PREPARING FOR CLIMATE CHANGE

CLIMATE CHANGE VULNERABILITY ASSESSMENT FOR STORMWATER

CITY OF TOLEDO

EXECUTIVE SUMMARY

The climate in Toledo is changing, and these changes are causing immediate threats to our citizens, our health, our economy, and our community's overall vitality. We know that over the last several years we have experienced a 3.0°F increase in average annual temperature, with winter experiencing the greatest amount of warming (a 4.0°F increase). Nighttime temperatures are rising, and the number of cold days (< 32°F) are declining. Annual precipitation is changing too: in the last several decades Toledo has experienced a 19.4% increase in annual precipitation, with the greatest change happening in winter (30.9% increase, amounting to roughly an extra 1.9 inches). In addition, we have seen an increase in the frequency and intensity of severe storms, with the City experiencing a 41% increase in the total volume of rainfall in extreme precipitation events (most extreme 1% of storms) annually. These are just some of the changes that have led to serious impacts to our 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 Toledo has decided to plan for climate change, making sure we are considering what changes are projected to take place in the future and integrating that information into how we, as a City, operate. Guiding this work is a commitment to ensuring the health, safety, and general welfare of all Toledo'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 our City's efforts to create a more equitable and resilient community for all Toledo residents – ensuring every resident is prepared for the current and future risks associated with a changing climate.

Within the pages of this report, readers will find more information about how changes in weather and long-term climate have already impacted Toledo 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 our stormwater systems, an assessment of Toledo's overall stormwater-system vulnerability to these changes, and which segments of the community may be most vulnerable. Finally, this report provides some initial suggestions on what we, as a community, can do to prepare our stormwater system and those it serves for climate-related impacts.

At a high level, we anticipate that climate change will exacerbate or create the following major impacts to stormwater in Toledo:

- Increased large rain events will lead to more flash flooding, overloading the storm sewer system and causing flooding issues throughout the City as well as structural damage to infrastructure.
- The increase in intense rainfall will also lead to more erosion and sedimentation of our local waterways.
- The rise in runoff and sedimentation will cause a decrease in water quality in the region, and may negatively impact aquatic wildlife and habitat.
- Flooding of roadways and homes will create hazardous conditions for citizens of Toledo.
- Flooding issues in the City may cause damage to properties and structures, leading to

additional expenses for residents.

In response to these projected changes and local impacts, the City of Toledo has initially identified the following actions:

- Engage all City divisions for additional input on this assessment and components they believe could be particularly vulnerable.
- Review current design practices and standards, not only for the stormwater system, but also for upgrades to our water treatment and water reclamation facilities, parks and forestry projects, tree planting practices, and other future infrastructure upgrades.
- Review citywide stormwater goals. Attempt to create a maintenance plan and practices that are proactive and collaborative. These plans will not just include one city division but many, in an attempt to help prolong the life of our infrastructure and reduce common issues experienced by our residents.
- Obtain additional asset data on the existing system to put in our GIS citywide map. This information would provide us the capability to assess other potential factors that may increase certain components of vulnerability.
- Work with partner organizations on the plan for the reutilization of vacant lots for stormwater benefits. These lots are highly concentrated in many of the vulnerable neighborhoods and could provide benefits to urban heat islands, stormwater retention, and quality of life.

We also plan on expanding on programs the City already has in place, such as:

- Gas Cap Testing and Replacement
- Bay View Water Reclamation Facility – Cogeneration Plant
- Better Buildings NW Ohio Municipal Government Energy Program
- Collins Park Water Treatment Plant Solar Field
- Green Infrastructure Program
- LimnoTech Toledo Water Intake Buoy
- Toledo Waterways Initiative
- Toledo Public Power
- Water Treatment Ozonation System
- Public Inflow Removal Program
- Basement Flooding Grant Program

Implementing these and other actions to effectively and efficiently address our community's climate and socio-economic vulnerabilities will require an "all hands on deck" approach. That is why we invite you to join us as we move forward with creating a more resilient, thriving, and sustainable Toledo for all.

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).

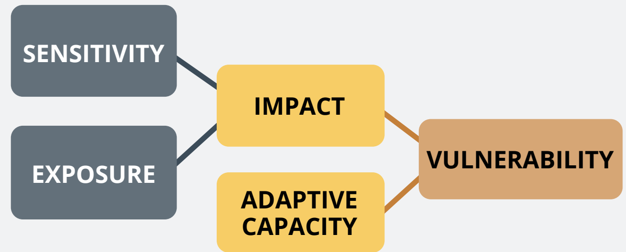
Impact: Effects on natural and human systems such as lives, livelihoods, health, ecosystems, economics, societies, cultures, services, and infrastructure (IPCC, 2014).

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

Figure 1: Graphical depiction of the various elements of vulnerability

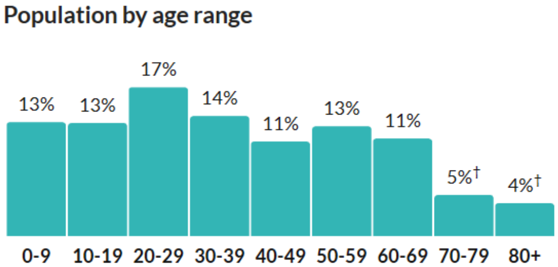


Once completed, the results of a vulnerability assessment can be used to inform the types of actions a community should take to reduce vulnerabilities or seize on potential opportunities.

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 our local community, the City of Toledo partnered with fellow Midwestern cities, the Huron River Watershed Council, the Great Lakes Integrated Sciences and Assessment (GLISA), and Headwaters Economics to develop a revised vulnerability assessment template that assesses our 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 Toledo’s stormwater system to climate change, socio-economic considerations, and local landscape features. We will use this document to help ensure that all our residents are safe, resilient, and thriving both today and in a climate-altered future.

2. SOCIO-ECONOMIC PROFILE OF TOLEDO

Table 1: Section Summary[1]

Population by age range	Age	Income	
	34.6 Median age	$20,902 Per capita income	$35,866 Median household income

Toledo is a unique and diverse city. It is this diversity that makes us great. "You will do better in Toledo" – the city's slogan since 1913. The City welcomes all walks of life and offers so much to the citizens that call this town home. Nicknamed "The Glass City" because of the prominence of the glass manufacturing industry, Toledo has humble beginnings. Historically known as "The Great Black Swamp", the entire northwest Ohio area, including Toledo, was marsh and wetlands with some drier land throughout, due to glacial deposits. Eventually these swamps were drained to become usable farmland, and Toledo shortly became a hub for manufacturing, attracting a diverse range of settlers to the area. Toledo is positioned at the mouth of the Maumee River and Lake Erie Basin, resulting in a driver of economics for the city, including fishing, shipping and recreation.

Along with many attractions such as Toledo Area Metroparks and the Toledo Zoo, the city offers its cultural diversity through its well-known Downtown area, the Toledo Museum of Art, University of Toledo and its well-known neighborhoods such as the Old West End, Polish Village, South Toledo, and East Toledo's Birmingham District (with world famous Tony Packo's Hungarian Hotdogs.) Communities celebrate their heritage and diversity through elaborate artwork, such as murals, and events such as the German American, Polish, Greek, African American, Birmingham Ethnic, Old West End, Hispanic Heritage Month, and Toledo Sister Cities International Festivals throughout the year. While Toledo experienced a 12% population drop from 2000 to 2014, a recent study from New American Economy and Welcome Toledo-Lucas County states that the foreign born population has partially offset the population loss, and had an impact of $200 million in spending power for the local economy.

In order to fully understand how the City of Toledo is resilient or vulnerable to climate change, we need to take a deep look at the social characteristics that make up our community. Using the Socio-Economic Data Mapper (Data Mapper) tool from Headwaters Economics, we analyzed ten characteristics that help explain our local vulnerability:

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 non-white population
F. Percent of households receiving public assistance
G. Percent of households where mortgage is greater than 30% of household income
H. Percent of disabled
I. Percent of renters
J. Percent of population without a high school diploma

A. Percent of population over 65

As of 2017, the City of Toledo had 279,455 residents, 13.7%

(38,238) of which were 65 years or older. This is lower than the U.S. national average for residents over 65, which is 14.9%. Of this population, approximately 5,717 (2.0%) are 80 years or older. 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 our community's age profile helps us determine the appropriate types of services and resources needed to ensure all of Toledo's residents are able to survive and thrive in a climate-altered future.

B. Percent of population under 5

As of 2017, 6.9% (17,641) of the City of Toledo's population was under 5 years of age. This is slightly higher than the national average (6.2%).[7] Knowing what percentage of our 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, 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.

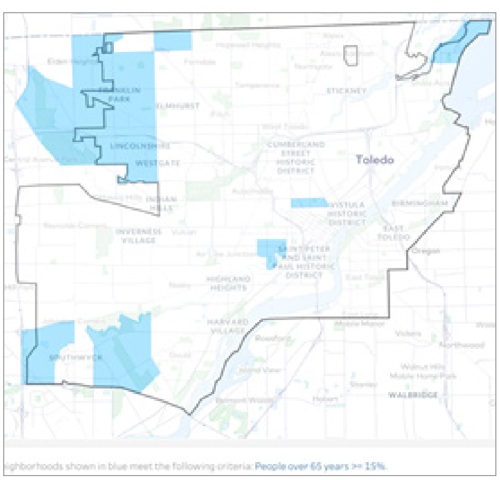


Figure 2: Census Tracts in Toledo where 15% or more of the population is 65 years of age or older (14.9% is the national average).

Focusing our efforts on reducing youth vulnerability makes sense for a number of 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 we have a healthy, productive community is pivotal to not only our wellbeing, but also our social structure and our economy.

As we seek to ensure our youth are resilient to climate change, we need to pay particular attention to youth that are living in poverty, as 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 we move 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

As of 2017, 71,924 City of Toledo residents were living in poverty; 32,925 were classified as living in deep poverty (meaning they earn less than ½ of the federal poverty level). This represents 26.5% of the City's population that is living in poverty and 12.1% that is living in deep poverty. In addition, data shows that 1.8% of the City's residents (4,766) are both living in poverty and over the age of 65. All of these numbers are above US national averages.[13]

The above information focuses on the number of individuals living in poverty. In addition, we also analyzed the number of families living in poverty. As of 2017, 14,362 families (22.0%) in Toledo lived in poverty. Of these, 11,428

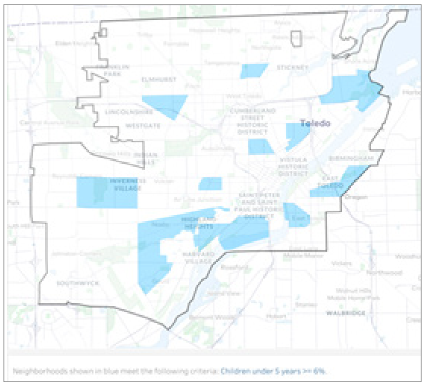


Figure 3: Census Tracts where in Toledo where 6% or more of the population is under 5 years of age (6.2% is the national average).

had at least one child residing in their household, and 8,056 were households with a single mother (12.3% of all households). This rate of family poverty is higher than the national average (10.5% for families in poverty and 4.8% for single mother families in poverty).

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, we know that natural disasters disproportionately impact low-income people 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 in order 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 residences are located in high crime areas, meaning that residents may feel unsafe opening their windows.[20] Finally, low-income individuals 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]

D. Percent of population with limited English proficiency

According to the US Census Bureau, in 2017, 1.0% of the Toledo community did not speak English well (2,702 people). This is lower than the national average (4.5%).[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 proficiency 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:

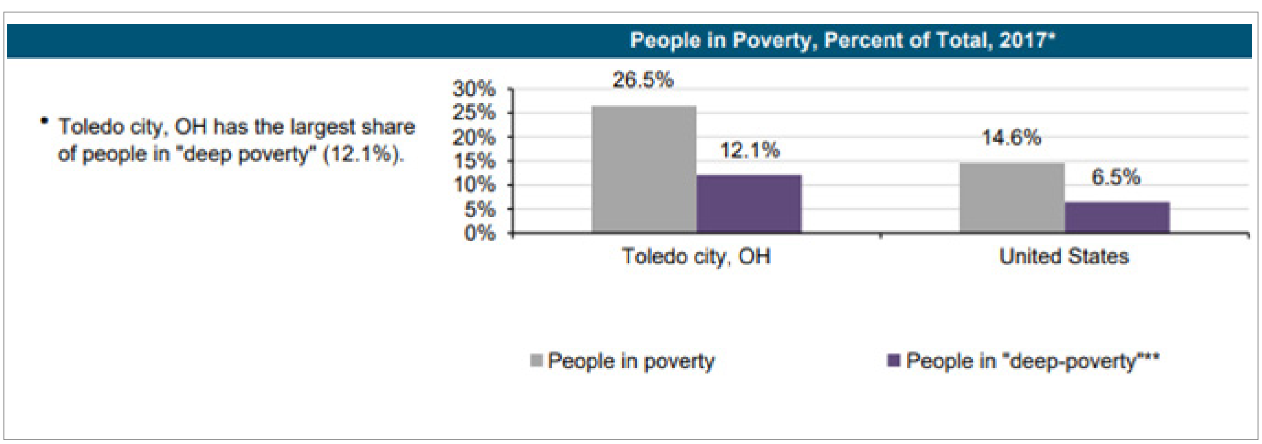


Table 2: Percentage of residents living in poverty. This table was taken from the Populations at Risk Tool created by Headwaters Economics (accessible here).

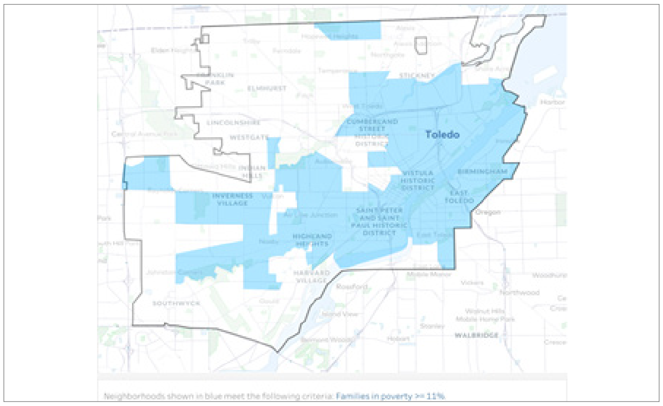


Figure 4: Census Tracts in Toledo where 11% or more of the families are living in poverty (10.5% is the national average).

- Limit a person's ability to effectively act during emergencies;[23]
- Make it harder to follow directions and interact with agencies, 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]

Because of these factors, it is important that we identify who within our population has limited English proficiency and work with trusted partners to ensure these populations have access to the information, tools, and resources they need to build resilience.

E. Percent of non-white population

As of 2017, 36.9% of the population in Toledo (103,188) identified as non-white. This is higher than the national average (27.0%). Of the total population of Toledo, 27.2% (76,138) identified as Black or African American, 8.3% (23,063) identified as Hispanic,[27] 0.3% (852) identified as American Indian, and 9.4% (26,198) identified as "Other Races".[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 blacks/African-Americans are less likely to have health insurance: but rates of uninsured are dropping for both groups.[32]
- Compared to other races, blacks/African-Americans have higher rates of infant mortality, homicide, heart disease, stroke, and heat-related deaths.[33]
- 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, variations in the quality of 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. population and our local community.[37]

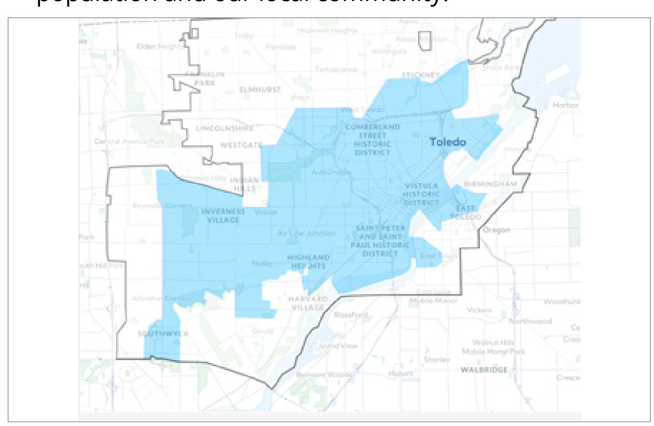


Figure 5: Census Tracts in Toledo where 27% or more of the population identifies as non-white (27% is the national average).

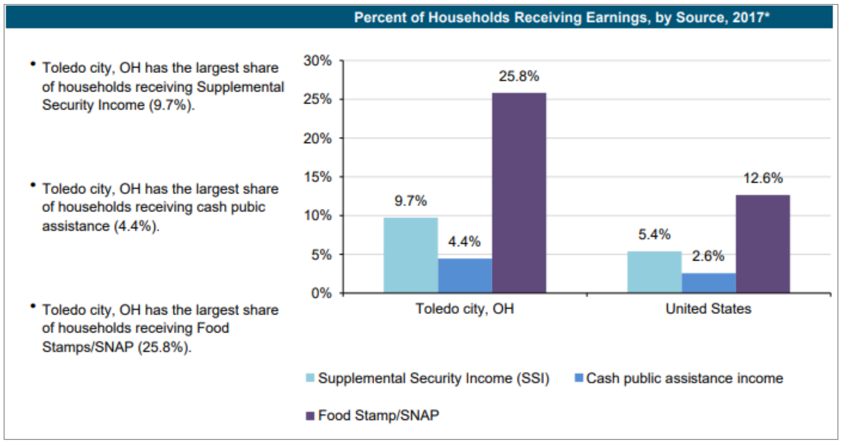


Table 3: Percentage of households in Toledo and in the U.S. that receive three types of public assistance.

Given these realities, it is important that the City of Toledo ensures that we effectively integrate the needs, perspectives, and lived realities of our population into our efforts to enhance resilience.

F. Percent of households receiving public assistance

As of 2017, 30,532 households within Toledo (25.8%) received Food Stamps/SNAP assistance. This rate of Food Stamp/SNAP assistance is significantly higher than the national average, which is 12.6% of all U.S. households.[38] While this isn't the only form of public assistance, we have chosen Food Stamps/SNAP assistance as our indicator of public assistance because it is more widely known than the other types of assistance and, as such, there is a higher likelihood that at-need households are getting this assistance compared to the more obscure forms of public assistance.

Understanding the percentage and location of residents receiving public assistance is important because this information is indicative of households living in poverty or households with insufficient resources. For example, in 2011, families receiving public assistance spent, on average, 77% of their household budget to meet the basic necessities of housing, food, and transportation,[39] leaving little to accommodate other important needs including disaster preparedness, response, and recovery.

G. Percent of households where mortgage is greater than 30% of household income

As of 2017, 10,054 households (26.9%) in Toledo were paying more than the sustainable 30% of household income towards their mortgage and 26,932 households (47.4%) were paying more than the sustainable 30% of household income towards their rent. Rental costs are slightly above the national average and point to a troubling sign regarding the affordability of housing in Toledo compared to the income being earned. The reason this is important is because the federal government considers families with housing costs that exceed 30% of their income to be "housing-cost burdened"[40] and therefore have less disposable income to spend on other necessities such as food, heating/cooling, transportation, healthcare, etc. Research also shows that those households living in affordable housing (those spending less than 30% of household income on housing) are more stable and less likely to move frequently. This can enhance community vitality and cohesion, an important element of creating a more resilient Toledo. In addition, this stability is linked to several positive health outcomes in children and young adults, such as improved emotional and behavioral problems, fewer unplanned pregnancies, reduced drug use, and a lower risk for depression.[41]

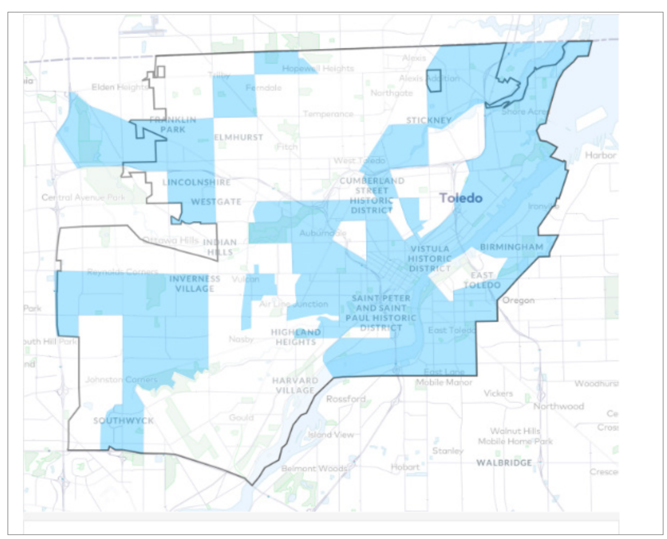


Figure 6: Census Tracts in Toledo where 13% or more of the population has a disability (12.6% is the national average).

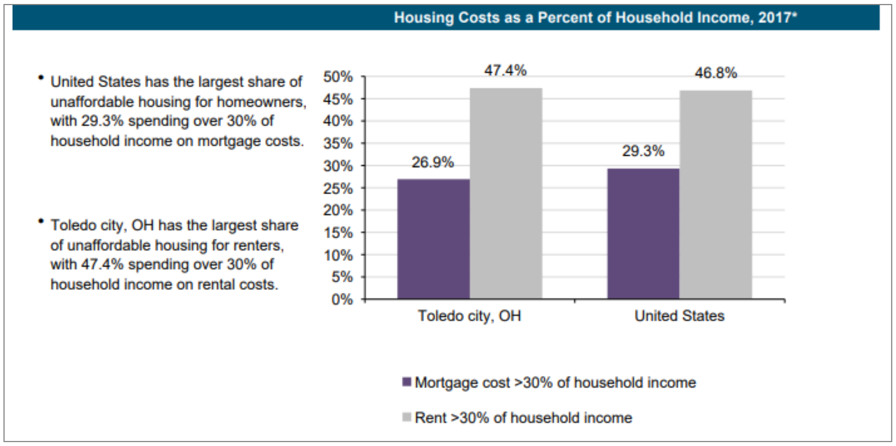


Table 4: Comparison of the percentage of households in Toledo and the U.S. that spend more than 30% of their income on rental fees or their mortgage.

As we work to ensure that Toledo is building resilience, we must be aware of the needs of all residents, including those with limited economic resources.

H. Percent of those with disabilities

As of 2017, 47,673 residents of Toledo were living with disabilities. This represents 17.3% of our total population; a figure higher than the national average of 12.6%.[42]

People with disabilities are subject to a series of health complications that are often significantly heightened due to environmental conditions. For example, limited mobility and/or being bed ridden raises heat mortality,[43] limited mobility can significantly delay and/or prevent effective evacuation during times of disaster, and extreme weather events can 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, Toledo is determined to incorporate the needs of this population in our attempts to create a more resilient community.

I. Percent of renters

As of 2017, 48.1% of housing units in Toledo were rentals; an additional 1.6% were mobile homes.[44] This rate is significantly higher than the national average of 36.2% for rentals, but lower than the national average of 5.7% for mobile home residences.

The median home value in Toledo is currently $82,216. This figure represents a decrease in home value of $28,856 based on average home values in 2010.

Understanding what percentage of our 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, creating a heightened sense of control over one's living situation and financial security.[45] On the flip side, the financial stress associated with losing one's home is heightened by people's attachment to place and their neighborhoods.[46]

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.[47] 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

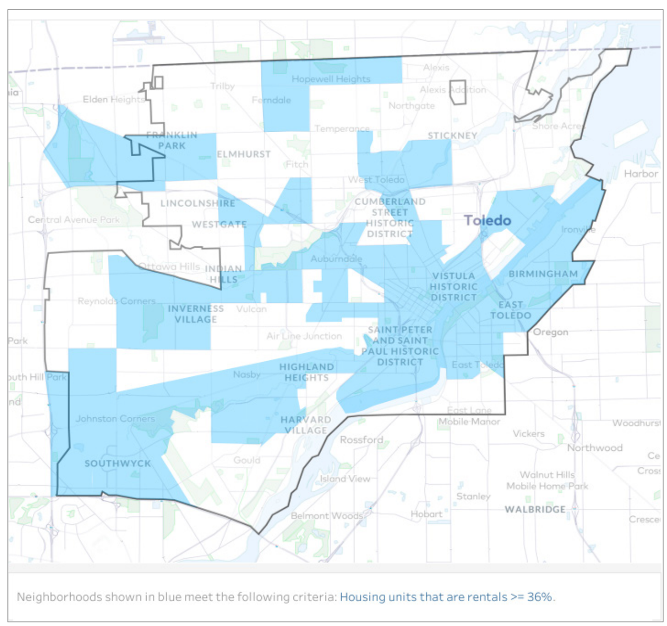


Figure 7: Census Tracts in Toledo where 36% or more of the housing units were rentals (36.2% is the national average).

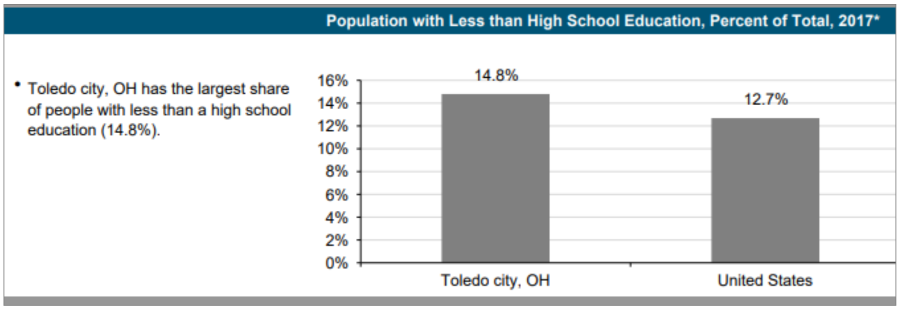


Table 5: Comparison of individuals in Toledo and the U.S. that have less than a high school education.

those residing in rental units.[48] 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.

J. Percent of population without a high school diploma

As of 2017, 27,118 people in Toledo did not have a high school diploma (14.8%). This is higher than the national average (12.7%),[49] a troubling statistic because 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.[50]
- Thirty-eight percent of Americans without a high school degree do not have health insurance, compared to 10 percent with a college degree.[51]
- 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.[52]

K. Other Social Vulnerability Determinants

U.S News rated Toledo 6.2 out of 10 overall for Best Places to Live (#94/125) and Best Places to Retire (#92/125.) The unemployment rate is 4.9%, the cost of living is relatively low, but the average commute time is 19.9 minutes. Means of transportation can be broken down to those driving alone (82.5%), carpooling (8.5%), walking (2.7%), using public transit (2.5 %), and other means- including bicycling (1.6%) (U.S Census Bureau's American Community Survey). Lack of bike lanes and access to public transit make it difficult to make a more environmentally conscious decision. Those that have to walk or don't have access to a vehicle are more at risk to the effects of climate change including higher temperatures and increased rainfall.

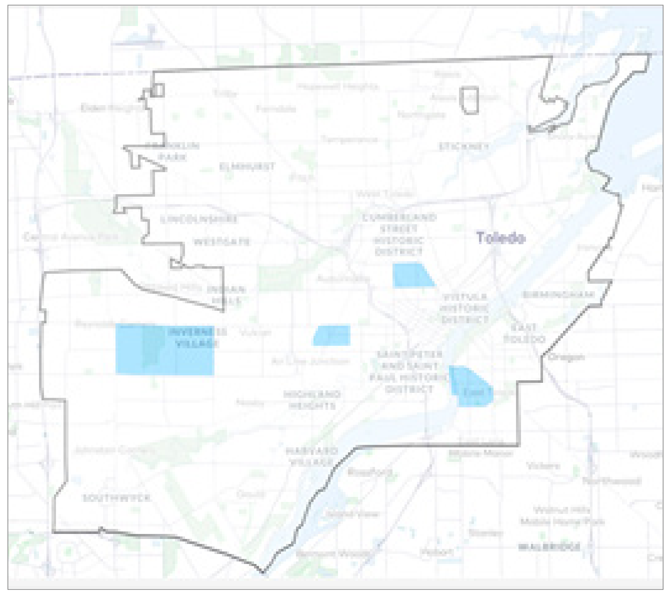


Figure 8: Census Tracts within the City of Toledo that have the highest overall socioeconomic vulnerability. The map highlights all of the Census Tracts with high averages relative to the rest of the City for: percentage of families in poverty; percentage of people with disabilities; and percentage of population that is non-white.

The Asthma and Allergy Foundation of America ranked Toledo, OH as #10 out of the Top 100 Most Challenging Places to Live with Asthma. It was also ranked #1 out of 20 for the highest use of quick relief medicine (also known as "rescue inhalers") for asthma relief, and #2 out of 20 for the use of long-term controller use. These are both indicators that there are more severe or uncontrolled cases of asthma. The poverty rate in Toledo is 26.5%, which is higher compared to the U.S. poverty rate of 14% and can correlate directly to high asthma cases, especially in children. Toledo is one of the six cities in Ohio ranked in the top 20 from the report. Poverty, pollen, urban location, and air quality are all key contributors for placement on the list. Those affected by asthma are considered vulnerable to the effects of climate change. According to Promedica Hospitals, "Childhood asthma is a major problem in the Toledo area as identified by the most recent community health needs assessment. While the national average for children ages 0-17 is 8.6 percent, in Toledo asthma affects 11 percent of children ages 0-5 and 17 percent of children ages 6 to 11."[53]

The National Allergy Bureau has a local branch in Sylvania, OH, a suburb of Toledo, which puts out reports from on daily mold and pollen levels and is broadcasted on American Academy of Allergy, Asthma & Immunology website. Outreach and education, especially in schools, communities and the families affected by asthma will be the most effective way to adapt to climate change.

Cumulative Socio-Economic Vulnerability

Combining the findings from the previous sections, we were able to create a map denoting some of our must socio-economically vulnerable neighborhoods (Figure 8). This figure identifies all the Census Tracts where the City of Toledo has higher than the national average for all of the following variables: percentage of families in poverty; percentage of people with disabilities; percentage of households that rent; percentage of population under the age of five; and percentage of population that is non-white. The neighborhoods affected identified in blue are Reynolds Corners, Inverness Village, Scott Park, Onyx, Old West End, Old Towne and East Toledo. Failing infrastructure and flooding affect Inverness Village, Scott Park and Onyx often. Old West End and East Toledo have great historical relevance and cultural diversity and are a target for protection and redevelopment. Through the Toledo Waterways Initiative, multiple projects are being done along the Maumee River and throughout the whole city of Toledo for infrastructure maintenance and improval. This includes storage basin improvement, sewer lining projects, and elimination or updating of Combined Sewer systems, especially in highly vulnerable areas. Continued focus on these highly vulnerable areas, especially the ones identified on the map, for funding, infrastructure improvement and education and outreach will be vital in adapting to the effects of climate change in the near future.

In the next section we highlight our exposure to historic, current, and projected futures changes in weather and climate.

3. CLIMATE CHANGE IN THE GREAT LAKES REGION AND TOLEDO

In the next section we highlight our exposure to historic, current, and projected futures changes in weather and climate.

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 our 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), 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 17 to 42 more days over 90°F in an average year compared to the late 20th century.

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.

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 vulnerabilities of a city's assets is a 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.

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 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. Toledo City Summary

Toledo City Summary

- Average air temperature in Toledo has increased by 3.0°F.
- Average air temperature is projected to rise 3°F to 5°F by the mid-21st century.
- Total annual precipitation has increased by 19.4%.
- The total volume of rainfall in extreme events (heaviest 1% of storms) has increased by 41%.
- 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 Toledo. This information is valuable in helping us understand what changes we have already experienced as well as what changes we anticipate.

Historic and Projected Changes in Climate for the City of Toledo

	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	50.1°F	53 to 55°F	55 to 60°F	3 to 5°F / 5 to 10°F	6 to 10% / 10 to 20%
Winter	27.6°F	30 to 33°F	33 to 36°F	2 to 5°F / 5 to 8°F	9 to 20% / 20 to 30%
Spring	48.7°F	51 to 55°F	54 to 60°F	2 to 6°F / 5 to 11°F	5 to 13% / 11 to 23%
Summer	71.3°F	75 to 78°F	79 to 83°F	4 to 7°F / 8 to 12°F	5 to 9% / 11 to 16%
Fall	52.4°F	54 to 58°F	56 to 64°F	2 to 6°F / 4 to 12°F	3 to 11% / 7 to 22%
Average Low Temperature	40.4°F	43 to 45°F	46 to 50°F	3 to 5°F / 6 to 10°F	6 to 11% / 14 to 24%
Average High Temperature	59.8°F	63 to 65°F	65 to 70°F	3 to 5°F / 5 to 10°F	5 to 9% / 9 to 17%
Days/Year Greater than 90°F	12.6 days	30 to 47 days	48 to 82 days	17 to 34 days / 35 to 69 days	138 to 273% / 281 to 551%
Days/Year Greater than 95°F	3.1 days	8 to 20 days	Not Available	5 to 17 days / Not Available	158% to 545% / Not Available
Days/Year Less than 32°F	120.1 days	90 to 99 days	Not Available	-30 to -21 days / Not Available	-25% to -18% / Not Available
Total Annual Precipitation	34.2 in.	33 to 37 in.	35 to 40 in.	-1 to 3 in. / 1 to 6 in.	-4 to 8% / 2 to 17%

Historic and Projected Changes in Climate for the City of Toledo					
Winter	6.8 in.	7 to 11 in.	5 to 10 in.	0 to 4 in. / -2 to 3 in.	3 to 62% / -26 to 47%
Spring	9.2 in.	8 to 11 in.	9 to 13 in.	-1 to 2 in. / 0 to 4 in.	-13 to 20% / -2 to 41%
Summer	9.9 in.	9 to 11 in.	9 to 11 in.	-1 to 1 in. / -1 to 1 in.	-9 to 11% / -9 to 11%
Fall	8.2 in.	7 to 9 in.	8 to 10 in.	-1 to 1 in. / 0 to 2 in.	-15 to 10% / -2 to 22%
Heavy Precipitation Days	3.4 days (> 1.25”)	4.2 to 6 days	5.5 to 6.2 days	0.8 to 2.6 days / 2.1 to 2.8 days (> 1”)	24 to 76% / 62 to 82%

*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 Toledo has increased by 3.0ºF from 1951 to 2017, with the current annual average temperature being 50.1ºF. Average seasonal temperatures have also increased, with winter experiencing the greatest increase of 4.0ºF. Average temperatures in Toledo are projected to increase 3.0 to 5.0ºF by mid-century under a business as usual (i.e., high emissions) scenario, with winter having the greatest increases of 4.0 to 6.0ºF.

Hot Days

Days with temperature at or above 90°F are common with multiple occurrences in most years and an increasing trend over time. Many years on record have experienced 2 to 4 consecutive days over 90°F, with events of 5 to 11 consecutive days occurring less frequently. By mid-century (i.e., 2050), models suggest an increase of anywhere from 17 to 34 more days per year over 90˚F, and an increase of 35 to 69 more days per year over 90°F by end of century. Models are not able, however, to tell us if those days will be consecutive or not.

Days with high temperatures at or above 95ºF have been rarer, with few occurrences of more than one consecutive day experiencing maximum temperatures over 95ºF. By mid-century (i.e., 2050), models suggest an increase of 5 to 17 days over 95ºF. 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, 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, Toledo experiences 120.1 days per year that fall below freezing (32ºF). Historical records show this number has decreased already. The city is projected to experience fewer nights below 32ºF, with decreases of 21 to 30 days by mid-century.

Days with temperatures at or below 10ºF are very common and have not experienced any clear trends over time. Consecutive days at or below 10ºF are also frequent, and typically last for 2 to 5 days with less frequent occurrences lasting 6 to 14 days. In the future, there are projected to be even fewer very cold days, so this type of event will be even rarer.

Precipitation and Flood/Drought Indicators

Average Precipitation

The amount of total annual precipitation in Toledo has increased by 19.4% (6.2") from 1951 to 2017. An increase in precipitation was observed in all four seasons, with the winter seeing the greatest percentage increase of 30.9% (1.9"). Average annual precipitation in Toledo is projected to increase by up to 3 inches by mid-century and by up to 6 inches by the end of the century.

Heavy Precipitation

The frequency and intensity of severe storms has in creased historically, with a 36% increase in the number of extreme precipitation events (heaviest 1% of storms) and a 41% increase in the total volume of rainfall during these events between 1981-2010. Toledo is projected to experience an increase of up to 2.6 days of heavy precipitation (days with over 1" of rainfall) per year by mid-century and by up to 2.8 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 our existing infrastructure (Bulletin 71 (Huff and Angel, 1992), used data through 1986, and Atlas 14 (NOAA HDSC) added 1987-2011) are dependent on fluctuating estimates of rainfall.

The table below shows 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.

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 (USGCRP, 2017).

Precipitation events of more than 2" in a day (i.e., 24-hour period) are projected to increase by up to one day by mid-century and up to about 1.5 days by end of century. Precipitation events of more than 3" in a day are projected to increase by less than a day by both mid-century and by

This table does not show projections for how the design storm may change in the future due to climate change.

Precipitation Frequencies for the City of Toledo

	1-Yr	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
1-hr	0.95 in. / 1.02 in. [7.4%]	1.18 in. / 1.23 in. [4.2%]	1.49 in. / 1.55 in. [4.0%]	1.74 in. / 1.80 in. [3.4%]	2.08 in. / 2.14 in. [2.9%]	2.37 in. / 2.40 in. [1.3%]	2.69 in. / 2.68 in. [-0.3%]
12-hr	1.77 in. / 1.63 in. [-7.9%]	2.19 in. / 1.95 in. [-11.0%]	2.77 in. / 2.44 in. [-11.9%]	3.22 in. / 2.87 in. [-10.9%]	3.85 in. / 3.47 in. [-9.9%]	4.39 in. / 3.98 in. [-9.3%]	4.99 in. / 4.54 in. [-9.0%]
24-hr	2.03 in. / 2.01 in. [-1.0%]	2.52 in. / 2.42 in. [-4.0%]	3.18 in. / 3.03 in. [-4.7%]	3.70 in. / 3.53 in. [-4.6%]	4.43 in. / 4.25 in. [-4.1%]	5.05 in. / 4.84 in. [-4.2%]	5.73 in. / 5.47 in. [-4.5%]

end of century.

Annual snowfall totals have been variable, with no clear increasing or decreasing trend in the last 40 years. There has been a decreasing 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 2" to 10" by mid-century and by 9" to 16" by end-of century.

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 most prominent in fall events. 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.

In the following chapter we look at local landscape features that influence our exposure and overall vulnerability to climate change in Toledo.

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

Coupled Model Intercomparison Project (CMIP) Version 3. The future (mid-century) climate projections for Toledo 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 Toledo, OH from 1981-2010 is available at: http://glisa.umich.edu/station/W00094830

"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 Detroit 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

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

Summary

- Local landscape features such as floodplain location and extent, elevation, slope, landscape cover, and stormwater asset conditions all influence the vulnerability of our stormwater system as well as local flooding potential.
- By combining the aforementioned factors, we were able to generate a holistic assessment of where in Toledo landscape features affect our stormwater systems and our community's vulnerability to flooding. Results showed that certain areas of the City of Toledo are most vulnerable to localized flooding due to aging infrastructure and the topography of the region.
- Local features influence heat impacts, including: impervious surfaces, urban heat island, and vegetation coverage.
- By considering the aforementioned factors, we were able to assess the potential of local landscape features in Toledo that may affect our vulnerability to heat.

In addition to our socio-economic composition and projected changes in climate, certain features related to the way Toledo is designed and our physical environment make us more or less vulnerable to climate change. This section explores a number of these landscape characteristics or features that affect the vulnerability of our residents and our systems to flooding. We chose to look specifically at our local vulnerability to flooding because this is one of the largest climate impacts we expect to continue experiencing in a climate-altered future.

Landscape Features that Affect Our Stormwater System and Flooding Exposure

Flooding is one of the most common and pervasive climatological impacts to affect the City of Toledo. Every year we experience numerous localized flooding events. These events can cause property damage, road closures, economic disruptions, and other issues. Larger events have far reaching implications for our local economy, transportation systems, and health and safety. Nationally, flood deaths are highest in adults over the age of 50 (although 20-30 years old also have a fairly high vulnerability to flooding-related deaths and injuries).[54] Males are notably more vulnerable to flooding-related deaths, particularly those tied to flash flooding events.[55]

Because of the acute vulnerability we have in Toledo, we want to understand what local landscape features enhance or reduce our local stormwater systems vulnerability as well as our local vulnerability to flooding. The following factors are important elements of understanding these vulnerabilities.

a) Location of Floodplains

b) Elevation

c) Land Cover

d) Stormwater Asset Map

a) Location of Floodplains

Because we know that certain areas of our community are already susceptible to flooding, we used our 100-year and 500-year floodplains as an indicator of future flooding risk. Using data from the Federal Emergency Management Agency (FEMA), we were able to identify areas within Toledo that lie within both the 100 and 500-year floodplains (Figure 9). Land within the 100-year floodplain has a 1% chance of flooding each year. Land within the 500-year floodplain has a 0.2% chance of

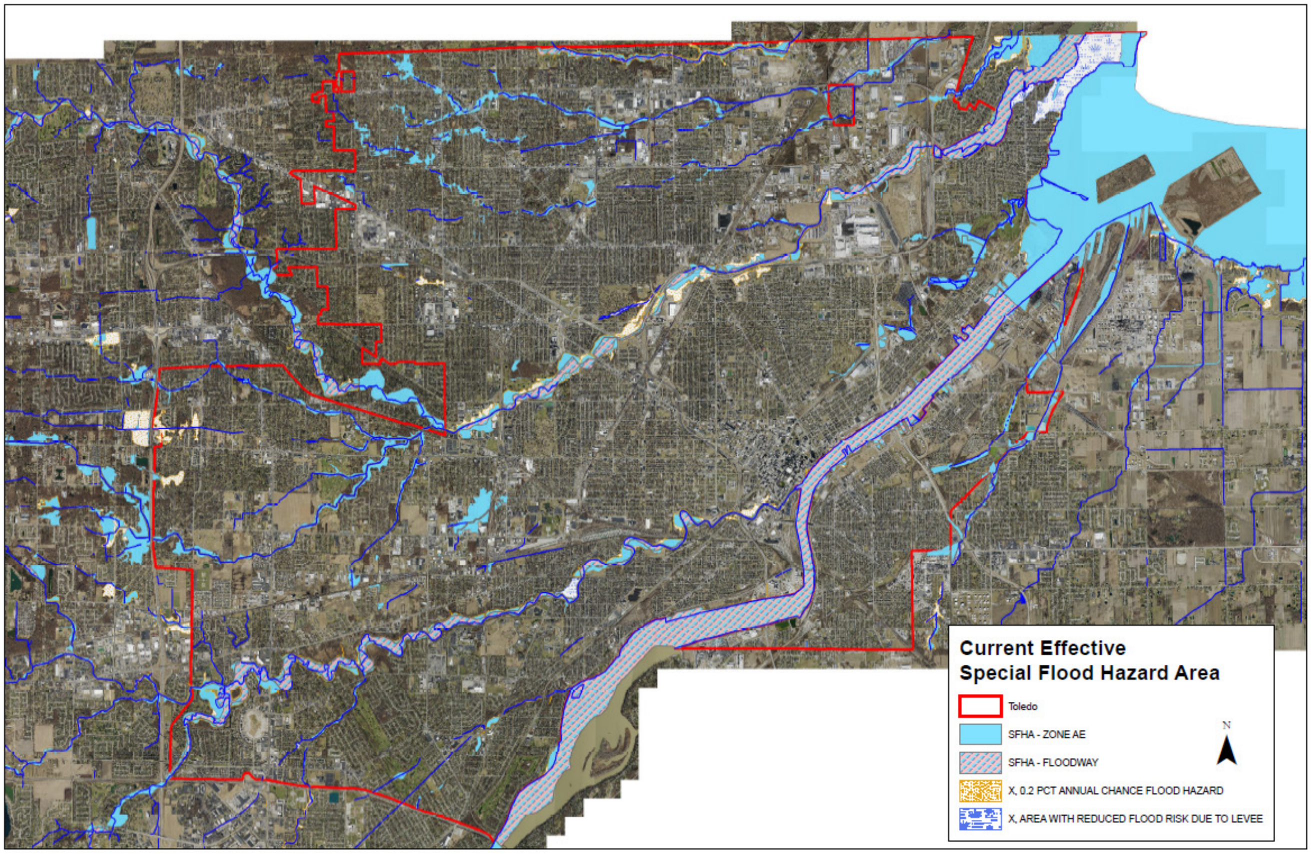


Figure 9: Flood hazard areas

flooding in any given year. However, we know that climate change is altering these frequencies, making the likelihood of flooding in any given year significantly greater. As such, we thought it important to use both the 100 and the 500-year floodplains as these represent our current and likely future flood risks. In addition to identifying locations vulnerable to flooding, floodplains help us understand where additional demand may be placed on our stormwater system – thereby providing insight into where additional stormwater-related solutions may be needed.

Based on the flood risk denoted in Figure 9, some areas of Toledo are particularly vulnerable to flooding. The section of the City located near the bay and mouth of the Maumee River are especially vulnerable, along with some areas next to waterways throughout the City.

Floodplains are naturally susceptible to flooding, and help prevent flooding in other areas of the city. To reduce the impacts of flooding, responsible management of this resource is key. The City of Toledo limits development in floodplains. However, as Toledo continues to urbanize there is added pressure from developers to build in these areas. Structures have been built in the floodplain (Figure 10). These structures will be especially prone to flooding and may contribute to additional flooding. Developers have requested permission to modify the floodplain, submitting plans that reduce the floodplain in one section, with the addition of floodplain in another. However, it is often difficult to ensure the developers correctly modify the floodplain and do not reduce the water storage capacity.

In recent years there has also been an initiative to increase citizen access to green space. Often this green space serves as a floodplain, so the development of creating access to these areas needs to be done responsibly and with flooding and water storage in mind.

b) Elevation

Understanding the elevation of various areas of our city helps us to understand which areas might be more prone to future flooding and, therefore, where we may have greater stormwater-related challenges. Recognizing that, we used data and images from topographic-map.com to show the elevation of the City. According to data gathered by the Shuttle Radar Topography Mission, the lowest elevation in Lucas County is 150 meters. This ranks Lucas County 8th in terms of lowest elevations out of the

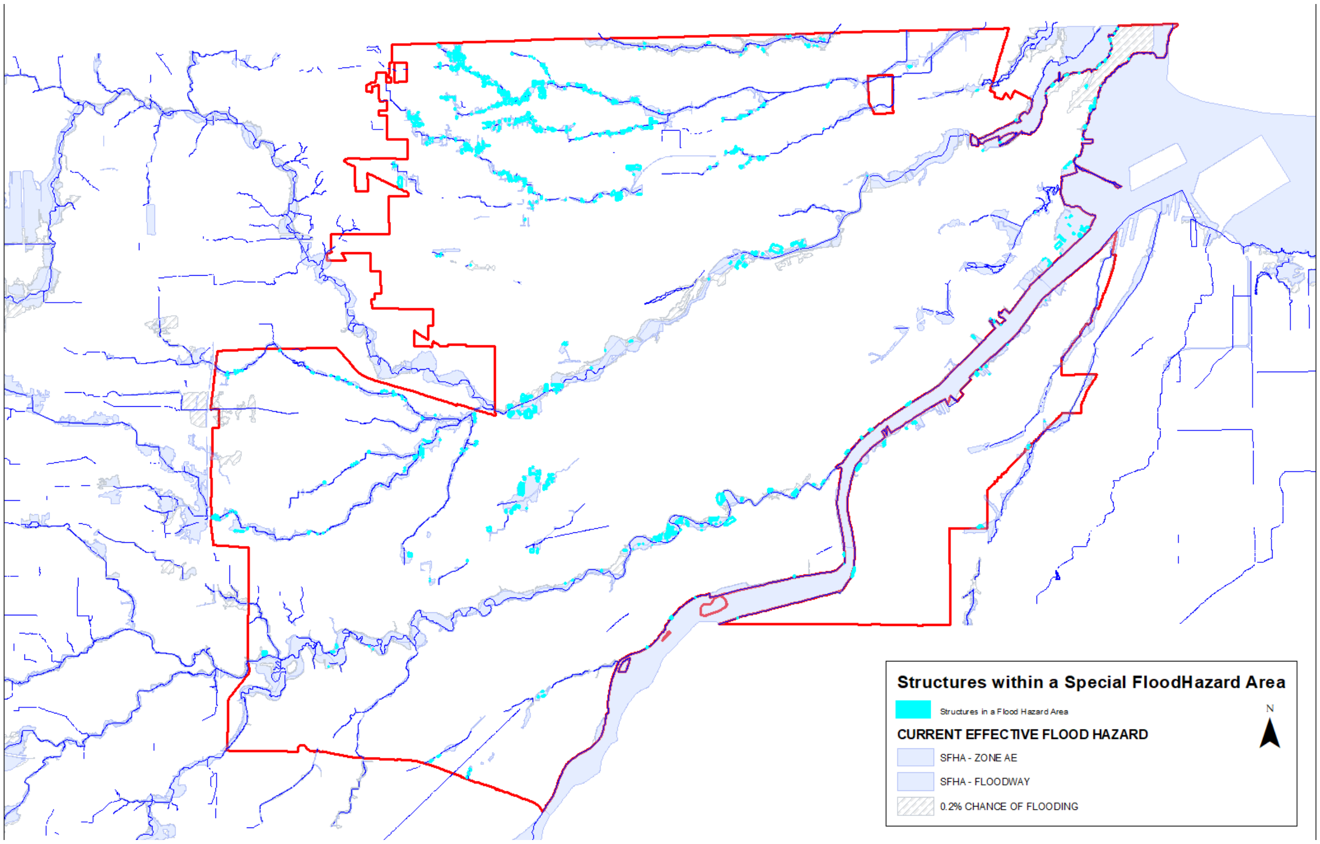


Figure 10: Structures within Special Flood Hazard Area

88 counties in Ohio. The highest elevation in Lucas County is 208 meters, which ranks it last in terms of highest elevations when compared all the counties in Ohio.

As shown in Figure 11, the majority of Toledo is at a low elevation. The low elevation coupled with a high water table creates unique water management issues throughout our city.

c) Land Cover

Land cover is an important factor affecting flood potential (as well as heat potential). Impervious surfaces and low vegetative covering are indicators of runoff potential. We

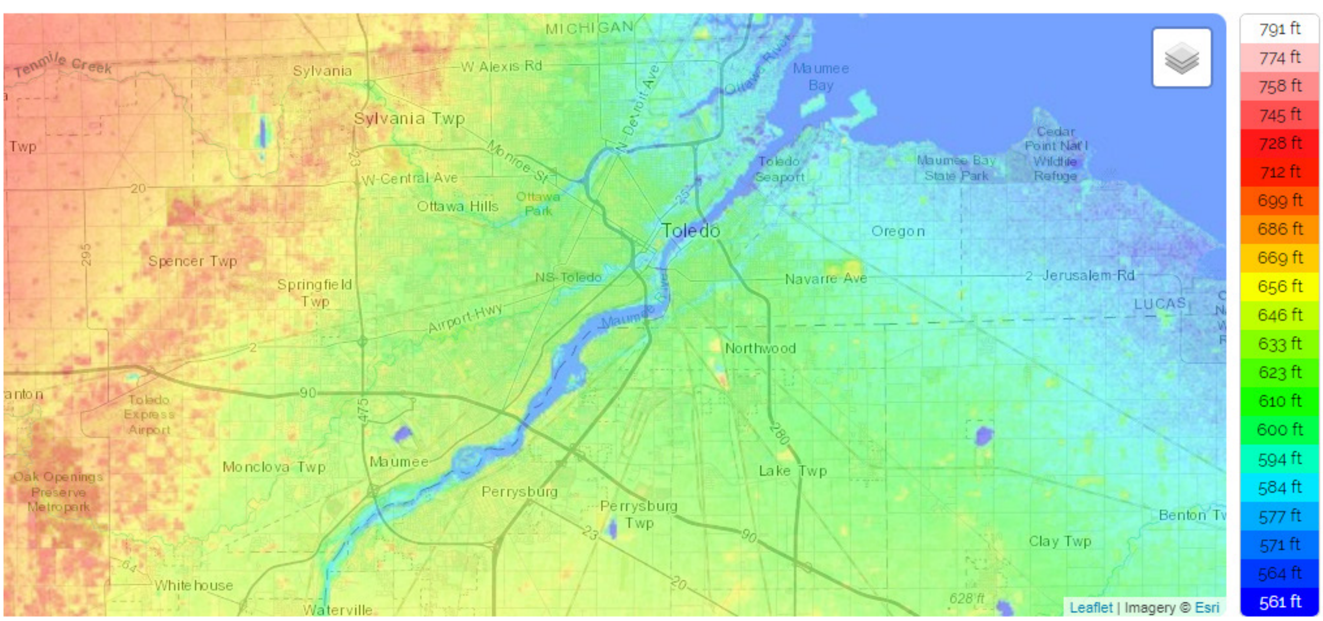


Figure 11: Elevation of Toledo.

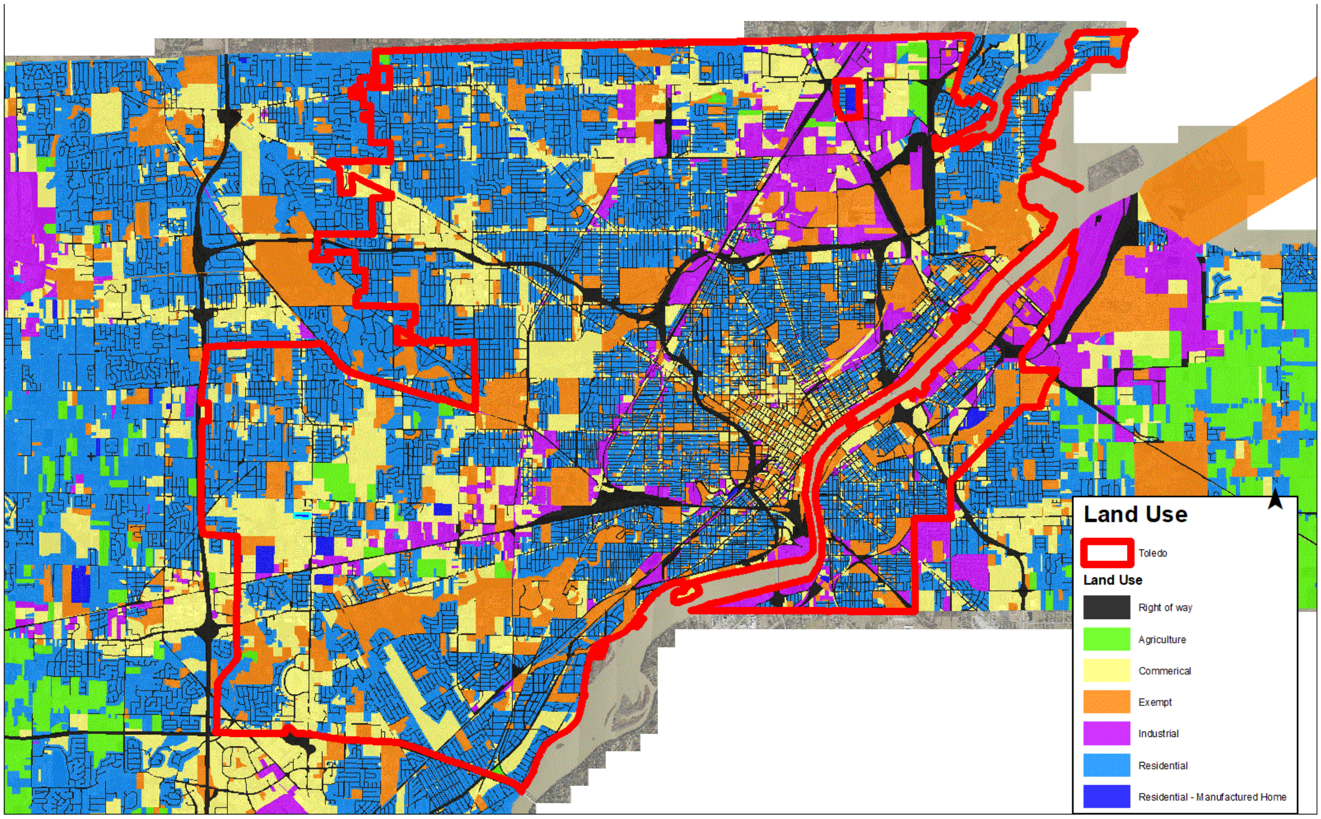


Figure 12: Land use in Toledo.

know that when precipitation falls on impervious surfaces, such as roads, streets, sidewalks, and buildings, it is unable to infiltrate into the soil and is diverted directly into our grey infrastructure. 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 run-off. Because of this, the City of Toledo has decided to use impervious surface coverage and vegetation coverage as indicators of local landscape vulnerability to flooding.

Increasing development has lead to an increase in impervious surface throughout the City of Toledo. This has created a rise in both the amount of water entering the City of Toledo storm sewer system and the amount of pollution. In order to reduce the impact that impervious surface has on flooding and water quality, the City of Toledo requires that new and redevelopment projects (over a certain size) manage stormwater on their site using post construction stormwater controls.

As shown in Figure 12, much of the City has a high concentration of impervious surface. Commercial and industrial zones in particular have large amounts of impervious surface because they often include large parking lots and roofs and little green space. The downtown district, along with several commercial and industrial zones of Toledo, are more urbanized than the residential areas. The higher percentage of impervious surface will increase the amount of stormwater runoff and vulnerability to flooding, and also increase the heat index potential in these areas.

e) Stormwater Asset Conditions

The quality (age, condition, capacity) and design of our city's stormwater infrastructure is another important element that influences our flooding potential. The City maintains a stormwater asset map using ArcGIS. The asset map shows the location of all known storm sewers and stormwater controls for detention and water quality along with specific recorded attributes. The City of Toledo consists of 1100 miles of sanitary sewers, 986 miles of storm sewers, and 64 miles of drainage ditches, and has over 1600 stormwater control measures for detention and water quality.

For the purposes of this landscape assessment, we attempted to look at various elements of our stormwater system recorded in our stormwater asset map. We found that data typically used to assess vulnerability, such as age, design capacity and condition assessments, are

Storm and Combined Sewer Mains

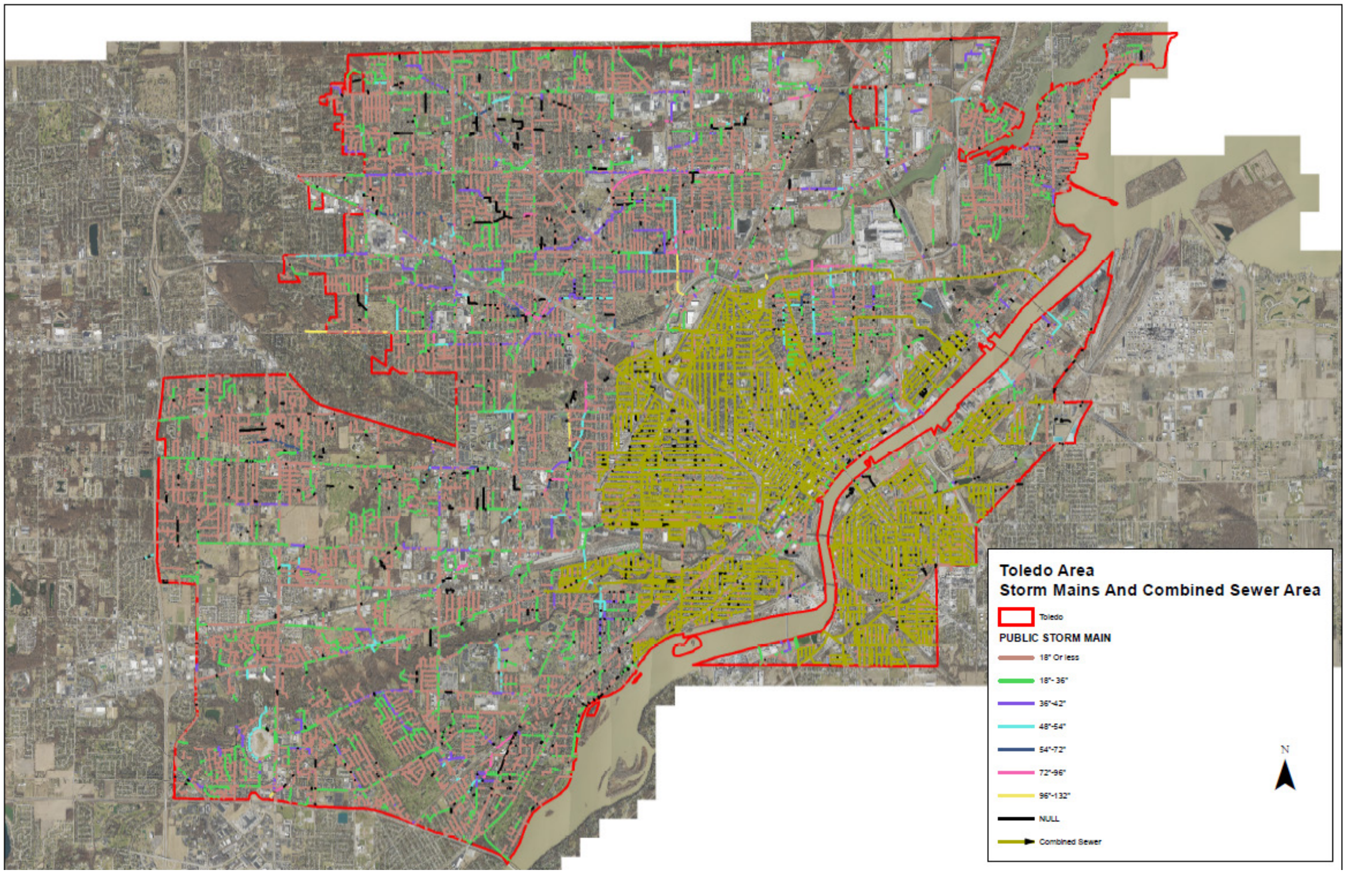


Figure 13: This figure shows the storm sewer system and the combined sewer system within the City of Toledo. The storm sewer mains are differentiated by size of the diameter of the pipe.

limited within the City's asset map. Age of a system could indicate the need for additional maintenance burden or replacements/rehabilitation of pipes. It was found that roughly only 12% of the City's stormwater pipe system has a recorded date of installation. Pipe design capacity could provide insight into the system's ability to adapt, or not, to larger storm events. However, pipe design capacity has not been recorded as an attribute within the asset map. Storm sewer cleaning and televising data is typically completed only as a reactive measure to current flooding situations. A program is not currently in place for systematic cleaning and televising of the storm sewers.

Toledo's current design standards for storm sewers are in line with regional standard practices. Current standards require that storm sewer pipes are designed to handle a 5-year storm flowing full, and a 10-year storm event with the hydraulic grade line at or below the gutter line. Major ditch improvement projects are designed with a goal to reduce the number of structures located within the existing floodplain boundaries to the maximum extent practicable. The City also requires that all new private development sites provide detention for their onsite stormwater runoff before releasing at a slower rate into the public system. Detention helps reduce peak flow associated with storm events and can reduce the demand on the existing storm system. Older systems and systems installed before the area was annexed into the City may not conform to those standards and therefore are likely to have a diminished capacity to adapt to climate change.

The City also has a large area of combined sewers, which convey both sanitary and stormwater flow. Combined sewer areas often have an increased number of sewage basement backups during heavy rainfall events and are the source of combined sewer overflows that outlet sewage directly into waterways. Although much of the City's combined system has been separated or supplemented with storage tanks or tunnels through the Toledo Waterways Initiative, a large area of combined infrastructure remains. Removing the combined system in some areas of the City is not feasible due to the amount of infrastructure located above the combined sewer. Combined sewer systems are particularly vulnerable to climate change; heavier and more frequent rainfall can lead to high frequency of overflows and basement backups.

Toledo's Stormwater and Flooding Vulnerability Map

By reviewing all the above information, we can see that certain neighborhoods and regions of the city have the highest vulnerability to climate change based on local landscape features. Several of the areas with high concentration of impervious surface, such as the downtown district and the area immediately north of it, are located in a combined sewer area. The combined sewer system in Toledo is older infrastructure that is more prone to higher maintenance needs and structural issues. The combined sewer system poses an added threat because it often includes sewage backups into residents homes, and/or combined sewer overflows (CSOs) into the waterways. These sewage backups pose a serious health risk to citizens of Toledo, and both sewage backups and CSOs can significantly impact the health of our environment and water quality in the region. The high concentration of existing infrastructure located above ground (buildings, homes, roadways) often makes it difficult to adapt existing systems. All of these elements collectively make these areas particularly vulnerable to changes in climate and the dangers of increased intense rain events.

Some the outer portions of the City, in particular areas that were annexed into the City, are more likely to have been constructed without street curbs and little to no drainage. Often these areas are also located within or adjacent to a flood hazard zone. Localized street flooding is a common complaint among residents on uncurbed streets.

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

Extreme heat is the number one weather-related killer in the United States.[56] 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.[57] 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.

Because of the very real and serious threats posed by extreme heat to Toledo residents, we have chosen to include three local landscape indicators that increase our vulnerability to heat.

a) Vegetation Coverage: Normalized Difference Vegetation Index

b) Impervious Land Cover

c) Urban Heat Island Effect

a) Vegetation Coverage: Normalized Difference Vegetation Index

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 value 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.

b) Impervious Land Cover

In contrast to vegetated areas, we know that impervious surfaces, surfaces made from materials that do not absorb precipitation (e.g., asphalt, concrete, brick) are extremely effective at trapping heat, leading to increased temperatures in areas that are more densely built.

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 EPA, "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 and stone, have high heat capacities. As a result, cities are typically more effective at storing the sun's energy as heat within their infrastructure."[58] 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.[59]

Summary of Landscape Vulnerability

The results in this section shed light on some of the local characteristics that can reduce or increase our community's vulnerability to flooding and extreme heat. Based on the cumulative results from this section, we know some areas of our community are extremely vulnerable to projected changes in climate. These sections of the city will likely be disproportionately negatively impacted by an increase in large rain events and rising temperatures. There are also portions of our stormwater system that are particularly susceptible to changes in climate. In the next section we use all the previous information to complete our vulnerability assessment.

5. TOLEDO'S VULNERABILITY ASSESSMENT RESULTS

In the next section we use all the previous information to complete our vulnerability assessment.

Using the information outlined in the previous sections, the City of Toledo completed a vulnerability assessment of our stormwater system. A vulnerability assessment helps determine the extent to which our city and its major elements are susceptible to harm from climate change. Our vulnerability assessment helps us understand:

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 Toledo's vulnerability assessment, we chose to focus on the below elements of City of Toledo assets. The remainder of this section provides a short description of the the various components evaluated as part of our vulnerability assessment.

Elements Included in a System-Wide Stormwater Vulnerability Assessment

Stormwater System Element	Type of System
Green Infrastructure	Built System
Maintenance Practices	Social System
Stormwater Sewer Pipes	Built System
Flood Prone Areas	Natural System
Water Treatment Plant	Built System
Water Reclamation Plant	Built System

Description and Location of Built Elements of the Stormwater System in Toledo

Green Infrastructure Practices

Green Infrastructure practices can be defined as an approach to stormwater management that uses natural systems or engineered systems that mimic natural processes to infiltrate, evapotranspire, and/or recycle stormwater runoff. Practices include structures such as rain gardens, green roofs, permeable pavement, and bioretention. In the city of Toledo there are numerous examples of green infrastructure both publicly and privately owned/operated. As Toledo works to become a more sustainable community, the City has installed multiple green infrastructure practices throughout the city (Figure 14). Some of these projects have been funded through grant funding to help improve drainage concerns and water quality in the region. The City of Toledo has seen great success with many of these projects. They have improved flooding issues, helped beautify neighborhoods, increased public understanding and involvement in stormwater management, and reduced sediment and pollutant loading in our local waterways. We chose to assess the vulnerability of green infrastructure practices because they play a key role in helping Toledo become a more resilient city in the future.

Stormwater Sewer Pipes

The City of Toledo storm sewer system drains and carries surface water runoff from rain and melting snow, and

Green Infrastructure

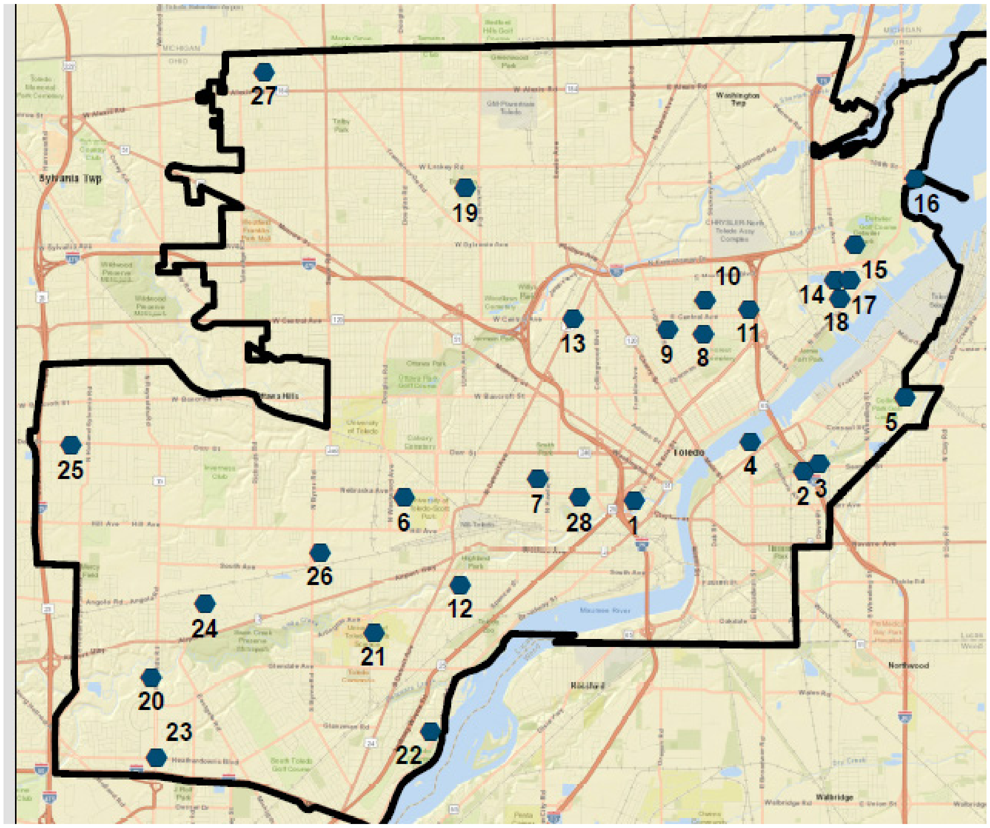


Figure 14: Publicly Owned Green Infrastructure in the City of Toledo

conveys this runoff to water bodies such as creeks, streams, rivers, and the lake. The storm sewer system includes 986 miles of storm sewers and 64 miles of ditch drainage systems (Figure 15). This vast network of pipes and ditches transport stormwater to prevent and reduce flooding throughout the city. We chose to assess this system component because it is a major tool used to manage stormwater.

The City of Toledo sewer system includes the separate storm sewer system, separate sanitary sewer system and the combined sewer system. The combined sewer system, which carries both stormwater and sewage, is directed to the wastewater treatment plant. However, during heavy rains, the system overflows into the rivers. Many of those overflows, called combined sewer overflows, or CSOs, are still present today. In 2002, the City of Toledo launched the Toledo Waterways Initiative (TWI) to eliminate the majority of these overflows and reduce water pollution.

TWI will reduce contaminants in our rivers, streams, and Lake Erie by building several types of structures to hold, separate, or divert storm and wastewater during periods of heavy rain; and funneling this water for treatment before being returned to the waterways. TWI is a $527 million program that will prevent 80% of the average annual overflow volume from entering our waterways.

Water Treatment Plant

The Collins Park Water Treatment Plant is responsible for the effective production, filtration, and quality control of water for the City of Toledo. The Division's responsibility starts at the source of raw water, Lake Erie, and extends throughout the treatment process. This Division operates and maintains the largest softening plant on Lake Erie. Located on the east side of Toledo, the treatment plant filters an average of 75 million gallons of water per day. At no time in the process is the water allowed to stop moving. Every area within the plant can be isolated, so maintenance or repairs can be made without affecting the flow or quality of the water produced. The Collins Park Water Treatment Plant is known for the quantity and quality of water produced, and it is for these reasons that many suburban communities purchase water from Toledo and why many businesses choose to locate in the Toledo area. The water treatment plant produces safe drinking water for approximately 400,000 people in the region. This

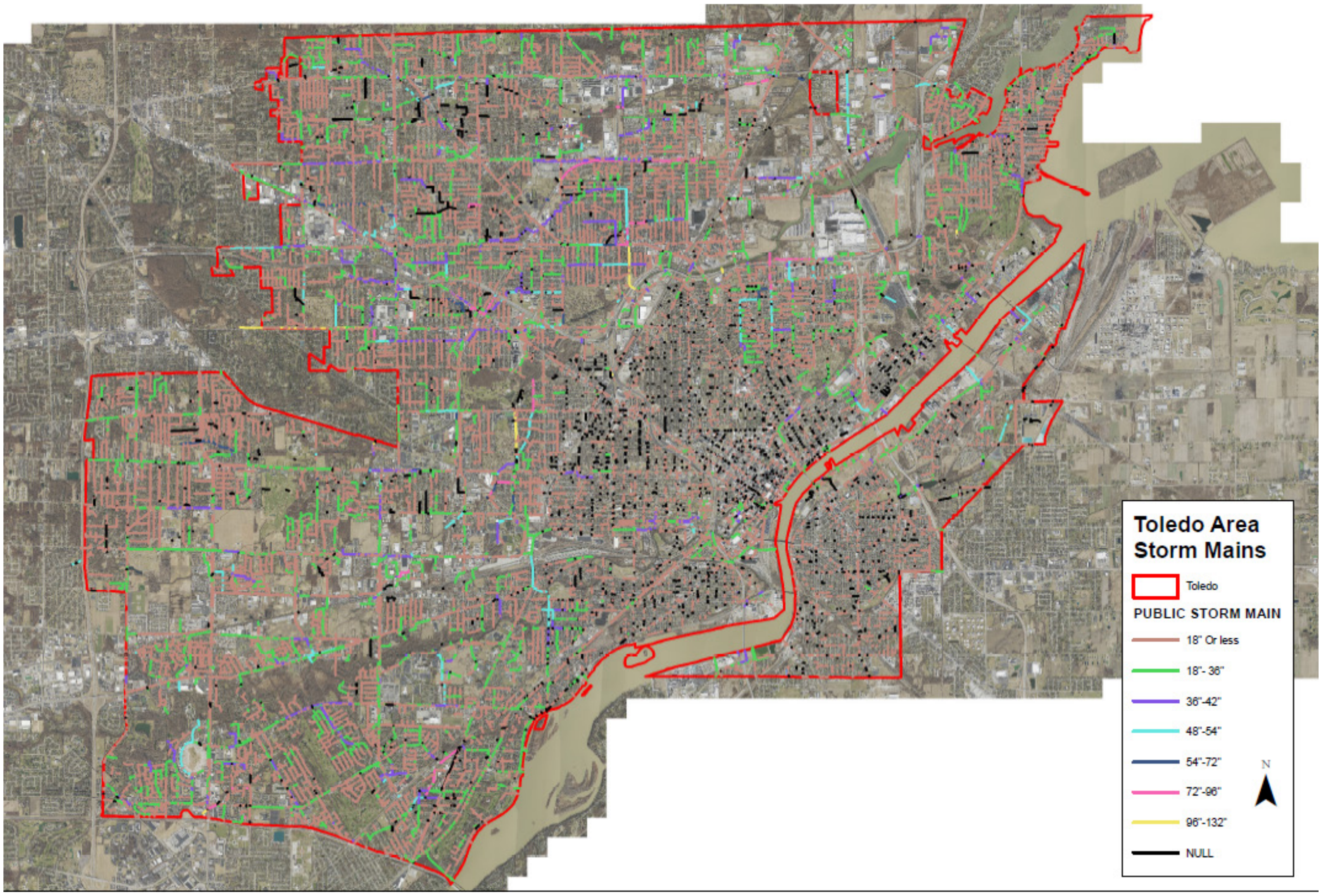


Figure 15: Storm Sewers in Toledo

drinking water is a vital resource during extreme weather events. For this reason we chose to assess its vulnerability to climate change. Issues with the treatment plant due to future climate change could have catastrophic impacts on the people of Toledo.

Water Reclamation Plant

The Bay View Water Reclamation Plant is one of the largest wastewater treatment facilities in Northwest Ohio. The facility, located near the mouth of the Maumee River, provides treatment services to an area of approximately 100 square miles. The population of the service area is approximately 400,000. The Toledo area wastewater collection system is composed of combined sanitary and storm sewers in the older sections of the city, and separate sanitary sewers in the newer areas.

We included the Bay View Water Reclamation Plant in the assessment because it provides a vital service to the city, and properly and effectively treating wastewater is of the utmost importance to protecting the water quality of Lake Erie. If we can identify vulnerable areas in our wastewater treatment process, the City would like to address these items proactively.

Description and Location of Natural Systems in Toledo

Flood Prone Areas

Throughout the City of Toledo there are floodplains, which are low-lying areas adjacent to creeks, streams, and rivers that are subject to frequent flooding. There are also areas where drainage issues due to problems with infrastructure have led to repeated flooding. We have chosen to examine these flood prone areas in our Climate Change Vulnerability Assessment to see how these areas would be affected. Residents of Toledo that live in flood prone areas experience hazardous conditions and reoccurring expenses. Some of these residents live in the floodplain (Figure 16) while others live in areas with drainage issues, such as unimproved roads that do not have curbs and gutters.

Flood Prone Areas

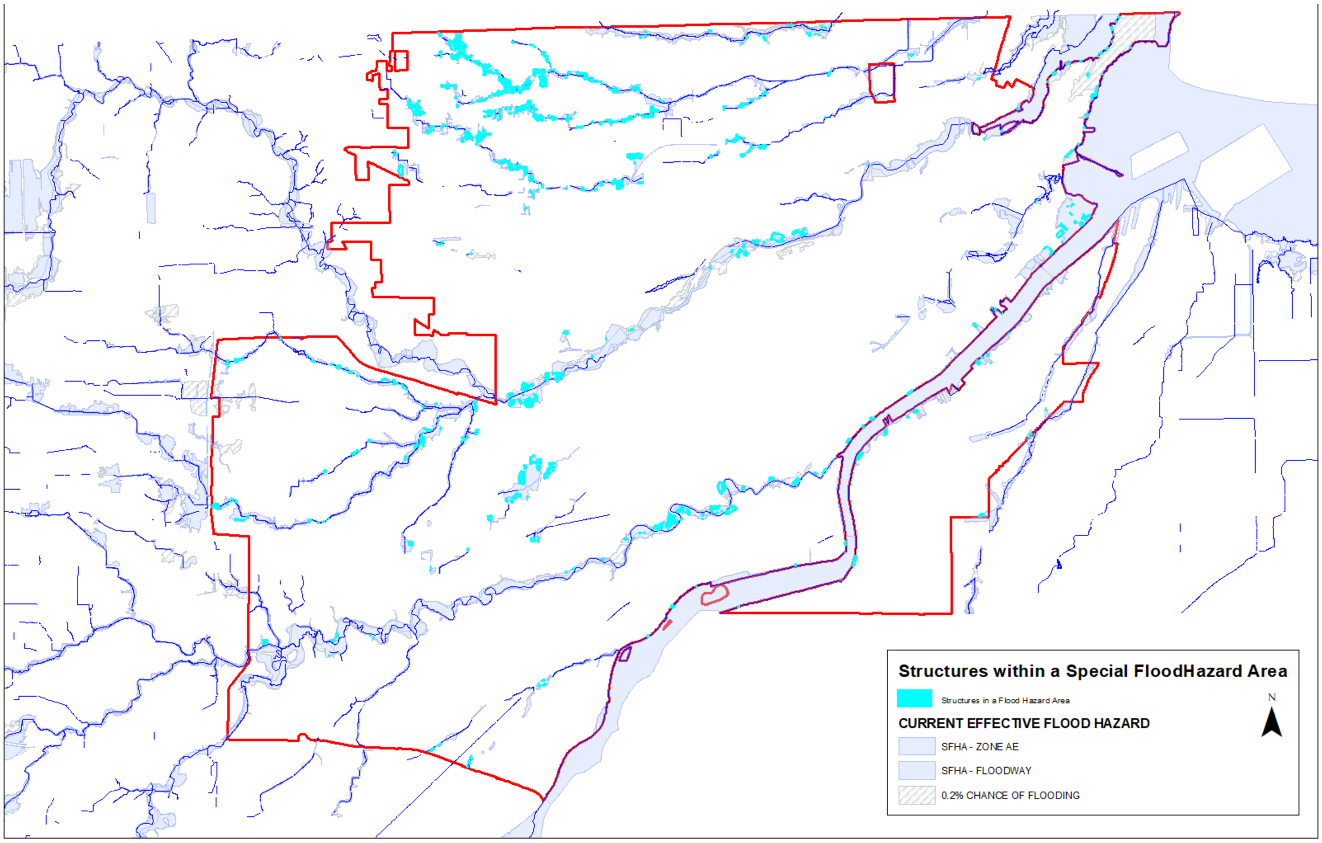


Figure 16: Stuctures within a Special Flood Hazard Area

Description and Location of Social Systems and Vulnerable Populations in Toledo

Maintenance Practices for Stormwater Infrastructure

Stormwater management practices are found throughout Toledo. Whether traditional gray or green infrastructure, all aspects of the stormwater conveyance system will require some type of maintenance to retain their functionality. Maintenance activities are typically divided into routine activities, which should occur on a regular basis, and emergency or infrequent activities. Both green and gray infrastructure practices require both regular and emergency maintenance. Most infrastructure practices will require some form of trash, sediment, and debris removal; structural repairs and replacements; and vegetation maintenance, such as mowing or invasive species control. Planning and budgeting for routine and some non-routine repairs is the foundation of an effective maintenance program for both green and gray infrastructure. In order to create a more successful stormwater maintenance program in the future, the City of Toledo chose to include this component in our vulnerability assessment. Stormwater maintenance can play a huge role in preventing flooding and infrastructure issues. However, a solid understanding of how climate change will affect our stormwater infrastructure and affect the maintenance needs will be necessary to create a plan of action for the future.

Social Systems and Vulnerable Populations

Social Systems and Vulnerable Populations in Toledo were included in this assessment. In order to fully understand how the City of Toledo is resilient or vulnerable to climate change, we needed to examine the social characteristics that make up our community. Using the Socio-Economic Data Mapper (Data Mapper) tool from Headwaters Economics, we analyzed ten characteristics that help explain our local vulnerability. Please see Section 2 of this document.

Cumulative Vulnerability Assessment Scope

We chose to examine the effects of climate change and vulnerabilities of our community on a variety of aspects in the City because they all play an important role in providing a safe, healthy, resilient community for our residents to live and work in the future.

Table 6 provides a sample of the systems and system elements evaluated as part of the City of Toledo's stormwater system vulnerability assessment process.

Table 6: Scope of Vulnerability Assesments

Ref#	City	System	System Component	Geographical Distribution System Component (Census Tract, if applicable)
1	Toledo	Stormwater	Green Infrastructure	All_Toledo vs. All_Toledo
2	Toledo	Stormwater	Stormwater Maintenance Practices	All_Toledo vs. All_Toledo
3	Toledo	Stormwater	Stormwater Pipes	All_Toledo vs. All_Toledo
4	Toledo	Stormwater	Flood Prone Areas	59.02 vs. All_Toledo
5	Toledo	Drinking Water	Water Treatment Plant	Not_Applicable vs. All_Toledo
6	Toledo	Wastewater	Water Reclamation Plant	Not_Applicable vs. All_Toledo

Step 2: Socio-Economic Analysis

The second step of our assessment focused on compiling and analyzing socio-economic information, at the pertinent geographical scale, for the various elements evaluated as part of our stormwater-system vulnerability assessment.

To do this, we built upon the data outlined in Chapter 2 to more deeply understand who could be affected by each of the elements evaluated in our vulnerability assessment.

Guiding this section were two key questions:

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

Table 7 below demonstrates the results from this step of our assessment for a subset of our system.

Project Details					Socio-Economic Vulnerability											
Ref #	City	System	System Component	Geographical Distribution of System Component (Census Tract, if applicable)	% 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?
1	Toledo	Stormwater	Green Infrastructure	All_Toledo	13.7	6.9	26.5	1	36.9	25.8	26.9	17.3	48.1	14.8	In some cases Green Infrastructure relies on homeowners for maintenance, with renters, this does not work well. There is time and money cost for the property owners, with is socio economic vulnerable areas may make this option difficult. The city also struggles to funding maintenance for grant funded Green infrastructure projects.	It can help reduce flooding, it can reduce basement flooding in older neighborhoods, with potential vulnerable populations. However if not maintained over time it becomes a problem again. There is also an aesthetic value to Green Infrastructure that can add beautiful green space to socio economic vulnerable areas that may be highly urbanized and plagued with blight. Green Infrastructure can also be a great learning opportunity to teach people about the water cycle, improving water quality, wildlife habitats. Maintenance issues would need to be solved before Green Infra. becomes a viable long term solution in Socio- Economic challenged areas.
				vs												
				All_Toledo	13.7	6.9	26.5	1	36.9	25.8	26.9	17.3	48.1	14.8		
2	Toledo	Stormwater	Maintenance Practices	All_Toledo	13.7	6.9	26.5	1	36.9	25.8	26.9	17.3	48.1	14.8	Maintenance of stormwater structures is complaint driven. Residents without time or knowledge of the stormwater system do not submit complaints, so issues in Socio- Economic areas may get overlooked. Some socio-economic vulnerable areas are Combined sewer systems, these systems are often old and in need of more maintenance.	Insufficient maintenance can cause flooding. Leading to damages to homes and properties of residents, in socio economic vulnerable populations, these citizens may struggle to afford clean up or replacement costs for damages after flooding.
				vs												
				All_Toledo	13.7	6.9	26.5	1	36.9	25.8	26.9	17.3	48.1	14.8		
3	Toledo	Stormwater	Stormwater Pipes	All_Toledo	13.7	6.9	26.5	1	36.9	25.8	26.9	17.3	48.1	14.8	Socio- Economic areas often have older infrastructure and more mature trees --leaves and roots can impact the functioning of the stormwater systems. The roots can also cause damage to the pipes. In some of these areas we don't know much about the condition or even location of pipes.	Lower economic areas which may have Combined Sewer system and/or an aging sewer system may experience more flooding. Which will negatively impact socio-economically vulnerable populations.
				vs												
				All_Toledo	13.7	6.9	26.5	1	36.9	25.8	26.9	17.3	48.1	14.8		
4	Toledo	Stormwater	Flood Prone Areas	59.02	14.9	5.8	19.4	0.3	12.8	22.5	36	17.9	38.9	9.8	Some flood prone areas include unimproved streets (which means they have no storm sewer, curb or gutters). These unimproved areas are often in Socio- economic vulnerable communities. Improvements only come with assessment of property owners and this cost is prohibitive	Flood Prone areas can negatively impact Socio Economic vulnerable who may be subject to more frequent flooding and the cost associated with this including paying for flood insurance (for homes in floodplain)
				vs												
				All_Toledo	13.7	6.9	26.5	1	36.9	25.8	26.9	17.3	48.1	14.8		
5	Toledo	Drinking Water	Water Treatment Plant	All_Toledo	0	0	0	0	0	0	0	0	0	0	Socio- Economic Vulnerability has the potential to impact the workforce of the water treatment plant. Increases in water rates can negatively affect vulnerable communities. The inability of the community residents to afford water rates can negatively impact the funding of the plant	The Water Treatment plant can reduce the socio-economic impact by providing affordable water to all classes of people in the region
				vs												
				All_Toledo	13.7	6.9	26.5	1	36.9	25.8	26.9	17.3	48.1	14.8		
6	Toledo	Wastewater	Water Reclamation Plant	All_Toledo	0	0	0	0	0	0	0	0	0	0	Socio- Economic Vulnerability has the potential to impact the workforce of the water reclamation plant. Increases in sewage rates can negatively affect vulnerable communities. Less rate payers will negatively affect incoming funds and the plant budget	Stormwater utility may proportionally distribute the cost burden for repairs and maintainence
				vs												
				All_Toledo	13.7	6.9	26.5	1	36.9	25.8	26.9	17.3	48.1	14.8		

Step 3: Exposure Analysis

The third step in our assessment was the compilation and analysis of pertinent climate change information to understand how the various elements being evaluated as part of our 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 our stormwater vulnerability assessment?
2. How will the elements (i.e., the thing being evaluated as part of our stormwater vulnerability assessment) impact (i.e., help or hinder) projected changes in climate?

Table 8 below demonstrates the results from this step of our assessment for a subset of the stormwater system.

Project Details			Climate Vulnerability								
Ref #	City	System	System Component	Variable of Interest	Sub-Variables of Interest		Historical/ Current	Mid-Century Projected Changes	% Change Between Historic and Future; Mid Century % / End Century %	How Will Projected Changes in Climate Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Projected Changes?
1	Toledo	Stormwater	Green Infrastructure	Temperature	Avg Annual Temp	Toledo-Temperature-Avg Annual Temp	50.1°F	55 to 60°F	6 to 10% / 10 to 20%	Some types of green infrastructure is designed to treat and hold a certain amount of water. With increase rainfall they don't function as intended because they overflow. So sizing and designing standards with changes to overflow capacity would need to be changed . Plant selection for some practices may also need to change, to better suit differences in temperature and precipitation. Some species may grow really fast, crowding others, some species might not be able to tolerate the increased temperatures and rainfall.	In some cases green infrastructure may be able to help with projected climate changes. In areas with high flooding, green infrastructure may be able to manage stormwater (especially in communities were repairs and upgrades to grey infrastructure is not possible). Also the increased green space would help mitigate urban heat island effect.
				Temperature	Avg Low Temp	Toledo-Temperature-Avg Low Temp	40.4°F	46 to 50°F	6 to 11% / 14 to 24%		
				Precipitation	Total Annual Precip	Toledo-Precipitation-Annual Precip	34.2 in.	35 to 40 in.	-4 to 8% / 2 to 17%		
				Precipitation	Heavy Precipitation Days(>1.25")	Toledo-Precipitation-Heavy Precipitation Days(>1.25")	3.4 days / year	5.5 to 6.2 days	24 to 76% / 62 to 82%		
				Precipitation	Spring Avg Precip	Toledo-Temperature-Spring Avg Temp	9.2 in.	9 to 13 in.	-13 to 20% / -2 to 41%		
2	Toledo	Stormwater	Maintenance Practices	Temperature	Avg Annual Temp	Toledo-Temperature-Avg Annual Temp	50.1°F	55 to 60°F	6 to 10% / 10 to 20%	An increase in extreme rain events will increase the frequency of maintenance which means a increase in maintenance costs. Increased runoff will lead to more wear on stormwater infrastructure throughout the City. Some stormwater practices may require more maintenance needs with increased temperature. Larger rainfall events leading to more runoff will also increase the maintenance needs of detention ponds which will fill with sediment sooner.	Effective and proactive maintenance practices would help reduce the effects of climate change. Scheduled maintenance and cleaning of stormwater pipes would help reduce current flooding issues and curb the effects of future climate projections. Proper maintenance on other stormwater practices would maintain their retention/ detention capacity, helping prevent overwhelming the storm sewer system and flooding.
				Temperature	Summer Avg Temp	Toledo-Temperature-Summer Avg Temp	71.3°F	79 to 83°F	5 to 9% / 11 to 16%		
				Temperature	Winter Avg Temp	Toledo-Temperature-Winter Avg Temp	27.6°F	33 to 36°F	9 to 20% / 20 to 30%		
				Precipitation	Total Annual Precip	Toledo-Precipitation-Total Annual Precip	34.2 in.	35 to 40 in.	-4 to 8% / 2 to 17%		
				Precipitation	Summer Avg Precip	Toledo-Precipitation-Summer Avg Precip	9.9 in.	9 to 11 in.	-9 to 11% / -9 to 11%		

Project Details			Climate Vulnerability								
Ref #	City	System	System Component	Variable of Interest	Sub-Variables of Interest		Historical/ Current	Mid-Century Projected Changes	% Change Between Historic and Future; Mid Century % / End Century %	How Will Projected Changes in Climate Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Projected Changes?
3	Toledo	Stormwater	Stormwater Pipes	Temperature	Days/Year Greater Than 90F	Toledo-Temperature-Days/Year Greater Than 90F	12.6 days	48 to 82 days	138 to 273% / 281 to 551%	The current storm sewer system pipes may be undersized in the future with projected climate change. We will need to change the design requirements and standards to be able to handle more volume coming into the system at a faster rate (aka increasing capacity). we will likely need to replace or upgrade some of the older instructure to accommodate the changes in precipitation	If updated or resized stormwater pipes can help manage flooding. If paired with green infrastructure, or design standards changed the storm sewer can help manage increased precipitation. There is capacity for more volume than what is currently being experienced (for landscape features and adaptive capacity)
				Temperature	Winter Avg Temp	Toledo-Temperature-Winter Avg Temp	27.6°F	33 to 36°F	9 to 20% / 20 to 30%		
				Precipitation	Heavy Precipitation Days(>1.25")	Toledo-Precipitation-Heavy Precipitation Days(>1.25")	3.4 days / year	5.5 to 6.2 days	24 to 76% / 62 to 82%		
				None_ Selected	None_ Selected	Toledo-	#N/A	#N/A	#N/A		
				None_ Selected	None_ Selected	Toledo-	#N/A	#N/A	#N/A		
4	Toledo	Stormwater	Flood Prone Areas	Temperature	Days/Year Greater Than 90F	Toledo-Temperature-Days/Year Greater Than 90F	12.6 days	48 to 82 days	138 to 273% / 281 to 551%	With projected climate change flood prone areas will flood more. This will affect people's desire to live in these areas and may impact property values. The people living in these area will also experience additional cost of repairs and clean up from flooding. The floodplain would also extend so this would mean that new areas would be located in the floodplain which necessitates zoning changes and other flood mitigation changes (like carrying flood insurance). Potential for more setbacks for development purposes in order to handle increased rainfall	The residents living in flood prone areas might have creative ideas about how to handle flooding since they regularly have to live with these issues. There will be a greater incentive for increased setbacks and regulation on development in these areas with increased rainfall.
				Temperature	Avg Annual Temp	Toledo-Temperature-Avg Annual Temp	50.1°F	55 to 60°F	6 to 10% / 10 to 20%		
				Precipitation	Spring Avg Precip	Toledo-Precipitation-Spring Avg Precip	9.2 in.	9 to 13 in.	-13 to 20% / -2 to 41%		
				Precipitation	Heavy Precipitation Days(>1.25")	Toledo-Precipitation-Heavy Precipitation Days(>1.25")	3.4 days / year	5.5 to 6.2 days	24 to 76% / 62 to 82%		
				Precipitation	Total Annual Precip	Toledo-Precipitation-Total Annual Precip	34.2 in.	35 to 40 in.	-4 to 8% / 2 to 17%		
5	Toledo	Drinking Water	Water Treatment Plant	Temperature	Days/Year Greater Than 90F	Toledo-Temperature-Days/Year Greater Than 90F	12.6 days	48 to 82 days	138 to 273% / 281 to 551%	Rising lake levels may require flood protection to be installed by Low Service Pump Station and the raw water main structures. Extended lack of supply of power, chemicals, waste disposal and workforce have the potential to interrupt operations	A reliable supply of clean water from the water treatment plant will be critical to supporting a stressed community. Especially during extreme weather events.
				Precipitation	Heavy Precipitation Days(>1.25")	Toledo-Precipitation-Heavy Precipitation Days(>1.25")	3.4 days / year	5.5 to 6.2 days	24 to 76% / 62 to 82%		
				None_ Selected	None_ Selected	Toledo	#N/A	#N/A	#N/A		
				None_ Selected	None_ Selected	Toledo	#N/A	#N/A	#N/A		
6	Toledo	Waste Water	Water Reclamation Plant	None_ Selected	None_ Selected	Toledo	#N/A	#N/A	#N/A	Greater intensity rains overwhelm existing infrastructure which were designed for longer term rain events. The increased rain events and duration may cause us to retain the water for longer periods in the newly designed wet weather facilities. This may put added unforeseen stress of the new system requiring increased maintenance cost or perhaps an increase in CSOs.	This component can help projected changes. The Increase pipe carrying capacities and eliminate bottlenecks; however, this will increase sewer cleaning and televising of the lines.The wet weather facility can help reduce flooding and CSOs due to its capacity to hold the increased volume of water and release it in metered intervals.
				None_ Selected	None_ Selected	Toledo	#N/A	#N/A	#N/A		
				None_ Selected	None_ Selected	Toledo	#N/A	#N/A	#N/A		
				None_ Selected	None_ Selected	Toledo	#N/A	#N/A	#N/A		
				None_ Selected	None_ Selected	Toledo	#N/A	#N/A	#N/A		

Step 4: Landscape Analysis: Flooding

The fourth step in our vulnerability assessment focused on compiling and analyzing pertinent information needed to understand how the various elements in our stormwater system already are exposed to flooding. To do this, we collected information, to the extent available, regarding elevation; whether or not the system was in the floodplain; slope; percent impervious land cover; and the storm event capacity and condition of infrastructure in the region. Where possible, we used data on the census tract level. When not available, we used citywide data.

Once data was compiled we used two questions to guide our assessment of each stormwater element's vulnerability to flooding:

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?

Tables 9 below demonstrates the results from this step of our assessment:

Project Details				Landscape Vulnerability: Flooding		
Ref #	City	System	System Component	Geographical Distribution of System Component (Census Tract, if applicable)	How Do Local Landscape Features Influence This System Component's Vulnerability to Flooding?	How Does This System Component Exacerbate or Reduce Landscape Vulnerability to Flooding?
1	Toledo	Stormwater	Green Infrastructure	All_Toledo	Green infrastructure is constructed with set sizing criteria design standard but is often designed to fit the available space.We don't do any monitoring of the performance of these practices. When GI is getting established, too much rain or too much dry weather can cause the project to fail. Clay and sand soils can likely necessitate alternative installations to maximize performance.	Reduces flooding vulnerability by helping manage stormwater. These practices decrease the amount of water entering the stormwater system, and the rate at which it enters. However, these practices can get inundated if not sized correctly - especially if it's offline and not online treatment.
2	Toledo	Stormwater	Maintenance Practices	All_Toledo	We do not have a great maintenance program that monitors erosion issues or includes a remediation program. Currently no good solution in CIP to maintenance issues. Areas with higher imperviousness and those with greater tree canopy will likely need more maintenance, without extra maintenance these areas will experience flooding issues.	This component could reduce our vulnerability to flooding, by ensuring the stormwater system is functioning well. However at this time maintenance is reactionary instead of proactive so with climate change, this problem is likely to be perpetuated.
3	Toledo	Stormwater	Stormwater Pipes	All_Toledo	In some areas mature trees lead to more leaves in the system, which leads to flooding. Tree roots can get into the pipes and disrupt flow or cause damage. People throw things into the ditches (leaves, appliances, furniture, tires). More expensive to upgrade pipe system in areas that are built up. Pipes aren't right-sized for changes in climate - pipes are sized for a past 5-year storm to flow full and a 10-year storm curve line. Basins are sized for a 2-year storm. Ditches we try to go to a 100 year storm.	If the pipes are not able to handle the capacity, it's going to contribute more to erosion in ditches, flooding, standing water.
4	Toledo	Stormwater	Flood prone areas	59.02	With very little slope in some areas, we will have more people in the floodplain. Areas with high percentage of impervious surface and a lot of development will be especially prone to flooding due to large amount of runoff.	Floodplains help protect other areas from flooding, if they are managed responsibly and development of these areas is limited they can help reduce flooding.
5	Toledo	Drinking Water	Water Treatment Plant	n/a	Low Service Pump Station and the raw water main structures may require flooding protection structures.	n/a
6	Toledo	Waste Water	Water Reclamation Plant	n/a	Need to increase stormwater management facilities and staffing dedicated to the stormwater infrastructure. A lot of the tree canopy leads to more leaves in the system, which leads to flooding. People throw things into the ditches (leaves, appliances, furniture, tires). More expensive to upgrade pipe system in areas that are built up. Pipes aren't right-sized for what's coming - pipes are sized for a past 5-year storm to flow full and a 10-year storm curve line. Basins are sized for a 2-year storm. Ditches we try to go to a 100 year storm. Tree roots can get into the pipes and disrupt flow or cause damage	Better maintenance of existing facilities will increase available capacity during storm events.

Step 5: Cumulative Impacts

The fifth step in our analysis combined the information and analysis done in steps 2-4 to gather a holistic sense for the different ways each element evaluated as part of our stormwater system vulnerability assessment was impacted by socio-economic considerations, changes in climate, and local landscape features. Once we had combined all of this information, we then asked 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 10 below demonstrates the results from this step of our assessment.

Project Description				Cumulative Impacts
Ref #	City	System	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	Toledo	Stormwater	Green Infrastructure	Green infrastructure can reduce the impact of flooding and urban heat island. However climate change requires we revisit design, performance and maintenance. Ensure we use these practices in areas with the greatest need and choose appropriate plant species that can tolerate changing conditions over time.
2	Toledo	Stormwater	Maintenance Practices	A well maintained system will be less prone to flooding and reduce impacts but currently we are more reactive than proactive. Would benefit from scheduled maintenance and make sure all areas are receiving the attention they need. Lack of maintenance can increase flooding incidents which disproportionately impact low income communities.
3	Toledo	Stormwater	Stormwater Pipes	Undersized pipes and older infrastructure are often located in socio economic vulnerable areas, with an increase in large rain events this will lead to an increase in flooding and damages. These areas are also commonly have combined sewer systems and lack of backflow prevention, which can lead to hazardous and costly basement flooding.
4	Toledo	Stormwater	Flood Prone Areas	Will increase the amount of flood prone areas, or high frequency of flooding. Which will trigger more homeowners to need flood insurance. Homes not originally in flood prone areas may have flood damages, because they not designed for that. Cost associated with culvert and drainage repairs due to increase in silt and sediment in system will burden on city resources. Vulnerable populations may be affected by high rent or mortgage due to flood insurance. Number of homes in flood plain may greatly increase. With proper management can maintain affected properties.
5	Toledo	Drinking Water	Water Treatment Plant	1.Rising lake levels may require flood protection to be installed for Low Service Pump Station and the raw water main structures. Extended lack of supply of power, chemicals, waste disposal and workforce have the potential to interrupt operations. 2. A reliable supply of water from the Water Treatment Plant will be critical to supporting a stressed community.
6	Toledo	Waste Water	Water Reclamation Plant	1 .The increased duration and intensity of the precipitation events will cause increased stress on the system especially in older parts of town where the more vulnerable population lives. The wet weather facility will have to hold the storm and sewage longer before release to the treatment plant. Increased storm events may contribute to more CSOs 2. A reliable waste water Plant will be critical to supporting a stressed community. If more holding areas are needed due to increased storm events Socially, the poorer parts of town will be reclaimed for stormwater structures, strictly economics.

Step 6: Sensitivity Assessment

The sixth step of our 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 500-year floodplain with flood-proofing measures is much less sensitive to a flood than one in the 100-year floodplain with no flood proofing measures.

To determine how sensitive each of our stormwater elements were, we answered three questions:

1. What, if any existing stresses affect this element?
2. How might demand for this element change given impacts identified in Step 5?
3. What, if any, limiting factors does this element have that make it more sensitive?

We answered these questions for each of the Elements included in the scope of our assessment. The responses to these three questions were used to assign a sensitivity score for each element. We used the qualitative evaluation criteria provided in Figure 17 to assign sensitivity scores.

Figure 17: 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 found that we have a particularly high sensitivity (scores of S3-S4) for:

- Maintenance Practices
- Stormwater Pipes
- Flood Prone Areas
- Water Reclamation Plant

Table 11 below demonstrates the results from this step of our assessment for a subset of the stormwater system.

Project Description				Cumulative Impacts	Sensitivity Assessment			
Ref #	City	System	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.	What, If Any Existing Stresses Affect This System Component?	How Might Demand For This System Component Change Given Cumulative Impacts Identified?	What, If Any, Limiting Factors Does This System Component Have? (e.g., think about how projected impacts might influence the System Component's operational thresholds)	How Sensitive is This System Component to Projected Changes in Climate? (e.g., Sensitivity Score)
1	Toledo	Stormwater	Green Infrastructure	Green infrastructure can reduce the impact of flooding and urban heat island. However climate change requires we revisit design, performance and maintenance. Ensure we use these practices in areas with the greatest need and choose appropriate plant species that can tolerate changing conditions over time.	Currently there is no funding for Green Infrastructure maintenance or monitoring.	Demand would increase as we get more stormwater to manage.	Design standard will have to be updated (because of maintenance costs, installation costs, etc., are prohibiting factors). Politically limiting factor - if systems aren't maintained, then the public doesn't like them, complains about them, and then our elected officials and commissioners do not want to invest in more. A negative perception impacts ability to move forward with more projects.	S2 - System will be somewhat affected by the climate-related impact
2	Toledo	Stormwater	Maintenance Practices	A well maintained system will be less prone to flooding and reduce impacts but currently we are more reactive than proactive. Would benefit from scheduled maintenance and make sure all areas are receiving the attention they need. Lack of maintenance can increase flooding incidents which disproportionately impact low income communities.	Lack of strategic plan spelling out which areas should be a priority, how to fund this work, and help ensure that maintenance is performed in a proactive manner, not just reactive.	Demand would increase with an increase of water, which will increase the wear on the system.	Education to those doing the maintenance (i.e., workforce education); Lack of knowledge on best maintenance practices for some components. Lack of funding and resources.	S4 - System will be greatly affected by the climate-related impact
3	Toledo	Stormwater	Stormwater Pipes	Undersized pipes and older infrastructure are often located in socio economic vulnerable areas, with an increase in large rain events this will lead to an increase in flooding and damages. These areas are also commonly have combined sewer systems and lack of backflow prevention, which can lead to hazardous and costly basement flooding.	Existing stresses include an elevated water table, older infrastructure, including brick sewers that can not be cleaned well. (often located in vulnerable areas). lack of funding for upgrading the stormwater sewer system Packaged projects often leave out vulnerable areas.	With changes in climate will need changes in system designs to accommodate a wide variety of flow (oversized pipes can cause issues during dry periods).	Design standards will have to be reconsidered, changes to rainfall. Will have to consider changes to funding needs.	S4 - System will be greatly affected by the climate-related impact
4	Toledo	Stormwater	Flood Prone Areas	Will increase the amount of flood prone areas, or high frequency of flooding. Which will trigger more homeowners to need flood insurance. Homes not originally in flood prone areas may have flood damages, because they not designed for that. Cost associated with culvert and drainage repairs due to increase in silt and sediment in system will burden on city resources. Vulnerable populations may be affected by high rent or mortgage due to flood insurance. Number of homes in flood plain may greatly increase. With proper management can maintain affected properties.	Development in floodplain including homes. Lack of funding, resources and integrated stormwater management and maintenance.	It will increase with an increase of water to manage	No standard on how incorporate climate data into planning. It can be very expensive to plan using these projections. Need to make changes to planning and design criteria, additional hydrology information would be helpful to do so. Impacts of communities upstream may limit our ability to manage water. There is a need to education of residents about illegal dumping in ditches etc, maintaining stormwater system to help prevent flooding.	S3 - System will be largely affected by the climate-related impact
5	Toledo	Drinking Water	Water Treatment Plant	1.Rising lake levels may require flood protection to be installed for Low Service Pump Station and the raw water main structures. Extended lack of supply of power, chemicals, waste disposal and workforce have the potential to interrupt operations. 2. A reliable supply of water from the Water Treatment Plant will be critical to supporting a stressed community.	Funding upgrades and improvements.	Extended drought and heat would increase the capacity demands on the Water Treatment Plant.	The Water Treatment Plant will be rated at 160 million gallons per day upon completion of improvements in 2023.	S1 - System will be minimally affected by the climate-related impact
6	Toledo	Waste Water	Water Reclamation Plant	1 .The increased duration and intensity of the precipitation events will cause increased stress on the system especially in older parts of town where the more vulnerable population lives. The wet weather facility will have to hold the storm and sewage longer before release to the treatment plant. Increased storm events may contribute to more CSOs 2. A reliable waste water Plant will be critical to supporting a stressed community. If more holding areas are needed due to increased storm events Socially, the poorer parts of town will be reclaimed for stormwater structures, strictly economics.	Funding upgrades and improvements. Some people may have to be relocated if additional basins have to be built. Where will the people be moved? How would they afford the move? What will a move do to them physically, emotionally and economically?	Increased and extended duration of precipitation events puts increased on the Water Reclamation Plant.	1. Money, trained staff and competent leadership. 2. Operated the Wet Weather Facility capable of treating chemically 200+ million gallons of sewage per day during heavy rain events. 3. Completed the construction of the Highland Park Pump Station project.	S3 - System will be largely affected by the climate-related impact

Step 7: Adaptive Capacity Assessment

The seventh step of our 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, access to social safety nets, and overall social connectivity.

To determine the adaptive capacity each of the elements evaluated in our stormwater system vulnerability assessment have, we answered five questions:

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. We used the qualitative evaluation criteria provided in Figure 18 to assign these adaptive capacity scores.

Figure 18: 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 Pipes.

Table 12 below demonstrates the results from the adaptive capacity assessment.

Project Description				Cumulative Impacts	Adaptive Capacity Assessment					
Ref #	City	System	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.	Does the System Component Have What it Will Need to Adapt to the Identified Cumulative Impacts?	What Does the System Component Need to Help it Adapt to the Identified Cumulative Impacts?	What Would You Need in order to Provide What the System Component Needs to Adapt to the Identified Cumulative Impacts?	Can the System Component Accommodate Projected Identified Cumulative Impacts at Minimum Disruption or Costs?	Is the Project or System Component Already Stressed in Ways that Will Limit its Ability to Accommodate Identified Cumulative Impacts?	How Adaptive is the System Component to Projected Identified Cumulative Impacts? (i.e., adaptive capacity score)
1	Toledo	Stormwater	Green Infrastructure	Green infrastructure can reduce the impact of flooding and urban heat island. However climate change requires we revisit design, performance and maintenance. Ensure we use these practices in areas with the greatest need and choose appropriate plant species that can tolerate changing conditions over time.	Somewhat; green infrastructure can adapt but design standards may need to changed. It would adapt better to these changes with additional city support.	Funding, skills training, maintenance practices, education, appropriate design and plant species mix; sales person (someone to sell the idea)	Personnel working internally to increase the political support, so funding and education can be provided	Somewhat and even more so if maintained	Yes - politically and with lack of public support. Needs changes to design standards	AC3 - System is mostly able to accommodate or adjust to projected changes in climate
2	Toledo	Stormwater	Maintenance Practices	A well maintained system will be less prone to flooding and reduce impacts but currently we are more reactive than proactive. Would benefit from scheduled maintenance and make sure all areas are receiving the attention they need. Lack of maintenance can increase flooding incidents which disproportionately impact low income communities.	No	Needs more work force capacity; direction; funding; prioritization mechanism so we can determine what needs work and when (i.e., inspections).	Maintenance policy/plan. We need something to provide guidance on maintenance needs before they are an emergency.	No	Yes - having a hard time meeting current demand. Reactively functioning	AC2 - Systems is somewhat able to accommodate or adjust to projected changes in climate
3	Toledo	Stormwater	Stormwater Pipes	Undersized pipes and older infrastructure are often located in socio economic vulnerable areas, with an increase in large rain events this will lead to an increase in flooding and damages. These areas are also commonly have combined sewer systems and lack of backflow prevention, which can lead to hazardous and costly basement flooding.	No	Needs more pipe capacity; funding; updated design criteria so we can adapt to climate change	Updated modeling data. Additional funding. Guidance on how to include projected climate change into design	No	Yes - aging system	AC1 - System is minimally able to accommodate or adjust to projected changes in climate
4	Toledo	Stormwater	Flood Prone Areas	Will increase the amount of flood prone areas, or high frequency of flooding. Which will trigger more homeowners to need flood insurance. Homes not originally in flood prone areas may have flood damages, because they not designed for that. Cost associated with culvert and drainage repairs due to increase in silt and sediment in system will burden on city resources. Vulnerable populations may be affected by high rent or mortgage due to flood insurance. Number of homes in flood plain may greatly increase. With proper management can maintain affected properties	Somewhat; having to adapt, however, may negatively affect properties and owners	We will need an increase in education and maintenance, and upgrades/changes in building practices. Will also need overall changes to stormwater management policies.	Updated modeling data, additional funding. Guidance on how to include projected climate change into design.	No	Yes because some residents are already affected by flooding	AC2 - Systems is somewhat able to accommodate or adjust to projected changes in climate
5	Toledo	Drinking Water	Water Treatment Plant	1.Rising lake levels may require flood protection to be installed for Low Service Pump Station and the raw water main structures. Extended lack of supply of power, chemicals, waste disposal and workforce have the potential to interrupt operations. 2. A reliable supply of water from the Water Treatment Plant will be critical to supporting a stressed community.	Yes	Reliable supplies of power, chemicals, waste disposal and workforce.	Continued funding and resources	Yes	No	AC4 - System is able to accommodate or adjust to projected changes in climate in a beneficial way
6	Toledo	Waste Water	Water Reclamation Plant	1 .The increased duration and intensity of the precipitation events will cause increased stress on the system especially in older parts of town where the more vulnerable population lives. The wet weather facility will have to hold the storm and sewage longer before release to the treatment plant. Increased storm events may contribute to more CSOs 2. A reliable waste water Plant will be critical to supporting a stressed community. If more holding areas are needed due to increased storm events Socially, the poorer parts of town will be reclaimed for stormwater structures, strictly economics.	Yes	Reliable supplies of power, chemicals, waste disposal and workforce.	More training, efficient engineering and the use of successful and multifaceted best stormwater management practices.	Yes	Operating in a negative budget and poorly trained staff.	AC3 - System is mostly able to accommodate or adjust to projected changes in climate

Step 8: Calculating Vulnerability

The final step in our vulnerability assessment was combining the sensitivity and adaptive capacity scores into a vulnerability score. Using Figure 19 below, we were able to determine which elements within our stormwater system were the most vulnerable (red) and which were the least vulnerable (green).

Figure 19 shows the results for our citywide vulnerability assessment.

This stormwater system vulnerability assessment found that our most vulnerable elements are:

- Stormwater Pipes
- Maintenance Practices
- Flood Prone Areas

The assessment showed that the less vulnerable components are:

- Water Reclamation
- Green Infrastructure
- Water Treatment

Through performing this assessment it has become apparent that components of Toledo's stormwater system are highly vulnerable to climate change, it has also become clear that adverse impacts to these components will disproportionately affect socio-economically vulnerable populations of our City. With this knowledge it is obvious that Toledo must begin to plan for future conditions and consider the changing climate when making improvements to infrastructure and changes to standards. We also need to begin building more proactive and resilient systems in order to prevent some of the adverse effects on our community and to be able to adapt to future conditions.

		Sensitivity: Low to High				
		S0	**S1**	**S2**	**S3**	**S4**
Adaptive Capacity: High to Low	**AC4**		Water Treatment			
	AC3			Green Infrastructure	Water Reclamation	
	AC2				Flood Prone Areas	Maintenance Practices
	AC1					
	AC0					Stormwater Pipes

Figure 19. Results for our citywide vulnerability assessment.

6. NEXT STEPS

This document represents an important step in building resilience to climate change in Toledo. To truly prepare, however, we need to implement actions that will reduce our local vulnerability and enhance our resilience. Through the course of this stormwater system vulnerability assessment, we identified a handful of actions that are currently in action which can lay the foundation for longer-term adaptation planning and action. These actions include:

- Gas Cap Testing and Replacement
- Bay View Water Reclamation Plant – Cogeneration Facility
- Better Buildings NW Ohio Municipal Government Energy Program
- Collins Park Water Treatment Plant Solar Field
- Green Infrastructure Program
- LimnoTech Toledo Water Intake Buoy
- Toledo Waterways Initiative
- Toledo Public Power
- Water Treatment Ozonation System
- Public Inflow Removal Program
- Basement Flooding Grant Program
- Participation in TMACOG Stormwater Action group
- Toledo Lucas County Rain Garden Initiative

In addition we have identified several initial actions that could be taken to further evaluate the City's Climate Change Vulnerabilities:

- Engage all City divisions for additional input on this assessment, and components they believe could be particularly vulnerable.
- Acquire additional asset data on the existing system to put in our GIS. This information would provide us the capability to assess other potential factors that may increase certain components vulnerability.
- Obtain more climate change data and hydrology study information for our area. Incorporate this information into engineering and maintenance standards and plans.

These, however, are just initial actions. We know that far more thought and planning are needed to design a cohesive strategy for enhancing local resilience to climate change. In our quest to create a more resilient Toledo, we are prepared to immediately undertake the following actions:

1. Present this vulnerability assessment to City Council and seek formal adoption.
2. Initiate a formal adaptation planning process that includes a diversity of community stakeholders.
3. Align our vulnerability reduction efforts with our community's multi-hazard mitigation planning and disaster risk reduction efforts.
4. Align our vulnerability reduction efforts with other relevant community planning and action initiatives, including:
    - Toledo-Lucas County Sustainability Commission (TLCSC)
    - Great Lakes Climate Adaptation Network (GLCAN)
    - Maumee Area of Concern (AOC) Advisory Committee
    - Partners for Clean Streams (PCS)
    - Toledo Metropolitan Area Council of Governments (TMACOG)
    - American Rivers
    - University of Michigan (UM) Graham Sustainability Institute
    - NOAA Coastal Services Center
    - ASFPM/APA
    - Metro Parks of Toledo
    - Lucas County Soil and Water Conservation District
    - Alliance for the Great Lakes
    - Cleveland Water Alliance
5. Annually report on progress implementing the strategies identified in this plan and others related to reducing local vulnerability.
6. Every 5 years, revise this assessment based on new information (e.g., changes to climate science) and any relevant changes to community priorities. As part of this review process, include metrics that denote how our community's overall vulnerability to climate change has evolved. This may take the form of revising our

community's landscape vulnerability as well as our socio-economic vulnerability to see if there have been notable changes. We may also identify, through public input processes, a number of other key metrics we'd like to track to measure reductions in vulnerability. To the fullest extent possible, we will regularly track and report on these metrics so that we can demonstrate how our community's vulnerability is changing.

7. Begin and/or enhance collaboration with peer communities in the region in order to foster greater regional resilience towards climate change and natural disasters.
8. Share successes and lessons learned with our peers to help foster greater resilience not only in our community but also in the region, across the state, and throughout the nation.

Conclusion

Preparing for climate change is a process, not an outcome. This plan represents an important step in that process for the City of Toledo. Our 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 we live, work, play, and operate in our city. We, as a City, are committed to working with all residential, business, and interested stakeholders to make sure we build a thriving, sustainable, and resilient Toledo. It's time to get to work!

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