DEFINING VULNERABILITY IN THE GRAND HAVEN COMMUNITY

This report summarizes the results of a climate vulnerability assessment conducted for the Grand Haven Community, including the City of Grand Haven and Grand Haven Charter Township as part of the Resilient Grand Haven planning process. This project was developed by the Land Information Access Association (LIAA).
This report was prepared by the Land Information Access Association (LIAA) as part of the Resilient Grand Haven project. Support for the project came from the Michigan Municipal League (MML), Michigan Association of Planning (MAP), and the University of Michigan’s Taubman College of Architecture and Urban Planning. A special thank you is owed to the many organizations and individuals that contributed to the planning process.

This project was funded in part by Grand Haven Charter Township, the City of Grand Haven, the Michigan Coastal Zone Management Program, Department of Environmental Quality, Office of the Great Lakes; and the National Oceanic and Atmospheric Administration, U.S. Department of Commerce.
Defining Vulnerability in the Grand Haven Community

The impacts of climate variability on agriculture, infrastructure and human health are being felt almost everywhere across Michigan. With thoughtful planning and preparation, communities can better withstand and recover from severe storms, becoming even better places to live and thrive. Through community-wide planning efforts like this one, resilient municipalities can actively cultivate their abilities to recover from adverse situations and events, working to strengthen and diversify their local economies and communication networks, increase social capital and civic engagement, enhance ecosystem services, improve human health and social systems, and build local adaptive capacity.

Building Community Resilience

Community resilience is a measure of the sustained ability of a community to utilize available resources to respond, withstand, and/or recover from adverse situations. The Rockefeller Foundation, a noted global leader on such issues, emphasizes equity as an important component of resilience, stating that community resilience is the capacity for people – particularly the poor and vulnerable – to survive and thrive no matter what stresses or shocks they encounter. Communities that are resilient are able to learn from adversity and quickly adapt to change. In general, the most important characteristics of community resilience are: (1) strong and meaningful social connections, (2) social and economic diversity, (3) innovation and creative problem solving capacity, and (4) extensive use of ecosystem services. The Rockefeller Foundation has identified 12 indicators that make for a resilient community (see right panel). However, it is important to acknowledge every community is unique and not all indicators or characteristics are needed to be “resilient.”

Community master planning processes can increase resilience by fostering civic engagement and improving communication and cooperation between cultural and service organizations. To improve economic resilience, communities can work to encourage and support local production of goods and supplies, increasing self-reliance and reducing the flow of money and resources out of the community. Programs to encourage local investing and entrepreneurship have been helpful in building both employment and production capacity. Consuming locally produced products, shopping at locally owned businesses and investing in local companies are activities that help to diversify the community’s economy, giving it greater resilience.

The following report discusses the results of a community vulnerability assessment for Grand Haven Township and the City of Grand Haven. This assessment begins with an overview of regional climate trends and predicted societal impacts, then transitions to detailed assessments of the community’s vulnerabilities to extreme heat

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Defining Vulnerability in the Grand Haven Community

Although the assessment is concentrated on these specific types of events, many of the considerations and societal impacts identified would be present under other stresses and shocks within the community.

In completing the assessment, factors such as demographics, environmental conditions, locations of critical facilities and essential services, and the built environment were considered. This assessment informs recommendations throughout this Master Plan.

CLIMATE CHANGE AND VARIABILITY

Climate and weather are directly related, but not the same thing. Weather refers to the day-to-day conditions we encounter in a particular place: sun or rain, hot or cold. The term climate refers to the long-term weather patterns over regions or large geographic areas. When scientists speak of global climate change, they are referring to generalized, global patterns of weather over months, years and decades. To help predict what the climate will be in the future, scientists use three-dimensional computer models of the earth’s atmosphere, oceans and land surfaces to understand past trends and predict future changes. These General Circulation Models (GCM) have been improved and verified in recent years, resulting in relatively reliable predictions for climate changes over large regions. To help predict future climate patterns for smaller regions, scientists apply downscaling techniques.

As stated by the Intergovernmental Panel on Climate Change (IPCC), significant changes in the earth’s climate have been observed and thoroughly documented.\(^4\) Warming of the climate is now evident in combined average air and ocean temperatures around the globe (Figure C.1 provides a summary of observed changes in land and ocean temperatures over the last 150 years).\(^5\) This change has significant impacts for the Midwest. The graph in Figure C.2 presents observed changes in the amount of ice cover on the Great Lakes. Overall, there has been a 71% reduction in the extent of Great Lakes ice cover between 1973 and 2010, with Lake Ontario experiencing the greatest loss.\(^6\)

The Great Lakes Integrated Sciences Assessment (GLISA) is a consortium of scientists and educators from the University of Michigan and Michigan State University that is funded by the National Oceanic and Atmospheric Administration (NOAA) to provide climate resources, including downscaled models, for communities across the Great Lakes Region. According to GLISA, the Great Lakes Region has already experienced a 2.3° F increase in average temperatures. An additional increase of 1.8 to 5.4° F in average temperatures is projected by 2050. Although these numbers are relatively small, they are driving very dramatic changes in Michigan’s climate.

Based on the most recent models, the climate of the Grand Haven Community will continue to warm, with greater increases in temperature during the winter months and at night. There are a variety of weather impacts expected with this change. Some of the potential impacts of climate variability in the Grand Haven Community include:

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\(^5\) NCDC/NEDIS/NOAA www.ncdc.noaa.gov
Defining Vulnerability in the Grand Haven Community

- Storms are expected to become more frequent and more severe.
- Increases in winter and spring precipitation
- Less precipitation as snow and more as rain
- Less winter ice on lakes
- Extended growing season (earlier spring/later fall)
- Greater frequency and intensity of storms
- More flooding events with risks of erosion
- Increases in frequency and length of severe heat events
- Increased risk of drought, particularly in summer

It is important to note that increased flooding and more intense droughts are not mutually exclusive nor contradictory. In the Great Lakes region, scientists are predicting more intense rain events in the fall and winter and more intense droughts in the summer months. These changes in climate could have a number of positive and negative effects on the Grand Haven Community.

Figure C.2 Great Lakes Ice Cover Decline


What About the Winters of 2014 & 2015?
Remember, weather reflects the short-term conditions of the atmosphere while climate is the average daily weather for an extended period of time. This difference was never more evident in Michigan than over the last two years. Although most of the Great Lakes froze during the winters of 2014 and 2015 overall there has been a 71% reduction in the extent of ice cover between 1970 and 2010.

For example, an extended growing season could help support new crops and increase crop yields for area farmers. On the other hand, the highly variable weather conditions such as severe storms and flooding mixed with summer droughts could impact future crop production and stress groundwater supplies.

Much of the U.S. has been warmer in recent years, and that affects which plants grow best in various regions. The Arbor Day Foundation completed an extensive updating of the U.S. Hardiness Zones based upon data from 5,000 National Climatic Data Center cooperative stations across the continental United States. As is illustrated in Figure C.3, zones in West Michigan are shifting northward. Zone 5 plants that previously thrived in the Grand Haven community now do best in Northern Michigan, while Zone 6 plants that once thrived in states like Tennessee, now will grow well in the Grand Haven Community.

**Agricultural Impacts**

According to the third U.S. National Climate Assessment (2014), “Future crop yields will be more strongly influenced by anomalous weather events than by changes in average temperature or annual precipitation. Cold injury due to a freeze event after plant budding can decimate fruit crop production, as happened in 2002, and again in 2012, to Michigan’s $60 million tart cherry crop.

While there are no cherry farms in Grand Haven Township, analogous weather events could affect local crop production.
SEVERE WEATHER EVENTS IN THE GRAND HAVEN COMMUNITY

The following section summarizes a few of the major weather-related events in the Grand Haven Community and West Michigan over the past 100 years. Oftentimes, severe weather events result in negative impacts to the local economy and to vulnerable populations within the community.

Figure C.4. Severe Weather Events Timeline

- **JUNE 1-SEPTEMBER 21, 1996**
  Ottawa County was granted a disaster declaration for drought by the U.S. Secretary of Agriculture.

- **JULY 17-18, 1982**
  Record rain fall - 11.0 inches, 20% of the Holland area population was without power for an extended period of time. Resulted in property damages throughout West Michigan.

- **1904**
  One of the driest years on record for Ottawa County with only 23.97 inches of rainfall in Grand Haven.

- **APRIL 6, 1997**
  An intense low pressure system with wind gust up to 70 miles per hour and wave heights of 10 to 15 feet passed though Ottawa County. Widespread wind damage and lake shore beach erosion was reported across the area.

- **APRIL 2013**
  Steady rain caused the Grand River to crest at 21.85 feet, causing large amounts of debris and sediment to deposit on the community’s shoreline (as pictured to the right).

- **JUNE 1-SEPTEMBER 21, 1996**
  Ottawa County was granted a disaster declaration for drought by the U.S. Secretary of Agriculture.

- **APRIL 2013**
  Steady rain caused the Grand River to crest at 21.85 feet, causing large amounts of debris and sediment to deposit on the community’s shoreline (as pictured to the right).

- **JUNE 17, 2013**
  Heat Emergency - officials opened the Grand Haven City Hall and the Grand Haven Community Center to serve as emergency cooling centers. Temperatures reached the 90s and heat indices approached 100.

- **MAY 31, 1998**
  Severe thunderstorms passed through west Michigan, producing winds up to 130 miles per hour. Hundreds of homes sustained significant property damage, 45 people were evacuated, and 31 people required emergency shelter.

- **JUNE 17, 2013**
  Heat Emergency - officials opened the Grand Haven City Hall and the Grand Haven Community Center to serve as emergency cooling centers. Temperatures reached the 90s and heat indices approached 100.

- **APRIL 2013**
  Steady rain caused the Grand River to crest at 21.85 feet, causing large amounts of debris and sediment to deposit on the community’s shoreline (as pictured to the right).
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**PUBLIC HEALTH AND CLIMATE**

Major health effects of long-term changes to the climate are predicted for the Midwest Region. Already, people in Michigan are experiencing higher rates of skin and eye damage from increased exposure to ultraviolet radiation, increased incidence of respiratory and cardiovascular diseases, and increased incidence of vector-borne and water-borne diseases.\(^7\) Weather conditions and high heat events exacerbate poor health conditions like allergies, asthma, and obesity.

In 2011, the Michigan Department of Health and Human Services (MDHHS) published their Michigan Climate and Health Adaptation Plan. The Plan notes there is an increase in the number of illnesses and deaths as a result of extreme heat events; declining air quality as a result of increased production of ozone and particulate matter from heat and drought events; and adverse changes to water quality and availability following severe weather events. In the long-term, health experts are most concerned with a rising incidence of infectious diseases and outbreaks of new diseases not currently endemic to Michigan, increasing numbers of disease vectors and appearance of new vectors not currently established in Michigan, and a degradation of food safety, security, and supply. For example, backlegged ticks are one disease vector that has increased in recent years. According to the MDHHS, the first official reported human case of Lyme disease was in 1985. Cases have now been reported in both the upper and lower peninsula and are increasing. It is anticipated the number of cases reported will continue to increase due to public and medical personnel education, and expanding tick ranges. Figure C.4 illustrates the distribution of the risk for lyme disease in West Michigan.

**VULNERABILITY ASSESSMENTS**

Communities interested in becoming more resilient assess their vulnerabilities and make action plans to reduce their sensitivities and exposures to hazards of all kinds. This Community Vulnerability Assessment has been compiled to provide a wide variety of useful information aimed at improving climate resilience by reducing human and community vulnerabilities. This Assessment focuses on Grand Haven Charter Township and the City of Grand Haven.

A Vulnerability Assessment is designed to identify and help prioritize adaptation strategies in the community planning process. A model that defines ‘vulnerability’ as ‘exposure plus sensitivity,’ is used to complete the Assessment.\(^8\) Exposure refers to hazards in the natural or built environment, while sensitivity refers to the degree to which a community or certain segments of a community could be impacted by an event. This concept has been used recently in a variety of studies such as equity and adaptation assessments conducted by the NAACP,\(^9\) vulnerability and its relationship to adaptation,\(^10\) and hazard-specific vulnerability assessments aimed at measuring exposure.

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\(^9\) Equity in Building Resilience in Adaptation Planning. National Association for the Advancement of Colored people (NAACP)

sensitivity, and resilience.\textsuperscript{11}

By assessing the potential for exposure to a hazard and the sensitivities of specific populations, maps are generated that identify areas with greater vulnerability. This tool provides direction for planning commissioners, staff and public health workers as they work to reduce risks to human health.

Based on the greatest risks for Michigan and predicted climate trends, the vulnerability assessments were limited to extreme heat waves and flooding. However, climate change is predicted to result in increases of other exposures that should also be considered in community planning and development (e.g., high winds, tornadoes, and extreme heat).

These assessments were based in part on data obtained from the 2009-2013 American Community Survey (ACS). This data includes information on housing, income, and education characteristics of the populations in geographic areas called Census Block Groups, containing between 600 and 3,000 individuals. Data from the 2010 Census was also used, including population age and racial composition collected by Census Blocks, which are the smallest available geographic areas for demographic data. Data sets concerning parcel characteristics were obtained from Ottawa County, Grand Haven Charter Township and the City of Grand Haven. Building footprint data was obtained from Ottawa County and tree canopy cover was digitized using an orthophotograph from 2009.\textsuperscript{12}

**HEAT VULNERABILITY**

Community vulnerability to heat events varies depending on location. In Michigan, there are varying degrees of vulnerability to heat based on a community’s proximity to the Great Lakes. Access to air conditioning, and surrounding environmental factors like tree canopy and impervious surfaces also play a role.

Studies have shown that heat-related mortality generally occurs in areas of the community that are warmer, less stable, and home to more disadvantaged populations.\textsuperscript{13} One study found that neighborhoods with the highest temperatures and the least amount of open space and vegetation were also likely to be the most socioeconomically disadvantaged.\textsuperscript{14} The same study also found the strongest protective factor for residents was access to air conditioning in the home and in other places, as well as having access to transportation.

A 2012 literature review conducted by researchers at the University of Michigan indicates that infants under five and persons over 65 are highly sensitive to heat events, as are persons living in lower-income census tracts and minority populations. Living alone, being confined to bed, having a mental illness, not leaving home daily, living on higher floors of multi-story buildings, and suffering from alcoholism are additional factors that are associated with increased risk of heat-related mortality.

There have been limited studies conducted on how heat events impact rural and suburban communities, but one study notes that rural populations may exhibit patterns of vulnerability different from those of urban populations.\textsuperscript{15}


\textsuperscript{12} USDA and NRCS Geospatial Data Gateway

\textsuperscript{13} Foundations for Community Climate Action: Defining Climate Change Vulnerability in Detroit. University of Michigan. December 2012


HEAT SENSITIVITY ASSESSMENT

To create the sensitivity and exposure maps for this Plan, as well as the resulting vulnerability maps, the consultant relied on methodologies developed at the University of Michigan’s Taubman College of Architecture and Urban Planning.\textsuperscript{16}

To conduct the heat sensitivity assessment of the Grand Haven Community, the project team used a geographic information system (GIS) for spatial data analyses to show the relative distribution of people most at risk. Five factors were identified as the primary contributors to the sensitivities and risks of people exposed to a heat wave:

- People over 65 years of age
- People living alone
- People over 25 with less than a high school education
- Minority populations
- People living below the poverty line

Using U.S. Census data, the project team identified the percentages of people living in each area (by Block Group or Block) for each sensitivity factor.

Studies show that people who are older have greater sensitivity to extreme heat events. Studies also indicate that older age is associated with higher hospital admission rates in heat waves. The Percent of Population 65 and Older (Map 1) depicts the relative concentration of older adults in the community by Census Block.

Upon review of the map, planning commission members noted that many older people do not live in the Grand Haven Community full-time, thus people who leave for the winter (snowbirds) may not be counted. It was also noted there are three senior complexes in close proximity to one another at the intersection of Ferry Street and Robbins Road.

Another sensitivity factor is living alone, which serves as a measure of social isolation. Although living alone is not necessarily a risky thing, people who are socially isolated are at greater risk during an extreme heat event. Isolated people may not be able to recognize symptoms of heat-related illness and take proper action. For this factor, the project team used the American Community Survey data for Census Block Groups, broken out into individual Census Blocks for geographic representation (Census Blocks with no population were not included). Map 2 depicts the high concentrations of people living alone. The higher concentration of people living alone in downtown Grand Haven is in line with nationwide trends because downtowns generally have a greater supply of live-work units, single apartments, and condominium units.

Studies also suggest that minorities are at greater risk during extreme heat events for various reasons, including less reliable access to health care, transportation and other social supports needed to reduce heat exposures.\textsuperscript{17} Census Blocks were used to map the relative percentages of non-white populations in the Grand Haven Community (see Map 3). One specific area noted by the planning commission was a cluster of migrant housing in the southeast corner of the community.

Two socioeconomic factors associated with increased heat-related morbidity and mortality are the percentage of the people living in poverty and percentage of people without a high school diploma. In general, persons living at or below the poverty line have less access

\textsuperscript{16} Foundation for Community Climate Action: Defining Climate Change Vulnerability in Detroit (December 2012) University of Michigan’s Taubman College of Architecture and Urban Planning.

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to air conditioning or cooling options for their residences. This could limit a person’s access to relief from an extreme heat event. Census Block Groups were used to map the relative percentages of households living below the poverty threshold in the Grand Haven Community (please see Map 4).

Similarly, the University of Michigan research team found studies that demonstrate a direct link between low education attainment and poor health. There is also an established correlation between lower educational attainment and income. Based on these findings, Census Block Groups were used to map the relative percent of persons 25 years and older with less than a high school education in the Grand Haven Community (see Map 5). One area with a high concentration of low education attainment was the Village Green Mobile Home Park. However, the planning commission also noted that higher income neighborhoods in the northern part of the Township were being flagged as having high concentrations of low education attainment, but may not necessarily be at higher sensitivity for heat events.

To complete the heat sensitivity assessment, a cumulative score for all five sensitivity factors for each Census Block was created. In each of the sensitivity factors, the percentages were grouped into five categories (ranging from a very low percentage of people to a relatively high percentage living with the identified sensitivity). The five categorical groupings were generated by the GIS software ArcMap using natural breaks in the data (groupings). A ranking of 1 to 5 was assigned to each of the categories, ranging from 1 for the lowest percentage to 5 for the highest. Finally, the team combined the scores within each Census Block. Thus, the most sensitive Census Blocks could be scored up to 25. The sensitivity is color coded for ease of identifying areas with the greatest sensitivity.

The Grand Haven Community Sensitivity to Excessive Heat Map (Map 6) provides a reasonably detailed map of locations where the highest percentages of at-risk residents live. This does not mean these community residents are in immediate danger. Rather, the map provides planning officials a new way of identifying areas where heat waves could present serious problems for a significant number of citizens. These are populations that could be sensitive to extreme heat events.

The Census data used likely counts people twice, such as in cases where a person is both a minority and over 65. This may over-estimate the severity of the sensitivities in some locations. Additionally, the sensitivity analysis may underestimate risk because it leaves out several key sensitive populations, such as those with preexisting health concerns (for example, cardiovascular disease or psychiatric disorders). Such data is not often available publicly or on the Census Block level. Emergency managers, hospitals, and community health departments within the region may have additional data available that can be analyzed and considered as the community looks to better understand its overall sensitive populations. To further improve the analysis, additional variables could be collected through local surveys and observation, such as the degree of social connections among individuals within a community, or materials used in housing.

HEAT EXPOSURE ASSESSMENT

When larger communities experience heat waves, air temperatures can vary significantly from place to place during the day and at night. Some of these differences can be attributed to the varying types of land cover found throughout the community. For example, temperatures can be significantly lower at night in locations with a heavy tree canopy and very little pavement. Conversely, temperatures can be higher in locations with little greenery and lots of pavement.

Impervious surfaces such as paved parking lots, roadways, and buildings absorb large amounts of heat from the air and sunshine which is radiated back into the environment when temperatures begin to fall. At the same time, tree canopy and other vegetation can help cool an area through evaporation and transpiration of water, and by providing shade. In places with a high percentage of impervious surface and

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Little tree canopy, the immediate environment can be much warmer. Urban areas typically have higher heat indexes (combinations of temperature and humidity) than surrounding suburban or rural areas. This condition has been termed the “Urban Heat Island Effect.”

People living in settings with a Urban Heat Island Effect suffer greater exposures to heat over longer periods of time (e.g., warmer nights), making them more vulnerable to health impacts. Studies of the Urban Heat Island Effect (whereby air temperatures in an urban area are 2–9°F, higher than in a nearby rural area) have shown that the albedo, or reflectivity, of an urban area is one of the most important determinants in reducing the magnitude of the heat island. Increasing the tree canopy cover can also reduce air temperature by 1–3°C. Green roofs and plantings on roofs and in large parking lots, may also decrease the Urban Heat Island Effect and decrease stormwater runoff and building energy use. An added benefit that stems from increasing albedo and vegetation include the reduction of ground level ozone and energy costs associated with air conditioning use.

With data obtained from Ottawa County, two separate exposure maps were created. The first exposure map depicts the percentage of impervious surfaces within each Census Block, as used in the sensitivity assessment (Map 7). These percentages are divided into five categories using the GIS software’s natural breaks calculation. Since exposure is lowest in areas with the lowest percentage of impervious surface, those scored a 1, with a rating of 5 assigned to areas with the highest percentage of impervious surfaces.

The second exposure factor is percentage of tree canopy. Tree canopy is mapped within each Census Block (Map 8) and scored using a similar five category process. As illustrated on Map 8, the highest percentage of tree canopy (therefore the lowest heat exposure) received a 1 and the least vegetative areas received a 5.

The project team combined the results of the two exposure maps to provide a single Community Excessive Heat Exposures Map (Map 9), which provides a reliable depiction of where the Urban Heat Island Effect would be most and least intense during a heat wave. The Planning Commission and staff can use this map to better assess where new vegetation and tree canopy should be placed.

**Composite Heat Vulnerability**

The Grand Haven Community Heat Vulnerability Map is a simple additive combination of the overall sensitivity map and the overall exposures map (see Map 10). The resulting vulnerability index depicts where concentrations of exposures and sensitive populations create a higher risk for community residents. In general, those areas with a composite score of 22 to 27 (red) have residential populations that may be particularly vulnerable to

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20 Basu and Samet. (2002) Relation between Elevated Ambient Temperature and Mortality: A Review of the From the Department of Epidemiology, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD.


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HEAVY RAIN AND FLOODING

Climate models suggest the Grand Haven Community and West Michigan can expect more frequent storms of increasing severity in the decades ahead. The total amount of rainfall per year is also likely to increase. However, climate models suggest the precipitation will be more concentrated in the winter, spring and fall seasons and there will be more localized, intense storms at almost any time of year. The potential for substantially larger rain events raises concerns over the potential for harm to human health and damage to buildings and infrastructure.

The following pages summarize a Flooding Vulnerability Assessment conducted for the Grand Haven Community. In assessing vulnerability, local officials can evaluate potential exposures as well as sensitivity to flooding. Buildings, roads, bridges, sewer lines and other infrastructure located in a flood zone are exposed to greater risks. Where flowing floodwaters have the greatest energy, structures may be undercut, collapse or move, and soils will erode. Even areas outside of an identified floodplain are subject to flooding from heavy downpours. Where the soils have low permeability and physical drainage is inadequate, water will accumulate and cause ponding during large storm events. Appropriate planning and land-use regulations can help reduce exposures caused by poor site selection. The sensitivity of structures can be modified to reduce risk of damage by applying flood-resistant design standards. Figure C.6 illustrates recommendations from FEMA for retrofitting homes to make them more resilient to flooding events.

EXPOSURE TO FLOODING HAZARDS

The Digital Elevation Model Map (Map 11) offers a useful view of the topography of the Grand Haven Community, including the most prominent drainage patterns. On this map, the darkest green colors identify the lowest elevations, while the darkest red colors identify the highest elevations.

The Federal Emergency Management Agency (FEMA) develops Flood Insurance Rate Maps (FIRMs) for many counties in the United States (see Map 5.6 in the Resilient Grand Haven Charter Township Master Plan). According to FEMA, the FIRM is “the primary tool for state and local governments to mitigate the effects of flooding in their communities.” The National Flood Insurance Program was created in 1968 to reduce future damage and provide an insurance program that would help protect property owners from losses. The FIRM shows areas subject to flooding, based on historic, hydraulic and meteorological data as well as flood controls. The maps identify a base flood elevation (BFE), sometimes referred to as the 100-year flood zone. These are areas that have a 1% chance of flooding in any given year. The maps also identify the areas with a 0.2% chance of flooding in any given year, also known as the 500-year flood zone. FEMA points out these percentages are only probabilities, not forecasts.

HOUSEHOLD SENSITIVITY TO FLOODING

In many communities, flooding impacts are felt most significantly at the household level. A home’s flood risk is based on its relative location to floodplains and other flooding hazard areas. The household flood sensitivity refers to how well the house structure is equipped to deal with flooding. As modeled by the University of Michigan, household sensitivity to flooding can be determined by looking at the age of the housing stock and homeowners financial ability to maintain and improve the home, which is approximated using the median household income. In general, homes built before 1940 used a more porous concrete material for basement construction, so water can flow more rapidly through the foundation (See Map 12). Older homes may be more vulnerable if residents have not had the financial resources to make improvements and upgrades. By looking at median household income as a marker of likely upkeep of the home, an attempt was
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made to exclude older homes that have been well-maintained and undergone upgrades from our areas of flood damage risk (see Map 13).

**Flooding Vulnerability**

By looking at the overlap of flooding exposure and housing sensitivity, the project team identified a number of Census Blocks that are the most vulnerable in the community to flooding damage. It is important to note that other factors contribute to flood risk. For example, mobile and manufactured homes are often particularly susceptible to flood damage because they generally lack a reinforced foundation. In addition, the municipal infrastructure plays an important role in protecting homes from flood damage. Communities with an aging storm sewer system or ones where the storm sewer has not been fully disconnected from the sanitary sewer are more prone to damage from an overloaded system in the event of a severe rain event. Map 14 depicts the Community Flooding Vulnerability.

**Other Considerations for Defining Community Vulnerability**

Locations of key community assets are helpful to map to provide insight on how accessible they are to residents. It is also helpful to map locations of key infrastructure and assets that could be at risk, or would be most negatively impacted.

**Critical Facilities**

In general usage, the term “critical facilities” is used to describe all man-made structures or other improvements that, because of their function, size, service area, or uniqueness, have the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if they are destroyed, damaged, or if their functionality is impaired.23

Map 15 shows locations of critical facilities within the Grand Haven Community. Critical facilities include:

- Emergency response facilities (fire stations, police stations, rescue squads, and emergency operation centers)
- Custodial facilities (hospitals, long-term care facilities, jails and other detention centers, and other health care facilities);
- Schools;
- Emergency shelters;
- Utilities (water supply, wastewater treatment facilities, and power);

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• Communications facilities;
• Other assets determined by the community to be of critical importance for the protection of the health and safety of the population; and
• Places where 300+ people congregate.

ACCESS AND DISTRIBUTION OF SOCIAL SERVICES

Service centers and institutions (such as homeless shelters and churches) are important in delivering day-to-day support to residents. In the event of an emergency, such as an extreme heat event or flash flooding episode, service centers and institutions are especially important as a safe place where residents can go if they cannot return home. Map 16 highlights key locations of places where residents may seek temporary refuge in the event of an emergency. These locations include schools, places of worship, governmental buildings, hospitals and clinics, libraries, and other non-profit social service organizations. In the Grand Haven Community, social services are concentrated in downtown Grand Haven and along major commercial corridors.

Communities with high population densities, frequent extreme weather events, or both, are likely to have designated service centers. In the event of extreme heat waves, designated community cooling centers may provide refuge for sensitive populations and those without access to air conditioning. In the event of loss of power due to flooding or extreme storms, locations with a backup power source, such as a generator, are essential.

A Best Management Practice for a resilient community is to designate community service centers that are accessible, evenly distributed across the population, open 24 hours, and well-known to residents.

FOOD AVAILABILITY

Climate variability will likely make significant impacts to the availability and cost of food. A community can decrease its vulnerability to disruptions in food sources by investing and supporting local agriculture and food processing activities. Support for, and reliance upon, locally produced foods not only alleviates potential future challenges in the food market, but also helps foster another strong economic sector for the region.

Just as cultivating local entrepreneurship makes a community stronger, the capacity of a community to produce and process its own food greatly increases resilience. Because of its ability to impact health, wealth, and quality of life, there is a national trend in support of the local food movement. Communities can leverage their existing assets, such as the local farmer’s market, community gardens, and an established agricultural base, to lay the foundation for additional local food-related jobs. Communities can take more creative approaches as well, such as allowing for agriculture on publicly owned and vacant lands in existing neighborhoods and parklands. To evaluate community vulnerabilities, locations of full service grocery stores in relation to where people live are mapped. In the event of loss of power or disruption in potable water supplies, it is important to ensure that residents have access to affordable food and drinking water.

The project team also evaluated access to healthy food to see if there are areas of the community that qualify as a food desert. According to the United States Department of Agriculture (USDA), a food desert is defined as an area vapid (one-mile) of fresh fruit, vegetables, and other healthful whole foods, usually found in impoverished areas. This is largely due to a lack of grocery stores, farmers’ markets, and healthy food providers.24 Communities looking to reduce the number of residents living in a food desert can promote or zone for pop-up farm stands in low income areas, enact housing policies supportive of mixed income, and establish community gardens in areas identified as food deserts.

24 http://americannutritionassociation.org/newsletter/usda-defines-food-deserts
Map 17 identifies neighborhoods within Grand Haven Charter Township that are located within one mile of a full service grocery store.

**ADDITIONAL RESOURCES DRAWN FOR THIS REPORT:**


Michigan Climate and Health Adaptation Plan 2010-2015 Strategic Plan, Prepared by the Michigan Department of Community Health (2001)
Grand Haven Charter Township
Percent of Population 65 Years and Older (male and female)
Map #1

Note: Areas with no data are shown in white.

61.55 - 100.00% (5)
33.34 - 61.54% (4)
19.29 - 33.33% (3)
9.56 - 19.28% (2)
1.22 - 9.55% (1)

Data Sources:
- U.S. Census Bureau, Block Level Data (2010)
- ACS data (2009-2013)
- Grand Haven Charter Township
- Ottawa County GIS
- Color symbols: ColorBrewer.org

Prepared March 2016 by:
1 inch = 4,750 feet
Grand Haven Charter Township
Percent of Non-white Population
Map #3

Data Sources:
U.S. Census Bureau, Block Level Data (2010),
ACS data (2009-2013)
Grand Haven Charter Township
Michigan Geo. Data Library
Ottawa County GIS
Color symbols: ColorBrewer.org

Prepared March 2016 by:
LIAA

Legend

- 50.01 - 100.00% (5)
- 31.68 - 50.00% (4)
- 15.80 - 31.67% (3)
- 6.91 - 15.79% (2)
- 0.80 - 6.90% (1)

Note: Areas with no data are shown in white.

Color symbols: ColorBrewer.org
Grand Haven Charter Township

Percent of Households Living Below the Poverty Threshold

Map #4

Data Sources:
- U.S. Census Bureau, Block Level Data (2010).
- Grand Haven Charter Township
- Ottawa County GIS
- Color scheme: ColorBrewer.org

1 inch = 4,750 feet

Legend:
- 17.2 - 22.8% (5)
- 9.0 - 17.1% (4)
- 6.9 - 8.9% (3)
- 3.9 - 6.8% (2)
- 2.0 - 3.8% (1)

Prepared March 2016 by:

10400 Michigan Ave. 
Lakeview, MI 48850
(989) 699-2828
www.ottawa.org
Grand Haven Charter Township
Percent of Population 25 years and Older with less than a High School Education
Map #5

Data Sources:
U.S. Census Bureau, Block Level Data (2010), ACS data (2009-2013)
Grand Haven Charter Township
Michigan Geo. Data Library
Ottawa County GIS

Prepared March 2016 by:
LIAA
Grand Haven Charter Township
Relative Exposure of Populations to Extreme Heat Events
Map #9

<table>
<thead>
<tr>
<th>additive score</th>
<th>re-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 - 10</td>
<td>(5)</td>
</tr>
<tr>
<td>7 - 8</td>
<td>(4)</td>
</tr>
<tr>
<td>5 - 6</td>
<td>(3)</td>
</tr>
<tr>
<td>3 - 4</td>
<td>(2)</td>
</tr>
<tr>
<td>1 - 2</td>
<td>(1)</td>
</tr>
</tbody>
</table>

1 inch = 4,750 feet

Data Sources:
U.S. Census Bureau, Block Level Data (2010), ACS data (2009-2013)
Grand Haven Charter Township
Michigan Geo. Data Library
Ottawa County GIS

Prepared March 2016 by: LIAA
Grand Haven Charter Township
Population Vulnerable to Extreme Heat Events
Map #10

Data Sources:
U.S. Census Bureau, Block Level Data (2010),
ACS data (2009-2013)
Grand Haven Charter Township
Michigan Geo. Data Library
Ottawa County GIS

Prepared March 2016 by:

1 inch = 4,750 feet

0 2,000  4,000  6,000  8,000

Feet

22 - 27  (5)
18 - 21  (4)
14 - 17  (3)
10 - 13  (2)
3 - 9    (1)

Additive score
re-score
Grand Haven Charter Township
Digital Elevation Model
Map #11

Data Sources:
USDA-NRCS Geospatial Data Gateway
Michigan Geo. Data Library
Grand Haven Charter Township
Ottawa County GIS

Prepared March 2016 by:

1 inch = 4,400 feet

High : 829.7 ft
Low : 578.4 ft

0 1,850 3,700 7,400 Feet

Lake Michigan
Lake