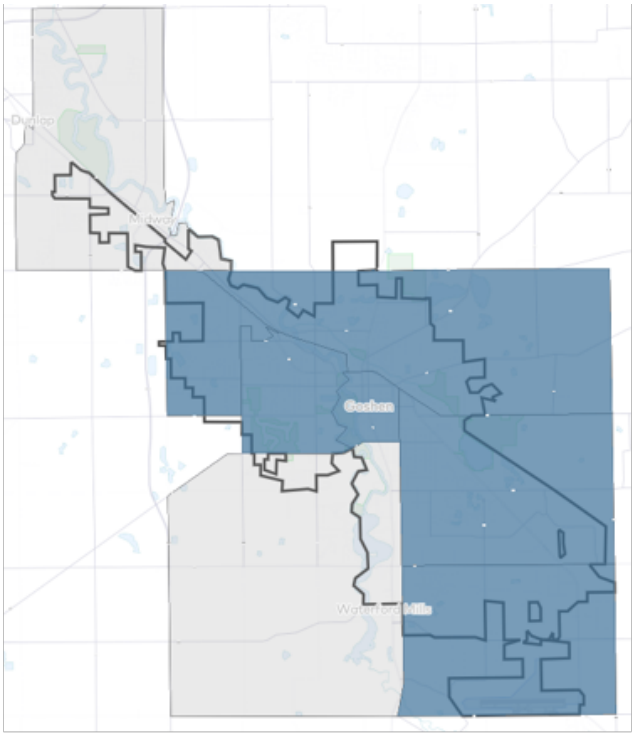


Figure 6: Blue Census Tracts: tracts in Goshen where the percentage of persons who do not speak English well exceeds the national average of 4.4%.

residences are located in high crime areas, meaning that residents may feel unsafe opening their windows.[20] Finally, the poor are least likely to have health insurance, which further exacerbates their vulnerability to the negative health impacts associated with climate change such as deteriorating air quality, higher incidences of asthma, and increased allergens.[21]

Goshen's rates of poverty being higher than the national average make these considerations all the more important. Lower-income areas tend to have the highest exposure to environmental harm and the least capacity to recover. With concerted effort, Goshen can work to be an exception to the trend that lower-income neighborhoods receive fewer climate mitigation efforts and slower and weaker emergency response in a disaster. Making resources accessible and incorporating vulnerability into emergency planning are important first steps.

D. Percent of population with limited English proficiency

Goshen's diversity of peoples makes for a dynamic City. According to the US Census Bureau, in 2018, 6.8% of the Goshen community "speak English 'not well'" (2,144 people). This is higher than the national average of 4.4%.[22]

Understanding the percentage and location of people with limited English proficiency is important because many, if not most aspects of life in the US require basic fluency in English. For example, knowing about and then accessing emergency services, learning about poverty reduction programs, or accessing health care all necessitate basic English proficiency. Research has found that limited English proficiency can:

- Limit a person's ability to effectively act during emergencies;[23]
- Make it harder to interact with agencies and access advisory information, thereby limiting the amount of support available to respond to and recover from disasters of all types;[24]
- Make it harder for people to get higher-wage jobs;[25] and
- Result in isolation from other segments of the US population, and social isolation can be a serious health risk.[26]

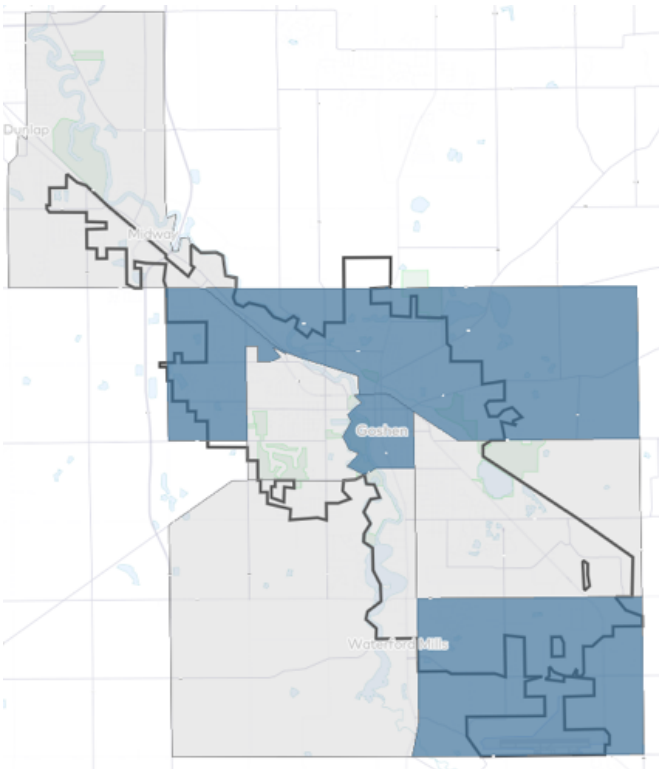


Figure 7: Blue Census Tracts: tracts in Goshen with a percentage of people identifying as a person of color or Hispanic exceeds the community median of 33.2% (the national average is 38.9%).

Because of these factors, the City must work to ensure populations with limited English proficiency have access to the information, tools, and resources they need to build resilience. In Goshen, this often means creating dual-language informational materials, but it also takes creative thinking about how to reach diverse populations and who the most effective messengers are.

E. Percent of population identifying as a Person of Color or Hispanic

As of 2018, 34.3% of the population in Goshen (11,639) identified as a person of color or Hispanic. This is lower than the national average of 38.9%. Looking in greater detail at a few key categories, 2.6% (891) identified as Black or African American, 3.7% (1,248) identified as two or more races, and 27.6% (9,372) identified as Hispanic or Latino.[27]

Looking to the next generation, the demographics of Goshen Community Schools (GCS) give some sense of the direction the community is heading. Of GCS's approximately 6,500 currently enrolled students, over 63% identify as a race other than white, non-Hispanic. Hispanic origin alone accounts for 56% of students—making them the largest single sub-group.[28]

This information is important because race and ethnicity strongly correlate with disparities in health, exposure to environmental pollution, and vulnerability to natural hazards, including climate-related natural hazards.[29] More specifically:

- Research consistently finds race-based environmental inequities across many variables, including the tendency for minority populations to live closer to noxious facilities and Superfund sites, and to be exposed to pollution at greater rates than whites.[30]
- Across races, the rates of preventable hospitalizations are highest among black and Hispanic populations. Preventable hospital visits often reflect inadequate access to primary care. These types of hospital visits are also costly and inefficient for the health care system.[31] Relative to other ethnicities and races, Hispanics and Black/African Americans are less likely to have health insurance but rates of uninsured are dropping for both groups.[32]
- Compared to other races, blacks have higher rates of infant mortality, homicide, heart disease, stroke, and heat-related deaths.[33]

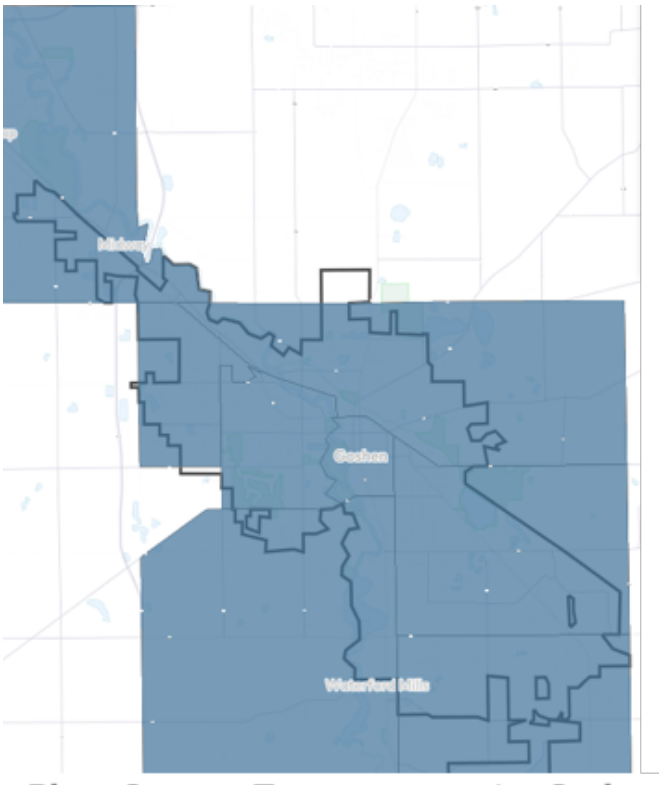


Figure 8: Blue Census Tracts: tracts in Goshen where the percentage of households without health insurance exceeds the national average of 9.4%.

- Hispanics have higher rates of diabetes and asthma, compared to other ethnicities.[34]
- Minority communities often have less access to parks and nutritious food and are more likely to live in substandard housing, all of which can negatively impact health outcomes.[35]
- Minorities tend to be particularly vulnerable to disasters and extreme heat events. This is due to language differences, housing patterns, substandard housing, community isolation, and cultural barriers.[36]
- Blacks and Hispanics, two segments of the population that are currently experiencing poorer health outcomes, are an increasing percentage of the U.S. and Goshen's population.[37]

Given these realities, it is important the City of Goshen ensures the effective integration of the needs, perspectives, and lived realities of its diverse population into efforts to enhance resilience. To this end, Mayor

Jeremy Stutsman (January 2016-present) has initiated a number of efforts to include more diverse voices in conversations about the City's work and future direction. These efforts include a number of citizen advisory councils and commissions including, but not limited to, the Community Relations Commission, Goshen Arts Council, Mayor's Environmental Advisory Committee, and Mayor's Latino Advisory Committee.

F. Percent of households without health insurance

As of 2018, an estimated 5,004 households within Goshen (15%) did not have health insurance. This is well above the national average of 9.4%. As apparent in Figure 8, all of the census tracts in Goshen have an uninsured rate that exceeds this national average.

Goshen's particular vulnerability in this regard means a number of services have developed over the years in an attempt to fill some gaps in available healthcare services. Maple City Healthcare, the Goshen Health Foundation, and The Center for Healing and Hope are a few organizations that work to provide lower-cost medical services to Goshen residents.

Researchers have found that those without health insurance often do not have a regular source of medical care which means they are more likely to use hospital emergency services for preventable conditions or standard needs.[38] About a quarter of uninsured adults have reported that they delayed or did not seek medical care due to the expected costs.[39] Many have also skipped medications and healthcare providers are less likely to prescribe medications to the uninsured in the first place.[40]

All of these consequences of being uninsured make Goshen's population less equipped to deal with health threats. Compromised sanitary conditions due to flooding, extreme heat, and increased air pollution are just a few health threats that residents may face in the future. Given the changing environment and the sensitivity of Goshen's population to health threats, the City needs to create systems and continue to support existing services that promote a healthier population with adequate health resources for all.

G. Percent of households without a car

As of 2018, 1,342 households in Goshen did not own a car. That is 10.9% of all households as compared to 8.7% nationally.

In a small sized city like Goshen where public transportation options are limited, lack of access to a car creates a major vulnerability for a sizeable percentage of the City's households. The City is actively working with the Michiana Area Council of Governments (MACOG) to expand the region's public transportation system. The latest efforts include expansion into the northside of Goshen—an area that is currently underserved.

Research has shown that access to a car promotes greater financial stability as people are more likely to be employed and work higher paying jobs.[41] Vehicles can also be essential during emergency situations. For natural disasters, heat waves, and other threats, cars give people the mobility to evacuate or seek safety and care within their community.[42]

H. Percent of population with disabilities

As of 2018, 4,416 residents in Goshen were living with some kind of disability. This represents 13.3% of the total population; a figure higher than the national average of 12.6%.[43]

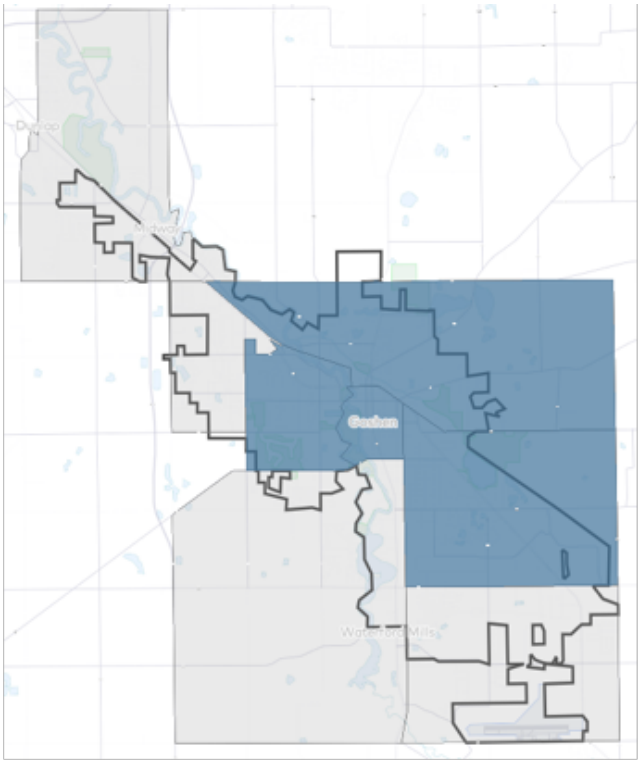


Figure 9: Blue Census Tracts: tracts in Goshen where the percentage of households without a car exceeds the national average of 8.7%.

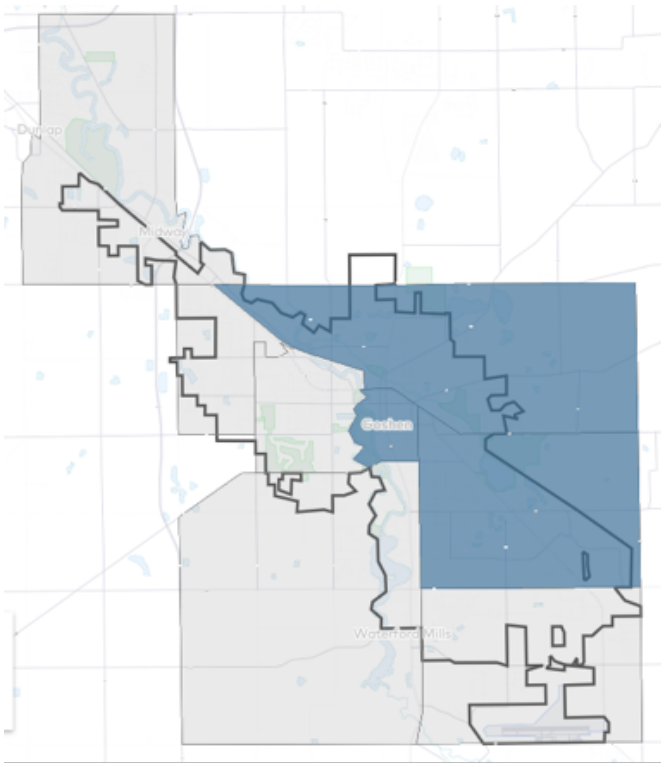


Figure 10: Blue Census Tracts: tracts in Goshen where the percentage of those living with disabilities exceeds the national average of 12.6%.

Disabled persons are subject to a series of health complications that are often significantly heightened due to environmental conditions. For example, limited mobility raises heat mortality,[44] as it can significantly delay and/or prevent effective evacuation during times of disaster. Extreme weather events can also disrupt one's ability to get medical treatment, which can be disastrous for those with compromised health. These are only some of the heightened vulnerabilities faced by people with disabilities.

Because of this, Goshen is determined to incorporate the needs of the disabled into attempts to create a more resilient community. This includes ensuring entities that service populations with disabilities (i.e., Courtyard Health Care, Greencroft, The Laurels of Goshen, Waterford Crossing, etc.) have adequate resources for responding to crises events.

I. Percent of rental or mobile homes

As of 2018, 44.9% of housing units in Goshen were rentals; an additional 10.7% were mobile homes.[45] This rate is significantly higher than the national average (36.2% for rentals, 5.6% for mobile homes).

Understanding what percentage of the population owns a home is important because home ownership contributes to well-being and stability. Home ownership also improves mental health, including increasing self-esteem and creating a heightened sense of control over one's living situation and financial security.[46] On the flip side, the financial stress associated with losing one's home is heightened by people's attachment to place and their neighborhoods.[47]

In terms of renters, studies have repeatedly shown that renters pay a larger proportion of their income in rent; rental rates have increased over the past 25 years with no sign of abatement.[48] This financial burden is exacerbated by the fact that rental homes are typically not well maintained with conditions such as dampness, mold, and exposure to toxic substances or allergens heightened for those residing in rental units.[49] Because of this, renters may pay even more to heat, cool, or make their rentals more accommodating, further exacerbating the financial impact associated with renting.

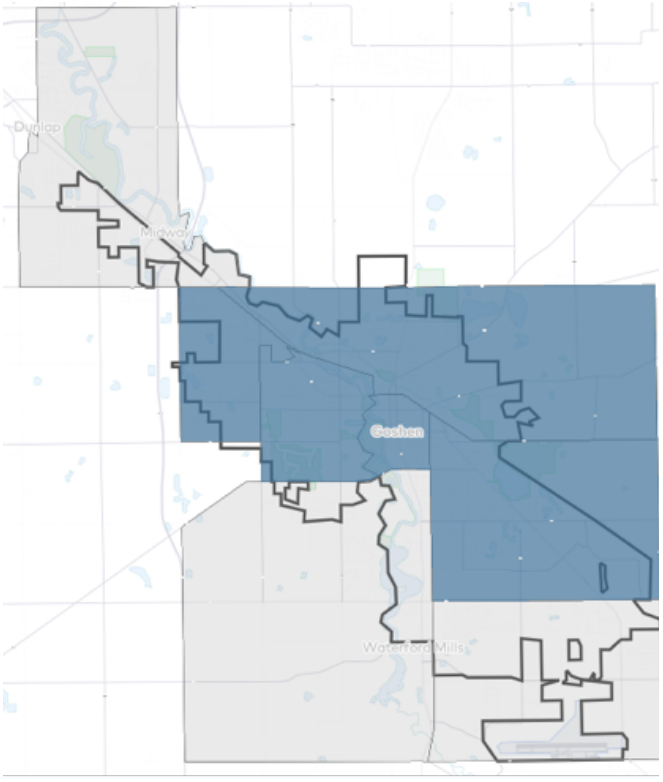


Figure 11: Blue Census Tracts: tracts in Goshen where the percentage of rental housing units exceeds the national average of 36.2%.

Not explicitly shown in census data, another important factor impacting Goshen is sufficient affordable housing. Goshen's median home tax valuation for a single family, non-rental home is currently $148,400.[50] Lack of available rental units and increasing costs of home ownership in Goshen pushes more and more people to substandard and overcrowded housing. Interrelated, people experiencing temporary or prolonged periods of homelessness are especially vulnerable during extreme heat and rain events. To decrease the vulnerabilities associated with inadequate and substandard housing, Goshen must work to address its lack of affordable and appropriate housing.

J. Percent of population without a high school diploma

- As of 2018, 4,666 people age 25 or older in Goshen did not have a high school diploma (21.9%). This is significantly higher than the national average of 12.3%,[51] a troubling statistic since high school completion is a common proxy for overall socio-economic circumstances. In particular, lack of education is strongly correlated with poverty and poor health. For example:
- People without a high school degree are more than twice as likely to live in inadequate housing compared to those with some college education.[52]
- Thirty-eight percent of Americans without a high school degree do not have health insurance, compared to 10 percent with a college degree.[53]
- The rate of diabetes is much greater for those without a high school degree. Incidence of this disease is more than double the rate of those who have education beyond high school.[54]
- Binge drinking is most severe among those without a high school degree. This demographic group had the highest rate of binge drinking across all measured categories (such as income, race, ethnicity, or disability status).[55]

The high percentage of the population without a high school diploma requires special considerations for how information is communicated regarding disaster risks and response. Identifying which population segments are more likely to be without a high school diploma will help in creating better targeted community risk education and ensuring equitable disaster response.

A Note on Vulnerabilities Faced by Goshen's Immigrant Community

The census data alone cannot fully describe the unique vulnerabilities within significant segments of Goshen's population. A notable part of Goshen's community profile is the immigrant community and the sizable undocumented population. Goshen is home to many first- and second-generation immigrant families—the majority from Mexico and other parts of Central America. Many of the vulnerabilities looked at in this section disproportionately affect immigrant families including a percentage of the community living in poverty, peoples with limited English proficiency, and those lacking health insurance, high school diplomas, and access to affordable, adequate housing.

For many, there are also the added stresses and barriers of life without legal documentation. Even if a person could afford to own a car for example, they may be unable to obtain a valid driver's license. Similar barriers exist for obtaining health insurance or securing a home loan.

A sizable portion of the community without legal documentation requires a few special considerations when considering climate mitigation and disaster response planning. First, there is the possibility that the census statistics undercount persons living with a particular vulnerability. Second, much work is needed to establish trust and work in collaboration with partners who are already serving immigrant populations. Hesitancy to work with government agencies creates barriers to climate disaster risk education, informed emergency response, and recovery efforts.

Cumulative Socio-Economic Vulnerability

Combining the findings from each of the previous sections, a map was created denoting some of the most socio-economically vulnerable neighborhoods (Figure 12). This figure identifies all the Census Tract where the City of Goshen has higher than the national average for all of the following variables: people who have difficulty speaking English; the number of rental units; population that is uninsured; households who lack access to a car; children under 5 years and people over 65 years old; and people with disabilities.

While the characteristics in this section give a window into Goshen's particular vulnerabilities and the area of the

City most impacted, they are limited. The United States' most accessible census tools are on a scale that does not necessarily make sense for the size of the community. For example, the census track in the northeast corner of Goshen identified as the most vulnerable represents a large area that encompasses a wide variety of smaller communities ranging from wealthier suburbs to truly underserved neighborhoods. Thus, on-the-ground knowledge remains incredibly important. At this time, the above section offers a starting point, but as climate vulnerable areas are identified, more work needs to be done to understand the particular needs of residents in diverse neighborhoods.

For those new to the demographic data of Goshen, the above numbers may seem dramatic (i.e., a City-wide rental unit rate of 44.9%). It's helpful then to look at these numbers with some kind of context. How does the City of Goshen stack up with the rest of Elkhart County? Indiana? What about the rest of the Country? Figures 13 and 14 below put Goshen's vulnerability in a Local, State, and National context using the Center for Disease Control's (CDC) Social Vulnerability Index.

The CDC pulls US Census Bureau data for a census-tract level data set called the Social Vulnerability Index (SVI). The SVI greatly simplifies the process of demographic data gathering and the indexing methodology relates multi-variable markers of vulnerability into a single, comparable score based on extensive research on factors impacting vulnerability. The CDC developed the SVI as a tool specifically for community natural disaster planning and response for events like flooding and earthquakes.[58]

Looking at the broader context of socio-economic vulnerability in Goshen through the SVI, it becomes clear that overall Goshen may be considered fairly vulnerable. However, as observed in earlier analysis, this vulnerability is not necessarily distributed equally throughout the City. Northeast Goshen emerged as particularly vulnerable when looking at individual markers of social vulnerability and the SVI reemphasizes this point. The Northeast Goshen census tract falls in Indiana's 92nd percentile for vulnerability.[59]

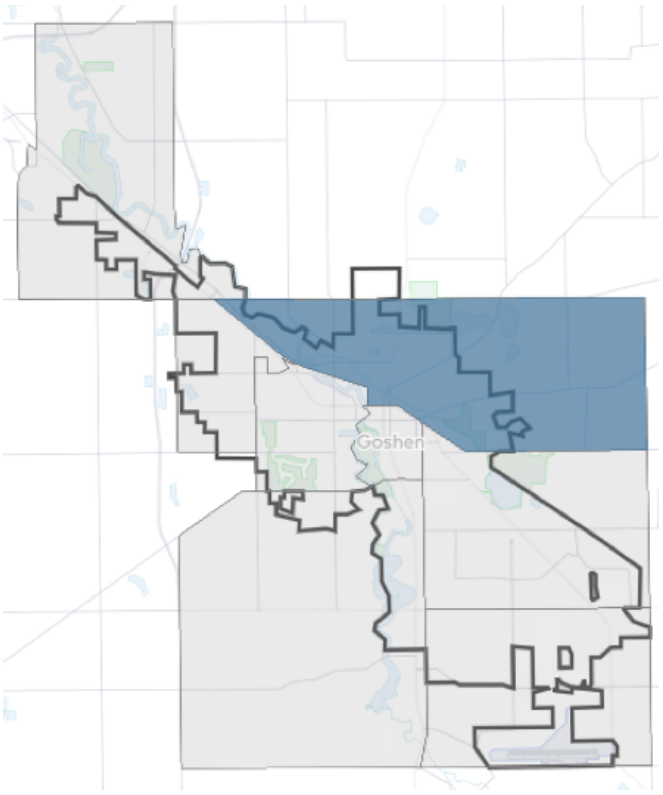


Figure 12: Census Tract within the City of Goshen that has the highest overall socioeconomic vulnerability. This map highlights a Census Tract with percentages higher than the national average for: people who have difficulty speaking English; the number of rental units; population that is uninsured; households who lack access to a car; children under 5 years and people over 65 years old; and people with disabilities.

It may be worth noting as well that a number of census tracts in Elkhart are even more vulnerable than Goshen's most vulnerable. Being downstream, the City of Elkhart directly benefits from Goshen's efforts to mitigate flooding. Goshen thus has a part to play in protecting people in those neighborhoods as well.

Evaluating social vulnerability is important because of the ways it exacerbates flood risks, damage, and recovery. Goshen's climate future holds far greater risk than ever before. In the next section we highlight our exposure to historic, current, and projected future changes in weather and climate.

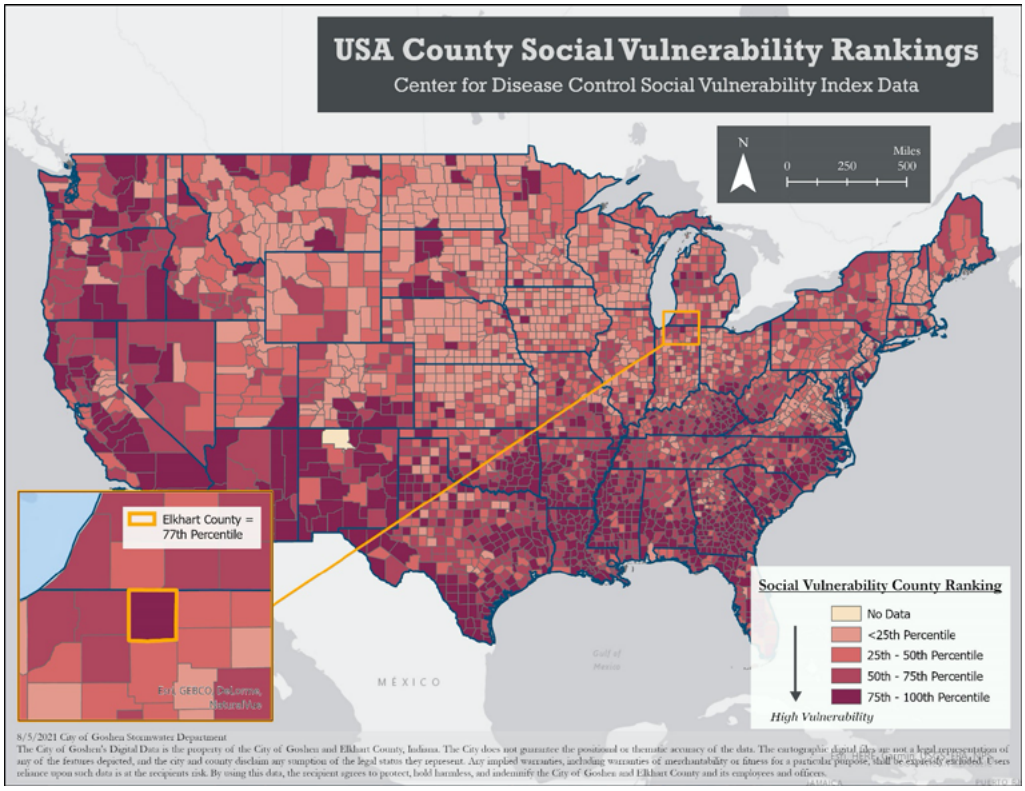


Figure 13: The Center for Disease Control (CDC) Social Vulnerability Index data showing vulnerability percentile rankings in comparison to all counties in the United States. Elkhart County falls in the 77th percentile nationally for vulnerability factors.[56]

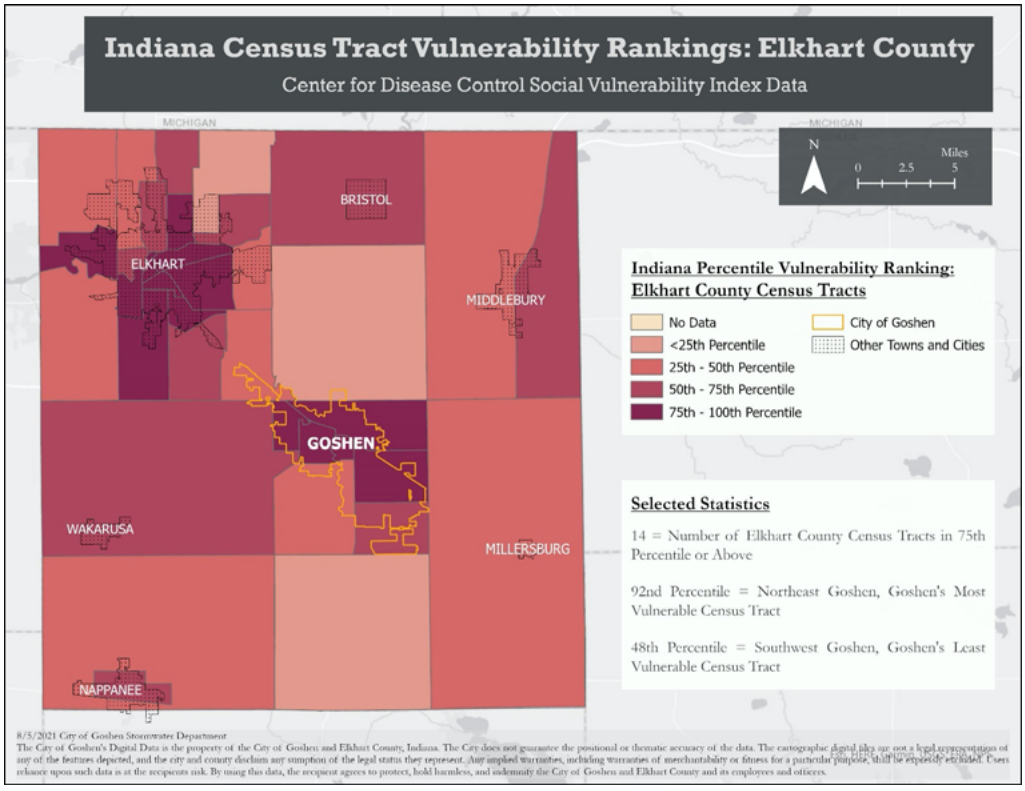


Figure 14: The Center for Disease Control (CDC) Social Vulnerability Index data showing vulnerability percentile rankings compared to all census tracts in Indiana. This map looks at Elkhart County census tract vulnerability as a percentile ranking across Indiana.[57]

3. CLIMATE CHANGE IN THE GREAT LAKES REGION AND GOSHEN

Great Lakes Regional Summary

- Average air temperature in the Great Lakes region has increased by 2.3°F.
- Average air temperature is projected to rise 3°F to 6°F by the mid-21st century.
- Total annual precipitation has increased by 14% in the region with significant intra-regional variation.
- The total volume of rain falling in the most extreme 1% of events has increased 35%.
- 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).

A. Climate Change Profile for the Great Lakes Region

The climate of cities throughout the Great Lakes region is already changing. Rising temperatures are leading to more storm activity in the atmosphere, helping to fuel extreme weather and increased precipitation. While heat, drought, and other changes associated with climate change remain a concern for the future, many areas of the region are already facing challenges associated with more total precipitation and more frequent downpours.

Temperature

Average annual temperatures in the Great Lakes region have increased by 2.3°F since 1951, faster than the global and national rates. Most of this warming has been observed during the late spring and early winter, and in overnight low temperatures. The average temperature for the Great Lakes region is projected to increase in the future (3°F to 6°F by 2050),[60] and many of the northern parts of the region will likely experience the most change. The region is projected to see increases in the number of hot and very hot days by the end of the 21st century, with projections indicating the region will see 36 to 71 more days over 90°F in an average year compared to the late 20th century.[61]

Precipitation

The Great Lakes region has experienced changes in the frequency, amount, and form of precipitation. Total precipitation has increased by 14% since 1951 across the region, though this change varies within the region. Therefore, more local data should be used where available. In addition, heavy precipitation (over 1.25" of rainfall in 24hrs) has increased rapidly throughout the region. The amount of rain falling in the most extreme events (heaviest 1% of storms) has increased by 35% and these events have generally become more frequent since 1951. Much of the region is projected to experience more average annual precipitation with total amounts ranging from an additional 2 to 6 inches per year by the end of the 21st century. In addition, the Great Lakes themselves are projected to contribute more water vapor to the air. This increase in moisture combined with rising temperatures, which are necessary for storm formation, will likely produce more intense storms in the future.[62]

Climate change will likely accelerate in the future.

The observed trends in temperature, precipitation, and seasonality are projected to continue or accelerate into the future. The rate of warming has been fastest during the winter, with some locations experiencing twice the annual warming rate of the Great Lakes region. Temperatures will continue to warm at a pace near or faster than the current rate, and precipitation will likely continue to increase, though variability and multi-year dry periods should still be anticipated. By mid-century, summer and spring temperatures may have greater increases compared to fall and winter.

Preparing for the next normal, not a new normal.

The climate system is dynamic and will continue to change rapidly due to greenhouse gas emissions and inherent feedback systems. The challenges, priorities, and risks of the current or next generation climate will continually change and will affect all sectors. Importantly, climate and weather conditions will not change to a new set of static conditions. This means long-term planning efforts

in all departments should regularly evaluate climate and be as flexible and adaptable as possible. Assessing the vulnerabilities of a city's assets is the first step toward this goal.

The following table summarizes how various climate risk factors in the Great Lakes region are expected to change in the future. The number and direction of arrows indicate the relative projected trend for mid-century and end of century. A single arrow indicates a projected moderate increase or decrease by mid-century, and two arrows indicate a substantial increase or decrease by end of century.

Table 2: Climate Change in the Great Lakes Region

Risk	By Mid Century	By End of Century	Summary
Convective Weather (Severe Winds, Lightning, Tornadoes, Hail)	**Uncertain***	**Uncertain***	While extreme precipitation has increased in the region, specific severe weather types (e.g., tornadoes and hail) have remained relatively stable over time.
Severe Winter Weather (Ice/Sleet Storms, Snow Storms)	**Uncertain***	⌄	Warmer, shorter winters will reduce the length of winter and winter-related impacts. However, some areas may see more ice, sleet, freezing rain, and wet snow with slightly warmer winter temperatures.
Extreme Heat	⌃	⌃⌃	The number of extremely hot days, those over 95°F and 100°F, will likely increase, though not as fast as in areas farther south. Overnight lows have warmed faster than daytime highs, which may lessen opportunities for relief during heat waves.
Extreme Cold	⌄	⌄⌄	The number of extremely cold days (i.e., days below 10oF) have decreased in the region and are projected to decrease even more in the future.
Dam Failures	⌃	⌃⌃	Stronger and more extreme precipitation events coupled with aging dam infrastructure will increase the probability of dam failure, if appropriate measures are not taken.
Flood Hazards	⌃	⌃⌃	Stronger and more extreme precipitation events will be more likely to overwhelm stormwater infrastructure without appropriate adaptation efforts.
Wildfires	**Uncertain***	⌃	Summer drought and the number of consecutive dry days may increase in the future, despite more precipitation annually, increasing the risk of wildfires.
Drought	**Uncertain***	⌃	Summer drought and the number of consecutive dry days may increase in the future.
Infestation	⌃	⌃	With shorter winters and longer growing seasons, conditions may become more suitable for invasive species and pests currently found elsewhere and distribute vector-borne illnesses.

**Boxes labeled uncertain reflect either a lack of available data to discern a trend or no apparent trend from existing data.*

The arrows in this table reflect a qualitative assessment made by the Great Lakes Integrated Sciences and Assessments (GLISA) project team based on the best available data for the Great Lakes region. While these trends hold true for projections for most of the region, they should not be assumed to hold true for any particular location. Data used to make this assessment is provided by the NOAA Technical Report NESDIS 142-3 and the Third National Climate Assessment.

B. Goshen City Summary

Goshen City Summary

- Average air temperature in Goshen has increased by 1.4°F.
- Average air temperature is projected to rise 3°F to 5°F by the mid-21st century.
- Total annual precipitation has increased by 10.1%.
- The total volume of rainfall in extreme events (heaviest 1% of storms) has increased by 16%.
- 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).

The following is a summary of historic as well as projected changes in climate specific to Goshen. This information is valuable in helping understand what changes Goshen has already experienced as well as what changes might be anticipated.

Please note, the projected changes columns are based on data from a "business as usual" emissions scenario, which assumes nothing is done to reduce current rates of greenhouse gas emissions growth. Information on the model used in these projections can be found in the "About the Data" section. The Indiana Climate Change Impacts Assessment is another excellent source of climate projection information for this region. Footnotes throughout this section reference additional information from that assessment.

Table 3: Historic and Projected Changes in Climate for the City of Goshen

	Historic (1981-2010)	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	50.2°F	53 to 55°F	55 to 60°F	3 to 5°F / 5 to 10°F	6 to 10% / 10 to 20%
Winter	27.3°F	29 to 32°F	32 to 36°F	2 to 5°F / 5 to 9°F	6 to 17% / 17 to 32%
Spring	48.9°F	51 to 55°F	54 to 60°F	2 to 6°F / 5 to 11°F	4 to 12% / 10 to 23%
Summer	71.4°F	76 to 78°F	79 to 84°F	5 to 7°F / 8 to 13°F	6 to 9% / 11 to 18%
Fall	52.5°F	55 to 59°F	57 to 65°F	2 to 6°F / 4 to 12°F	5 to 12% / 9 to 24%
Average Low Temperature	41.1°F	44 to 46°F	47 to 51°F	3 to 5°F / 6 to 10°F	7 to 12% / 14 to 24%
Average High Temperature	59.2°F	62 to 65°F	64 to 69°F	3 to 6°F / 5 to 10°F	5 to 10% / 8 to 17%
Days/Year Greater than 90°F	9.9 days	27 to 47 days	46 to 81 days	17 to 37 days / 36 to 71 days	173 to 375% / 365 to 718%
Days/Year Greater than 95°F	1.7 days	7 to 16 days	Not Available	5 to 14 days / Not Available	312 to 841% / Not Available

Table 3: Historic and Projected Changes in Climate for the City of Goshen					
	Historic (1981-2010)	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	116.5 days	91 to 95 days	Not Available	-26 to -22 days / Not Available	-22% to -18% / Not Available
Total Annual Precipitation	38 in.	38 to 42 in.	40 to 46 in.	0 to 4 in. / 2 to 8 in.	0 to 11% / 5 to 21%
Winter	6.8 in.	7 to 9 in.	5 to 10 in.	0 to 2 in. / -2 to 3 in.	3 to 32% / -26 to 47%
Spring	9.5 in.	10 to 13 in.	10 to 14 in.	0 to 3 in. / 0 to 4 in.	5 to 37% / 5 to 47%
Summer	11.6 in.	11 to 13 in.	10 to 14 in.	-1 to 1 in. / -2 to 2 in.	-5 to 12% / -14 to 21%
Fall	10.1 in.	9 to 11 in.	10 to 12 in.	-1 to 1 in. / 0 to 2 in.	-11 to 9% / -1 to 19%
Heavy Precipitation Days	4.5 days (> 1.25")	4.9 to 6.6 days	6.1 to 7.6 days	0.4 to 2.1 days / 1.6 to 3.1 days (> 1")	9 to 47% / 36 to 69%

*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."

Temperature and Hot/Cold Extremes

Average Temperature

The average air temperature in Goshen has increased by 1.4°F from 1951 to 2017, with the current annual average temperature being 50.2°F. Average seasonal temperatures have also increased, with spring experiencing the greatest increase of 2.4°F. Average temperatures in Goshen are projected to increase 3.0 to 5.0°F by mid-century under a business as usual (i.e., high emissions) scenario, with summer having the greatest increases of 5.0 to 7.0°F.

Hot Days

Days with temperatures at or above 90°F are common with multiple occurrences in most years and a slight decreasing trend over time. Many years on record have experienced 2 to 6 consecutive days over 90°F, with events of 7 to 15 consecutive days occurring less frequently. By mid-century (i.e., 2050), models suggest an increase of anywhere from 17 to 37 more days per year over 90°F and an increase of 36 to 71 more days per year over 90°F by end of the century. Models are not able, however, to consider if those days will be consecutive or not.

Days with high temperatures at or above 95°F have been much rarer, with few occurrences of more than one consecutive day experiencing maximum temperatures over 95°F in the last 40 years. By mid-century (i.e., 2050), models suggest an increase of 5 to 14 days over 95°F.[63] However, such hot days will not necessarily occur consecutively.

Heat waves can result from a combination of different drivers including high humidity, daily high temperatures, high nighttime temperatures, stagnant air movement, and etc. In the future, models project an increase in the number of days experiencing high temperatures that could lead to additional heat waves, especially since air stagnation events are projected to increase. There is greater certainty that summer nighttime low temperatures will continue to increase, thereby making it more difficult

to cool off at night during extended heat events. In addition, any periods of future drought will also contribute to extreme heat.

Cold Days

On average, Goshen experiences 116.5 days per year that fall below freezing (32°F). Historical records show this number has increased slightly. The city is projected to experience fewer nights below 32°F, with decreases of 22 to 26 days by mid-century.[64]

Days with temperatures at or below 10°F are very common and have not experienced any clear trends over time. Consecutive days at or below 10°F are also frequent and typically last for 2 to 6 days with less frequent occurrences lasting 7 to 14 days. In the future, there are projected to be fewer very cold days, so this type of event will be rarer.

Precipitation and Flood/Drought Indicators

Average Precipitation

The amount of total annual precipitation in Goshen has increased by 10.1% (3.9") from 1951 to 2017.[65] An increase in precipitation was observed in all four seasons, with the fall seeing the greatest percentage increase of 18% (1.7"). Average annual precipitation in Goshen is projected to increase by up to 4 inches by mid-century and by up to 8 inches by the end of century.

Heavy Precipitation

The frequency and intensity of severe storms have increased historically, with a 9% increase in the number of extreme precipitation events (heaviest 1% of storms) and a 16% increase in the total volume of rainfall during these events between 1981-2010. Goshen is projected to experience an increase of up to 2.1 days of heavy precipitation (days with over 1" of rainfall) per year by mid-century and by up to 3.1 days per year by end of century.

Flooding results when rainfall volumes exceed the capacity of natural and built infrastructure to handle precipitation. Stormwater managers look at several different "design" storms (inches falling over a certain length of time) when designing and managing their systems. These "design" storms are effectively the probability of any given amount of precipitation falling in a set period of time, based on historical experience. Monitoring over time shows that the volumes falling during these "design" storms are increasing. What this means is that the values used to build existing infrastructure (Bulletin 71 (Huff and Angel, 1992), used data through 1986, and Atlas 14 (NOAA HDSC) added a longer period of data into the 21st century) are dependent on fluctuating estimates of rainfall.

The table below helps illustrate this point by showing precipitation volumes in inches for both Bulletin 71 and Atlas 14 (Bulletin 71/Atlas 14) along with percent change between the two in brackets. This data shows how the "design" storm has changed over time.

This table only shows precipitation frequencies based on historic observations, and demonstrates how they have already changed, thus it does not show projections for how the "design" storm may change in the future due to climate change.

Table 4: Precipitation Frequencies for the City of Goshen

	1-Yr	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
1-hr	1.11 in. / 1.09 in. [-1.8%]	1.31 in. / 1.33 in. [1.5%]	1.61 in. / 1.68 in. [4.3%]	1.88 in. / 1.95 in. [3.7%]	2.30 in. / 2.31 in. [0.4%]	2.66 in. / 2.59 in. [-2.6%]	3.07 in. / 2.89 in. [-5.9%]
12-hr	2.05 in. / 1.88 in. [-8.3%]	2.42 in. / 2.27 in. [-6.2%]	2.98 in. / 2.85 in. [-4.4%]	3.48 in. / 3.34 in. [-4.0%]	4.26 in. / 4.03 in. [-5.4%]	4.93 in. / 4.60 in. [-6.7%]	5.69 in. / 5.22 in. [-8.3%]
24-hr	2.36 in. / 2.18 in. [-7.6%]	2.78 in. / 2.63 in. [-5.4%]	3.43 in. / 3.27 in. [-4.7%]	4.00 in. / 3.79 in. [-5.3%]	4.90 in. / 4.53 in. [-7.6%]	5.67 in. / 5.12 in. [-9.7%]	6.54 in. / 5.75 in. [2-12.1%]

In the Great Lakes region, projected changes in seasonal mean precipitation span a range of increases and decreases. In the winter and spring, the region is projected to experience wetter conditions as the global climate warms. By mid-century, some of this precipitation may manifest in the form of increasing snowfall, but projected warmer conditions by end of century suggests such precipitation events will most likely be in the form of rainfall (Wuebbles et al. / USGCRP, 2017).

Precipitation events of more than 2" of rain in a day (i.e., 24-hour period) are projected to increase (on average) less than one day per year by mid-century and up to about 2 days per year by the end of century. Precipitation events of more than 3" of rain in a day are projected to increase (on average) by less than a day per year by both mid-century and by end of century. These projected changes are calculated in comparison to the average number of days with 2" and 3" of rainfall per year in the historical reference period (1980-1999).

Annual snowfall totals have been variable, with a strong increasing trend in the last 40 years. There has been an increasing trend in days with snowfall (over 0.1" of snowfall in 24 hrs), with varying year-to-year conditions. Warmer temperatures in the future will cause some winter precipitation to transition from snow to rain over time. The projected change in annual snowfall is variable. Annual snowfall is projected to decrease by 3" to 11" by mid-century, with decreases of 9" to 17" by end of century.

Figure 15: A rain gauge is a helpful tool to have at home or on a construction site.

Rain Free Periods (3-week events with less than 0.5" of rain)

Drought, defined here as periods of 3 weeks with less than 0.5" of rainfall, has been highly variable year-to-year, with an overall decreasing trend. In the future, even though more annual precipitation is projected overall, more is anticipated to fall in shorter, extreme events. Thus, there will be longer periods of time that experience no rainfall, increasing the potential for drought.

The following section looks at local landscape features that influence exposure and overall vulnerability to climate change in Goshen.

About the Climate Change in the Great Lakes Region and Goshen Data

Coupled Model Intercomparison Project (CMIP) Version 3. The future (mid-century) climate projections for Goshen are based on the Coupled Model Intercomparison Project Version 3 (CMIP3) A2 emissions scenario, representing "business as usual" high emissions scenario. These data were selected because they were used in the Third National Climate Assessment (Melillo et. al., 2014). More information is available at: https://www.wcrp-climate.org/wgcm-cmip

"Dynamical Downscaling for the Midwest and Great Lakes Basin." Future projections are based on the dynamically downscaled data set for the Great Lakes region developed by experts at the University of Wisconsin-Madison. There are a total of six downscaled models that represent how a variety of different variables are projected to change (mid-century, 2040-2059, compared to the recent past, 1980-1999). The ranges are comprised of the lowest and highest values from all six dynamically downscaled data sets. The regional data are available for download at: http://nelson.wisc.edu/ccr/resources/dynamical-downscaling/index.php.

National Oceanic and Atmospheric Administration National Centers for Environmental Information Global Historical Climatology Network Station Observations (GHCN). More information about this station located in South Bend, IN from 1981-2010 is available at: https://glisa.umich.edu/station/c00200230

"National Oceanic and Atmospheric Administration ThreadEx Long-Term Station Extremes for America". ThreadEx is a data set of extreme daily temperature and precipitation values for 270 locations in the United States. For each day of the year at each station, ThreadEx provides the top 3 record high and low daily maximum temperatures, the top 3 record high and low daily minimum temperatures, the top 3 daily precipitation totals, along with the years the records were set for the date (NCAR, 2013). ThreadEx data for the South Bend area from 1966 to 2016: http://threadex.rcc-acis.org/

National Oceanic and Atmospheric Administration Hydrometeorological Design Studies Center Atlas 14 Precipitation Frequency Estimates. Data are available at: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

Note: This section was assembled by the Great Lakes Integrated Sciences and Assessments—a collaboration between the University of Michigan and Michigan State University and supported by the National Oceanic and Atmospheric Administration (NOAA). An excellent source of additional localized climate data not used for the assessment, but referenced in footnotes, can be found in the Indiana Climate Change Impacts Assessment produced by the Purdue Climate Change Research Center (https://ag.purdue.edu/indianaclimate/).

4. LANDSCAPE FEATURES THAT AFFECT GOSHEN'S STORMWATER SYSTEM VULNERABILITY

Summary

- Natural landscape features such as the location and extent of predicted floodplains, elevation, slope, and landscape cover all influence that areas of Goshen that may be most vulnerable to flooding. Characteristics of the built infrastructure such as the conditions of stormwater assets and locations of critical infrastructure are additional factors that influence the community's overall vulnerability to flood events.
- By combining the aforementioned factors, a holistic assessment of where in Goshen local landscape features impact the community's vulnerability to flooding was generated. Results showed that areas with high percentages of impervious surfaces and low percentages of vegetative cover—developed areas—within the floodplain are of particular concern. The overall landscape directs water to these low-lying areas along waterways and, in some cases, natural vegetation and stormwater infrastructure are not sufficient to slow down, spread out, and soak in stormwater. This has occurred already during past major flood events and is likely to continue into the future.
- Impervious surfaces and vegetation coverage that influence flood vulnerability also reflect vulnerability to heat impacts and urban heat island affects.
- By combining insights into impervious surfaces and vegetative coverage, an assessment of where in Goshen local landscape features may affect vulnerability to heat was completed. Results showed that areas with large amounts of pavement and little tree canopy already experience hotter temperatures and create urban heat island effects. These areas are, and will be, more prone to thermal pollution in stormwater runoff, which could have a negative impact on the water quality in the Elkhart River and other waterways.

In addition to socio-economic composition and projected changes in climate, certain features related to the way Goshen is designed and its physical characteristics make areas more or less vulnerable to climate change. This section explores a number of these landscape characteristics or features that affect the vulnerability of residents and infrastructure to climate impacts. The section looks specifically at local vulnerability to flooding because this is one of the largest climate impacts expected to worsen in a climate-altered future.

Landscape Features that Affect the Stormwater System and Flooding Exposure

Flooding is one of the most common and pervasive climatological impacts to affect the City of Goshen. Nearly every year Goshen experiences some kind of localized flood event. These events can cause property damage, road closures, economic disruptions, and other issues. Larger events have far reaching implications for the local economy, transportation systems, and health and safety. Nationally, flood deaths are highest in adults over the age of 50 (although 20- to 30-year-olds also have a fairly high vulnerability to flooding-related deaths and injuries).[66] Males are notably more vulnerable to flooding-related deaths, particularly those tied to flash flooding events.[67]

Because of the acute vulnerability in Goshen, it is important to understand what local landscape features enhance or reduce local stormwater system vulnerability as well as local vulnerability to flooding. The following factors are important elements of understanding these vulnerabilities:

a) Elevation

b) Slope

c) Location of Floodplains

d) Soil Drainage Capacities

e) Stormwater Infrastructure

f) Land Cover (vegetation and impervious cover)

g) Other

a) Elevation

Approximately 13,600 years ago, melting and retreating glaciers formed the landscape in and around Goshen. As the glaciers retreated they deposited clay, silt, sand, gravel, and boulders forming the hilly regions surrounding the present-day City of Goshen. In contrast, the deposition of sediment on the outwash plain (floodplain) of a glacial river, now occupied by the Elkhart River, formed the flatter areas within City limits where most development has occurred.

Understanding the elevation of various areas of Goshen helps point to areas that might be more prone to future flooding and, therefore, where there may be greater stormwater-related challenges. Recognizing this, LiDAR data was used to map the elevation above sea level for the entire city. In Figure 16, elevation change is denoted by color change with blues indicating the lowest elevations and reds and browns indicating higher elevations. There is a 111-foot elevation change within the City of Goshen with the highest elevation of 874 feet located on the north side of the city and the lowest elevation of 763 feet located in the Elkhart River on the northwest corner of the city. Water flows towards the City of Goshen from all directions except the northwest as the overall topography flows in that direction. The City developed in the lower lying areas between hilly regions and there is relatively little elevation change within city limits. The mean elevation is around 805 feet.

b) Slope

Slope is the degree of incline or tilt that exists between two points. An understanding of slope can help determine which areas might be particularly susceptible to runoff and erosion from major rain events. Using a Digital Elevation Model raster image from the United States

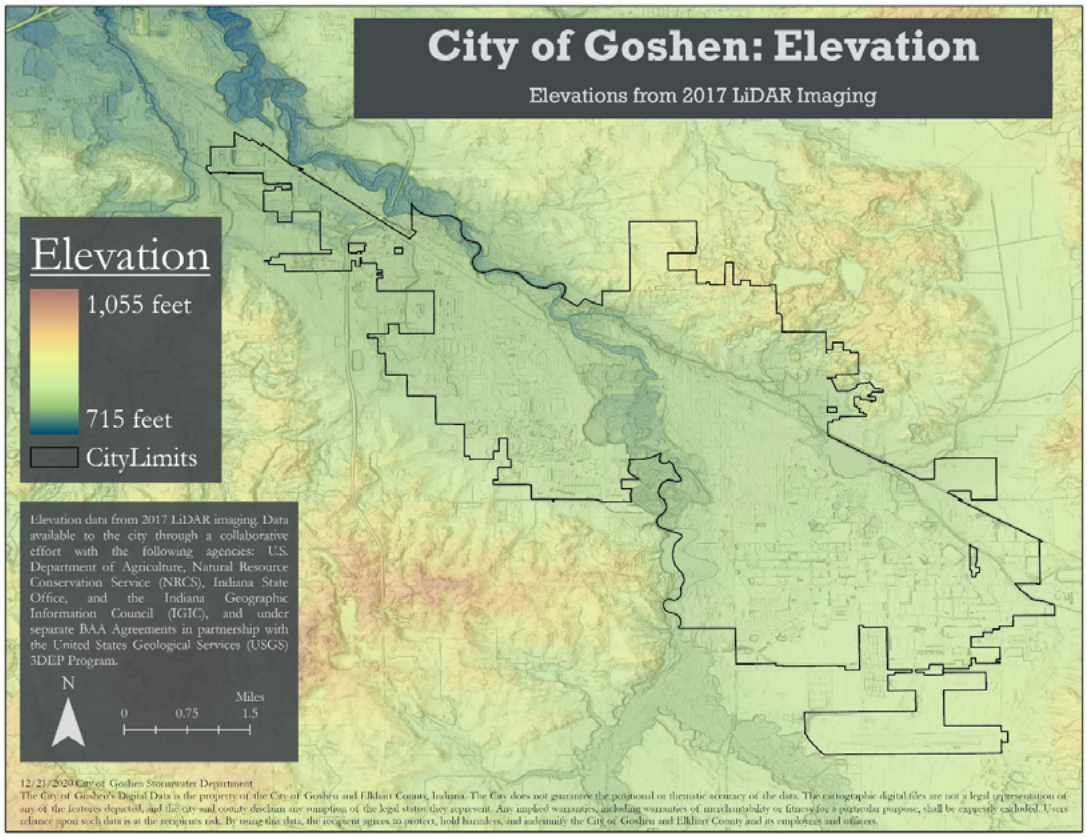


Figure 16: The changing elevations in and around the City of Goshen are shown here with elevations derived from 2017 LiDAR imaging.

Geological Survey (USGS), slopes across the city were mapped.

As shown in Figure 17, there are relatively few places within city limits with dramatic (high percentage) slopes. Note that the classifications all show relatively small ranges of percent values, but the final category encompasses all slopes ranging from 12% to the steepest value of 75%. The relatively gradual inclines of slopes in Goshen helps in reducing stormwater volumes and speeds.

The dominant characteristics within City limits show how Goshen is comparatively low lying and flat compared to the surrounding hilly regions meaning additional stormwater runoff flows into the City from surrounding areas. Looking at slopes in Figure 17 alongside the elevation map in Figure 16, readers may note relatively few dramatic elevation changes within City limits; however, steeper slopes and higher elevations in the surrounding hills mean large volumes of water flow towards Goshen. The edge regions of the City at the toe of slopes receive faster moving water that then moves through the gentler slopes found in the rest of the City on its way to waterways. Stormwater runoff eventually exits the City via the Elkhart River on its northwest path towards the City of Elkhart.

c) Location of Floodplains

Because certain areas of Goshen are already susceptible to flooding, the 1% annual chance (100-year) and 0.2% annual chance (500-year) floodplains were used as a baseline indicator of future flooding risk. Using the most recent (2011) flood insurance rate map (FIRM) data from the Federal Emergency Management Agency (FEMA), areas of Goshen were identified that lie within several "flood zones" including the floodway and both the 1% and 0.2% annual chance predicted floodplains.[68]

It is now understood that climate change is altering the frequencies of flood events, making the percent likelihood of flooding in any given year significantly greater. As such, using both the 1% and 0.2% annual chance floodplains helps represent the current and likely future flood risks. Someday, today's 0.2% chance floodplain may occur with a frequency closer to 1% annually. In addition to identifying locations vulnerable to flooding, floodplains call attention to where additional demand may be placed on the stormwater system—thereby providing insight into where additional stormwater-related solutions may be needed.

Figures 18 and 19 zoom into Southeast and Northwest Goshen respectively to show a greater degree of detail.

A few definitions to aid in understanding Flood Zone Classifications:

A. Base flood – The base flood refers to the 1% annual chance flood, commonly referred to as the 100-year flood. The elevation of floodwaters at the base flood helps to understand the extent of floodways and floodplains.

B. Floodway – The floodway refers to the channel of a river and the adjacent land area that can accommodate a determined base flood. In other words, the floodway is the area where water will run deepest and fastest during a 1% annual chance flood. This area is more highly regulated than other parts of the floodplain. In Indiana, no development can occur in the floodway without approval from the Indiana Department of Natural Resources.

C. 1% Annual Chance Floodplain – The 1% annual chance floodplain refers to the entire extent of floodwaters during a 1% annual chance base flood event. This includes the floodway and the area beyond the floodway where waters are shallower and slower during a base flood event (also called the "flood fringe"). Development in this area is more highly regulated for floodproofing measures and other aspects than the rest of the City.

D. 0.2% Annual Chance Floodplain – The 0.2% annual chance floodplain refers to the extent of floodwaters during a 0.2% annual chance flood. In Goshen, this area is currently not considered part of the regulatory floodplain and does not have flood-based development restrictions.

Comparing Figures 18 and 19 to the elevation map in Figure 16, the floodplains coincide with the lower elevations on the LiDAR map. The city limits of Goshen cover 11,487 acres or 17.95 square miles. Of this land area, approximately 0.57 square miles (3.2% of Goshen's total land area) is covered by open water, with an additional 1.87 square miles (10.4% of total) within FEMA's floodway 1% annual chance and 0.2% annual chance floodplain extent.

FEMA's 2011 flood zone classifications mapped above serve as a base point for predicting flood boundaries, but during flooding in 2018, Goshen saw that these predictions do not always reflect on the ground realities. After receiving over 5 ½ inches of rainfall in two days, the Elkhart River rose to 12.53 feet—6.53 feet above the flood

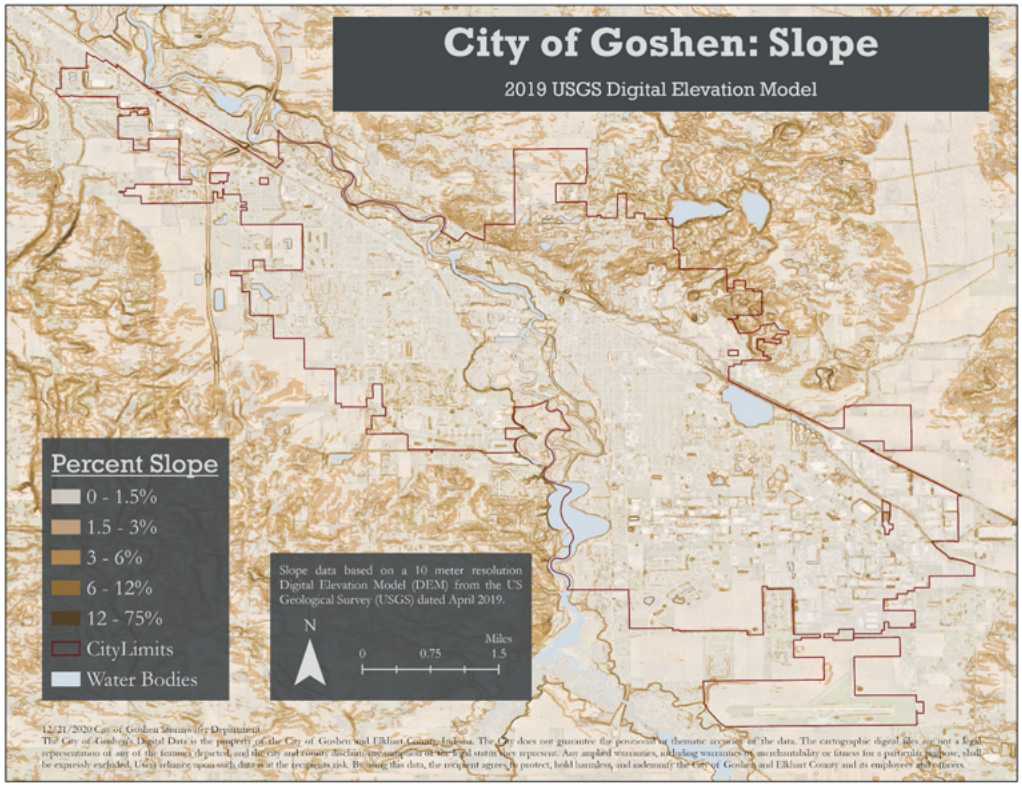


Figure 17: Slope percentages in the City of Goshen generated from a USGS 10-meter resolution Digital Elevation Model raster.

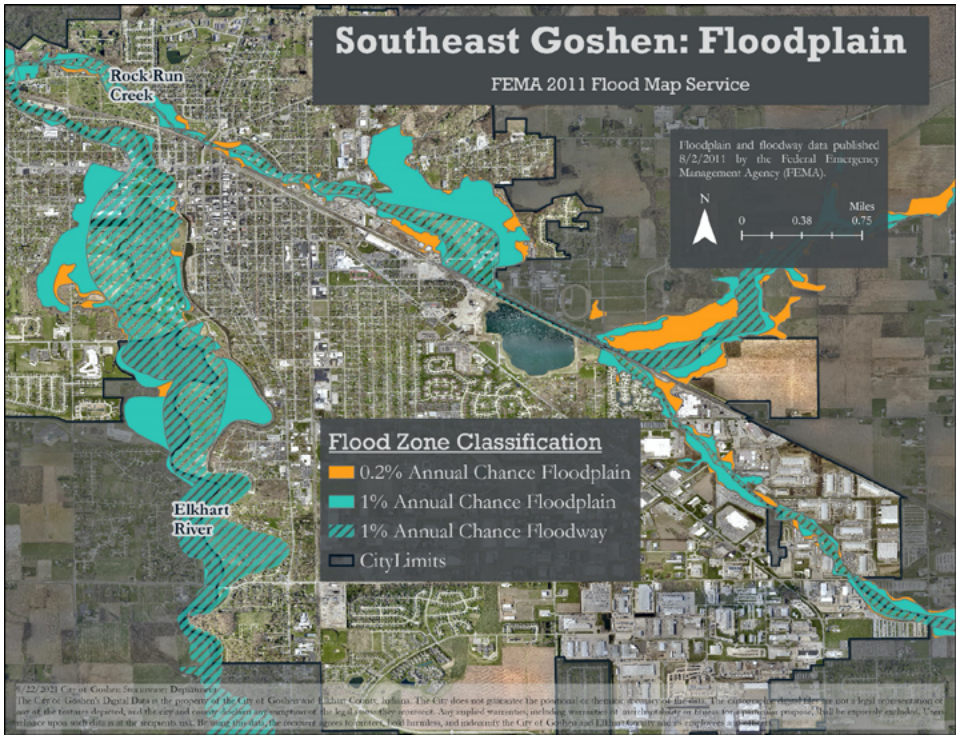


Figure 18: There are several waterways flowing through the City of Goshen with identified floodplains: the Elkhart River, Rock Run Creek, and Horn Ditch. The above map shows flood zone boundaries for parts of all three.

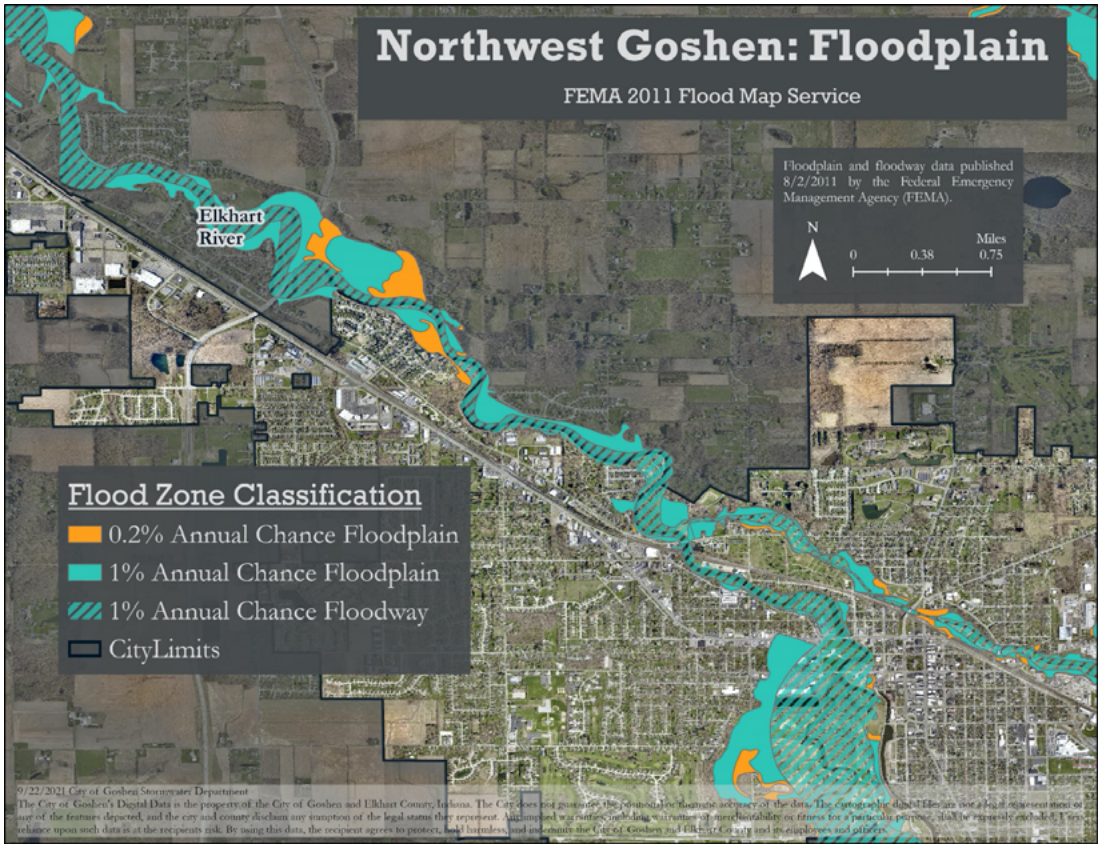


Figure 19: This map shows the floodplains of northwest Goshen focusing on the Elkhart River. Near the bottom right-hand corner of the map, the confluence of Rock Run Creek with the Elkhart River is visible.

Figure 20: An aerial drone image of the flooded commercial and residential areas along Pike Street and Lincoln Avenue during the February 2018 Flood (photo credit: Andrew Kauffman).

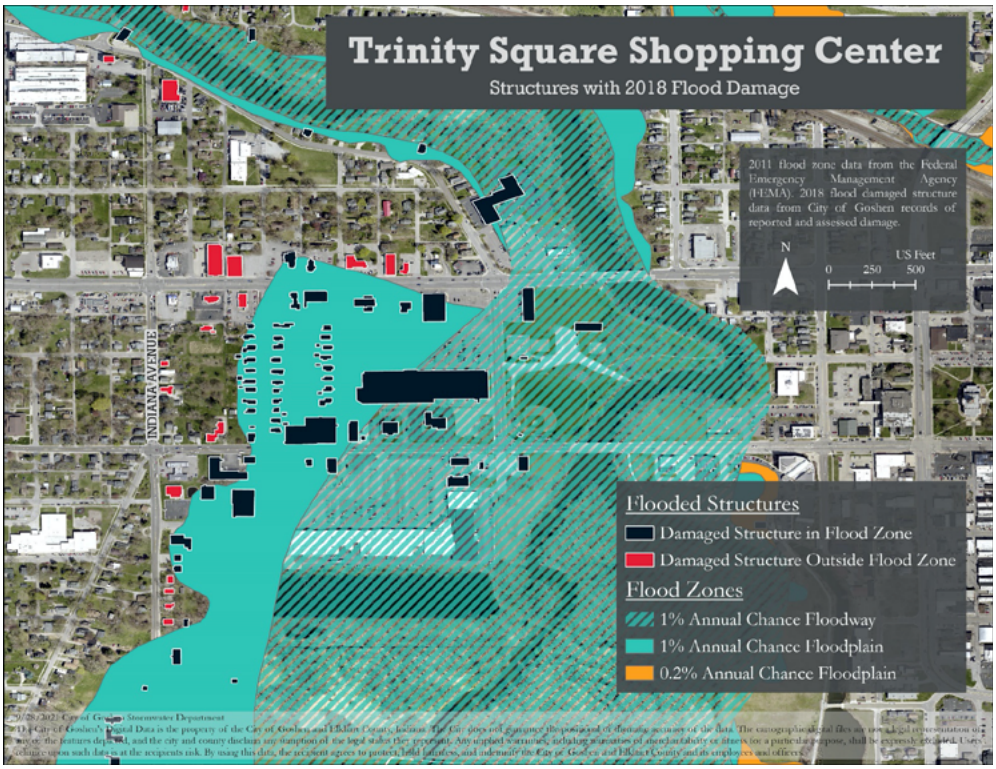


Figure 21: Structures with assessed 2018 flood damage in and surrounding Trinity Square Shopping Center.

Figure 22: Structures with assessed 2018 flood damage along Wilden Avenue southeast of where Rock Run Creek empties into the Elkhart River.

"action" stage. This constituted the largest flood event in the recorded history of the City of Goshen. City staff scrambled to document as much as they could of the floodwaters' extent and the damage caused. These efforts now provide a fuller picture of flood hazards in Goshen and allow City staff to more easily identify vulnerable infrastructure. While at the same time some areas of FEMA's predicted floodplain stayed dry, the documented extent of 2018 flooding in other areas stretched much further than predicted by FEMA's 2011 flood zone maps. Figures 21 and 22 highlight two areas where significant flood damage occurred to structures that were not within FEMA's flood zones. These are not the only areas in Goshen where flood damages occurred during the 2018 event, but they serve to illustrate the continued unpredictability of flooding in the City.

As shown in Figures 21 and 22, businesses, homes, and city facilities near Trinity Square Shopping Center and along Wilden Avenue (where Rock Run Creek empties into the Elkhart River) experienced significant impacts from flooding whether they were located within the predicted floodplain or not. Some of the damages sustained were caused by saturation that allowed groundwater to surcharge through basement walls, but many other damages were a direct result of riverine flooding.

The 2018 flood revealed the need and urgency for up-to-date floodplain maps based on the realities of what Goshen experienced and what is possible as it moves into a future with greater flood uncertainty due to climate change. FEMA is currently working to create updated floodplain maps for the entire St. Joseph Watershed—including the Elkhart River and its tributaries. The draft maps look at previously un-studied smaller tributaries like Leedy Ditch here in Goshen and make updates to other areas based on more current engineering methodologies. There have also been many updates communicated since 2011 by the Indiana Department of Natural Resources (IDNR) about the risks associated with individual properties which are not reflected in the more generalized data set used for these maps. Updated maps will help homeowners, businesses, and cities better prepare for the next major flood.

d) Soil Drainage Capacities

The elevation, slope, and flood zone maps help explain how large volumes of stormwater may arrive and collect in Goshen, but what factors affect how quickly floodwaters recede? Another important landscape feature that affects flooding is the ability of water to infiltrate soils in place. Not all soils possess the same capacity to infiltrate water, with clay-heavy soils holding water and sandier soils draining quickly. Understanding the City's soil profile aids in knowing how quickly stormwater may recede during a flood event. To map drainage capacities of areas in Goshen, soil class data was used from the Natural Resources Conservation Service (NRCS)—an agency of the US Department of Agriculture (USDA).[69] Keep in mind that as part of the USDA, the soil survey focuses on agricultural lands with fewer data points assessed in urban areas like Goshen; thus, the NRCS survey only offers a starting point for understanding the area. This National Cooperative Soil Survey includes classifications of soil drainage capacities based on soil profiles. Figure 23 highlights the mapped drainage classes.

The drainage classification map in Figure 23 illustrates the high drainage capacity of the vast majority of lands within city limits. The majority of land in Goshen is classified as "well-drained" with poorly draining soils largely outside or along the edges of city limits. Soils outside city limits remain important, however, because previous analysis of slope and elevation showed how water runs into the city from these outlying areas.

The second-largest drainage class in Goshen are those areas where stormwater infiltration is negligible or not expected to drain at all. The cross-hatched areas in Figure 23 represent ponds or other open water and highly urbanized areas with impervious surfaces that prevent stormwater from infiltrating. Thus, these areas, along with the categories of "very poorly drained" and "poorly drained," need special attention when considering flood risk.

e) Stormwater Infrastructure

Land cover types with characteristics that affect flood potential (as well as heat potential) were also analyzed for this assessment. Impervious surfaces and low vegetative cover are indicators of high stormwater runoff potential. When precipitation falls on impervious surfaces, such as roads, streets, sidewalks, and buildings, it is unable to infiltrate into the soil and instead flows into the storm sewer system and directly to waterways. Conversely, the greater portion of vegetation cover present, the more precipitation may infiltrate the soil, and thus, the less precipitation moves through the city as runoff. Because

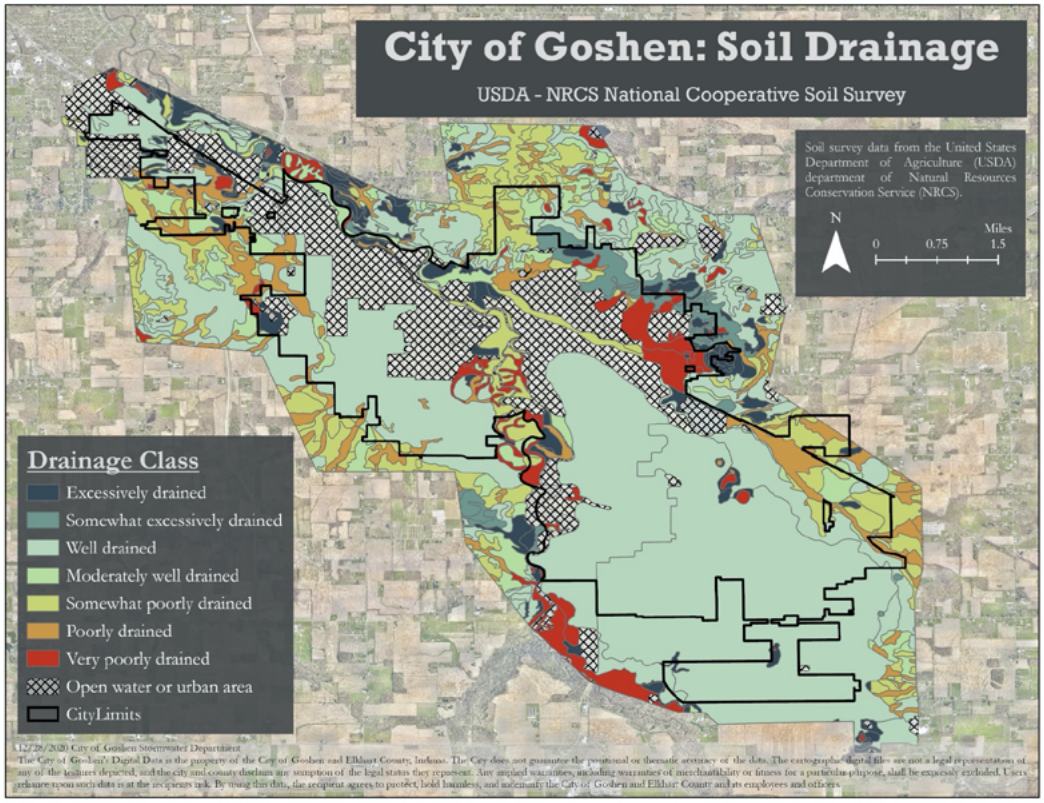


Figure 23: City of Goshen drainage classifications based on the National Cooperative Soil Survey and assembled by the Natural Resources Conservation Services (NRCS).

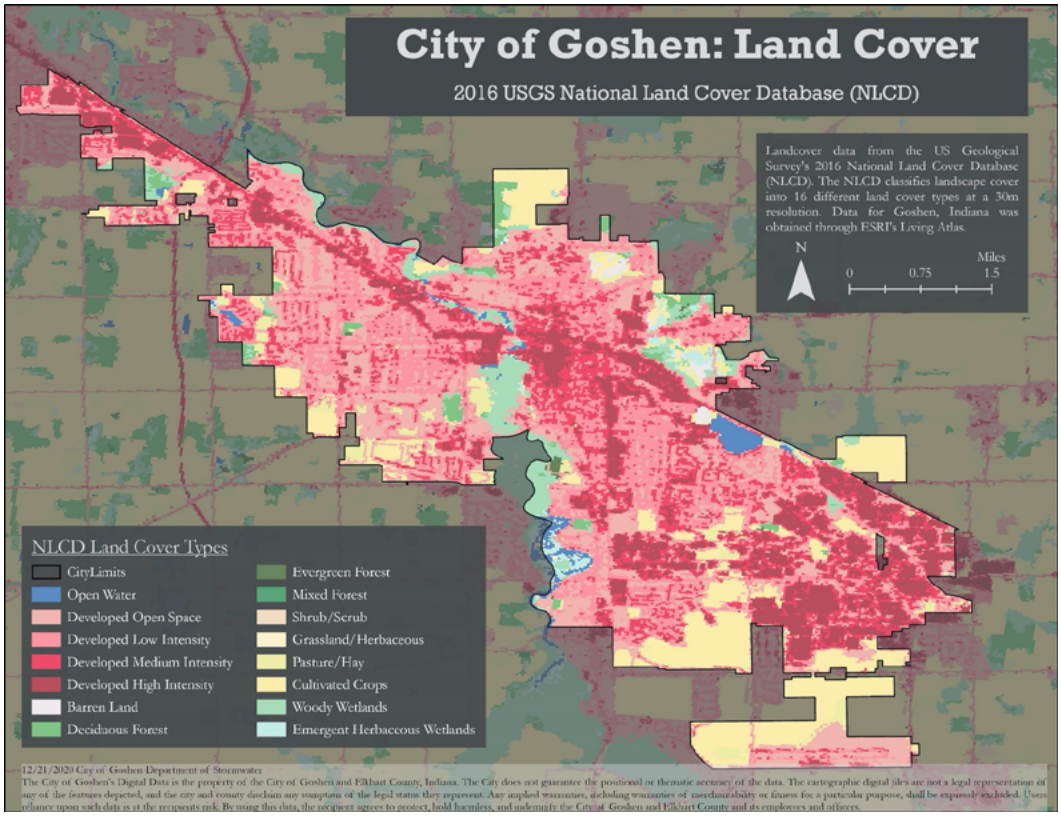


Figure 24: Map of land cover types in the City of Goshen as classified by the USGS's 2016 National Land Cover Database (NLCD).

of this, the City of Goshen has decided to use impervious surface coverage and vegetation coverage as indicators of local landscape vulnerability to flooding.

To analyze green space in comparison to impervious surfaces in Goshen, data from the USGS National Land Cover Database (NLCD) was utilized. This data uses satellite imagery to analyze vegetation type and development intensity at a resolution of 30 meters. The database then characterizes the dominant land cover type into one of 16 different classifications.[70] ESRI's Living Atlas layers were used to obtain NLCD land cover classifications in Goshen and the mapped results can be found in Figure 24.

As shown in Figure 24, the dominant NLCD classifications for Goshen are within the broader category of development intensity which reflects the urban characteristics of Goshen. Notice the high-intensity development along the US 33 corridor running from Dunlap in northwest Goshen to the industrial areas on the southeast edge of city limits. Also clearly visible in Figure 24 is the clustered development along SR 15 running south from near the center of the City.

Encouragingly, Goshen has maintained a major undeveloped greenway along the Elkhart River running through the heart of the City. This region, largely made up of woody wetlands, is an essential natural resource for flood mitigation in Goshen. The natural flood protection properties of trees and other vegetation in this region save the city incalculable amounts of money in flood damage, clean-up, and rebuilding costs. A concerted effort needs to be made to further convert developed areas within the identified floodplains into managed areas free of development.

The urban tree canopy of Goshen is an important element of the City's land cover that cannot be represented in the simplified land cover map. While tree canopy will be discussed in greater depth regarding its important cooling properties, tree canopy also helps slow down, spread out, and soak in stormwater. A tree's leaves help capture and store rainfall while leaf litter and tree roots increase groundwater recharge by creating healthier soils.

The City is working to preserve these vegetative resources which are anticipated to face climate change caused stresses. Climate change may allow invasive plants to gain a stronger foothold in the region, threatening some stormwater controls. For example, phragmites, otherwise known as Common Reed, pose a particular threat to stormwater control measures like stormwater basins and vegetated swales. The aggressive properties of phragmites allow them to proliferate in areas where they reduce the volume capacities of stormwater basins and swales. Increased heat in the region could also leave native vegetation more exposed to stresses such as predatory insects (invasive especially) and blight from bacterial or fungal infestations. In the past, hard winter freezes acted as a check on pests and infection, but warmer winters may disrupt beneficial winter die-offs. Looking to the future, the expanded use of native vegetation should be encouraged while limiting the impact of invasive species.

f) Land Cover (vegetation and impervious cover)

Besides the natural elements of the City of Goshen's landscape, another landscape characteristic affecting vulnerability is that of the built environment. The quality (i.e., age, condition, and capacity) and design of the City's stormwater conveyance system and other infrastructure is an important element that influences flooding potential. Properly functioning stormwater infrastructure can help alleviate unpredictable flooding and protect important infrastructure by conveying water to another location through storm pipes, culverts, and drainage swales or by capturing stormwater in designated storage basins and ponds. If storm pipes or stormwater capture infrastructure were to fail, improper drainage could cause the City's storm infrastructure to exacerbate rather than alleviate flooding.

Well over 123 miles of stormwater pipe—including City, private, County, and State-owned—make up the City of Goshen's documented stormwater sewer. Unfortunately, many private stormwater systems are missing from the documentation. Too many pipes are also missing basic characterization information that provides a window into their condition, like the year built or the material used to construct them. For those pipes with available information, the number of feet of pipe constructed in a given year is graphed in Figure 25. Without the ability to visually inspect some pipes, age serves as an important predictor for a pipe's condition. Figure 25 also categorizes feet of pipe into ownership categories with "public" indicating those storm pipes owned and maintained by the City of Goshen. This allows for analysis of how much infrastructure the City is responsible to maintain.

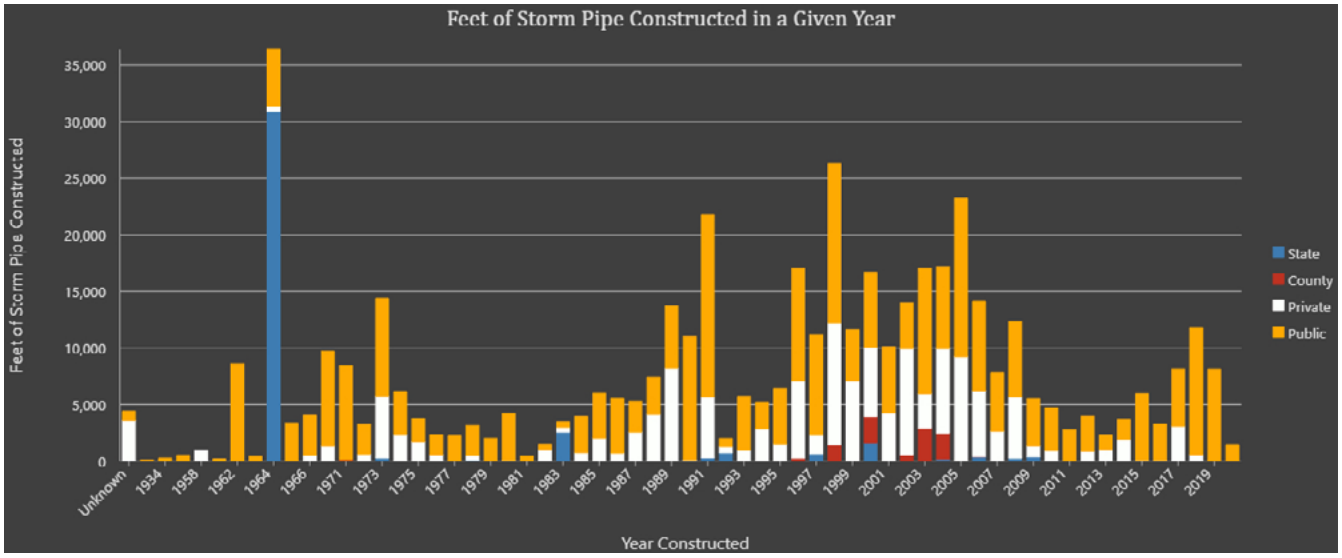


Figure 25: The total feet of storm pipes constructed in a year subdivided by ownership type where "public" means owned by the City of Goshen. Statistics as of January 2021.

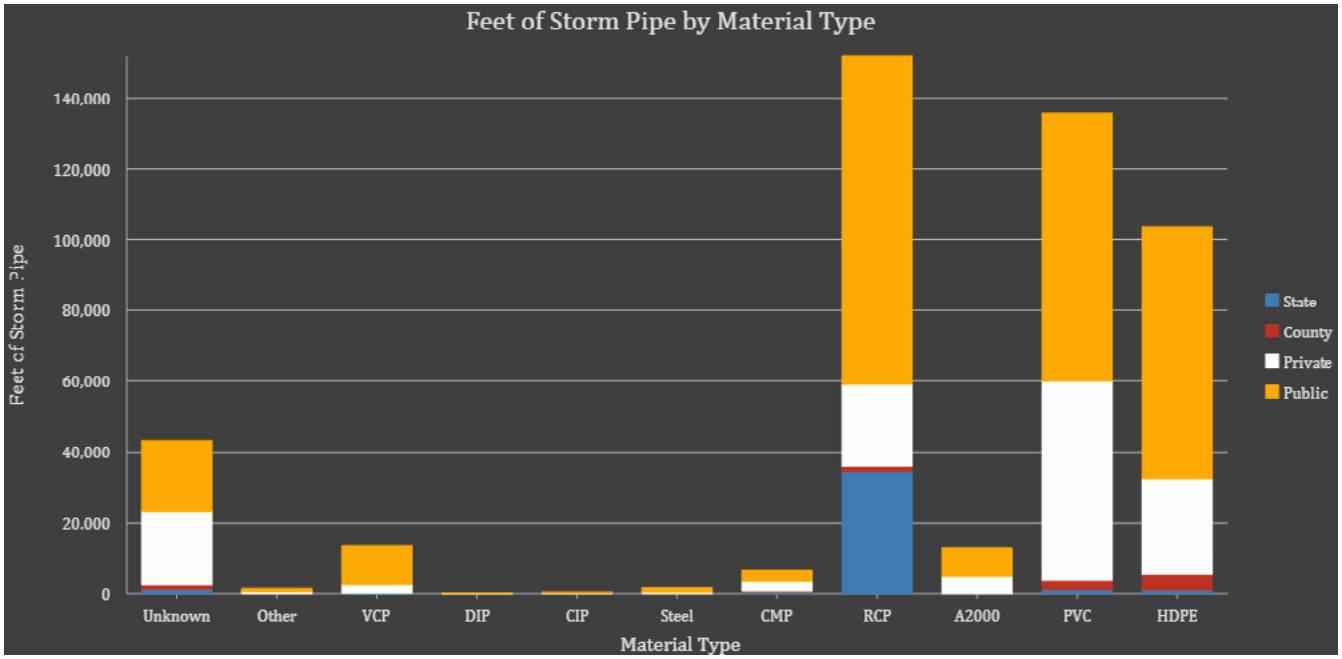


Figure 26: Feet of storm pipe constructed of each material type category classified by ownership type where "public" means owned by the City of Goshen. Abbreviations are as follows: VCP - Vitrified Clay; DIP - Ductile Iron; CIP - Cast Iron; CMP – Corrugated Metal; RCP - Reinforced Concrete; A2000 – a type of PVC; PVC - polyvinyl chloride (plastic); HDPE – high-density polyethylene (plastic). Statistics as of January 2021.

Another important indicator of the condition of the public stormwater infrastructure is the pipe material used as some materials hold up over time better than others. Ever-changing technologies, conditions, and knowledge mean stormwater infrastructure consists of a diverse set of pipe construction materials. Some of these, like vitrified clay pipes (VCPs), are a relic of another era and susceptible to shattering. Metal pipes like ductile iron pipe (DIP), cast iron pipe (CIP), and steel may be damaged by rust. While plastic piping like polyvinyl chloride (PVC) and high-density polyethylene (HDPE) are more commonly used today, they are not without downsides. In some heavily polluted brownfield sites, other materials must be used to avoid the breakdown of plastic materials by chemical contamination. Larger pipes, those over 18 inches, in Goshen are typically constructed of reinforced concrete. Figure 26 shows the breakdown of the City's pipe infrastructure by material type and again classified by ownership.

A number of important storm infrastructure characteristics do not show up in the storm pipe data. For example, the City of Goshen does not yet have the necessary data to conduct a study of stormwater conveyance capacity. This means areas where the system might be undersized for the volume of water flowing through are not easily identified for upgrades and mitigation projects. For many of the older parts of the system, the design standard is unknown or no specific storm event was ever designed for. Currently, the City designs all new and upgraded conveyance systems to handle a 10-year storm event. Major roads where ponding of stormwater constitutes a greater hazard are designed for 25-year events. However, the frequency and intensity of storms are changing due to climate change and estimates of 10 and 25-year storm events based on the historic record may no longer be sufficient.

Even without infrastructure failures, the conveyance system can exacerbate flooding in Goshen's waterways—especially during major storm events. Overland stormwater flows encounter all kinds of objects and barriers that slow down stormwater and reduce its volume by allowing opportunities for infiltration. In contrast, water funneled to waterways through stormwater pipes moves quickly through the system and increases the peak flow in a hydrograph (a graph of changes in the water level of a waterway over a given period of time) and thus contributes to flood events. The solution to pipe systems that are under capacity may not be bigger pipes, but rather greater efforts to capture and slowly release stormwater closer to where it falls—to the benefit of reducing peak stream flows and the expense of infrastructure upgrade projects.

These stormwater capture and controlled release systems are another important factor for flood control. Stormwater ponds, constructed wetlands, infiltration (retention) basins, detention basins (temporarily capture stormwater to settle pollutants and evaporate/infiltrate before conveying on to other infrastructure), and etcetera all must be designed to handle certain rainfall events. Per City standards, these stormwater capture and slow release features must be designed to handle 3-inch, 24-hour rain events. Again, a changing climate means that design standards may no longer be sufficient to appropriately balance risks. Stormwater capture and slow release methods must also be maintained in order to preserve their functionality. For example, tree growth in an infiltration basin will take up space and can potentially reduce the capacity a basin was designed for.

To address knowledge gaps and more effectively prepare for a more intense climate future, the Stormwater Department will participate in more robust asset tracking and management to identify and address vulnerabilities before residents and businesses are impacted. This process starts with more reliable, complete data for the age and condition of the conveyance system as well as an understanding of capacity vulnerabilities throughout the City. This important knowledge can help the City prioritize infrastructure projects and aid in updating standards to prepare for a climate future that includes more frequent and intense storm events.

g) Other

As discussed, characteristics of the built environment like impervious surfaces and stormwater infrastructure play a critical role in overall flood vulnerability. The locations and vulnerabilities of other critical infrastructures that ensure the proper functioning of City services present an important landscape feature that must be considered. Flooding in 2018 provided insight into some of these potentially flood-vulnerable critical infrastructure assets and the records compiled by City staff were used to visualize these.

As the Elkhart River cuts through the center of Goshen, a select number of roads with bridges allow east-west traffic flow. These river crossings are essential for everyday

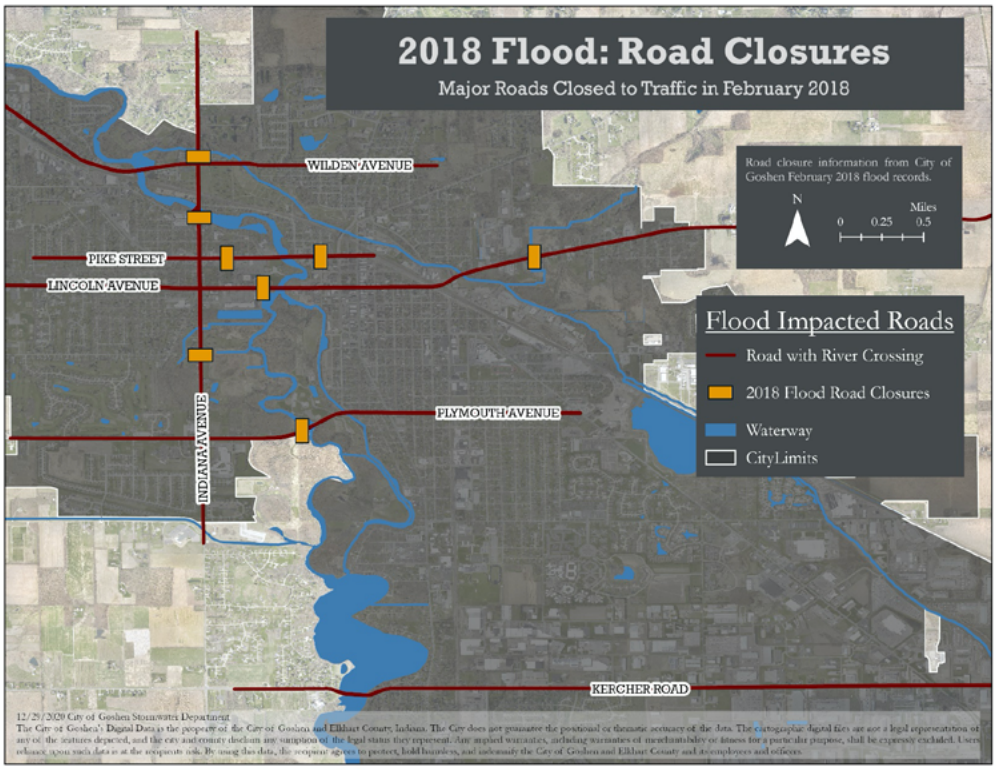


Figure 27: 2018 road closures due to flooding overlaid with major roads with bridges over the Elkhart River.

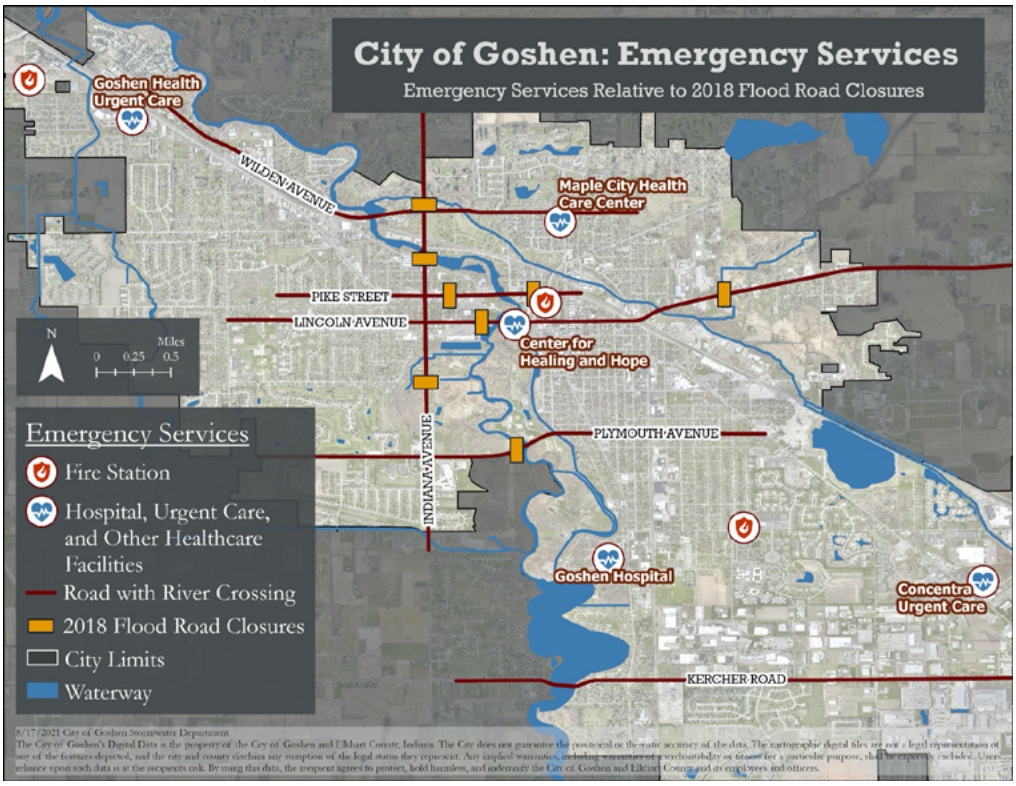


Figure 28: Emergency services locations overlaid with road closures in 2018 due to flooding.

commuters and emergency vehicles. Figure 27 maps the major roads that connect the west side of Goshen with the east side. During flooding in February 2018, flooded roadways presented a major hazard to vehicles, and several major roads were closed to traffic. The map above shows the locations of road closures and illustrates the ways flooding severely restricted river crossings.

Of the six major roads with river crossings in Goshen, all but Kercher Road were closed at some segment during the 2018 flood. Plymouth Avenue and Pike Street also serve as major arterials that service the State and Federal transportation systems respectively. Road closures blocked bridge access completely at the Plymouth Avenue, Lincoln Avenue, and Pike Street river crossings. This left only Kercher Road and Wilden Avenue open to the City's emergency vehicles for east-west travel. If flood waters had risen any higher, the bridge crossing at Wilden Avenue likely would have been lost as well.

For most, temporary road closures pose a hassle, but for those in need of emergency care, road closures can be catastrophic. In extreme cases, flooded roadways can cut off emergency vehicle access which delays life-saving care. Road closures due to flooding in Goshen do not impact each neighborhood in the same way. The locations of emergency services were mapped in relation to road closures in Figure 28. The map helps visualize how easily neighborhoods west of the Elkhart River can become cut off, or partially cut off, from Goshen Hospital during a major flood event. Goshen Health's urgent care facility is the only available clinic or healthcare resource left to the west of the Elkhart River unless residents travel to Elkhart for assistance (which also experienced major flooding in 2018 and has experienced challenges to hospital access during flood events).

The locations of city owned properties are another important aspect of Goshen's built landscape. Flood damage to City property and structures can end up costing taxpayers who help fund the shared resources. Essential services provided by the City like wastewater treatment and clean drinking water must be protected from flood-related damage and the City of Goshen is working to think long-term about how it ensures proper functioning even during a significant flood event. Figure 29 maps city facilities and parks while pointing to especially vulnerable infrastructure within the 500-year floodplain or threatened by 2018 flooding.

The facilities in Figure 29 point to the flood-vulnerable, City facilities that are threatened and/or have been impacted by flooding. The North Well Field indicates the location of one of the two water treatment plants and wellheads for the City's water utility. The plant, located along Rock Run Creek, is within FEMA's delineated floodplain, but the 2018 flood did not threaten its infrastructure. Similarly, the Environmental Center was not of particular concern during the 2018 flooding despite its location in relation to FEMA's current floodplain mapping. The two starred facilities furthest south in Figure 29 are Parks Department facilities within Shanklin Park. Due to their location in the floodplain and damages incurred during the 2018 flood, the Parks Department Office has been moved and options are being considered for the relocation of the Parks Maintenance Building.

The Wastewater Treatment Plant (WWTP) and Wet Weather Detention Facility (WWDF) are for the most part not located in FEMA's current floodplain maps but are worth noting in connection with flooding in 2018. Elevated floodwaters surcharged the WWTP outfall causing a mixture of plant effluent and river water to discharge to the dry side of the WWTP levee, threatening critical electrical equipment. Additionally, floodwaters nearly reached the WWTP power feed substation, which could have shut down operations at the WWTP for an extended time while equipment was inspected and repaired. Floodwater also threatened the banks of the plant's bio-solids holding lagoon (a part of which is located within the 1% annual chance floodplain) which could have released hazardous biosolids into the river. A major plant upgrade currently under construction will offer additional protections for the plant by enveloping its power feed substation and eliminating the holding lagoon.

The WWDF started operations in 2011, and was designed to help protect WWTP operations from being overwhelmed by storm events and to reduce the number and volume of combined sewer overflows that dump untreated sewage into the Elkhart River. It served exactly this function during flooding in 2018 when floodwaters covered portions of the wastewater collection system and allowed a great deal of river water into the sewers. Part of a past era in stormwater management, many storm drains in Goshen still empty to the City's sanitary sewer lines, termed a "combined" sewer system. Of the City's seven sewer service areas, all but one utilizes a combined system. This means during rain events, large volumes of combined wastewater and stormwater flow to

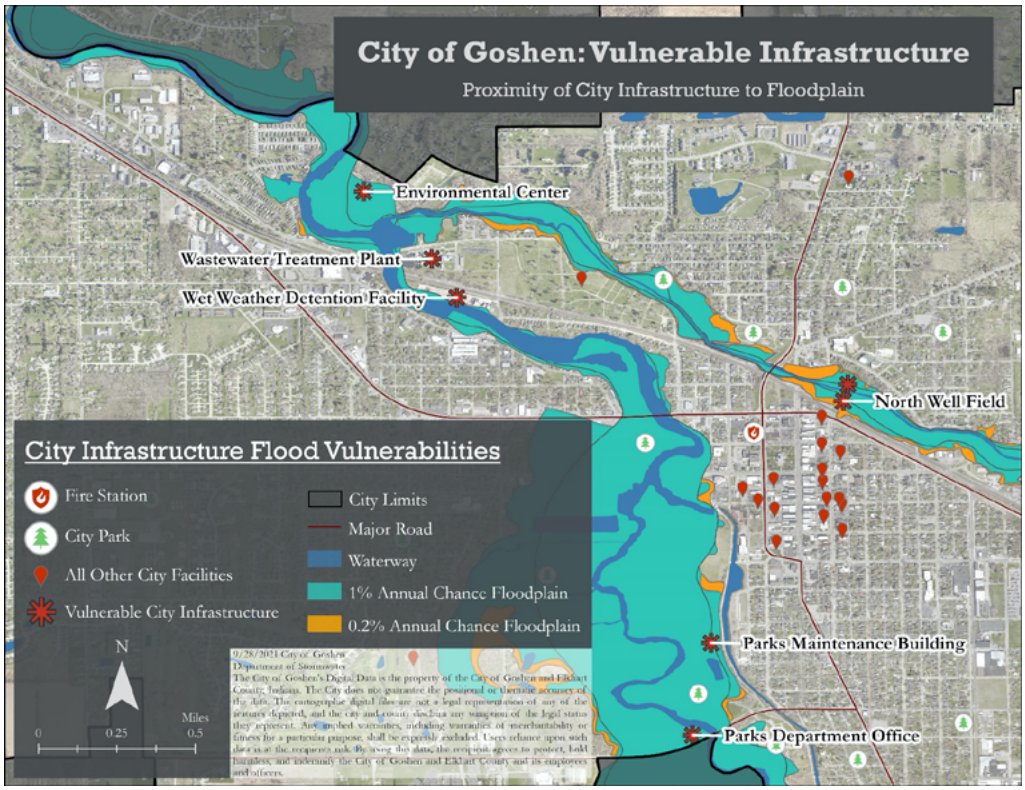


Figure 29: City owned infrastructure in relation to the floodway and 1% and 0.2% annual chance floodplains.

Figure 30: Flooding at the Wastewater Treatment Plant on February 21, 2018. The Elkhart River came within a few inches of overtopping the solid-waste holding lagoon (center of photo) and flooding wrapped around the south side (left of photo) of the property.

the plant through the sanitary sewer system. The WWDF temporarily holds, and partially treats, this combined sewage so that flows during a storm event do not overwhelm the WWTP. Flows that exceed the detention capacity of the WWDF have a discharge point to the river after being screened and settled. The WWDF includes these emergency overflow points in order to prevent surcharging of wastewater into the collection system and overflows into the streets or even basements.

Analysis of the roads and critical facilities that make up the built landscape helps draw attention to a few key flood vulnerabilities and is useful for prioritizing actions. While the 2018 flood caused costly damage, it also provided a unique window into what future flood events in Goshen might look like as the frequency and intensity of major storm and flood events increase over time.

h) Flood Mitigation Projects

Other important features to consider when looking at Goshen's vulnerability to flooding are efforts to mitigate flooding already in place. Flooding in Goshen is not a new phenomenon and many projects have been instituted in an effort to mitigate some of the worst impacts of flooding. Projects include a two-stage ditch construction along Horn Ditch and various regional stormwater solutions for West Goshen.

West Goshen Drainage Study and Regional Storage Efforts

Over the decades the western areas of the City of Goshen have flooded causing damage to property and infrastructure. In 1986, a watershed study of this area was completed to determine ways of reducing flood risks and allow continued development. The study presented a number of options with the intent to "alleviate the most troublesome flood water problems while taking advantage of the existing water courses and structures whenever possible."[71] Of the flood protection options presented in the Study, the Elkhart County Commissioners decided to construct a diversion ditch along County Road 36 from County Road 19/Greene Road east to the edge of the Elkhart River floodplain. The construction of the Count Road 36 Diversion Ditch substantially reduced flooding in portions of this watershed.

No additional flood reduction projects outlined in the plan were implemented while urbanization in the area continued to increase. Significant development changes, that in some cases occurred in areas previously identified for flood improvement projects, necessitated an update to the study in 2012. This study focused on a smaller area of West Goshen and suggested new flood protection solutions. At the time of writing, none of the suggested flood protection solutions have been implemented at the City or County level; however, the construction of the Goshen Community Schools Intermediate School did incorporate substantial storage capacity into its onsite stormwater detention basins and thus addressed some of the areas of concern. The basins help manage stormwater runoff flowing from the drainage area to the south and protect residential neighborhoods previously in runoff flow paths. The Intermediate School now releases to the City of Goshen's storm sewer flowing north along Greene Road and has an emergency overflow to the farm field to the west. Additionally, the City of Goshen is working with the property owners in and around The Crossing Subdivision, another area identified in the 2012 Study, to create regional stormwater detention basins to manage stormwater flow volumes.

Further development in the West Goshen area will take into consideration regional drainage and as opportunities arise the City will pursue additional stormwater storage projects.

Horn Ditch Two-Staged Ditch Project

In July 2006, an extreme rain event occurred over portions of Elkhart County causing flood conditions in Goshen, Millersburg, and Wakarusa with rain amounts ranging between 2.14" to 8.17". The rainfall over southeast Goshen and the surrounding land to the southeast resulted in flood damages to businesses along Horn Ditch on Century Drive, County Road 31, and Kercher Road. The flooding spurred conversations between the City of Goshen, Elkhart County officials, and impacted business leaders to discuss potential drainage solutions that would protect against future property damages. A two-stage ditch from County Road 31 to College Avenue (County Road 36) was completed in 2014, as part of a partnership between industrial property owners along Horn Ditch, Elkhart County, and the City of Goshen. Since the two-stage ditch's completion floodwaters have been adequately contained with no damage to the surrounding properties or businesses.

A Note on the Purpose and Function of "levee" along the Elkhart River in Rogers Park

Figure 31: Flooding near the Wet Weather Detention Facility on February 21, 2018. (Photo credit: Andrew Kauffman)

Figure 32: Looking east from Northstone Road at sediment-laden stormwater flowing through the County Road 36 Diversion Ditch during a May 2018 rain event.

Figure 33: Looking east at the flooding of business along Horn Ditch at the College Avenue bridge during a July 2006 flood event.

Figure 34: An image of the same area shown in Figure 33 during the 2018 February Flood illustrating how the floodwaters were contained within the two-stage ditch.

In 1991, an embankment was constructed along the bank of the Elkhart River in Roger's Park from Lincoln Avenue on the south to US 33/Pike Street on the north. The construction of this earthen berm was meant to act as a levee to protect the Roger's Park area but does not function as such. The low area for the boat launch prevents any flood mitigation. Additionally, as the river rises, there is no flood protection for the area from floodwaters coming from the south overtopping Lincoln Avenue. The embankment actually inhibits floodwater from flowing out of Rogers Park until the Elkhart River water level drops to the level of the areas' four drainage pipes.

Steury and Lincoln Avenue Stormwater Detention Basin

In preparation for future improvements to the intersection of Steury Avenue and East Lincoln Avenue (former State Route 4) and on both roadways, the City of Goshen acquired and demolished an existing auto salvage yard in 2016 and 2017. This allowed for a large stormwater detention basin to be constructed in order to collect stormwater runoff from the roadway and to address drainage and flooding issues along Steury Avenue. At the writing of this report, the roadway improvements are anticipated to be constructed in 2022.

Goshen's Stormwater and Flooding Vulnerability Map

By combining observations and key landscape vulnerabilities highlighted in the landscape features section, areas of the community that are particularly sensitive to stormwater-related impacts and flooding were identified. Figure 35 combines impervious surface, tree canopy, and floodplain extent. Overlaid on top is a heat map showing clustering of damaged structures during the 2018 flood which points to particularly vulnerable, urbanized areas. More in-depth information on these highlighted areas can be found in the vulnerability assessment results section of this report.

The largest flood damage "hotspot" from 2018 flooding is along the western edge of FEMA's current flood zone delineations as shown in Figure 35. This area is a highly urbanized sector of the City within the Elkhart River's floodplain. Figure 36 takes a closer look and illustrates the relationship between 2018 structure damage and the degree of development in or near the floodplain. The map on the left shows damaged structures (navy blue) in relation to vegetative land cover types from the NLCD. The map on the right shows flood damaged structures in relation to impervious surfaces. The takeaway from these maps—generally the City has done an excellent job of preserving greenway in floodplains, but a few developed areas remain with the potential for costly flood damages. Green spaces represent a significantly better use of floodplain space than does infrastructure. These comparative maps demonstrate the importance of limiting development in the City's floodplain as it moves into a future of higher intensity, less predictable flooding.

The natural and built elements of Goshen offer insights into why certain areas experienced flooding and flood damages in 2018, and others did not. Knowledge from that event now provides much-needed insight into what the next event may look like, and lessons learned from the landscape characteristics of those areas can help the City plan safer, more resilient development as it moves into a different climate future.

The next section takes a look at how some of the same characteristics that impact flood vulnerability also impact the community's vulnerability to another localized climate change impact—more intense heat.

Landscape Features that Affect Heat and Associated Exposure to the Stormwater System

Extreme heat is the number one weather-related killer in the United States.[72] The majority of people who have traditionally died from heat exposure die in their homes, generally in environments with little or no air conditioning. Extreme heat has the most negative impact on adult populations aged 50+, with men being notably more vulnerable to heat exposure and death than women.

Extreme heat can be exacerbated by local environmental conditions, especially the urban heat island. An urban heat island is a phenomenon whereby urban regions experience warmer temperatures than their rural surroundings.[73] Some of the reasons for the localized urban heat island include: reduced vegetation in urban areas; the materials used to build in urban areas; and urban geometry.

Extreme heat can also impact water quality by causing thermal pollution in stormwater. As stormwater flows

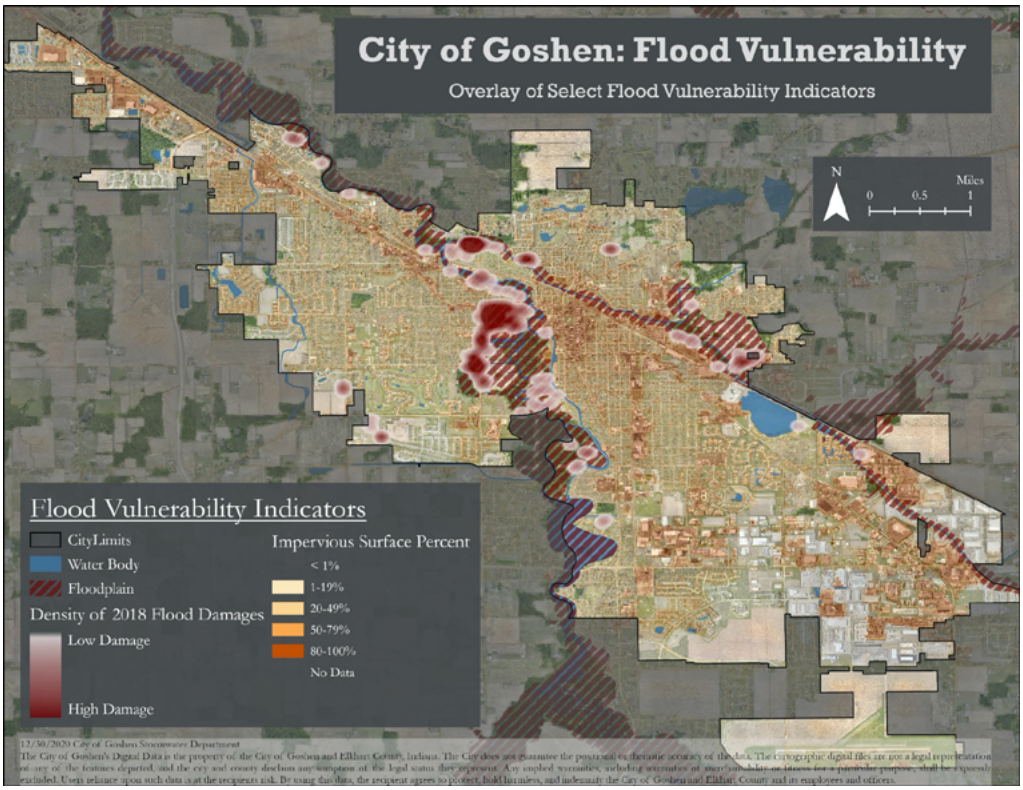


Figure 35: Flood vulnerability indicators overlaid to highlight vulnerable locations within the City of Goshen.

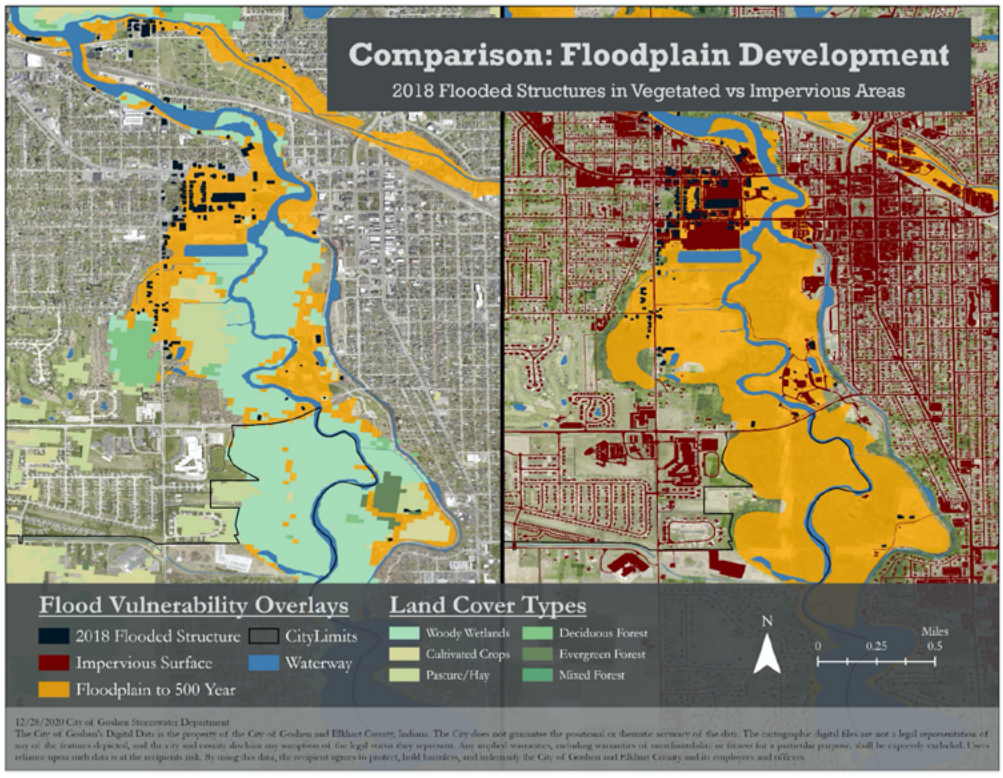


Figure 36: Comparative maps of impervious surfaces and vegetative cover in relation to the floodplain and 2018 flooded structures.

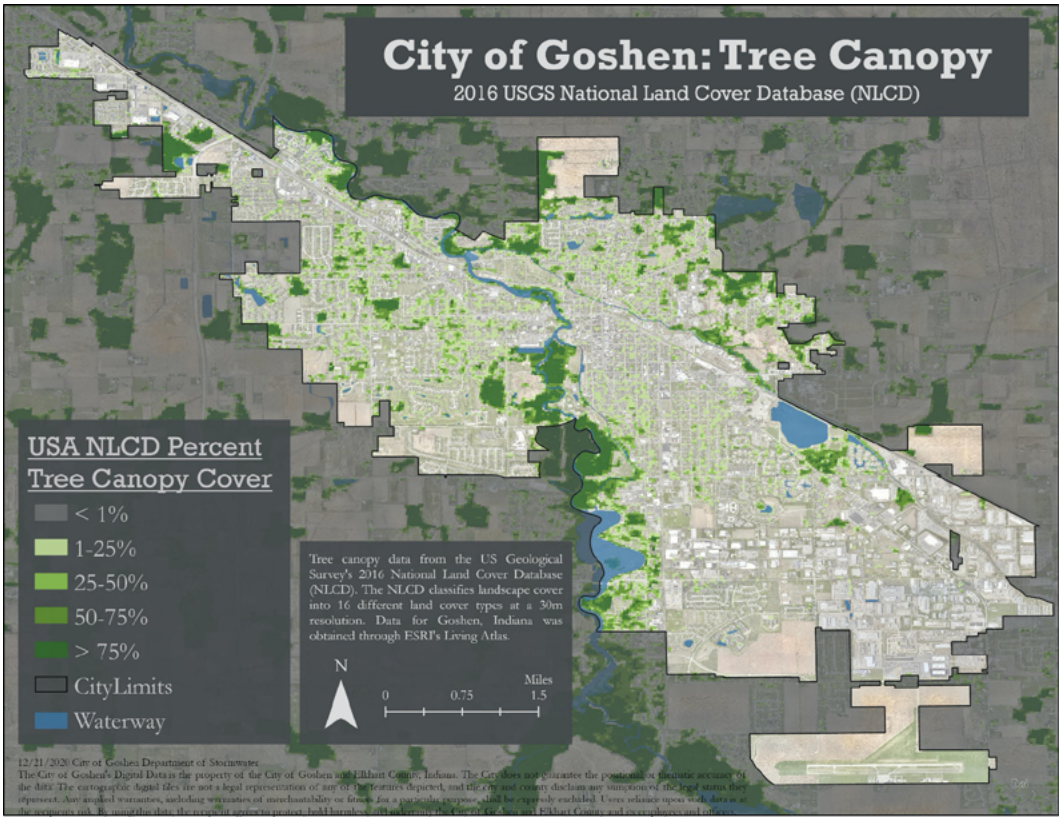


Figure 37: 2016 NLCD percent tree canopy cover in Goshen, Indiana.

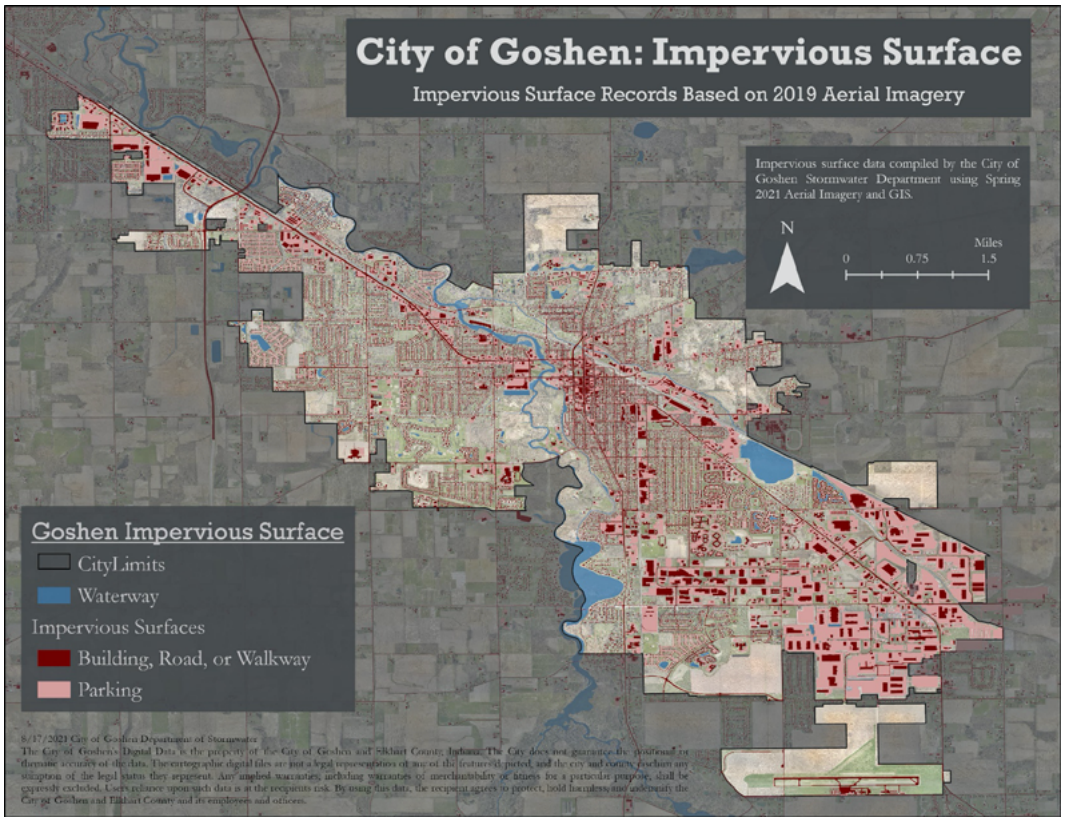


Figure 38: Impervious surfaces tracked and updated by the City of Goshen using GIS and 2019 aerial imagery.

across impervious surfaces like asphalt and concrete, it picks up debris and other visible pollutants, but it can also heat up before it enters waterways. Heat is considered a stormwater pollutant when it impacts the levels of dissolved oxygen (DO) in the water as warmer water cannot hold as much oxygen as cooler water. Lowered levels of DO is one of the leading causes of fish and other aquatic organism die-offs.

Because of the very real and serious threats posed by extreme heat to Goshen residents and water quality, three local landscape indicators were considered that increase vulnerability to heat:

a) Vegetation Coverage: Normalized Difference Vegetation Index

b) Impervious Land Cover

c) Urban Heat Island Effect

a) Vegetation Coverage and Tree Canopy

Many urban areas have a lower percentage of green space compared to rural regions. Since trees and vegetation provide shade, which helps lower surface temperatures, the lower percentage of green space in urban areas can directly translate into higher temperatures compared to more vegetated rural areas. In addition, trees and other vegetation help reduce air temperatures through a process called evapotranspiration, in which plants release water to the surrounding air, dissipating ambient heat. In urban areas with limited green space, the amount of shading and evapotranspiration is limited, particularly when compared to more rural or less developed regions, thereby contributing to elevated urban surface and air temperatures.

Revisiting the land cover map from the landscape features section (Figure 24), you can see the amount and locations of areas dominated by vegetative coverage in comparison to those with a more urban infrastructure. While vegetation has been preserved relatively well in some areas, the City of Goshen is committed to increasing vegetative cover.

Goshen has already set at least one measurable goal that will help increase vegetative shade cover. The City of Goshen has set an ambitious 45% tree canopy goal by the year 2045 or "45 by '45." This goal aims to capitalize on the many benefits of urban tree canopy cover and one such benefit will be to mitigate the impacts of increased heat common to urbanized areas. Like the vegetation map in the previous section, Figure 37 uses the USGS's National Land Cover Database (NLCD) which is used this time to look at tree canopy cover specifically.

The highest percentages of tree canopy cover in Goshen currently cluster around the Elkhart River and Rock Run Creek where many of the City's public parks are located. There are a few wooded areas mixed among residential developments—especially on the west and north sides of town. The industrial parks to the southeast have the least amount of tree canopy cover.

An Urban Tree Canopy Assessment conducted in 2013 showed that the City's tree canopy was at about 22%. The City's ambitious tree canopy goals would double tree canopy cover. A new canopy assessment set for completion in the summer of 2021 will provide important insight into how canopy cover has changed over time and where the biggest opportunities for expansion exist. Researchers have found that percent tree canopy cover can have an exponential impact on reducing urban air temperatures and thus will be an important strategy to mitigate the impacts of a hotter future.[74]

b) Impervious Land Cover

In contrast to vegetated areas, impervious surfaces, surfaces made from materials that do not absorb precipitation (e.g., asphalt, concrete, brick), are extremely effective at trapping heat. Given this, the City of Goshen also mapped the location and percentage of impervious land coverage throughout the community. The City keeps and routinely updates a detailed record of impervious surface areas for the purposes of stormwater and other planning uses. The locations and coverage areas of impervious surface are mapped in Figure 38.

In contrast to tree canopy cover, the areas of highest impervious surface cover mostly cluster around the industrial parks to the southeast of Goshen. As shown in Figure 38, large swaths of the impervious surface in this area are made up of parking lots rather than building footprints. Large amounts of impervious surface also cluster near Goshen's downtown and along the well-traveled business corridors along US 33 (running diagonally from the northwest corner of Goshen towards the southeast) and SR 15 (running from north to south).

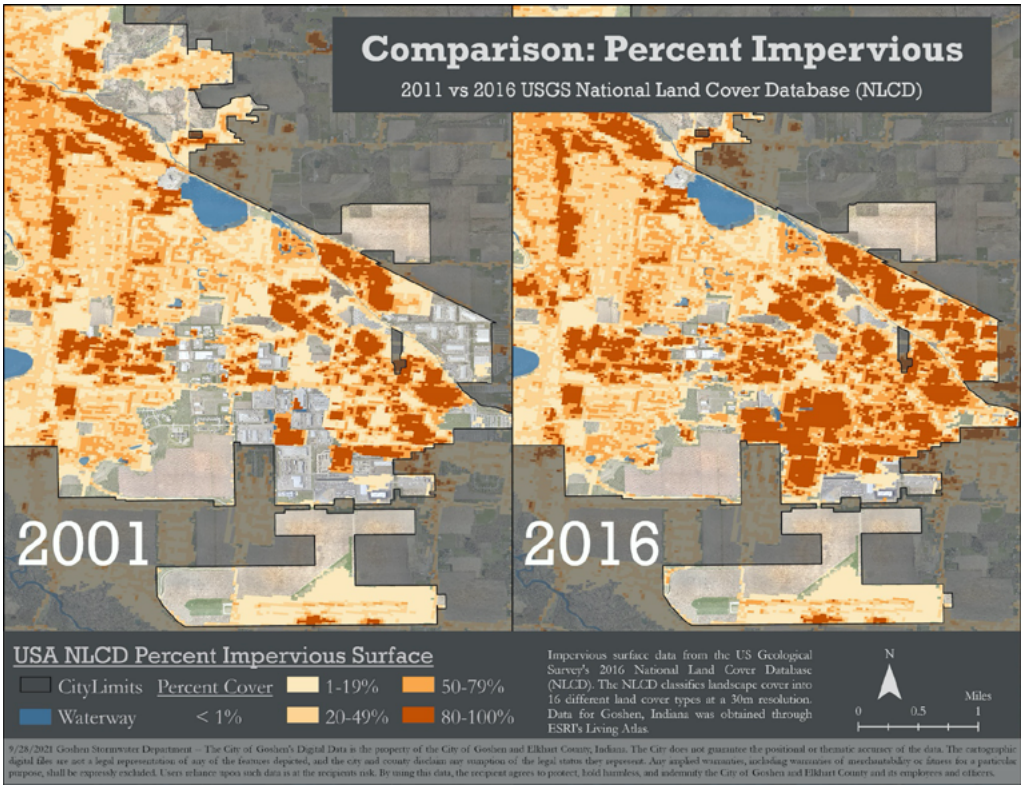


Figure 39: Percent impervious surface coverage mapped using 2001 and 2016 data from the USGS's NLCD.

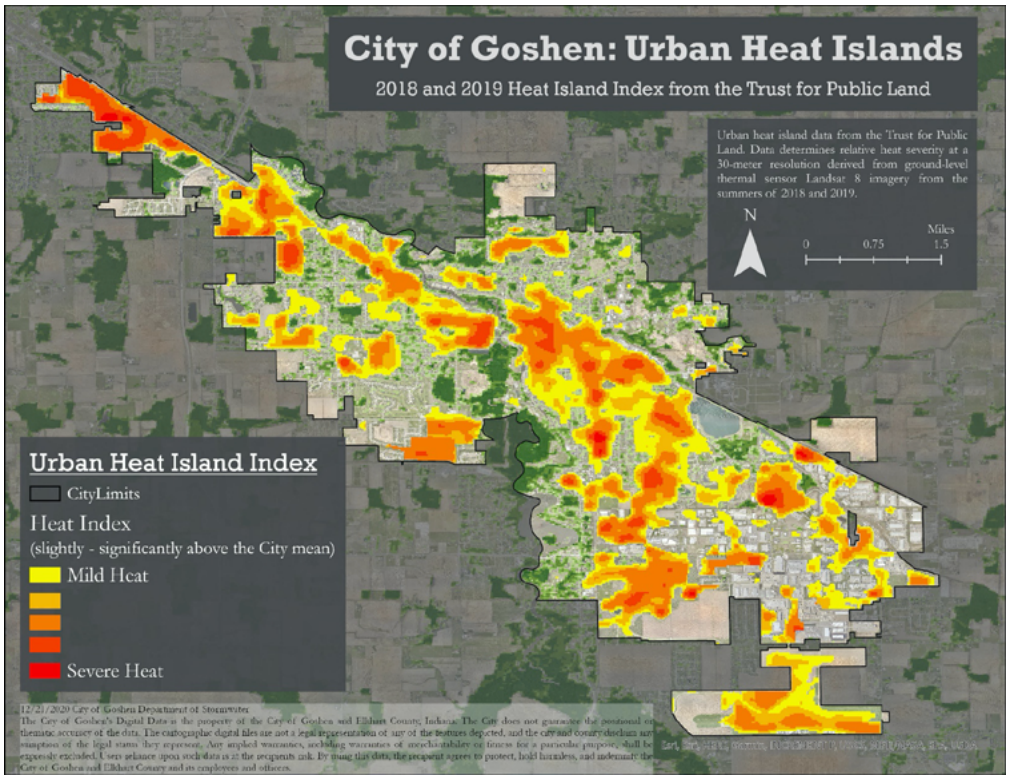


Figure 40: The urban heat island effect in the City of Goshen with data derived from Landsat 8 imagery by the Trust for Public Land.

Like land cover and tree canopy, impervious surface percentages are included in the USGS's NLCD. To get a better sense of general trends, impervious surface was also mapped by estimated percent coverage in Figure 39 which displays data from 2001 and 2016 side-by-side. Note the 15 years of development in the southeast of Goshen around the industrial parks in particular. Increasing urbanization of Goshen without a similar intensification of green spaces has consequences for both heat vulnerability and, as discussed briefly in the previous section, flood vulnerability. Hard surfaces generate greater stormwater runoff as little to no water can infiltrate. Even 10% impervious surface coverage in a watershed can have a negative impact on the health of the waterway receiving stormwater runoff.[75]

c) Urban Heat Island Effect

Most urban areas consist of roads, roofs, buildings, and other materials that, traditionally, have low solar reflectance and high heat capacity. Solar reflectance (also known as albedo) is the percentage of solar energy reflected by a surface. Darker surfaces, which tend to abound in urban areas, have lower solar reflectance values compared to lighter surfaces meaning that they reflect less and absorb more of the sun's energy. This absorbed heat increases surface temperatures and contributes to the formation of urban heat islands. According to the US Environmental Protection Agency, "another important property of building material that influences heat island development is a material's heat capacity, which refers to its ability to store heat. Many building materials frequently used in urban areas, such as steel, concrete, and asphalt, have high heat capacities. As a result, cities are typically more effective at storing the sun's energy as heat within their infrastructure."[76] As an example, studies have shown that downtown metropolitan areas can absorb and store twice the amount of heat compared to rural surroundings during the daytime.[77]

Using data from the Trust for Public Land hosted by ESRI's Living Atlas, the approximate "hot spots" that experience urban heat island effects in the City of Goshen were identified. The Trust for Public Land's dataset determines relative heat severity at a 30-meter resolution derived from ground-level thermal sensor Landsat 8 imagery from the summers of 2018 and 2019. The heat values are thermal readings of surface temperature which is related to, but different, from air temperature. Figure 40 shows Goshen's urban heat island.

In Figure 40, the Urban Heat Island Index is mapped on top of percent urban tree canopy from Figure 37—giving some insight into the relationship between the two. Similar to the impervious surface map, the greatest heat island effect is largely concentrated in the more densely developed areas around the center of Goshen and along US 33. The US 33 corridor in the far northwest part of the City is home to several major shopping centers with large parking lots and little vegetation. Similar correlations between shopping centers and heat islands are apparent along the US 33 corridor in the southeast of Goshen as well. On the west side of Goshen, the heat island effect instead closely correlates in some areas with newer housing developments where construction has occurred in once open space and the tree canopy is not present or has not yet matured.

Other Factors That Influence Stormwater Vulnerability and Local Vulnerability to Flooding

In addition to the factors discussed above, there are a series of local environmental conditions that can affect vulnerability to flooding and other climate-related impacts. Of particular note in Goshen are the impacts of current and legacy industrial development. For example, factors such as the number and location of impaired waterbodies, the location of hazardous waste sites, the locations and number of brownfield sites, the current condition of drinking water (especially data related to contaminants), and the location of solid waste sites and generators are all important factors that can influence neighborhood-level vulnerability to extreme events.

The scope of this assessment does not allow for close evaluation of these factors, but the City of Goshen's work to understand their impacts on flood vulnerability is ongoing. Updated maps of current and redeveloped brownfield sites are needed along with a more complete understanding of specific water quality impairments in waterbodies and waterways.

Summary of Landscape Vulnerability

The analysis in this section shed light on some of the local characteristics that can reduce or increase the community's vulnerability to flooding and extreme heat. Based on the cumulative results from this section, waterways flowing through Goshen are essential factors

in understanding vulnerability to future climate impacts. Stormwater throughout Goshen generally runs towards the Elkhart River and its main Goshen tributary, Rock Run Creek, which flow out of the City to the northwest. Maps of elevation and slope illustrate how the City takes on additional flow from surrounding higher elevation areas outside City limits. In addition, these maps help comment on the potential impacts of the increasing urbanization of upland areas and the disruption of natural drainage paths to allow development in lower lying areas. All of these characteristics of stormwater flow through the City help in gaining an understanding of where waters may collect and cause flooding.

Estimated floodplains along the Elkhart River and Rock Run Creek corridors are another essential element for predicting flood vulnerability. While in some areas the City of Goshen has historically done an excellent job of preserving natural spaces and converting areas to low-impact, less developed land uses like parks, built infrastructure near the floodplains are threatened by trends toward higher intensity, more frequent flooding. Flooding in 2018 revealed that some of these developed areas are threatened by floodwaters whether or not they are within FEMA's current floodplain designations. Updated regulatory maps are in the works, but for now, planners must rely on the currently described floodplain extents and localized knowledge gained during the 2018 flood.

Other landscape features related to future climate impacts covered in this section included land-use components like vegetative cover and impervious surface extent. As a small but urban City, developed areas unsurprisingly are home to a high percentage of impervious surfaces. Older residential areas tend to have mitigating factors such as larger rights-of-way with well-developed tree canopy cover, while industrial areas and newer developments are vulnerable to increasingly oppressive heat conditions. At the same time, lack of dedicated stormwater features and generally older infrastructure in some parts of town can open areas to greater flood vulnerability.

The built infrastructure of the City also plays a role in landscape vulnerability. More study is needed of the stormwater infrastructure to evaluate its strengths and vulnerabilities and help with future planning of more resilient systems. Green infrastructure will likely be a significant component of that future. This section additionally considered the locations and flood vulnerability of essential infrastructures such as major traffic routes, river crossings, and services like wastewater treatment, water treatment, and emergency services.

Compiling all these factors develops a preliminary picture of climate vulnerabilities as Goshen moves to a more uncertain future. The next section looks at specific areas around Goshen and evaluates their vulnerability by considering their landscape features, demographic characteristics, and particular climatic vulnerability.

5. GOSHEN'S VULNERABILITY ASSESSMENT RESULTS

Considering the information outlined in the previous sections, the City of Goshen completed a vulnerability assessment for stormwater. The guided assessment utilized a template and methodology developed by the Great Lakes Integrated Sciences and Assessments (GLISA).

A vulnerability assessment helps determine the extent to which the City and its major elements are susceptible to harm from climate change. The vulnerability assessment increases understanding of:

1. What changes in climate are projected to happen and what those changes could mean in terms of local **impacts**,
2. The level of **exposure** the community has to potential changes and impacts,
3. How **sensitive** the various city and community systems are to projected changes in climate, and
4. What **capacity** those systems have to adapt.

As previously identified, this vulnerability assessment is specific to the City's stormwater systems. As such, to undertake our vulnerability assessment we engaged in the following nine steps.

Step 1: Define Scope of Assessment

For the purpose of Goshen's vulnerability assessment, the Stormwater Department chose to focus on the built and natural elements of the stormwater system, along with selected neighborhoods, streets, parks, and other locations that were identified as potentially impacted by the changing climate. Especially prioritized were areas already threatened by flooding as emerged during the major flood event stretching from February 19-22 of 2018 when the river crested at 12.53 feet—the highest ever recorded (reading at US Geological Survey river gauge located on the Elkhart River near the Indiana Avenue Bridge).[78] The remainder of this section outlines the 18 components chosen for assessment and provides a short description of flood impacts to the area as learned largely during the events of the 2018 flood. Figure 41 first highlights the locations and approximate extent of these components.

2018 Flood Impacts in the 18 System Components Identified

1. **Trinity Square Shopping Center**: During flood events, floodwaters first fill up Roger's Park between the Elkhart River and Chicago Avenue and then begin to fill up the parking lot at the Trinity Square Shopping Center. A portion of Denver Avenue, southwest of the Kroger grocery store, also becomes inundated with flood water. Floodwaters cover Chicago Avenue, the Trinity Square parking lot, and Denver Avenue when the flood stage of the Elkhart River reaches nine (9) feet. The pressure of the water in the Elkhart River prevents stormwater from flowing out of storm sewer outfalls into the Elkhart River along Roger's Park meaning floodwaters do not begin to recede until the river height lessens and the storm sewer outfalls are no longer submerged. Additionally, floodwaters remain impounded within Roger's Park longer than they naturally would due to the embankment running along the west side of the Elkhart River. Kroger grocery and other businesses in the shopping center have already experienced flood damages during multiple flood events and undergone costly repairs. In 2018, Kroger was not able to reopen for nine months. Lastly, during extreme flood events water will cover Pike Street cutting access to a major east-west route and easy access to one of five bridges crossing the Elkhart River.
2. **Natural Areas – Floodplain:** Goshen historically located dumps and park infrastructure in the floodplain. This historic floodplain fill of low-lying and wetland areas defined the banks of the river and is a contributing factor to today's flooding. Luckily, these areas today are increasingly being made into open, natural spaces that can flood with minimal infrastructure damage. The dumps were converted to park land long ago and are no longer used for the disposal of waste; however, in some areas the waste is still there, just covered up. Today, there are many preserved natural areas along the City's waterways with the most significant being between the Elkhart River and the Millrace—encompassing Shanklin Park on the east side of the River and Mullet Park on the west and extending from the Goshen Dam Pond

to the south to Lincoln Avenue to the north. These areas experienced significant flooding during the 2018 flood event but minimal infrastructure damage due to their undeveloped nature. However, the Parks Department did have a few costly repairs to facilities and infrastructure (e.g. paths and ball diamonds) in the area and recently needed to move the park administration office to a new location. The park maintenance building is still along the edges of the floodplain extent and plans are moving forward for its relocation as well. Overall, the urgency and need for protecting natural areas along the floodplain is being increasingly recognized for the ability of these areas to "slow down, spread out, and soak in" floodwaters and thus help alleviate some potential downstream flood impacts.

3. **Conveyance System:** This system component looks at the stormwater conveyance system for the City as a whole (no location extent for this component is defined in Figure 41). The stormwater conveyance system here refers to the natural or built infrastructure that conveys stormwater through Goshen. This can include natural drainage pathways, ditches, swales, culverts, retention and detention basins, stormwater pipes, and other infrastructure. While flooding within the floodplain and surface flow of stormwater was somewhat obvious during the 2018 flood, considerably less is known about the vulnerabilities and/or strengths of the stormwater conveyance system. While much of the system's components are mapped, there is no record or assessment of its capability to convey a historical 10-year, 1-hour storm—today's design standard. The vulnerability assessment of this component is thus incomplete and based on limited information. Additional study is needed.
4. **Huron Street Neighborhood:** The Huron Street Neighborhood—stretching from Denver Ave. to Indiana Ave. and from Lincoln Ave. to Pike St.—in 2018, marked the approximant extent of the Elkhart River's floodplain in this area. This neighborhood was impacted by floodwaters covering the roads and flowing into homes. Additionally, higher groundwater levels caused water to flow into basements through walls and floors which damaged utilities like water heaters and heating/cooling systems.
5. **Southwest Goshen/Leedy Ditch Watershed:** This area was part of a 1986 and 2012 drainage study that looked at ways to minimize historic and ongoing flood impacts from upland runoff that has high peak runoff rates during snowmelt combined with a rainfall event. The natural drainage path(s) has been developed up to and, in some cases, over. Leedy Ditch runs south to north along the west side of Goshen and the watershed that drains towards the area encompasses the majority of west Goshen as seen in Figure 41. A rise in ground elevation to the southwest of Goshen directs runoff towards this side of the City and in the past caused widespread flooding. However, the construction of the diversion ditch along the north side of County Road 36 in the late 1980s helped to reduce the risk of overland flooding significantly. Instead, this runoff is now collected and diverted to the Elkhart River to the southeast of Goshen Middle School (1216 S. Indiana Avenue).
6. **Westoria to the Gardens Drainage Swale:** Past runoff events have caused flooding in Westoria, The Gardens, and Colonial Farms subdivisions. There are culverts at Berkey Avenue (County Road 32), Redspire Boulevard, and Clinton Street that restrict runoff and provide some runoff attenuation, but excess runoff overtops roadways when natural depressions fill. One of the largest concerns with this assessment area is that there is currently no defined drainage path with established management easements. This area is part of the Leedy Ditch Watershed (#5) and lies upstream of the Bashor Road Sanitary Sewer Lift Station area of concern (#11).
7. **Horn Ditch, Spring Brooke, Fidler Pond:** During the February 2018 flood, the two-stage ditch worked to protect industrial properties south of College Avenue; however, the two-stage ditch ends on the south side of College Avenue and properties along the ditch north of College experienced impacts from the 2018 flood. Lippert Components, Spring Brooke neighborhood, and Fidler Pond were all impacted in some way. Floodwaters reached Lippert's plant, muddy water and trash collected from upland farmland and industrial areas were pushed into Spring Brooke's detention basins, and the basins overflowed with high-velocity floodwaters flowing towards Fidler Pond causing the pedestrian path to wash out requiring costly repairs. The path washed out again in 2019, resulting in the City installing drainage culverts under the path, but the improvement has not yet been tested by a major storm event.

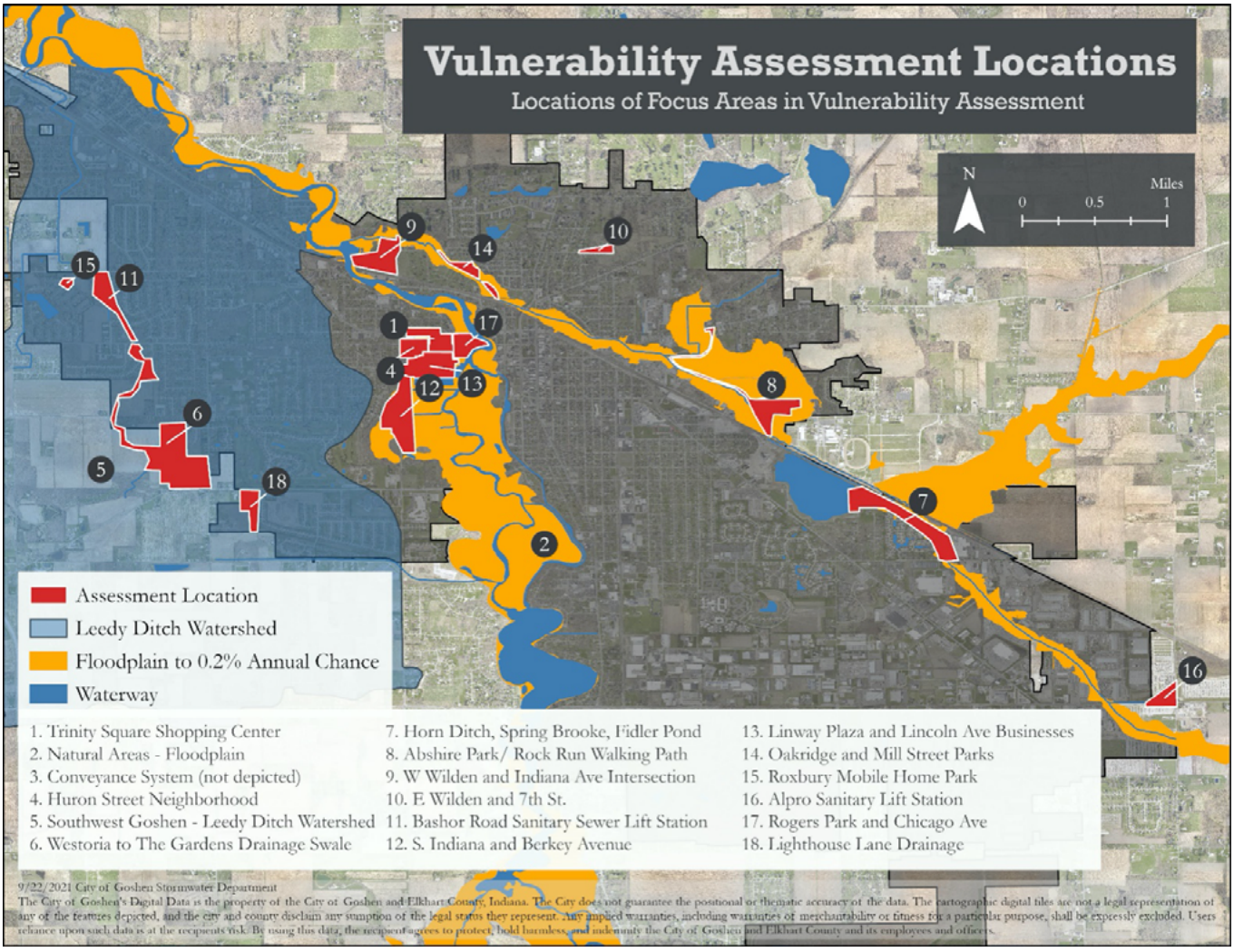


Figure 41: Climate change and stormwater vulnerability assessment components.

8. **Abshire Park/Rock Run Creek Walking Path:** The walking path along Rock Run Creek that stretches from E Monroe Street to the Pumpkinvine Trail in some areas was located in areas where fluvial erosion occurs—especially during flood events. High-velocity floodwaters have eroded the stream bank along the creek threatening the pedestrian path and covering other areas with large sediment deposits. This has resulted in costly repairs and the decision by the Parks Department to move the path further away from the creek.

9. **W. Wilden and Indiana Avenue Intersection:** In 2018, floodwaters overtopped the banks of Rock Run Creek and threatened infrastructure and residents at Creekside Estates Mobile Home Park located on the northwest corner of the W Wilden Avenue and Indiana Avenue intersection. Waters rose so quickly that emergency personnel resorted to a late-night rescue of residents using boats. Almost all the homes sustained some kind of damage. In addition, flooding of Indiana Avenue required closure just north of its intersection with Wilden Avenue. Wilden, a major east-west route in Goshen, also had significant flooding and closure was considered.

   As described in the Landscape Features Section (section 3), the Wastewater Treatment Plant (WWTP) was also threatened by floodwaters with concerns that the electrical substation could become inundated and lead to a plant shutdown while the station was evaluated and repaired. A major plant upgrade project from 2020-2022 includes the installation of a protective levy around the electrical substation, a stormwater lift station, and the decommissioning of the sludge pond along the river's edge to harden plant operations against future flood related impacts. While the upgrades will go a long way in protecting the operations of the plant, additional work may be needed to further prepare for major disaster events.

10. **E. Wilden Avenue and N 7th Street:** A few houses to the east of the E Wilden Avenue and N 7th Street intersection experienced damages during the 2018 flood. The wetland to the northeast of the end of the roadway was overwhelmed by flow from 189 acres of drainage area flowing from the northeast.[79] The excess water flowed overland along the backside (northside) of homes on E Wilden and overwhelmed the private drainage swale that directs water between 409 and 411 E Wilden towards the combined sewer system structure on the north edge of the street. The excess runoff bypassed the swale between the two houses and continued to flow west through the house at 405 E Wilden Avenue where it was captured by the combined sewer inlet at the intersection of N 7th and E Wilden.

11. **Bashor Road Sanitary Sewer Lift Station:** The sanitary sewer lift station along Bashor Road is located just to the east of the Colonial Gardens Ditch. In 2018, floodwaters reached a chokepoint at the culvert under the road and overtopped the ditch into an undefined floodplain surrounding this area. The extent of the floodwaters came concerningly close to the lift station. This is downstream of the Westoria to the Gardens Drainage Swale area of concern (#6).

12. **S. Indiana and Berkey Avenues:** The Elkhart River once flowed through this fluvial area and continues to do so during extreme rain events. Floodwaters from the Elkhart River flowed across the land and collected and backed-up along the West Goshen Ditch—the area's low spot. This is what happened during the historic flood of February 2018, causing floodwaters to cover S Indiana Avenue and the intersection with Berkey Avenue cutting off the flow of north and south bound traffic on this busy roadway.

13. **Linway Plaza and Lincoln Avenue Business:** During flood events, Rogers Park floods first, followed by the submergence of Chicago Avenue and then floodwaters rise to where the parking lot at Trinity Square Shopping Center and Denver Avenue become inundated. During extreme rain events, these floodwaters reach the area around Linway Plaza and overtop W Lincoln Avenue. When the floodwaters of the Elkhart River reach between 10 and 11 feet (on USGS river gauge at Indiana Ave. bridge), water fills the Linway Plaza parking lot and impacts businesses along both sides of Lincoln Avenue and at the intersections of Denver Avenue and Huron Street. The floodwaters completely cut off east and west bound traffic access on a major east-west route and to one of five bridges across the Elkhart River in the City of Goshen.

14. **Oakridge and Mill Street Parks:** In the floodplain area along the north side of Rock Run Creek in Mill Street Park and Oakridge Parks, park amenities are subject to some damage, sediment deposits, and repair or removal costs. A greater proportion of Oakridge Park becomes inundated than Mill Street

Park, however, Mill Street Park has contaminated soils in some areas that would be exposed to floodwaters on occasion.

15. **Roxbury Mobile Home Park:** A cluster of homes on the northeast side of this area were impacted by floodwaters in 2018 and residents have reported flooding issues at other times after heavy rain events. Storm drainage differs from the rest of the neighborhood here and back-ups of the private storm system caused flooding in the street that cut off vehicular access to a number of homes.
16. **Alpro Sanitary Lift Station:** Significant flood events over the years have surrounded the area around the sanitary lift station along Kercher Road and caused some erosion along its east side. Flood waters overtop the Lateral 'K' Ditch at County Road 31 causing flooding along the roadway and west towards the lift station. In 2018 floodwaters overtopped and completely covered Kercher Road extending into the property along the south side of the road. FEMA's 2011 FIRM maps do not include Lateral 'K', but the Indiana Department of Natural Resources (IDNR) has "best available" data for this area.
17. **Rogers Park and Chicago Avenue:** Rogers Park is located in the floodplain just behind an embankment constructed a number of years ago. This area is well known for flooding during many spring storm events over the years. A "bathtub" effect is created when the level of the Elkhart River runs high because storm pipe outfalls that drain this area become blocked and floodwaters cannot recede until the level of the Elkhart River drops below the outfall. Chicago Avenue marks a high point between the Park and Trinity Square Shopping Center so while it was significantly impacted and closed to traffic during the 2018 flood, this is less likely to occur during minor flood events that impact the Park.
18. **Lighthouse Lane Drainage Area:** The stormwater drainage system for the Crossing Subdivision and Plymouth Avenue Professional Park was constructed in a natural drainage path. Some of the flooding concerns were not fully understood during the construction of these developments, and the OBGYN and Birthing Center located along Plymouth Avenue had floodwaters entering their basements in 2018—completely flooding their shared parking lot and impeding access to these important services.

Step 2: Socio-Economic Analysis

The second step of the assessment focused on compiling and analyzing socio-economic information (economic, demographic, and other social statistics), at the pertinent geographical scale, for the various elements evaluated as part of the stormwater-system vulnerability assessment. To do this, this section builds upon the data outlined in Chapter 2 to more deeply understand who could be affected by each of the elements evaluated in the vulnerability assessment. Guiding this section were two key questions:

1. How will socio-economic vulnerability influence the elements being evaluated in the vulnerability assessment?
2. How will the elements (i.e., the thing being evaluated as part of the vulnerability assessment) impact (i.e., help or hinder) socio-economic vulnerability?

Table 5 below demonstrates the results from this step of the assessment.

Project Details		**Socio-Economic Vulnerability**											
System Component	Geographical Distribution of System Component	% of Population Over 65	% of Population Under 5	% of Community in Poverty	% of Population with Limited English Proficiency	% of Non-White Population	% of Households Receiving Food Stamps/ SNAP	% of Households Where Mortgage is >30% of HH Income	% Disabled	% of Renters	% of Population Without a High School Diploma	How Will Socio-Economic Vulnerability Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Socio-Economic Vulnerability?
Trinity Square Shopping Center	5.02 v All Goshen	12.4 v 17.2	7.2 v 7.4	15.3 v 17.3	5.8 v 7.9	18.5 v 11.3	14.8 v 11.2	26.1 v 22.7	10.6 v 13.7	44.7 v 44.5	18.2 v 23.1	The shopping center contains Kroger, one of several major grocery stores that serve most of Goshen. Trinity Square is located in an area with a higher percentage of households without a vehicle and where a greater portion of the population receives SNAP benefits compared to the rest of Goshen. So, when Kroger (centrally located and affordable) shuts down, residents have severely limited alternative places to shop.	Currently, Kroger grocery is considered an affordable grocery store and offers a centrally located place for many to shop. Loss of this store could impact food security by reducing access to low-cost, fresh foods. As the area is currently in the floodplain, adaptation to protect the store would require a huge infrastructure lift which would be an enormous and costly undertaking.
Natural Areas - Floodplain	All Goshen	17.2	7.4	17.3	7.9	11.3	11.2	22.7	13.7	44.5	23.1	Goshen has a growing homeless population that at times lives in temporary encampments in the floodplain. When flooding occurs, people lose tents and other resources when they need to move quickly. Generally, who lives in these areas is not well known.	Returning areas to natural floodplains needs to be considered because of the ecological benefits offered by the area for flood control, but alternatives for people living in the area need to be carefully considered. Sufficient affordable house is thus a prerequisite for reducing socio-economic vulnerability for those who inhabit this component. At the same time, natural areas have economic benefits for the rest of the City by increasing quality of life measures and general community livability.
Conveyance System	All Goshen	17.2	7.4	17.3	7.9	11.3	11.2	22.7	13.7	44.5	23.1	Areas of lower income and/or under educated populations do not always report flooding damages due to lack of experience or understanding, mistrust of government, and/or lack of resources (e.g., no Internet access). This means conveyance system improvement and maintenance needs do not always occur in a timely manner in areas where they may be needed most.	Improving stormwater management systems will help improve the health and financial stability of residents by protecting and preserving homes and businesses. Holistic management systems that use green infrastructure techniques and prioritize methods for capturing and filtering stormwater in place also have big impacts for general neighborhood beautification, mitigation of the heat island effect, and human health.
Huron Street Neighborhood	5.02	12.4	7.2	15.3	5.8	18.5	14.8	26.1	10.6	44.7	18.2	If accessibility to the neighborhood is diminished during flood events (i.e., 2018 flood conditions) it disrupts housing accessibility with potential public health implications. Cars driving through several inches of water pose risks such as inoperable vehicles, wave action onto adjoining properties, and damage from unseen hazards. While relatively small in area, the residential neighborhood may face repetitive flood losses and is easily cut off from services during flooding events. The neighborhood's proximity to Trinity Square Shopping Center makes it particularly vulnerable to the loss of adjoining food resources like Kroger and the various restaurants. In addition, homeowners here tend to not carry flood insurance as some homes damaged during the 2018 flooding were not in the identified floodplain.	Reducing the risk of flooding, or in some cases buying out at-risk properties, will help improve the health and financial stability of the neighborhood. Flood events could lead to repetitive loss properties, decreasing the value of homes in the area. Damage to heating/ cooling systems, water heaters, and other home components are an additional financial stress to residents of the neighborhood and, for some, may require public assistance to address.
Southwest Goshen - Leedy Ditch Watershed	4	16.4	5.6	14.3	4.8	8	3.2	8.8	9.9	17.6	12	This area encompasses a variety of lower to upper income homes. If flooding occurs along the Leedy Ditch Watershed, it could impact the more vulnerable mobile and modular home communities located along its banks. If this area begins to experience flooding conditions due to the failure of the County Road 36 Drainage Ditch, it will catch residents unaware. Many, if not most, of the residents in this area of the City, do not have flood insurance and could be devastated by a flooding event. Finally, recent increases in development in the area could create bigger water quality and quantity issues.	Reducing the potential for flooding will help residents remain in their homes and reduce the financial risks of flood damage.

Project Details		Socio-Economic Vulnerability											
System Component	Geographical Distribution of System Component	% of Population Over 65	% of Population Under 5	% of Community in Poverty	% of Population with Limited English Proficiency	% of Non-White Population	% of Households Receiving Food Stamps/ SNAP	% of Households Where Mortgage is >30% of HH Income	% Disabled	% of Renters	% of Population Without a High School Diploma	How Will Socio-Economic Vulnerability Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Socio-Economic Vulnerability?
Westoria to The Gardens Drainage Swale	5.01	6.7	14.6	24.5	10.9	16	12.8	19.7	9.4	42.5	24.4	These two neighborhoods are around natural drainage areas that during a heavy or prolonged rain/flood event could see flooding impacts. The residents in these areas are generally upper income, but with residents of Westoria tending to be of retirement age with fixed incomes. Any negative impacts from flooding (repeat flooding) could be difficult to recover from.	Reducing the potential for flooding will help residents remain in their homes and support further, much needed, housing development.
Horn Ditch, Spring Brooke Neighborhood, and Fidler Pond	3.02	41.2	2.3	12.1	4.5	4.4	7.7	24.7	23.2	45.3	16.3	This area, made up of mixed land uses, has a number of socio-economic factors to consider. The Lippert Component plant located in this area employs hundreds of people. Spring Brook is largely comprised of residents on fixed incomes (retirement age) and so is particularly vulnerable if they experience damages. Finally, flood damage at Fidler Pond impacts the City's Parks and Recreation budget.	The two-stage ditch has protected industries south of College Ave from the financial costs of flooding experienced in the past. A Lippert Components location on the other hand is still vulnerable and the facility employs hundreds of people. Future flooding could have a negative impact on the ability of residents to recover from a flood due to repair expenses exceeding their fixed incomes. Parks and Recreation Department funds could benefit the greater community if they can be used for purposes other than flood damage repair.
Abshire Park/Rock Run Creek Walking Path	2	9.3	7.4	17.3	14.4	7.8	8.3	25.7	12.7	46.9	37.5	Poor trash, debris, and effluent management associated with some neighboring properties could impact the Abshire Park floodplain and surrounding ecosystems as flooding increases. A high percentage of the population in this area are without a high school diploma and have limited English proficiency, creating some barriers to effective community education efforts regarding flood mitigation.	Most of the floodplain encompassed in this geography is public park property, and as such does not represent much private socio-economic vulnerability. However, the woodland near the floodplain is an area that homeless people use with some regularity. Their already fragile status is jeopardized even more by increased flooding in the park.
W Wilden and Indiana Avenue Intersection	2	9.3	7.4	17.3	14.4	7.8	8.3	25.7	12.7	46.9	37.5	Creekside Estates mobile home park, located on the northwest corner of the intersection, can flood quickly during large precipitation events. Unsecured items and property common to this area can become debris carried downstream during a flood.	While basements are not in jeopardy, access and long-term damage to homes and property pose financial burdens to an already income vulnerable neighborhood. Wilden Ave is a major east-west traffic corridor on the north side of town, and when it is unpassable it hinders emergency vehicle response and grocery store access (Martins and Kroger) for many residents.
E Wilden and 7th Street	2	9.3	7.4	17.3	14.4	7.8	8.3	25.7	12.7	46.9	37.5	Broadly, this area of town has more limited English proficiency, lower levels of education, and a higher number of rental units. Residents of this neighborhood may be less likely to report or intervene in flooding. Lack of reported information can make municipal response slower or more difficult.	Some properties can be affected and damaged by flood events, increasing the economic burdens of property owners. Information about recovery resources may take longer to reach residents than in other areas of Goshen.

Project Details		Socio-Economic Vulnerability											
System Component	Geographical Distribution of System Component	% of Population Over 65	% of Population Under 5	% of Community in Poverty	% of Population with Limited English Proficiency	% of Non-White Population	% of Households Receiving Food Stamps/ SNAP	% of Households Where Mortgage is >30% of HH Income	% Disabled	% of Renters	% of Population Without a High School Diploma	How Will Socio-Economic Vulnerability Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Socio-Economic Vulnerability?
Bashor Road Sanitary Sewer Lift Station	5.01	6.7	14.6	24.5	10.9	16	12.8	19.7	9.4	42.5	24.4	The flooding and loss of any sanitary sewer lift station is a concern as it could cause sewage backups into homes and businesses with resulting health and financial impacts. In this case, many residential houses and mobile homes and the Meijer and Target commercial areas are serviced by the station. Many of the impacted areas are low-income and households with small children.	Protecting sanitary sewer lift stations from floodwaters reduces the negative health and financial impacts on residents served by the lift station and protects commercial operations from costly shut-downs.
S. Indiana and Berkey	5.02	12.4	7.2	15.3	5.8	18.5	14.8	26.1	10.6	44.7	18.2	This area has some low-income parcels that have already been impacted by flooding. Continued flooding will cause some residents to no longer be able to live here.	Continued flooding could depress home and property values. Without opportunities for buyouts, residents may become trapped in cycles of damage and costly repairs that may eventually lead to the loss of homes.
Linway Plaza and Lincoln Ave. Businesses	5.02	12.4	7.2	15.3	5.8	18.5	14.8	26.1	10.6	44.7	18.2	Existing economic vulnerabilities like low-profit margin businesses and services for vulnerable populations (i.e., Lighthouse Autism Center) will be exacerbated by the additional stress of flooding and increases the potential for business closures and empty buildings. The area is also a source of floatable trash pollutants like take-out containers.	Linway Plaza is a major entertainment district for Goshen—several restaurants and a movie theater. These businesses traditionally have a low profit margin and flooding has already cost them significantly in terms of lost revenue and infrastructure damage due to flooding. Continued flooding could push some of these businesses beyond viability.
Oakridge and Mill Street Parks	2	9.3	7.4	17.3	14.4	7.8	8.3	12.7	46.9	37.5	18.2	These parks are located in a region of town where the percent of the population with limited English proficiency is nearly double that of the community average. In addition, a large percentage of nearby residents are without a high school diploma. These indicators present barriers to community education and outreach concerning the parks.	Flood damage to park property and infrastructure can be costly to replace and lead to a sense of neglect in these parks. This is especially the case if flooding becomes more frequent.
Roxbury Mobile Home Park	5.01	6.7	14.6	24.5	10.9	16	12.8	19.7	9.4	42.5	24.4	This is a low-income mobile home community whose private drainage infrastructure is overwhelmed during heavy rain events causing some streets to flood.	Any reduction in flooding potential will help increase the financial security of the residents and reduce the risk of infrastructure damage in the park. Some repetitive damage homes may be targeted for voluntary buyouts or other public assistance projects.

Project Details		Socio-Economic Vulnerability											
System Component	Geographical Distribution of System Component	% of Population Over 65	% of Population Under 5	% of Community in Poverty	% of Population with Limited English Proficiency	% of Non-White Population	% of Households Receiving Food Stamps/ SNAP	% of Households Where Mortgage is >30% of HH Income	% Disabled	% of Renters	% of Population Without a High School Diploma	How Will Socio-Economic Vulnerability Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Socio-Economic Vulnerability?
Alpro Sanitary Lift Station	3.02	41.2	2.3	12.1	4.5	4.4	7.7	24.7	23.2	45.3	16.3	The flooding and loss of any sanitary sewer lift station is a concern as it could cause sewage backups into business with resulting health and financial impacts. This lift station does not serve any residential areas.	Protecting sanitary sewer lift stations from floodwaters reduces the negative health and financial impacts on businesses and industries served by the lift station.
Rogers Park and Chicago Avenue	1	9.9	5.6	23.7	6.2	14	15.3	21.6	14.4	55.6	19.7	Rogers Park leaves significant open space in the floodplain; however, it is also a highly used community recreation area. Damage caused by flooding is paid for by taxpayers out of the City's budget and can impact the overall services provided by this park.	Chicago Avenue is a major north south traffic corridor and when it is flooded, limits access to Trinity Plaza and Kroger. The bus stop located in this corridor further disrupts transportation access. This can be especially hard on residents for whom access to other grocery stores may be limited. The Park's skate park, baseball field, and pavilion provide recreation and opportunities to safely congregate. These facilities are largely used by neighborhood teenagers, Latinx participants in summer baseball leagues, and Goshen's homeless population—all of whom can be particularly vulnerable during flood events.
Lighthouse Lane Drainage Area	4	16.4	5.6	14.3	4.8	8	3.2	8.8	9.9	17.6	12	An OBGYN and Birthing Center are located in this area and during flooding events their accessibility is extremely limited. This makes providing services to expectant mothers very difficult. Additionally, both buildings have water coming into their basements which is a health concern. The well laid plans of an expectant mother and father can be impacted by a flood event leading to stress and unanticipated financial costs.	In order to reduce the impacts of flooding on the residents and expectant families, the City of Goshen is working with surrounding property owners to come up with a drainage system to help collect and direct the drainage so it does not cause hardship. This will come at a financial cost to all parties involved.

Step 3: Exposure Analysis

The third step in the assessment was the compilation and analysis of pertinent climate change information to understand how the various elements being evaluated as part of the stormwater vulnerability assessment could be or already are exposed and impacted by a changing climate.

The intent of this step is to understand responses to two key questions:

1. How will projected changes in climate influence the elements being evaluated as part of the stormwater vulnerability assessment?
2. How will the elements (i.e., the thing being evaluated as part of the stormwater vulnerability assessment) impact (i.e., help or hinder) projected changes in climate?

Table 6 below and continued on page 53 demonstrates the results from this step of our assessment with climate projections provided by GLISA.

Variable of Interest	Sub-Variables of Interest	Historical/Current	Mid-Century Projected Changes	%Change Between Historic and Future; Mid Century % / End Century %
Precipitation	Heavy Precipitation Days (>1.25")	4.5 days (> 1.25")	4.9 to 6.6 days	9 to 47% / 36 to 69%
	Total Annual Precipitation	38 in.	38 to 42 in.	0 to 11% / 5 to 21%
	Winter Average Precipitation	6.8 in.	7 to 9 in.	3 to 32% / -26 to 47%
	Spring Average Precipitation	9.5 in.	10 to 13 in.	5 to 37% / 5 to 47%
Temperature	Days/Year Greater Than 90°F	9.9 days	27 to 47 days	173 to 375% / 365 to 718%
	Spring Average Temperature	48.9°F	51 to 55°F	4 to 12% / 10 to 23%
	Summer Average Temperature	71.4°F	76 to 78°F	6 to 9% / 11 to 18%
	Winter Average Temperature	27.3°F	29 to 32°F	6 to 17% / 17 to 32%

Ref #	System Component	How Will Projected Changes in Climate Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Projected Changes?
1	Trinity Square Shopping Center	Businesses will see more high-water events, particularly in spring. Impervious surfaces may need more frequent repair due to degradation from freeze/thaw, but possibly fewer resources will be needed for snow removal. Flood events reduce the availability of parking (some residents/employees have had vehicle damage in the past) and there will be economic losses from store closures and clean-up efforts.	Due to highly impervious land cover, non-existent tree canopy, and very little vegetation, this area exacerbates flooding issues in the area.
2	Natural Areas - Floodplain	Climatic changes will impact the biodiversity profile of the floodplain's natural areas. The ranges of more southern species could move north into the area and highly adaptable invasive species may have more opportunities to gain footholds. If large rainfall events happen back to back, the river could leave its channel and enter the floodplain. Increased volume and velocity of floodwaters could change the natural path of waterways and grow the extent of the floodplain. This is a natural process that can happen with minimal damage if the infrastructure is kept out of fluvial erosion hazard areas. Hotter, drier summers reduce infiltration potential and can lead to higher runoff events during summer pop-up storms.	Protected areas in the floodplain with vegetation provide uncountable ecosystem benefits. The low infrastructure development in these natural areas also reduces the potential for costly damage. There is some good connectivity between natural areas, but there is a barrier at the center of the city where connectivity is limited.
3	Conveyance System	The stormwater conveyance system was designed for historic rainfall conditions or used no design standard at all. Much of the City is also a combined sewer system with stormwater and wastewater being conveyed to the wastewater treatment plant. The capacity in some areas is already stressed and this system will become increasingly undersized as storm intensities increase. System capacity is also impacted by higher groundwater levels—especially the capacity of stormwater capture components like basins.	The stormwater conveyance system is an essential component of dealing with storm events as its purpose is to reduce damages by conveying water away from developed areas and infrastructure. However, poorly functioning elements of the stormwater conveyance systems because of outdated capacity, damage, or poor maintenance could exacerbate flooding issues in some areas. Stormwater conveyances that utilize pipe infrastructure with outfalls to waterways also increase peak flows during flood events—causing issues downstream. Thus, alternatives that manage stormwater in place with controlled releases are a better path forward than major infrastructure upgrades that address pipe capacities.
4	Huron Street Neighborhood	This neighborhood is likely to see more flooding in the future. Efforts to reduce flooding in Trinity Square could have unintended consequences (good or bad) for this neighborhood because of its proximity.	The area currently has good tree canopy cover. The neighborhood's storm sewer system is part of the City's combined sewer system so increased flooding in this neighborhood could stress sanitary sewer infrastructure.
5	Southwest Goshen – Leedy Ditch Watershed	Increased precipitation (especially winter/spring) will result in greater flood potential. There is also greater potential for infrastructure losses and damage as development continues in this area of Goshen. Increased intense storm events and existing landscape features could lead to high velocity runoff that creates flash flood conditions and erosion.	Portions of this watershed are well canopied, but not uniformly across the area. Existing and/or continued development could exacerbate flood potential. The existing culvert under US 33 and the railroad acts as a restriction point to slow the release of water to the Elkhart River but also exacerbates the flooding upstream. An increase in trash pollution could create more clogging and restriction in the US 33 culvert.
6	Westoria to The Gardens Drainage Swale	Existing land use includes agricultural lands and the longer the drainage swale is full of water the less area will be farmable. Hotter temperatures and wetter soils will make farming more difficult. Heavier and more intense rains could lead to higher water levels in the drainage swale and throughout The Gardens—creating risks from surface flooding, but more likely basement groundwater infiltration damage. Limited tree canopy (and the overplanting of non-native pear species) in The Gardens may also exacerbate flood potential and heat stress.	An area of higher elevation, poorer draining soils borders this region and runs towards the Colonial Gardens Ditch. On both the west and east sides of the ditch, preserved agricultural lands provide an opportunity for stormwater to slow down, spread out, and soak in. Development in, and redirection of, natural drainage paths may have unforeseen consequences for this area.
7	Horn Ditch, Spring Brooke Neighborhood, and Fidler Pond	More frequent and heavy rain events will lead to high water and flooding along Horn Ditch and the potential for stormwater collecting on roadways in Spring Brooke. Additionally, during flood events, stormwater can overflow into Spring Brooke's detention basins and cascade into Fidler Pond causing pedestrian path erosion. Poor trash and vegetation management by upstream industries and agricultural land uses mean more frequent and heavy rains will allow trash and sediment to be collected by stormwater runoff and pushed downstream impacting residential neighborhoods and Fidler Pond. The industrial areas along the two-stage ditch portion seem to be well protected.	Horn Ditch carries stormwater from the southeast industrial corridor and thus protects businesses in the area. There is a young canopy on portions of Century Drive, but the large majority of the industrial neighborhood within the Horn Ditch Watershed has little to no tree canopy. Lack of canopy within this system will lead to further flooding and other stormwater related issues (debris, pollutants) moving downstream.

Ref #	System Component	How Will Projected Changes in Climate Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Projected Changes?
8	Abshire Park/ Rock Run Creek Walking Path	Heavy rains and the resulting flooding have already washed out portions of the path. Additional damage to park infrastructure is possible.	The park provides a place for trees and native prairie plants to grow, which act as carbon sinks and mitigate urban heat island effects. The area's large wetland also acts as an essential flood storage area. This park will help mitigate climate impacts as long as the changing climate does not negatively impact the plant species growing there already.
9	W Wilden and Indiana Avenue Intersection	Creekside Manor homes are likely to flood with more regularity and possibly experience greater damage. Higher intensity storms and flood risks also endanger the Indiana Avenue bridge at Rock Run Creek. More frequent flooding will represent more disruptions to traffic on Wilden Ave.	This area is generally well canopied without extensive hard surface, but the built environments along the Rock Run floodplain at this intersection do not currently allow for good flood management.
10	E Wilden and 7th Street	The increased flow of water across surfaces due to heavy rain will have a negative impact upon properties in this area. Increased precipitation could also overwhelm the wetland located to the northeast of this area with excess water flowing towards residences.	Depending upon the time of year, flooding in the area from heavy rain could be exacerbated by frozen ground or storm drains covered by fallen leaves.
11	Bashor Road Sanitary Sewer Lift Station	Heavy rain events and the resulting flooding could damage the sanitary sewer lift station resulting in sanitary sewer backups and overflows. Impacts to the wastewater treatment in the event of stormwater infiltration to this separated sewer system are also of concern.	This sanitary lift station is not tied into storm infrastructure in any way so no impacts to flooding are anticipated.
12	S Indiana and Berkey	Extended flood conditions could lead to deterioration of the roadway, washing out of the culvert, and damage to homes.	Large parts of this area currently sit within the 100-year floodplain—some are well vegetated and protected natural space while other sections are developed. Currently, the high percentage of tree canopy and open spaces take on water and help mitigate greater flooding downstream.
13	Linway Plaza and Lincoln Avenue Businesses	Increased flooding will likely cause more economic stress to the plaza and the businesses there.	Without changes to the plaza - infiltration points such as greenspace and tree wells, and possibly more intrusive measures - the plaza will continue to be an exacerbating part of the overall problem, rather than a point of mitigation. In addition, floodwater from the plaza parking lots will carry significant amounts of pollution.
14	Oakridge and Mill Street Parks	Increased flooding will likely cause erosion damage to both parks and likely to the Oakridge Cemetery adjacent. Damage will affect green space as well as built infrastructure, including bridges.	The course of Rock Run Creek upstream has been channelized which places greater demand on the two parks. These parks provide an area for floodwaters to spread out.
15	Roxbury Mobile Home Park	Heavy and extended rainfall events have and will continue to impact the drainage in this neighborhood. Some areas experience short-term high water while other areas experience longer periods of high water that flood the entire street cutting off vehicular access. The potential for water damage to property is also a concern.	This developed area largely drains to a detention pond, but stormwater from a cluster of mobile homes on the far northeast edge of the development drains towards the Colonial Gardens Ditch where flooding may be an issue.
16	Alpro Sanitary Lift Station	Heavy rain events and the resulting flooding could damage sanitary sewer lift stations resulting in sanitary sewer backups and overflows.	This sanitary lift station is not tied into storm infrastructure in any way so no impacts to flooding are anticipated.
17	Rogers Park and Chicago Avenue	Clearly, in the Elkhart River floodplain, both the Park and Chicago Avenue will flood with increasing frequency. In effect, they function as part of the capacity to deal with excess water by "slowing it down, spreading it out, and soaking it in." This is good for stormwater management but bad for the built infrastructure that exists in this location.	As a system component, flooding in this area helps to minimize further flooding downstream.
18	Lighthouse Lane Drainage Area	Increases in heavy rainfall events could lead to more frequent flooding resulting in restricted access to businesses. Flooding could impede commercial and residential development in this area. Land area will be lost to build necessary regional stormwater drainage infrastructure. Higher temperatures will increase electrical bills for cooling.	Currently, this area's landscape features relatively low tree canopy and low diversity of vegetative species that allow better infiltration of stormwater. As a natural drainage area, this component takes on water and whether it helps alleviate projected impacts or exacerbate them is dependent on future development characteristics.

Step 4: Landscape Analysis: Heat

The fourth step in the vulnerability assessment focused on compiling and analyzing pertinent information needed to understand how the various elements in the stormwater system already are vulnerable to heat.

Two questions were considered to guide the assessment of each component's vulnerability to flooding:

1. How do local landscape features influence the element's vulnerability to heat?
2. How will each element exacerbate or reduce landscape vulnerability to heat?

Table 7 below demonstrates the results from this step of the assessment.

Ref #	System Component	How Do Local Landscape Features Influence This System Component's Vulnerability to Heat?	How Will This System Component Exacerbate or Reduce Landscape Vulnerability to Heat?
1	Trinity Square Shopping Center	The landscape—nearly 100% impervious with almost no vegetation and in the floodplain—makes this area particularly vulnerable to heat. Asphalt pavement will make this area even hotter on high heat days.	Because the heat island is severe here, this may affect not just the shopping center but nearby areas as well. There are some strategies to implement (like tree planting) that would reduce the vulnerabilities at this location.
2	Natural Areas - Floodplain	Increased heat can increase the humidity of highly vegetated areas. Some native plants may suffer from new heat profiles with consequences for tree canopy cover and vegetation.	Natural areas are a powerful asset as vegetation has measurable impacts on reducing urban heat island effects.
3	Conveyance System	Increasingly hot impervious surfaces could increase thermal pollution in stormwater conveyed to waterways. Extreme heat can cause the expansion and shifting of street pavements which can potentially lead to damaged storm sewer structures.	Currently, a heat impacted conveyance system can damage other landscape features such as soil and plant life. If green infrastructure were more widely implemented, it would have the opposite effect by helping to mitigate urban heat island effects.
4	Huron Street Neighborhood	Depending on the ability of existing vegetation to survive, heat may increase vulnerability. If maintained and expanded, the current tree canopy will help reduce vulnerability to heat. The proximity of the highly impervious landscape in Trinity Square will make this neighborhood more vulnerable to the urban heat island effect.	The tree canopy in this residential neighborhood can help alleviate some vulnerability to heat. Storms that lead to power outages combined with increased heat and humidity will greatly impact residents of this neighborhood.
5	Southwest Goshen – Leedy Ditch Watershed	Land use ranges from agriculture to residential so there is a mixture of tree canopy coverage. Far less impervious surfaces compared to the rest of Goshen reduces the urban heat island effect here. Crop growth will be negatively impacted and the existing tree canopy could be impacted as increased heat stresses trees that grow better in a cooler climate. In areas with very little to no shade, the water temperature in Leedy Ditch will increase—leading to thermal pollution and impacting aquatic wildlife.	Increased humidity is correlated with crop growth creating a higher heat index. Tree canopy will keep the immediately adjacent areas cooler but crops will be exposed to the high temperatures. Undeveloped surfaces can help mitigate heat to an extent.

Ref #	System Component	How Do Local Landscape Features Influence This System Component's Vulnerability to Heat?	How Will This System Component Exacerbate or Reduce Landscape Vulnerability to Heat?
6	Westoria to The Gardens Drainage Swale	This watershed has a mixture of agriculture and residential land uses with little tree cover in agricultural areas but greater cover in residential areas. Crop growth will be negatively impacted and the existing tree canopy could be impacted as increased heat stresses trees that grow better in a cooler climate. Algae growth in the detention ponds could increase due to increased temperatures causing property values to fall and potential health issues. Hard surface areas will increase thermal pollution in stormwater runoff. The residential areas are 10-30 years old and so some have fairly young trees that do not provide much shade.	The area along the drainage swale will provide a ready source of water and trees could grow well along this corridor providing cooling effects. An increase in street side trees would reduce the thermal impact of asphalt surfaces. Humidity from extreme heat and agricultural land use could be an issue.
7	Horn Ditch, Spring Brooke Neighborhood, and Fidler Pond	Some areas of Horn Ditch have little to no tree canopy which will increase the surface and runoff temperatures. Hard surface areas in industrial, commercial, and residential areas will increase the temperature of stormwater runoff leading to thermal pollution. Fidler Pond does not have a lot of tree canopy along the edges but it is a deep pond so it will not be as negatively impacted.	Lack of tree cover can contribute to thermal pollution. Considerable open space in both the residential and industrial land use areas means there is potential for an increased tree canopy that would help mitigate and alleviate these issues.
8	Abshire Park/ Rock Run Creek Walking Path	Portions of the trail are forested, and therefore shaded from intense heat. Vegetation and wetland habitat in Abshire could potentially increase humidity and has little direct shade, but high rates of evapotranspiration have an important cooling effect on the entire area.	Generally, this area will have a net cooling effect for the surrounding residential and industrial neighborhoods. Forest canopy and wet prairie ecosystems will dissipate heat rather than exacerbate it.
9	W Wilden and Indiana Avenue Intersection	Mature trees which once existed in Creekside Manor have slowly been removed over the past 10 years. There are no shade trees remaining near the intersection, and shade trees only persist toward the north and west side of the park. This area is also adjacent to the Oakridge Cemetery which is a large open space with very little canopy cover. Landscape maps showed a heat island effect centered around this unshaded area.	High percentages of pavement in the mobile home park and street intersection, metal roofs, and lack of tree canopy increase the heat vulnerability in what otherwise would be a less heat vulnerable area.
10	E Wilden and 7th Street	This residential neighborhood has some existing tree canopy and lots of green lawn space. The surrounding landscape has large, open green spaces and several wooded areas which will help to cool neighborhood ambient temperatures.	Additional tree canopy would help to further cool existing landscape components in the future.

Ref #	System Component	How Do Local Landscape Features Influence This System Component's Vulnerability to Heat?	How Will This System Component Exacerbate or Reduce Landscape Vulnerability to Heat?
11	Bashor Road Sanitary Sewer Lift Station	Increased temperatures could impact equipment.	This system component will not have an impact.
12	S. Indiana and Berkey	This area has a high percentage of canopy and greenspace at the intersection. Much of the canopy is still increasing, suggesting that heat vulnerability may decrease. Increased heat could cause greater humidity due to landscape features.	Mullet Park to the east of the intersection is a significant part of the Elkhart River floodplain and is undeveloped. Continuing to develop the tree canopy and allowing portions of the park to become wet prairie (rather than mowed) could allow the component to become even more efficient at dissipating heat in the center of town.
13	Linway Plaza and Lincoln Ave. Businesses	The Plaza has 0% vegetated landscaping, or 100% impervious hard surface (parking lot and rooftop). It is highly vulnerable to the urban heat island effect.	The introduction of landscape vegetation, while necessary, would be difficult given the high heat vulnerability that currently exists. Vegetation would need to be introduced in a large enough capacity to be self-sufficient in the high heat island environment.
14	Oakridge and Mill Street Parks	Good percentages of canopy and greenspace mean that there is limited vulnerability to heat overall. However, the cemetery in Oakridge Park has little canopy and currently has an identified heat island effect surrounding the area.	The park settings will allow for ongoing canopy growth and greenspace preservation. Heat should not be a significant concern.
15	Roxbury Mobile Home Park	Portions of the mobile home park are well canopied, others are not; however, there is significant greenspace throughout. Moderate vulnerability to heat could be decreased with further canopy development. The detention pond is a heat sink and generates humidity.	As a component, the mobile home park exhibits good capacity to reduce vulnerability to heat—lots of existing greenspace and soil moisture content.
16	Alpro Sanitary Lift Station	Increased temperatures could impact equipment.	This system component will not have an impact.
17	Rogers Park and Chicago Avenue	Rogers Park has high percentages of canopy and greenspace, which serve to reduce heat vulnerability. There are places where the canopy could be further developed. Chicago Ave, especially on the Trinity Square side, has little to no landscape vegetation and has higher urban heat island vulnerability.	The component is not likely to exacerbate heat and instead can help mitigate some heat island effect from the adjacent, highly impervious shopping centers.
18	Lighthouse Lane Drainage Area	Until the mid-2000s this area was largely farm land and so the tree canopy is relatively young. Land uses in this drainage area still includes agriculture which can cause increased humidity. Impervious surfaces like streets, parking lots, and driveways are exposed to the full sun—increasing the heat island effect and stormwater thermal pollution.	This area has high potential for tree canopy expansion, which could allow for tree species adapted to higher temperatures to be planted.

Step 5: Landscape Analysis: Flooding

The fifth step in the vulnerability assessment focused on compiling and analyzing pertinent information needed to understand how the various elements of the stormwater system are already exposed to flooding. To do this, information was collected, to the extent available, on: elevation; whether or not the system was in the floodplain; slope; impervious land cover; and storm event capacity and condition of infrastructure in the region when known. Local knowledge and data were primarily used for this assessment.

Two questions were answered for each component's vulnerability to flooding to guide this step of the assessment:

1. How do local landscape features influence the element's vulnerability to flooding?
2. How will each element exacerbate or reduce landscape vulnerability to flooding?

Table 8 below demonstrates the results from this step of the assessment.

Ref #	System Component	How Do Local Landscape Features Influence This System Component's Vulnerability to Flooding?	How Will This System Component Exacerbate or Reduce Landscape Vulnerability to Flooding?
1	Trinity Square Shopping Center	Impervious surfaces, zero tree canopy, and little vegetation give this area no infiltration capacity nor an ability to hold and slow stormwater. Storm pipes running towards the river in effect trap floodwaters for an extended period of time during major storm events because pipes are obstructed until the river height is lower than the pipe outfall.	Imperviousness exacerbates flooding. Runoff cannot make it to the river or infiltrate in place so flooding expands to adjacent land areas including the Huron neighborhood.
2	Natural Areas - Floodplain	The length of time natural areas in the floodplain are inundated with water could increase vulnerabilities. Public parks in the area can become inaccessible during flooding. Costs associated with damage from erosion and sediment deposition are already an issue in parks like Shanklin, Oakridge, and Abshire. Debris trapped in stormwater conveyance systems and waterways impacts their functionality. The floodplain has been developed in some areas increasing their vulnerability to flooding.	The vegetation is well adapted to flood conditions because they are floodplain species. Increased flooding along these tributaries to the Elkhart River in recent years is causing new problems and less is known about the floodplain in these areas.
3	Conveyance System	Trees are providing a service reducing the capacity needs of the storm sewer system. Goshen generally has well-drained soils which benefit elements of the conveyance system that allow for infiltration like retention basins and open spaces.	If storm drains clog from storm events, local flooding can occur. Outdated or damaged pipes can cause similar impacts. Goshen has a combined sewer overflow (CSO) system meaning in sections of the City the storm sewer infrastructure combines with the sanitary system and conveys stormwater and sewage to the wastewater treatment plant. Pumps associated with the sanitary system are in some low-lying areas making them vulnerable to flooding. In addition, 2018 flooding nearly caused the sanitary system to be inundated which would shut down the treatment plant and discharge sewage directly to the river.
4	Huron Street Neighborhood	The Huron Street neighborhood is directly adjacent to the current floodplain. The CSO system in this neighborhood means if/when the stormwater system reaches capacity and backs up, there is no path for stormwater to leave this neighborhood. Power outages from storms could cause sump pumps to be inoperable, creating greater risk to residents and flood damage in their homes.	If maintained and expanded, the tree canopy in this area can help mitigate some conditions. As the combined sewer is the only drainage path for stormwater, storm events will stress that system.

Ref #	System Component	How Do Local Landscape Features Influence This System Component's Vulnerability to Flooding?	How Will This System Component Exacerbate or Reduce Landscape Vulnerability to Flooding?
5	Southwest Goshen – Leedy Ditch Watershed	This watershed has an associated floodplain. Stormwater runoff will flow to the ditch but only as fast as the landscape or stormwater pipes allow it to. In agricultural areas, the presence and type of vegetation will determine how fast stormwater runoff flows to the ditch and how much sediment it takes with it. In residential areas, stormwater runoff will flow to stormwater ponds or detention basins and overflow into the ditch only as fast as the overflow pipe will allow. This could lead to flooding conditions and water finding other ways into the ditch. Accessibility issues in neighborhoods due to flooding are not likely to be an issue, except along Bashor Rd where floodwaters have come close to covering the road in the past. Finally, elevation changes towards the ditch can cause high runoff velocities leading to flash flood conditions.	Until relatively recently, floodplains along Leedy Ditch were not considered as development occurred and buildings were built in the floodplains. Currently, lower impervious surface coverage, along with large swaths of well-drained soils, allows water here to infiltrate.
6	Westoria to The Gardens Drainage Swale	The overall amount of hard surface area has increased and continues to increase as parts of this drainage area are developed. Development that does not carefully consider natural drainage could increase flood vulnerability in The Gardens neighborhood especially. Currently, the type, or lack, of vegetation in agricultural fields has an impact on how much water flows into The Gardens neighborhood. At this time there is no identified floodplain for the Colonial Gardens Ditch that runs through this area.	The significant agricultural land use of this area offers opportunities for water to slow down, spread out, and soak in. Drainage areas within the Westoria neighborhood have been altered and hold water on-site in stormwater ponds so the area no longer contributes to overall flow towards the ditch. The stormwater swale and ponds for The Gardens take on offsite drainage from the south as well as the runoff from streets and detains it until it overflows to the north or evaporates (depending on the intensity and length of a rainfall event). This design creates a choke point at culverts running under both Redspire Blvd. and Clinton Street that has the potential to exacerbate flooding if undersized or unmaintained.
7	Horn Ditch, Spring Brooke Neighborhood, and Fidler Pond	Once floodwaters reach a choke point (potential to overtop the road here) and pass under College Avenue from the two-stage ditch, they spread out and flooding occurs. Increased flood volumes through the Spring Brooke stormwater ponds could cause more frequent overflows towards Fidler Pond resulting in damages to the pedestrian path and the introduction of sediment into Fidler Pond. The Lippert Components Plant along the east side of Horn Ditch is also susceptible to flood damages.	The two-stage ditch section of Horn Ditch helps to contain floodwaters and prevents the flooding of the surrounding properties. Hard surfaces and lack of vegetation in industrial areas along Century Drive add to the amount of water flowing to and through the ditch. The natural area between Spring Brooke and Fidler Pond is another feature that helps mitigate flooding as it helps to slow floodwaters down and soak it in.
8	Abshire Park/Rock Run Creek Walking Path	Increased flood velocity and volume through Rock Run Creek could cause damage to the walking path and other park infrastructure currently located in fluvial erosion hazard areas. Already, the Creek has changed course from the 2018 flood and the path had to be moved and a pedestrian bridge repaired.	Wet prairie areas of Abshire Park are a natural part of the floodplain, and function to hold, slow, and infiltrate water. This area could be considered a net asset rather than a vulnerability. As a floodplain component, it reduces vulnerability to flooding downstream. Erosion in this area could cause sediment loading downstream.

Ref #	System Component	How Do Local Landscape Features Influence This System Component's Vulnerability to Flooding?	How Will This System Component Exacerbate or Reduce Landscape Vulnerability to Flooding?
9	W Wilden and Indiana Avenue Intersection	The high percentage of impervious surfaces in the floodplain greatly increase flood vulnerability in proximity to Rock Run Creek. In addition, parts of the mobile home park sit within the 500-year floodplain in FEMA's 2011 maps (updated maps currently in draft form encompass an even greater area of this neighborhood). Finally, high-intensity storm events stress the capacity of the nearby wastewater treatment plant meaning back-ups can potentially exacerbate issues at the intersection.	A higher incidence of flooding means that existing landscape components - both natural and built - are vulnerable. Built components will likely experience greater deterioration.
10	E Wilden and 7th Street	Surrounding elevation creates a natural drainage path for excess water that flows towards residential properties. Infiltration is not adequate to absorb large precipitation events.	While relatively well draining soils and vegetation play some part in slowing, spreading, and soaking in water, built areas do not offer the same capacity.
11	Bashor Road Sanitary Sewer Lift Station	This system component is very vulnerable to flooding. The station is located close to a choke point of the Colonial Gardens Ditch as it crosses under Bashor Road. Flooding in this region of the Colonial Gardens Ditch is a concern in general.	The component could cause back-ups elsewhere but otherwise has little to no impact on surrounding landscape features.
12	S. Indiana and Berkey	This area is largely within the floodway and 100-year floodplain. The elevation map suggests that the Elkhart River's course once moved through this area. Future climate impacts could cause more frequent inundation that reaches to a greater extent. This area is generally well vegetated (Mullet Park) with lots of tree canopy (Lehman woods), but portions are developed that are/ will be impacted by floodwaters. Floodwaters can also overwhelm Indiana Ave., restricting a major north/south traffic route. The storm infrastructure in this area is also vulnerable and has experienced back-ups during past flood events.	The protected areas of this floodplain offer ecosystem benefits that will help mitigate the impacts of heat locally and flooding downstream.
13	Linway Plaza and Lincoln Ave. Businesses	As the Plaza is located in the existing floodway and floodplain, the addition of vegetated landscape can do little to influence vulnerability to flooding. The infrastructure here is generally built high enough to avoid damage during flood events, but even slightly higher floodwaters could cause issues.	The impervious surfaces of the Plaza occupy the floodway/floodplain which could otherwise be vegetated. This likely pushes floodwaters further into adjacent areas than they might have otherwise reached.

Ref #	System Component	How Do Local Landscape Features Influence This System Component's Vulnerability to Flooding?	How Will This System Component Exacerbate or Reduce Landscape Vulnerability to Flooding?
14	Oakridge and Mill Street Parks	The parks are located in an existing floodway and floodplain. Increased vegetated landscape can do little to influence vulnerability to flooding. Some park infrastructure has been and will be impacted by floodwaters. In addition, some gravesites in Oakridge Cemetery have been flooded and could be further impacted in future flood events. Significant erosion upstream has resulted in heavy sediment deposits in these park areas. Mill Street Park is located on a remediated brownfield site so projects that disturb the clay cap here could lead to lead contamination.	The landscape features of this component currently act as a protected open space that can take on floodwaters with minimal damage. The floodplain helps protect other adjacent areas from flood impacts. However, much of the landscape vegetation is turf grass which is less effective for floodwater infiltration than native vegetation options.
15	Roxbury Mobile Home Park	The private stormwater infrastructure on the northeast corner of the development seems particularly vulnerable to large rain events as observed during the 2018 flooding. Landscape features such as greenspace and moderate canopy cover allow for some absorption/holding of stormwater.	The Roxbury detention pond has an outfall to Leedy Ditch on the west side and a few houses drain towards Colonial Gardens Ditch on the east side. Both could be impacted by an increased volume and velocity of water coming from the Roxbury development, but the development itself is not in the known extent of either waterway's floodplain.
16	Alpro Sanitary Lift Station	This system component is very vulnerable to flooding. Its location along Lateral 'K' Ditch makes it vulnerable to events where water overtops the ditch. High velocity flow here could cause additional erosion.	Taking up a very small area, the landscape features of this component will have little to no effect on flooding in the area.
17	Rogers Park and Chicago Avenue	The Park is located in the existing floodway and floodplain. Built infrastructure can be damaged by floodwaters with the financial burden for repairs born by the City budget and therefore taxpayers. The embankment running along the Elkhart River in effect traps floodwaters for an extended period of time during and after major storm events because drainage pipes through the embankment to the river become obstructed until the river height is lower than the pipe outfall.	This protected area of the floodplain helps to mitigate flooding in surrounding areas to some extent; however, much of the landscape vegetation is turf grass which is less effective for floodwater infiltration than native vegetation options.
18	Lighthouse Lane Drainage Area	The surrounding landscape is largely undeveloped turf grass with a young tree canopy and increasing hard surface area. Heavier storm events and these conditions mean water could flow faster and cause flooding and erosion. Clay soils and stormwater infrastructure placed in the natural drainage path mean basins and other measures have never functioned properly and can exacerbate issues.	The development in this area is being constructed in a natural drainage area and instead of water soaking into the soil, now there is hard surface area preventing infiltration and leading to more flooding. Development here could cause unforeseen drainage issues elsewhere as happened with the OBGYN Clinic and Birthing Center.

Step 6: Cumulative Impacts

The sixth step in the analysis combined information and analysis done in steps 2-5 to gather a holistic sense for the different ways each element evaluated as part of the assessment was impacted by socio-economic considerations, changes in climate, and local landscape features. This section asks the following question:

1. How will the element affect socio-economic, climate, and landscape features?
2. How will socio-economic, climate, and landscape features affect the element?

Table 9 below demonstrates the results from this step of the assessment for a subset of the stormwater system

Ref #	System Component	Based On All Analysis Completed So Far, Summarize How This System Component: 1) Will Be Affected By and 2) Will Affect Socio-Economic, Climate, and Landscape Features.
1	Trinity Square Shopping Center	Kroger grocery is central to many in Goshen and so flooding increases overall food insecurity—especially for those in nearby neighborhoods. The potential for annual flooding has increased and is projected to continue increasing. As an area already severely impacted by flooding, the businesses/property owners in Trinity Square have indicated that they are very concerned about rising flood risks as well. Kroger is the anchor business for this area so losing the grocery would have significant economic and food security ramifications. If not addressed, landscape features such as 100% imperviousness, zero tree canopy, and little to no vegetation will continue to exacerbate both heat and flood vulnerability. The landscape's built infrastructure such as storm pipes may also exacerbate flooding in this area.
2	Natural Areas - Floodplain	In the future, the extent of the floodplain is likely to grow and the natural path of waterways change course. In addition, current and anticipated climatic changes will affect the biodiversity of the area with unknown consequences for ecosystem health. Preserved, healthy natural areas are one of the financially cheapest ways of adapting to flood events. Losing the floodplains could have unintended and unanticipated impacts on the volume and velocity of water pushed downstream. The areas in the floodplain that have not been historically protected and are currently developed are facing threats to infrastructure from flooding.
3	Conveyance System	As climate and weather patterns change, it is important that the overall stormwater system has the capacity to handle bigger precipitation events. Undersized or damaged conveyance infrastructure can undermine that capacity and exacerbate flooding; however, there are opportunities to improve the overall system by directing greater effort to managing stormwater in place. This may include greater stormwater capture requirements (i.e., stormwater basins designed and sized for bigger storm events) and more widespread use of green infrastructure and low impact development principles. These efforts can decrease the amount of stormwater reaching the conveyance system—reducing stress on the wastewater treatment plant from combined sewer systems and reducing peak flows in waterways during flood events.
4	Huron Street Neighborhood	The neighborhood is economically vulnerable as it is and during disasters, the population can quickly become isolated and hard to reach. The close proximity of the neighborhood to the highly impervious Trinity Square means their flood vulnerability is inextricably tied to that of the shopping center. Improving the neighborhood's flood resiliency may also help improve the Trinity Square area (or vice versa). Additionally, features like proximity to the floodplain and the combined storm sewer infrastructure of the neighborhood affect flood vulnerability. The open space for tree canopy and other vegetation can help alleviate some flood and heat impacts and is of particular importance in this neighborhood.

Ref #	System Component	Based On All Analysis Completed So Far, Summarize How This System Component: 1) Will Be Affected By and 2) Will Affect Socio-Economic, Climate, and Landscape Features.
5	Southwest Goshen - Leedy Ditch Watershed	Leedy Ditch represents a variety of land uses and demographics from agriculture to commercial, and residents from high to low income. Some development has occurred in the floodplain as it was not part of the regulatory floodplain until recently. Consequently, changing intensity of future storm events could impact this area. The landscape features could create high runoff velocities leading to flash flood conditions and erosion. Overall, flooding in Leedy Ditch comes and goes quickly, except for some sections of Roxbury Park where flooding lasts longer (possibly due to an undersized or damaged stormwater management system). Agricultural land use in this area could be vulnerable to saturated soils or extreme heat.
6	Westoria to The Gardens Drainage Swale	Incomes in both neighborhoods range from middle to upper with some fixed incomes (retirement) making vulnerability variable here. Farmers may be more vulnerable as agricultural land uses could be negatively impacted by the changing nature of storms and increased heat. Westoria collects its stormwater on-site while The Gardens provides some flood storage in its basins and a defined channel through the neighborhood from south to north in the Colonial Gardens Ditch. Drainage culverts at Clinton St. and Redspire Blvd. have been and will be restrictive points that will influence floodwater levels in The Gardens neighborhood. There is the potential for basement impacts nearest to the drainage swale. Most homes in both developments are unlikely to be impacted.
7	Horn Ditch, Spring Brooke Neighborhood, and Fidler Pond	The variety of land uses spanning industrial, commercial, residential, and public space mark differing socio-economic vulnerabilities. This area has historically been impacted by flood waters with costly damage to Fidler Pond's walkways, Springbrooke's stormwater basins and walkways, and the Lippert Components plant. The two-stage ditch that ends just before this area has alleviated historic flooding impacts in the industrial area south of College Avenue, but its benefits do not necessarily extend to this area north of the bridge. Highly impervious surfaces and lack of vegetation surrounding Horn Ditch could exacerbate impacts from climatic changes.
8	Abshire Park/Rock Run Creek Walking Path	Much of the component continues to function as a floodplain, so impacts are minimal; however, recreational infrastructure (pathways, parking lot, bridges) are impacted to differing degrees. Recent flood damages have led to discussions and actions on infrastructure relocation.
9	W Wilden and Indiana Avenue Intersection	The Creekside Manor mobile home park near this intersection houses lower income residents and has experienced past infrastructure damage from flooding. Wilden is the main east-west corridor on the north side of town, so inaccessibility due to flooding would have an economic and public safety impact. Evacuation of residents, especially at Creekside Manor, can be an important safety issue depending on how quickly and what time of day water rises. Proximity to Oakridge cemetery may impact the area's vulnerability to heat and infrastructure back-ups during major flood events at the adjacent Wastewater Treatment plant may exacerbate flood vulnerability.
10	E Wilden and 7th Street	This socio-economically vulnerable residential neighborhood is a focus point for stormwater flowing from the northeast. During intense rain events, elevation changes direct water towards this area and to the city storm infrastructure. Flood issues depend on the season and amount of precipitation in this well vegetated, largely open, area.
11	Bashor Road Sanitary Sewer Lift Station	Water pools west of the lift station as the Colonial Gardens Ditch reaches a choke point at Bashor Road. Water can overflow Bashor Rd., and if the waters rise high enough, the lift station can be impacted. A lift station failure could cause sanitary sewage back-ups into residences and businesses on the northwest side of Goshen serviced by the station. Inundation could also allow stormwater infiltration to the separated sewer system here which would reduce wastewater treatment plant capacities.

Ref #	System Component	Based On All Analysis Completed So Far, Summarize How This System Component: 1) Will Be Affected By and 2) Will Affect Socio-Economic, Climate, and Landscape Features.
12	S. Indiana and Berkey	Much of the existing floodplain remains intact and functional. However, the periphery is impacted by floodwaters with consequences for generally low-income home and property owners in the area. Floodwaters also impact public infrastructure as they block or limit access to Indiana Ave. and overwhelm drainage systems. Buyouts and conversion of the floodplain to more appropriate uses would decrease the socio-economic and overall vulnerability of this component.
13	Linway Plaza and Lincoln Ave. Businesses	The potential for annual flooding has increased and is projected to continue increasing. During extreme flood events, businesses in and surrounding the Plaza are impacted by flooding to varying degrees, including water damage to complete demolition and reconstruction. The Plaza has high flood vulnerability, but also contributes to the severity of flooding in the immediate area and downstream due to hard surface area and fill in the floodplain.
14	Oakridge and Mill Street Parks	Much of the component continues to function as a floodplain, limiting the damage from climate impacts; however, recreational infrastructure (pathways, playscapes, parking lot, bridges) and other features (gravesites, contaminated soils) may be impacted to differing degrees. Open green space and room for canopy growth are major opportunities for mitigating climate impacts for surrounding areas.
15	Roxbury Mobile Home Park	Flooding near private storm infrastructure in the northeast corner of this development poses a risk to a few low-income residents of the mobile home park. This system component's stormwater has an emergency overflow towards Leedy and the Colonial Gardens ditches could impact velocity and volumes of stormwater downstream.
16	Alpro Sanitary Lift Station	This largely industrial area is vulnerable to flood impacts as waters rise in the Lateral 'K' Ditch and threaten the sanitary lift station along Kercher.
17	Rogers Park and Chicago Avenue	Floodplain is largely intact, but park infrastructure sustains damage regularly. During floods, stormwater can no longer out-flow through pipes to the river, causing flooding in the Park and impacting Chicago Ave, Trinity Square, and the Huron St. neighborhood. Floodwaters along Chicago Ave cut off a major north/south connection.
18	Lighthouse Lane Drainage Area	Flooding could impact future development of residential neighborhoods, and severely limit access to two healthcare facilities. Development in and around a natural drainage area could exacerbate future flooding while efforts at lighter development, green infrastructure, and diverse vegetative growth could help alleviate current flooding issues.

Step 7: Sensitivity Assessment

The seventh step of the assessment focused on the sensitivity of each element evaluated in the stormwater system to the impacts identified in the previous step. Sensitivity is the degree to which a system and its constituent parts (e.g., built, natural, human) can be or are affected by changes in climate conditions or specific climate impacts. For example, a building built in the 0.2% annual chance floodplain with flood-proofing measures is much less sensitive to a flood than one in the 1% annual chance floodplain with no flood proofing measures.

To determine how sensitive each of the elements are, the following three questions were addressed:

1. What, if any existing stresses affect this element?
2. How might demand for this element change given impacts identified in Step 6?
3. What, if any, limiting factors does this element have that make it more sensitive?

These questions were answered for each of the elements included in the scope of the assessment. The responses to these three questions were used to assign a sensitivity score for each element. Qualitative evaluation criteria provided in Figure 42 below were used to assign sensitivity scores.

Figure 42: Sensitivity Levels	
S0	Element will not be affected by the climate-related impact
S1	Element will be minimally affected by the climate-related impact
S2	Element will be somewhat affected by the climate-related impact
S3	Element will be largely affected by the climate-related impact
S4	Element will be greatly affected by the climate-related impact

Results from this analysis included particularly high sensitivity (score of S4) to climate impacts in those developed areas in or adjacent to the floodplain of the Elkhart River particularly. The most sensitive areas include Trinity Square Shopping Center, Linway Plaza, and other Lincoln Avenue businesses, Chicago Avenue and Rogers Park, and W Wilden and Indiana Avenue intersection. These are all places where development has occurred within the floodplain. They all also represent areas where essential public and private services are provided and accessed. The next most sensitive includes those slightly less developed areas that have also already experienced flood damages—many of which are located in more fringe regions of the floodplain or are part of the drainage areas of smaller tributaries. The least sensitive areas include the natural areas like City parks that are within the floodplain but have little to no infrastructure that may be impacted.

Finally, the stormwater conveyance system also appears in the second highest sensitivity category because of how essential it is to dealing with flooding by directing stormwater away from Goshen's developed areas. Clogged pipes, pipes in states of disrepair, and pipes with capacities no longer suitable to surrounding development or the changing nature of storm events all pose risks to flooding throughout the City by causing stormwater back-ups and localized flooding. Unfortunately, the limited knowledge about the condition of the conveyance system makes identifying particularly vulnerable areas difficult. The City is working to compile more accurate information and considering alternative, more forward-thinking methods of stormwater management that prioritize managing stormwater in place rather than relying entirely on the conveyance system.

Table 10 below demonstrates the results from this step of the assessment.

Ref #	System Component	What, If Any Existing Stresses Affect This System Component?	How Might Demand For This System Component Change Given the Identified Impacts?	What, If Any, Limiting Factors Does This System Component Have?	How Sensitive is This System Component to Projected Changes in Climate?
1	Trinity Square Shopping Center	While there were a few changes of ownership, all the businesses in the Square were able to survive and resume business after the 2018 flood. Landscape features add additional stress to this system. In addition, a high running river during a flood event can block the outfalls connected to this area which can create a "bathtub effect" where water has no outlet from the area.	Extreme weather that limits travel throughout the city can increase demand on Kroger, the Dollar Store, the gas station, and other sources of critical supplies in the center.	When the river rises high enough, stormwater becomes trapped. As this area continues to face the impacts of flood events, existing tenants could face financial hardships and the area may struggle to attract new businesses to replace those that leave.	S4 - System will be greatly affected by the climate-related impact
2	Natural Areas - Floodplain	Climatic changes are already impacting this area. Invasive species are a particularly visible impact. The City has a limited budget for addressing these impacts. In addition, some areas of the floodplain have already been developed.	Demand for the flood control benefits of natural areas will increase as the ability of the floodplain to absorb stormwater is impacted by climate change.	Expanding natural areas in the floodplain to meet increased demand is limited by existing development. Near downtown is the narrowest point of the Elkhart River in Goshen and becomes a sort of chokepoint for the entire watershed.	S1 - System will be minimally affected by the climate-related impact
3	Conveyance System	This component is limited by the available budget and the huge scale of the infrastructure adds additional stress. In addition, Goshen continues to grow adding additional development stress to existing systems. Potentially rising groundwater tables in some areas further stress this system.	Currently, with the well-drained soils that dominate Goshen, infiltration of stormwater is adequate. As groundwater rises, the infiltration rates will decrease leading to localized flooding and placing greater demand on the storm sewer system. System demand could also increase with new development and redevelopment on properties with little to no room for stormwater storage	The greatest limiting factor is the systems' current capacity. What is in the ground is in the ground—changes to that infrastructure would be costly.	S3 - System will be largely affected by the climate-related impact
4	Huron Street Neighborhood	Socio-economic vulnerability factors like low income, more renters than the city average, and higher rates of poverty are added stressors in this neighborhood.	Could see a loss of livable space due to expanding floodplain. Thus, there could be a decrease in demand for the neighborhood - which would push people to other parts of the city.	The fairly transient nature of the neighborhood's population limits intervention options. In addition, the mature age of the tree canopy limits its impact on future climate impacts if not regenerated.	S3 - System will be largely affected by the climate-related impact
5	Southwest Goshen – Leedy Ditch Watershed	Some development within existing floodplains can exacerbate immediate flooding issues. The amount of elevation change between the top of the watershed and the Elkhart River also leads to this area being "flashy" when it comes to flooding. A fair amount of agriculture in the area may contribute to potential runoff stresses (i.e., sediment and nutrient pollution).	Increasing development and larger storm events will increase the infiltration demands of open space in order to accommodate flooding with no impacts. In addition, higher flow volumes through the ditch will place higher capacity demands on culverts and other infrastructure.	The capacity of the culvert under US 33 / Railroad is a limiting factor.	S3 - System will be largely affected by the climate-related impact
6	Westoria to The Gardens Drainage Swale	Natural drainage in combination with impervious surface runoff leads to high water in The Gardens' detention basins, but no structural impacts.	Demand on the drainage swale could increase due to natural drainage from south to north—especially if development in this area continues.	Culvert size under Redspire Blvd and Clinton St. could limit runoff flow.	S3 - System will be largely affected by the climate-related impact

Ref #	System Component	What, If Any Existing Stresses Affect This System Component?	How Might Demand For This System Component Change Given the Identified Impacts?	What, If Any, Limiting Factors Does This System Component Have?	How Sensitive is This System Component to Projected Changes in Climate?
7	Horn Ditch, Spring Brooke Neighborhood, and Fidler Pond	Runoff from industrial properties along Century Dr and College Avenue (large amount of impervious surface) are an existing stress. In addition, this area has already experienced costly damage during previous flood events.	Demands on existing stormwater measures will continue to increase as rainfall events increase in intensity.	The two-stage ditch can only handle so much volume and the narrowed drainage channel at College Ave creates a choke point. Agreements made during the construction of the two-stage ditch limits the ability of the City to regulate the volume of stormwater flowing to the ditch from adjacent properties (the City can require stormwater quality controls).	S3 - System will be largely affected by the climate-related impact
8	Abshire Park/ Rock Run Creek Walking Path	Quantity and rate of water flowing through Rock Run Creek in flood events could be a stress on this protected floodplain. Industrial runoff from Horn Ditch and agricultural pollutants from farms and the County Fair Grounds through Rock Run Creek join together just upstream of Abshire Park and are carried to the area.	Demand on the capacity of the wetland to slow, hold, and infiltrate water will increase.	Development around the park limits the ability to expand natural areas and increase the flood control capacity. Other limiting factors include the City budget.	S2 - System will be somewhat affected by the climate-related impact
9	W Wilden and Indiana Avenue Intersection	During large stormwater events, backup of the sanitary sewer system at the Wastewater Treatment Plant can cause water to flow to the intersection. In addition, this is a primary east-west traffic corridor for the north part of town.	Road closures at other major east-west roads in the city during a flood event can increase traffic at this intersection.	A limiting factor for this area is that parts are already developed and changes to the Wastewater Treatment facilities require major capital investments.	S4 - System will be greatly affected by the climate-related impact
10	E Wilden and 7th Street	The amount of natural drainage flowing through the area due to topography is an additional stressor.	Demand will increase dependent on the size of a specific rainfall event, frequency of recent rainfall events, and seasonal conditions.	The capacity of the existing storm sewer system and its ability to accept flow are major limiting factors.	S3 - System will be largely affected by the climate-related impact
11	Bashor Road Sanitary Sewer Lift Station	The station is located in a low-lying area near a drainage choke point. Floodwaters could limit maintenance access and delay repairs. There are drainage concerns and continued development along the Colonial Gardens drainage path with limited information.	Demand is unlikely to change due to climate impacts.	The capacity of the ditch conveyance system under Bashor Road and lack of information on the Colonial Gardens Ditch are major limiting factors for this general area.	S3 - System will be largely affected by the climate-related impact
12	S. Indiana and Berkey	Development has already occurred within the functional floodplain.	Demand will increase.	A culvert under Indiana Ave. may restrict stormwater flow (more study is needed). Its location in a low-lying area limits options for protecting infrastructure.	S3 - System will be largely affected by the climate-related impact
13	Linway Plaza and Lincoln Ave. Businesses	Stresses include near 100% impervious surfaces in the floodplain, a bathtub effect (water can't run to the river because outfall is under water), and businesses at risk of repeated flood damages.	Demand on the floodplain will increase.	Floodplain functionality is limited by 100% impervious surfaces and adaptability by the financial risk to businesses.	S4 - System will be greatly affected by the climate-related impact

Ref #	System Component	What, If Any Existing Stresses Affect This System Component?	How Might Demand For This System Component Change Given the Identified Impacts?	What, If Any, Limiting Factors Does This System Component Have?	How Sensitive is This System Component to Projected Changes in Climate?
14	Oakridge and Mill Street Parks	The channelization of Rock Run Creek upstream of Mill Street Park affects the quantity and rate of water flowing towards this area during flood events. Bank erosion along Oakridge Cemetery is a concern.	Demands on the floodplain will increase.	Generally, few limiting factors were identified. However, Mill Street Park's clay capped, lead-contaminated, soils are a consideration for tree canopy and other land use planning.	S2 - System will be somewhat affected by the climate-related impact
15	Roxbury Mobile Home Park	The condition of the private storm sewer system is unknown but suspected to be in poor condition. Only a couple of homes may be impacted.	Demands on the conveyance system of this neighborhood are likely to increase, but the area is not in the known floodplain extent of Leedy Ditch or the Colonial Gardens Ditch.	This is a private storm sewer system, and thus is not likely an issue that will be addressed with public funding.	S1 - System will be minimally affected by the climate-related impact
16	Alpro Sanitary Lift Station	High rate of flow in flood events could create erosion of the lift station base. Slope of upstream watershed drains large volumes of water to the Lateral 'K' Ditch and towards this area. Much of the runoff comes from agriculture, roadways, and industrial impervious surface areas like gravel storage lots.	Since the lift station is not tied into the stormwater system, demand is unlikely to change due to rainfall events.	Inundation of the station or Kercher Road would limit access for maintenance and repairs which could extend sanitary sewer overflow impacts. The station and upstream sources of stormwater into Lateral 'K' are both outside City limits in the County.	S2 - System will be somewhat affected by the climate-related impact
17	Rogers Park and Chicago Avenue	Quantity and rate of water flowing through the Elkhart River during flood events are an added stress to the area. The effects of the embankment and adjacent impervious surfaces at Trinity Square also contribute to the amount of stormwater runoff collecting here.	Demand for this component will increase with rising volume and frequency of floodwaters.	The Pike Street bridge can constrict the Elkhart River's flow and increase the volume of water in this area. The embankment along the Elkhart River limits options for less costly solutions to increase adaptability.	S4 - System will be greatly affected by the climate-related impact
18	Lighthouse Lane Drainage Area	Stresses included: elevation change of watershed from southwest to northeast, development of the area, heavy clay soils, and installation of stormwater drainage infrastructure within the natural drainage path.	Demand will increase as development increases.	Limitations include the natural landscape features like heavy clay soils and slopes that make this a natural drainage area. Adaptability will also be limited by property owner buy-in for addressing issues.	S3 - System will be largely affected by the climate-related impact

Step 8: Adaptive Capacity Assessment

The eighth step of the assessment focused on the adaptive capacity of each element to the impacts identified in the previous step. Adaptive capacity is a measure of the ability of an element (e.g., institutions, humans, infrastructure, species) to adjust to potential damage, to take advantage of opportunities, or to cope with consequences. Some of the most important factors influencing the adaptive capacity of an element are access to and control over natural, social, physical, and financial resources. This includes things such as knowledge (or access to knowledge), good health, financial resources, ability to migrate (e.g., resources, space, lack of competition), redundant systems (e.g., generators), access to social safety nets, and overall social connectivity.

To determine the adaptive capacity of each component evaluated in the stormwater system vulnerability assessment, the following five questions were considered:

1. Does the element currently have what it will need to adapt to the impacts identified?
2. Can the element accommodate projected climate impacts with minimum disruption or costs?
3. If not, what does the element need to help it adapt to the identified impacts?
4. What is needed in order to help the element adapt to identified impacts?
5. Is the element already stressed in ways that will limit its ability to accommodate identified impacts?

Responses to these questions were then used to assess how adaptive each of the elements evaluated were to projected changes in climate. A qualitative evaluation criterion provided in Figure 43 was used to assign adaptive capacity scores. Figure 43 provides results from this element of the analysis.

Figure 43: Adaptive Capacity Levels

AC0	Element is not able to accommodate or adjust to projected changes in climate
AC1	Element is minimally able to accommodate or adjust to projected changes in climate
AC2	Element is somewhat able to accommodate or adjust to projected changes in climate
AC3	Element is mostly able to accommodate or adjust to projected changes in climate
AC4	Element is able to accommodate or adjust to projected changes in climate in a beneficial way

Results from this analysis found that we have a particularly low adaptive capacity (scores of AC0-AC1) for our stormwater infrastructure (AC1), street trees (AC0), impact on vulnerable populations (AC1), stormwater management staff (AC1) and budget (AC1). These results indicate that all of our selected elements chosen for evaluation are minimally or not able to accommodate projected changes in climate. To increase the adaptive capacity of each of these elements' significant engagement, data collection, funding, and support from community will be essential.

Table 11 below demonstrates the results from the adaptive capacity assessment.

Ref #	System Component	Does The System Component Have What It Will Need to Adapt to The Identified Impacts?	What Does The System Component Need To Help it Adapt To The Identified Impacts?	What Would You Need In Order To Provide What The System Component Needs To Adapt To The Identified Impacts?	Can The System Component Accommodate Projected Identified Impacts With Minimum Disruption or Costs?	Is The System Component Already Stressed In Ways That Will Limit Its Ability To Accommodate Identified Impacts?	How Adaptive Is The System Component To Projected Impacts? (e.g., Adaptive Capacity score)
1	Trinity Square Shopping Center	Providing a highly valued community resource, there is a clear demand to find a solution. Recent flooding has given this area particular attention. However, it is unclear if the area has enough financial resources for the adaptive changes needed to reduce vulnerability.	Green infrastructure that reduces imperviousness could aid somewhat in flood mitigation. A concern that needs further investigation is whether the soils under currently impervious surfaces are too compacted to have the needed infiltration benefits. To fully adapt to and protect against flooding would require major infrastructure updates that would raise the entire shopping center and utilities. However, consideration of where floodwaters would alternatively be pushed to and accumulate would also need to be considered. A comprehensive plan for the entire region of developed floodplain is needed to address this area. This area may eventually be the target of buyouts and conversion to a natural area—a more suitable use for the floodplain.	Money is the biggest obstacle to adaptive changes. Stakeholder education is needed to increase the understanding of businesses, local politicians, and the general public about the climate vulnerabilities and barriers to adaptive changes for this area.	No	Businesses in this area are already financially stressed from past flooding events making financing of adaptive solutions difficult. The physical location and landscape features severely limit adaptation options.	AC0 - System is not able to accommodate or adjust to projected changes in climate
2	Natural Areas - Floodplain	The sizable natural areas in Goshen can accommodate many impacts like the changing nature of the watercourse and floodplain. Vegetative assets are inherently flexible and adaptive.	To expand the capacity of the floodplain means protecting existing natural areas through various methods such as conservation easements, directing development outside the floodplain through City zoning and planning, purchasing of properties that are within the floodplain or directly adjacent to it, and other methods as they become known. Secondarily, converting current developed floodplain to natural areas would also increase the adaptive capacity of the floodplain.	The City needs the political will to implement floodplain development protections and property purchases. Stakeholder education is needed for property owners in the floodplain, elected officials, and the general public about why floodplain preservation is important in order to achieve this buy-in.	It can accommodate some change—especially limited, gradual changes.	There is some public frustration about the flooding of public parks. Currently, floodplain preservation is not coordinated across City departments.	AC3 - System is mostly able to accommodate or adjust to projected changes in climate
3	Conveyance System	Goshen no longer constructs new combined storm/sewer infrastructure which has nearly eliminated CSO (storm/ sewage overflow) events. However, there is still work to be done to make the system more adaptable.	To make the system more adaptable will take money for infrastructure improvements and implementation of green infrastructure, updated planning and zoning ordinances and policies for stormwater, and greater public education efforts. Green infrastructure, in particular, is needed to create a more flexible, climate adaptive system.	To implement these adaptive strategies, a beefed-up version of existing educational programming is needed to garner greater political will for these changes. Monetary and knowledge resources are also needed to implement greater green infrastructure across the system. Regional collaboration is also needed to develop shared knowledge resources in the surrounding area (i.e., engineers who consider green infrastructure, contractors with experience implementing, etc.) and to help develop a culture that recognizes the importance of these kinds of improvements.	The current system can take on greater climate impacts to an extent. However, addressing the identified vulnerabilities would take considerable resources and significant disruption.	In some areas (like College Avenue and 10th St.) the conveyance system is already stressed as it nears capacity for large storm events. The age of infrastructure and pipe materials used in some areas is an additional stress.	AC2 - System is somewhat able to accommodate or adjust to projected changes in climate
4	Huron Street Neighborhood	Currently the neighborhood has tree canopy and some public attention due to recent flooding, but it needs many additional resources for adaptability.	Canopy needs continued attention to regenerate and consider the appropriateness of tree species for changing climatic conditions. Property owners need to understand the potential impacts that they could see in the future (both people who own, renters, and landlords) and implement best practices (i.e., don't put things in the basement, keep critical equipment off the ground). Repetitive loss properties may need buyouts. This neighborhood could also benefit from green infrastructure improvements. If flood damage persists, this neighborhood may need buyouts and other financial resources.	Financial resources are needed along with increased public education that includes the recognition that there are no easy solutions (this is a chronic problem that is likely to get worse).	Not likely—it will take time and resources.	Socio-economic vulnerability factors like low income, more renters than city average, and higher rates of poverty are added stressors in this neighborhood.	AC1 - System is somewhat able to accommodate or adjust to projected changes in climate

Ref #	System Component	Does The System Component Have What It Will Need to Adapt to The Identified Impacts?	What Does The System Component Need To Help it Adapt To The Identified Impacts?	What Would You Need In Order To Provide What The System Component Needs To Adapt To The Identified Impacts?	Can The System Component Accommodate Projected Identified Impacts With Minimum Disruption or Costs?	Is The System Component Already Stressed In Ways That Will Limit Its Ability To Accommodate Identified Impacts?	How Adaptive Is The System Component To Projected Impacts? (e.g., Adaptive Capacity score)
5	Southwest Goshen – Leedy Ditch Watershed	Some components can adapt, while other components will be more challenging.	This system needs private-public partnerships between property owners and governmental agencies to slow down runoff. The area also needs public education for property owners regarding floodplain boundaries and the consequences of development within them. Other methods of protecting the floodplain may also be needed as well as efforts to create natural area buffers. In the future, undersized culverts running under roads may need to be addressed.	Greater political will is needed to implement programs and/or fund projects as well as maintain them. This will take funding and public participation as well as inter-governmental partnerships since the Watershed crosses political boundaries.	Yes, it can adapt but it will take financial input.	Low income areas could be a limiting factor to adaptation because of potential to displace population lacking alternative housing options. In addition, there has been development up to ditch edge.	AC2 - Systems is somewhat able to accommodate or adjust to projected changes in climate
6	Westoria to The Gardens Drainage Swale	Not entirely	Slow the water down. The review and improvement of downstream drainage areas will help to reduce flooding risks. Additionally, the consideration of a regional stormwater detention basin near these neighborhoods has been and should continue to be considered and installed when possible. Increased use of cover crops could keep farm fields vegetated and reduce runoff potential from agricultural areas and increased tree canopy would also be an asset. Finally, the culverts that act as choke points could potentially be resized, but a better understanding of downstream impacts would need to be considered first. Ideally, flows to the choke point would first be reduced.	To make this system component more adaptable would take greater public participation and interest including a willing property owner who would sell and allow for the construction of a regional detention basin. This project would also take considerable funding and the political will to implement and maintain these measures.	No; disruption to farming is likely, as well as financial cost.	The lack of an identified floodplain is a barrier to regulating development in this area. Private property ownership along this area limits options for a long-term, regional solution.	AC3 - System is mostly able to accommodate or adjust to projected changes in climate
7	Horn Ditch, Spring Brooke Neighborhood, and Fidler Pond	Not entirely: where the two-stage ditch has been installed, the area is fairly adaptable. Other areas are already feeling the impacts of flooding and have more limited solutions.	This area needs more opportunities for stormwater to slow down and spread out, but this highly developed area has limited options for this approach. Additional widening of Horn Ditch may be worthwhile to consider. Improving the storage capacities of stormwater on-site at upstream properties would help slow stormwater runoff releases to Horn Ditch and reduce flooding potential downstream at Lippert, Spring Brooke, and Fidler Pond. Already a pathway that allows water to flow beneath the pedestrian path into Fidler Pond has been constructed, but it is untested.	The projects would need public participation and interest, funding, and the political will to implement programs and maintain them. These efforts would also need buy-in from industries who discharge stormwater to Horn Ditch as the City has limited ability to control volumes.	Areas along the two-stage ditch can accommodate projected climate impacts, but the areas around Spring Brooke and Fidler Pond need improvements to become more resilient.	It is stressed, but adaptation is possible; options exist.	AC2 - Systems is somewhat able to accommodate or adjust to projected changes in climate
8	Abshire Park/Rock Run Creek Walking Path	Yes; this protected natural area in the floodplain allows for adaptation to occur.	To increase adaptive capacities includes things like moving the pedestrian path and parking lot near Monroe St., limiting other development, and watching for things like tree falls and bank erosion that could threaten infrastructure at the Monroe St bridge, along the creek bank, and the Pumpkinvine Trail. Work to improve the quality and reduce the quantity of stormwater upstream would benefit this area.	Inter-local governmental cooperation is needed to achieve upstream improvements and ensure banks remain stable. Funding for addressing infrastructure damage and potential damage is needed. Finally, government-private partnerships are needed to address polluting discharges to Rock Run Creek.	This system can generally accommodate climate impacts, but there will be some cost to moving threatened infrastructure like the walking path.	High velocity “flashy” flooding in this area has already caused some erosion issues.	AC3 - System is mostly able to accommodate or adjust to projected changes in climate

Ref #	System Component	Does The System Component Have What It Will Need to Adapt to The Identified Impacts?	What Does The System Component Need To Help it Adapt To The Identified Impacts?	What Would You Need In Order To Provide What The System Component Needs To Adapt To The Identified Impacts?	Can The System Component Accommodate Projected Identified Impacts With Minimum Disruption or Costs?	Is The System Component Already Stressed In Ways That Will Limit Its Ability To Accommodate Identified Impacts?	How Adaptive Is The System Component To Projected Impacts? (e.g., Adaptive Capacity score)
9	W Wilden and Indiana Avenue Intersection	While some improvements at the Wastewater Treatment Plant may help alleviate risks, its location in, and proximity to, the floodplain means this area largely will not be able to adapt to predicted impacts.	Slowing stormwater runoff down upstream of the Wastewater Treatment Plant can help reduce the likelihood of stormwater back-ups. To do this, multiple green infrastructure components would be needed to have the most cumulative adaptive impact. This system component may need additional protections to direct development away from the floodplain and in some cases, relocation of residents may be necessary.	To increase the adaptability of this area would take public participation and interest, funding, and the political will to implement and maintain programs and projects. Slowing down stormwater upstream would take significant public-private collaboration to achieve the needed cumulative impacts of green infrastructure.	Adaptation of this area would cause major disruptions to residents of Creekside Manor and/or major costs to address any possible concerns at the Wastewater Treatment Plant.	Only the most extreme events cause the Wastewater Plant to back up and so stress is limited to those extreme events.	AC2 - System is somewhat able to accommodate or adjust to projected changes in climate
10	E Wilden and 7th Street	No, currently this area would not have what it needed to adapt to more intense storms and flooding.	The intersection of Wilden and 7th is currently a combined system. Separating the sanitary and stormwater systems would help increase the system's capacity. The natural drainage path through this area is more difficult to address. Capturing and redirecting water (possibly buy-out some property) and/or a regional detention basin up-slope of the residential area could help. Other efforts might be resident focused like encouraging greater tree canopy, use of native plants, rain barrels, and rain gardens to help capture, slow, and soak in stormwater.	Accomplishing these improvements would take funding, public support/awareness, and political will. Residential fixes would take additional planning to make green infrastructure affordable/cost-free.	Changes to the storm infrastructure would be a major capital expense and disruption to residents.	Socio-economic factors in this neighborhood are an additional stressor.	AC3 - System is mostly able to accommodate or adjust to projected changes in climate
11	Bashor Road Sanitary Sewer Lift Station	Currently, it cannot adapt to climate impacts.	This station needs to be secured against inundation. Lift stations can be adapted by raising them, which doesn't require additional space, only funding. The system needs to be properly sized for current usage and steps should be taken to limit illicit connections and improper disposals to the system. Upstream efforts to reduce the volume of stormwater flowing through the Colonial Gardens Ditch should also be prioritized.	This system needs funding to raise the station and public education. In addition, this system would need education and buy-in from multiple stakeholders upstream in the Colonial Gardens Ditch sub-watershed.	No negative impacts to date, but damage to the station would be costly and backups would significantly disrupt residences.	Stresses exist from improper disposal practices by residents.	AC3 - System is mostly able to accommodate or adjust to projected changes in climate
12	S. Indiana and Berkey	The component will continue to function as a floodplain, adapting to flood events as needed, but improvements to developed areas will not be adequate for adaptation.	To adapt, this area will need reduced developed areas. In the short term, native plants, more tree canopy, and green infrastructure like rains gardens and rain barrels may help mitigate some impacts. Protecting and encouraging the expansion of natural areas in this area will be essential to protecting other areas of Goshen.	Reducing development may necessitate property buy-outs. Public funding and education regarding relocation are necessary in order to preserve floodplain functionality. Partnerships with local and regional Land Trust organizations could aid in this effort.	It can accommodate some change (especially gradual; within certain limits).	Stress is associated with developed property which has accrued damages over time.	AC2 - Systems is somewhat able to accommodate or adjust to projected changes in climate
13	Linway Plaza and Lincoln Ave. Businesses	Highly valued with a clear demand for this component and therefore, clear demand to find a solution. Currently, the plaza is not adaptable to changing climate impacts.	This area needs green infrastructure immediately and so does the wider vicinity. Reduction of impervious surface could help restore some infiltration to the area. The remaining infrastructure may need retrofits like flood barriers or major updates like raising the structure. To address water volumes, there is a need for a regional solution/strategy that addresses upstream runoff.	Money is the biggest obstacle to adaptive changes. Stakeholder education is needed to increase the understanding of businesses, local politicians, and the general public about the climate vulnerabilities and barriers to adaptive changes for this area.	No. Projects have a major financial cost in terms of the actual cost of the work and lost revenues to impacted businesses.	Yes	AC0 - System is not able to accommodate or adjust to projected changes in climate

Ref #	System Component	Does The System Component Have What It Will Need to Adapt to The Identified Impacts?	What Does The System Component Need To Help it Adapt To The Identified Impacts?	What Would You Need In Order To Provide What The System Component Needs To Adapt To The Identified Impacts?	Can The System Component Accommodate Projected Identified Impacts With Minimum Disruption or Costs?	Is The System Component Already Stressed In Ways That Will Limit Its Ability To Accommodate Identified Impacts?	How Adaptive Is The System Component To Projected Impacts? (e.g., Adaptive Capacity score)
14	Oakridge and Mill Street Parks	This largely preserved functional floodplain can likely adapt.	The continued preservation of natural areas and expansion of the tree canopy and native vegetation plantings will help this area meet continued demand on the floodplain to protect adjacent infrastructure.	This area will need a strong Parks Dept. and Cemetery budget to repair and maintain infrastructure after flood events and to maintain canopy along the creek banks.	Yes, with strategic planning.	No, as long as development allows functionality of the floodplain.	AC3 - System is mostly able to accommodate or adjust to projected changes in climate
15	Roxbury Mobile Home Park	Uncertain—there has been minimal observation of flood impacts on the existing system.	The needs of this system component are uncertain due to a lack of information. Maintenance or updates to existing private storm infrastructure is likely required.	The mobile home park's management needs to be aware of the risks and understand potential mitigating steps.	Likely—a minimal number of homes have been impacted and maintenance of the drainage system can likely solve the issue.	Some homes have already been damaged in the northeast corner of the development.	AC4 - Systems is able to accommodate or adjust to projected changes in climate
16	Alpro Road Sanitary Lift Station	Currently, this area does not have what it would need to adapt to climate impacts.	The lift station could be adapted by raising it—which doesn't require additional space but would take significant funding. Diversion of waters away from the station may also be considered, but would likely impact Kercher road where flooding already poses a threat to traffic. The sides of the station most impacted by flowing floodwaters (erosion) need armoring. Efforts upstream to reduce the volume and velocity of water traveling through Later 'K' Ditch would keep floodwaters from overtopping in this area. More information is needed about the sizing of the culvert just upstream where the Ditch crosses under CR 31.	A more adaptable station would require funding to raise the station and protect against erosion. Slowing, spreading, and soaking in stormwater before it reaches the Ditch upstream would take significant collaboration with industrial and agricultural landowners in the area. If adjusting the capacity of the CR 31 culvert is needed, it would require collaboration with Elkhart County.	Minor impacts to date, but damage to the station would be costly and sewer backups would significantly disrupt users.	System has experienced minor erosion to date.	AC3 - System is mostly able to accommodate or adjust to projected changes in climate
17	Rogers Park and Chicago Avenue	The functional floodplain here is mostly preserved meaning it is somewhat adaptable. Chicago Ave experiences the heaviest impacts and is less adaptable.	Continued preservation of the floodplain is a first step. Study of the area for solutions to the back-ups caused by the embankment and storm drainage system in this area may be needed.	Continued preservation of the floodplain is a first step. Study of the area for solutions to the back-ups caused by the embankment and storm drainage system in this area may be needed.	It can continue to accept floodwater because it is an active floodplain, but past events have filled it to capacity, and impacted surrounding development (Trinity Square and Linway Plaza).	Yes. Past flooding has caused damage here.	AC2 - System is somewhat able to accommodate or adjust to projected changes in climate
18	Lighthouse Lane Drainage Area	Currently, this area does not have what it would need to adapt to climate impacts.	This area needs a proper drainage plan for stormwater/ surface water as development continues.	The adaptive measure will need property and business owner buy-in and awareness. Projects will need public/private partnerships and funding.	Yes, with careful planning and development.	Yes, development in a natural drainage path has already stressed the area and led to flood impacts; however, issues were observed soon enough to limit development and allow for drainage issues to be addressed.	AC3 - System is mostly able to accommodate or adjust to projected changes in climate

Step 9: Calculating Vulnerability

The final step of the vulnerability assessment combined the sensitivity and adaptive capacity scores into a vulnerability score. Using Figure 44 below, elements within the stormwater system that were the most vulnerable (red) and the least vulnerable (green) were determined. System components are shown by their reference number.

A few trends have begun to emerge from this stormwater system vulnerability assessment based on the locations of the most vulnerable areas. Unfortunately, some of the most climate vulnerable areas also possess the least adaptive capacity (pink/red color in bottom right hand corner of Figure 44). These areas all cluster around the heavily developed floodplain area that encompasses Trinity Square Shopping Center, Chicago Avenue, and Linway Plaza. The built infrastructure in a flood-prone area, lack of vegetation, and virtually non-existent tree canopy makes it vulnerable to both heat and flood impacts. Its location in the floodplain severely limits low impact development and green infrastructure options and preservation would necessitate major infrastructure upgrades with incredible associated costs. The nearby Huron Street neighborhood and South Indiana/Berkey intersection are considerably more vegetated with less dense development giving them a greater degree of adaptative capacity, but residences here are still within known floodplain extents making them vulnerable.

Many of the other areas identified for this assessment with varying degrees of vulnerability and adaptive capacity are predictably located along the Elkhart River's tributaries. In this case, too, a trend is apparent—developed areas are considerably more vulnerable and less adaptive than the parks with large natural areas. Along Rock Run Creek, for example, Abshire, Mill Street, and Oakridge Parks all provide a space for floodwaters to collect in ways that minimize costly infrastructure repairs. Abshire Park in particular provides a valuable wetland resource for retaining, infiltrating, and removing pollutants from floodwaters. These areas contrast with the intersection at West Wilden and Indiana Avenues where built infrastructure including Creekside Manor mobile homes and the Wastewater Treatment Plant are at significant risk from flood damages and methods of adaptation may be costly.

The reasons for flood impacts on the west side of Goshen may be less immediately obvious than those located in the floodplains of the Elkhart River, Rock Run Creek, and Horn Ditch. The west side of Goshen consists largely of the Leedy Ditch sub-watershed where a series of drainage paths and ditches move water from the hilly regions just outside city limits towards the Elkhart River in the north. Emerging from this report, it appears issues may be even more hyper-local than once thought—Westoria, the Gardens, Lighthouse Lane, the Bashor Road Lift Station, and the Roxbury Mobile Home Park are all located near the drainage path that includes the Colonial Gardens Ditch running south to north before it empties to Leedy Ditch. Once largely made up of farmlands, recent and continued development in this area is increasing demand on the ditch. There has already been upstream flooding where the ditch reaches choke points at culverts under roads (Clinton Street and Bashor Road). The Colonial Gardens Ditch does not have identified floodplains or floodways which means development here has no special requirements based on flood risks. A more careful study of this drainage pathway may be required.

Even with these continued concerns, however, some historic flooding issues in the West Goshen area have actually been alleviated over the last few decades thanks to a few major regional drainage projects. In addition, the floodplain of Leedy Ditch has now been studied and is part of the regulatory floodplain. With these factors in mind, it is important that the City continues to carefully plan and protect drainage pathways through the region and implement regional stormwater solutions per the recommendations in the West Goshen drainage study described in the Landscape Features section of this assessment.

The City of Goshen continues work to protect and expand those natural assets in the floodplains that play important system functions for slowing down, spreading out, and soaking in floodwaters. While demand on these assets will increase as changing climatic conditions increase the frequency and intensity of flood events, the natural areas along waterways are incredibly resilient. The City of Goshen can celebrate that its history has left these invaluable areas natural—making Goshen more resilient and helping protect other communities downstream.

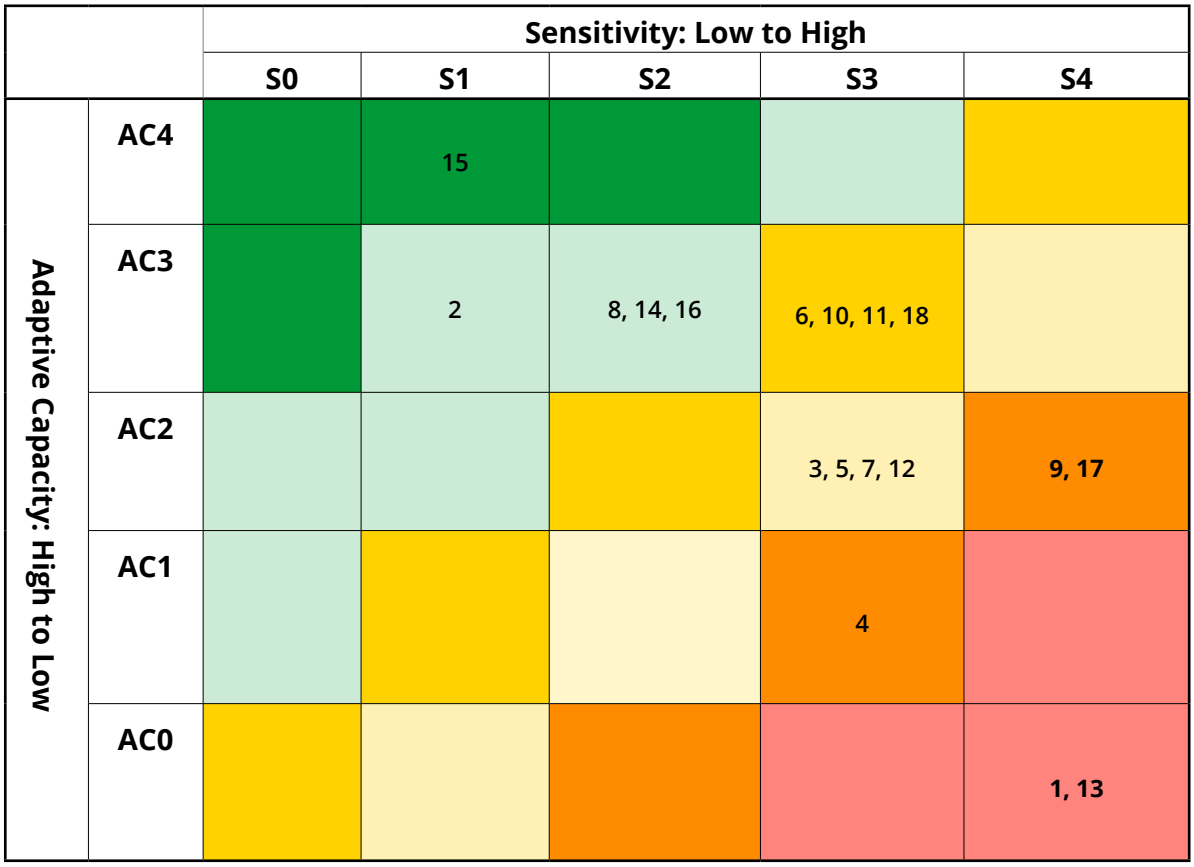


Figure 44: Results for our citywide vulnerability assessment.

Ref #	System Component
1	Trinity Square Shopping Center
2	Natural Areas - Floodplain
3	Conveyance System
4	Huron Street Neighborhood
5	Southwest Goshen - Leedy Ditch Watershed
6	Westoria to The Gardens Drainage Swale
7	Horn Ditch, Spring Brooke Neighborhood, and Fidler Pond
8	Abshire Park/Rock Run Creek Walking Path
9	W Wilden and Indiana Avenue Intersection

Ref #	System Component
10	E Wilden and 7th Street
11	Bashor Road Sanitary Sewer Lift Station
12	S. Indiana and Berkey
13	Linway Plaza and Lincoln Ave. Businesses
14	Oakridge and Mill Street Parks
15	Roxbury Mobile Home Park
16	Alpro Sanitary Lift Station
17	Rogers Park and Chicago Avenue
18	Lighthouse Lane Drainage Area

6. NEXT STEPS

This document represents an important step in building resilience to climate change in Goshen. To truly prepare, however, actions need implemented that will reduce local vulnerability and enhance resilience. Through the course of this stormwater system vulnerability assessment, City staff identified a number of initial actions that can lay the foundation for longer-term adaptation planning and action. These actions include:

- Align vulnerability reduction efforts with Goshen's Flood Resilience Plan which outlines specific actions that will help reduce flood vulnerabilities.
- Align efforts with other relevant community planning and action initiatives including the City's tree canopy goals and Climate Adaptation Plan—both initiated and led by the Environmental Resiliency Department.
- Align vulnerability reduction efforts with Elkhart County's multi-hazard mitigation planning and disaster risk reduction efforts and other regional watershed planning efforts.
- Expand collaboration with upstream and downstream peer communities in the region in order to foster greater regional resilience towards climate change and natural disasters.
- Update stormwater policies, ordinances, and strategic planning documents to align with and complement the elements of this assessment.
- Support efforts that reduce and address socio-economic vulnerability in the Goshen community. In addition, work to make pre-disaster education accessible to all residents and consider these factors in disaster response planning.
- Continue to work with Goshen's Floodplain Manager, the Indiana Department of Natural Resources (IDNR), and the Federal Emergency Management Agency (FEMA) to ensure the floodplains for relevant waterbodies are up to date and utilized for planning and flood risk education.
- Increase asset management documentation (i.e. update City's stormwater related GIS layers) and assess the age, health, and capacity of current stormwater conveyance systems to identify vulnerabilities and prioritize system updates.
- Participate in capital planning for storm infrastructure improvement projects and work to ensure adequate funding.
- Conduct drainage studies of those areas identified as in need of further study including the Colonial Gardens Ditch and pathway in particular.
- Convene a working group of City department stakeholders to evaluate the barriers to, and opportunities for, implementing green infrastructure and low impact development practices into City projects (address knowledge gaps, plan for changing maintenance needs, reevaluate policies and ordinances, etc.).
- Coordinate actions across City departments to fund, implement, maintain, and provide public education for flood resilient infrastructure including green infrastructure and low impact development.
- Seek grant funding opportunities for climate adaptation projects, green infrastructure, and other flood resilience projects.
- Continue to encourage the planting of trees and native plants on both public and private property to increase the urban tree canopy and the presence of deep-rooted native plants, which helps to capture, slow down, and soak in water before it can reach our storm drains.
- Prioritize system component vulnerability reduction efforts by the severity of climate impact and socio-economic stress.
- Present this vulnerability assessment to City Council and seek formal adoption.

Figure 45: Goshen's natural climate change protection resources along Rock Run Creek.

- Cultivate private and public support for more forward-thinking flood resilience planning.
- Engage in public education about expected climate impacts and their consequences for storms, flooding, and heat as relates to the stormwater system.
- Annually report on progress to City Council addressing the vulnerabilities identified in this plan.
- Every 5 years, review and revise this assessment based on new information (e.g., changes to climate science, updated infrastructure) and any relevant changes to community priorities. As part of this review process, include metrics that denote how the community's overall vulnerability to climate change has evolved. This may take the form of revising the community's landscape vulnerability as well as socio-economic vulnerability to see if there have been notable changes. It may also identify, through public input processes, a number of other key metrics to track that measure reductions in vulnerability.

Conclusion

Preparing for climate change is a process, not an outcome. This plan represents an important step in that process for the City of Goshen. Goshen's success in preparing for climate change will depend on whether the strategies identified in this plan and those developed through a formal adaptation planning process are implemented, and whether an iterative process is established to frequently revisit this plan and all the other plans and programs used to manage the way people live, work, play, and operate in Goshen. The City is committed to working with all residents, businesses, and interested stakeholders to ensure a thriving, sustainable, and resilient Goshen. It's time to get to work!

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