Foundations for Community Climate Action:

Defining Climate Change Vulnerability in Detroit

University of Michigan Taubman College of Architecture & Urban Planning

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University of Michigan Taubman College of Architecture & Urban Planning

Kelly Gregg, Peter McGrath, Sarah Nowaczyk, Andrew Perry, Karen Spangler, Taylor Traub, & Ben VanGessel

Advisors: Larissa Larsen & Eric Dueweke

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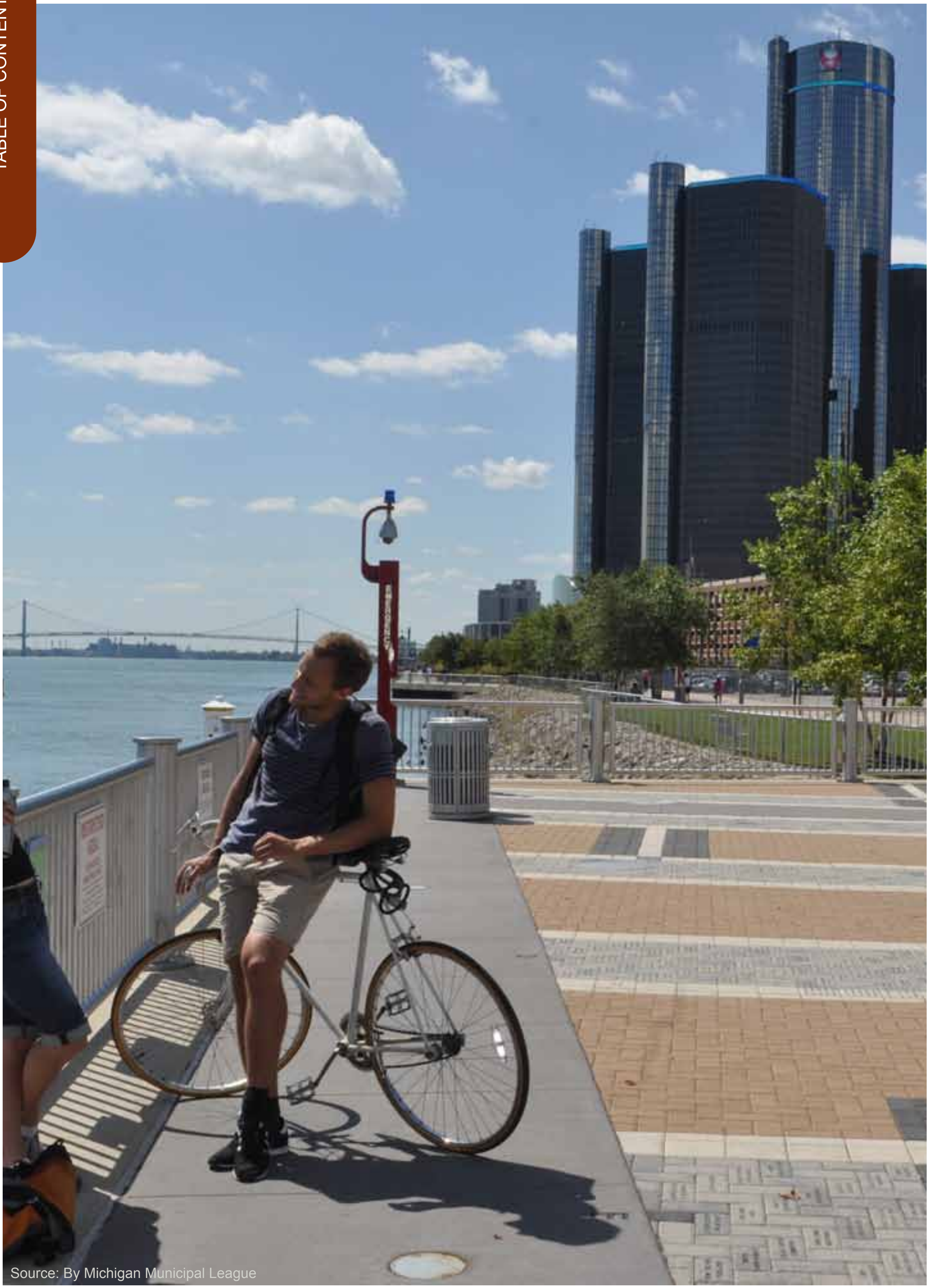

Source: By Michigan Municipal League

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EXECUTIVE SUMMARY

CLIMATE ACTION PLANNING

According to projections, the average annual temperature in Detroit is expected to increase 1.5-5.4°F by 2050. In the wake of increasing temperatures and changing climate conditions, many cities across the world recognize the need for climate action planning. This style of planning provides a proactive approach to climate change.

Comprehensive climate action planning involves both mitigation and adaptation. Mitigation aims to decrease the extent of climate change by reducing greenhouse gas emissions. Conducting a greenhouse gas inventory informs which mitigation strategies are needed and in which sectors. Adaptation aims to decrease the impacts from climate change by identifying distinct places and groups of people that may be disproportionately affected by a changing climate. Conducting a vulnerability assessment informs which adaptation strategies are needed, and where to implement them.

Literature often defines climate 'vulnerability' as 'exposure plus sensitivity.' Exposure refers to the presence of biophysical hazards in the current environment, and sensitivity refers to the degree to which a community is harmed by a given exposure. We conducted an initial vulnerability assessment in order to provide a foundation for future climate action planning.

Source: By Lowell Boileau detroityes.com

DETROIT CLIMATE ACTION COLLABORATIVE (DCAC)

Community-based non-profits, environmental organizations, universities, state agencies, private organizations and the City of Detroit comprise the DCAC. The DCAC is a grass-roots effort, led by Detroiters Working for Environmental Justice (DWEJ). The primary goals of the DCAC include:

1. Reduce greenhouse gas emissions for the sustainability and well-being of Detroit

2. Increase the resilience of Detroit's social, built and natural environments

Eight 'Work Groups' encompass the DCAC in order to ensure fair representation. These eight Work Groups include transportation, solid waste, homes and neighborhoods, businesses and institutions, community public health impacts, energy, research, and parks, public space and water infrastructure. Once assembled, the Work Groups will determine indicators, strategies and goals in order to monitor progress. We compiled a list of potential indicators, strategies and goals that serve to aid these Work Groups.

VULNERABILITY ASSESSMENTS & CONCLUSIONS

Our vulnerability assessments focus on two issues: extreme heat and flooding. We selected these two issues because local climatologists have identified extreme heat and increased precipitation as key concerns for Detroit.

With regard to extreme heat vulnerability, our assessment combines exposure and sensitivity. Exposure factors include areas with high percentages of impervious surfaces relative to pervious surfaces and low tree coverage. Sensitivity factors include the number of people over the age of 65, the number of households without access to a vehicle, household income, and educational attainment.

The heat assessment indicates that the greatest areas of vulnerability include the downtown core, along with the adjacent neighborhoods northwest of downtown. In addition, only 29% of the population is within a 15-minute walking distance of designated cooling centers, which the City of Detroit designates on an annual basis.

The flooding vulnerability assessment examines the vulnerability of current infrastructure systems, as well as household level vulnerability.

With regard to infrastructure, the analysis focuses solely on exposure factors. The primary exposure factor includes the runoff burden created during intense storm events. Land cover, soil type, and slope are the three factors that determine runoff burden. Data pertaining to the age, size, capacity and technology of existing infrastructure is necessary to determine the sensitivity of the City's nine sewersheds. Additional information from Detroit Water and Sewerage Department is necessary for a more comprehensive analysis.

At the household level, the exposure factor is determined from floodplain designations (100 and 500 year). Age of housing stock (pre-1940) and median household income constitute household sensitivity.

Similar to the heat assessment, system flood vulnerability concentrates around the downtown core and extends northward. Household flood vulnerability is seen in southeast Detroit and in the northwest fashion along the Rouge River.

FINAL RECOMMENDATIONS

The results of the vulnerability assessment informed a set of final recommendations. These final recommendations include:

- Reconsider distribution and location of designated cooling centers
- Reduce impervious surfaces in identified 'hotspots'
- Increase tree planting in identified 'hotspots'
- Acquire additional information from DWSD for further flood vulnerability analysis
- Ground-truth the most vulnerable heat and flood areas to further target efforts at the neighborhood scale

Source:By Michigan Municipal League

INTRODUCTION

Global climate change threatens to disrupt the function and livability of our cities. Although Detroit, Michigan, will not face the drastic effects of rising sea levels, the city is projected to experience higher temperatures, more frequent and intense precipitation events, and fluctuating lake levels. All of these effects will place further strain on the City of Detroit's ability to provide services and keep it's most vulnerable residents safe. With this in mind, the Detroit Climate Action Coalition (DCAC) has partnered with the University of Michigan in order to assess how Detroit can lower it's current impact on the environment to mitigate efforts and prepare itself for the effects of climate change through adaptation.

Traditionally, municipal-level climate action plans have focused on mitigation—actions that reduce Greenhouse Gas (GHG) emissions that aim to prevent climate change. Common recommendations included increasing mass transit options and increasing building energy efficiency. Although these mitigation policies generate positive outcomes, increasingly, recent climate action plans recognize that mitigation at the global scale must be coupled with adaptation at the local level.

While not a comprehensive document, this report from the University of Michigan intends to positively contribute to the DCAC's planning process. We begin with a brief history and current context section that addresses the relevant Detroit-specific information, and summarizes the current trends in climate science. Our Vulnerability Assessment applies current climate science projections to Detroit, and identifies places and populations in Detroit that are at risk from specific effects of climate change. This Vulnerability Assessment will form the basis for the Work Group reports, which will allow DCAC stakeholders to gain an accurate snapshot of where the city of Detroit currently stands, survey other plans and best practices from other cities, and show how stakeholders can measure progress. Based around the DCAC's work groups, we will suggest a set of area specific indicators from scholarly research, best practices from other climate plans, and feedback from DCAC workgroup members. Finally, our conclusions section will summarize our findings, and present our planning priorities to the DCAC.

DEFINITION

MITIGATION

Strategies that focus on reducing GHG emissions from human activity and promote the use and development of non-fossil fuel energy sources

ADAPTATION

The adjustment of human or natural systems in response to actual and/or anticipated climate change to lessen the potential negative impacts.

CONTEXT

DETROIT AT A GLANCE

Detroit's previous triumphs and current struggles are well documented. Once a symbol of American industrial might, the city's name is now a synonym for urban blight, abandonment, and uncertainty. Today Detroit is a minority-majority city that has lost population at an alarming rate— the city suffered a 25% drop in population from the 2000 to 2010 census, and the city's current population of 713,777 is 38.5% of its 1950 peak.[1] Despite the decline in population, the city is still forced to pay for the infrastructure and legacy costs of a city of 1.8 million people. This creates a tremendous strain on the city's remaining tax-base, and the city departments charged with providing basic services.

In 1701, the French explorer, Antoine Laumet de La Mothe, sieur de Cadillac recognized the Straits of Detroit as a strategic location on the Great Lakes, and founded the city as Fort Ponchartrain du Detroit. Founded as a military installation to protect the lucrative fur trade, French settlers soon noticed that Detroit had excellent soil for farming. The French Crown offered free land to settlers, who developed ribbon farms—long and narrow farms that allowed every settler to have access to the Detroit River. Detroit became an important agricultural center, and the ribbon farms formed the basis of the city's unique and often overbuilt street pattern. The fort became one of the largest trading centers in North America by 1760.

From the early 1800s through the turn of the century, while the fur trade declined, Detroit continued to grow as a manufacturing and trading center. Detroit enjoyed a diverse economy, well-known for making stoves, train cars, shipbuilding, cigars, and pharmaceuticals.[2] The city expanded in population, from just 1,650 in 1810 to 285,704 in 1900.[3] The city itself also grew in territory, annexing neighboring townships, building over the former farmland, and covering rivers to create sewers. While the city grew, compared to its Midwestern peers of St. Louis, Buffalo, Cincinnati, Cleveland, or Chicago, Detroit was still a relatively small city—a small manufacturing outpost.[4] In fact, when the Detroit Tigers baseball franchise began play in 1901, some even wondered how long the Major League team would last in Detroit.[5]

This perception changed with the advent of the automobile. Following the turn of the century, Detroiters began to apply their expertise in manufacturing, machining, forging, and metallurgy garnered from other industries and applied this knowledge to automobile manufacturing. Within twenty years, Detroit became the undisputed center of the nation's booming and lucrative auto industry. By 1930, the industry consolidated into an oligopoly of Ford, GM, and Chrysler - the "Big Three" - all of which centered their operations in or around Detroit. Detroit's economic fortunes have been closely linked to the domestic auto industry ever since.

In many ways, Detroit is the quintessential twentieth century city, mostly due to the rapid, unplanned growth encouraged by the auto industry. The city's built environment and territory expanded rapidly, from just a small loop located within Grand Boulevard in 1900, to its current borders of 139 square miles by 1926.[6] This expansion of territory was not possible without a meteoric rise in population. From 1900 to 1930, the city's population exploded from 285,704 to 1,568,662. While Detroit is widely known as a blue-collar, manufacturing town, the auto industry created massive fortunes for auto barons such as Henry Ford, John and Horace Dodge, and the Fisher Brothers, and employed thousands in managerial, engineering, and professional ranks.

Also, from 1900 to 1930, Detroit attracted hundreds of thousands of unskilled laborers from Central and Eastern Europe, and from the American South.[7] By the roaring twenties, the former sleepy outpost on the Detroit River became a booming metropolis, flowing in money from the prosperous auto industry and the prohibition-era illegal alcohol trade with Canada. However, the Great Depression hit Detroit hard, as many factories cut shifts or closed their doors altogether. Production of war material in World War II brought Detroit out of the depression, and Detroit became known as the "Arsenal of Democracy." The city experienced another influx of white and black migrants from the American south to fill the factories that ran on three shifts, but Detroit's wartime era of full employment was short-lived.[8]

Following the end of World War II, while the metro area of Detroit continued to grow, the city of Detroit began to decline. A confluence of federal subsidies, structural change in the auto industry, changing tastes, and poor race relations encouraged many whites to leave the city. For many years, Detroit's population loss was commonly perceived as the classic example of "White Flight." Indeed, Detroit became the manifestation of the Kerner Commission's worst fears—a wealthy ring of predominantly white suburbs surrounding an impoverished, underemployed, and majority African American city core.[9] However, as the years have gone by, many black residents have left for the suburbs as well. Indeed the decline in services and an increasing tax burden has created a vicious cycle. Today, the city has fewer financial resources to serve its most vulnerable residents.

Detroit's meteoric rise and decline has created unique challenges for the urban environment. The city's prosperous industrial economy allowed blue-collar autoworkers to purchase their own single-family homes, and Detroit became well known as a city of "house and yard" people.[10] Once a symbol of prosperity, many of Detroit's homes today lack insulation and modern, energy efficient HVAC systems. Also, Detroit was built at a time when auto-ownership was on the rise, and the city's planning professionals favored an auto-dependent urban form. In 1958, the city shut down the last of its streetcars, while highways were constructed throughout the city. Today, Detroit faces the challenge of large areas of vacant land and an auto-dependent transportation system. Moreover, during the late 1800s, to make way for development, many of the city's creeks and streams were paved over, or turned into sewers—decreasing pervious surface for storm water management. Much of the city's infrastructure is technologically out of date and has suffered from years of deferred maintenance. Climate change threatens to increase the pressure on this fragile infrastructure system, and the city's ability to cope is currently limited.

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Source: Detroit Skyline 1954. Wayne State Historical Image

BIOPHYSICAL

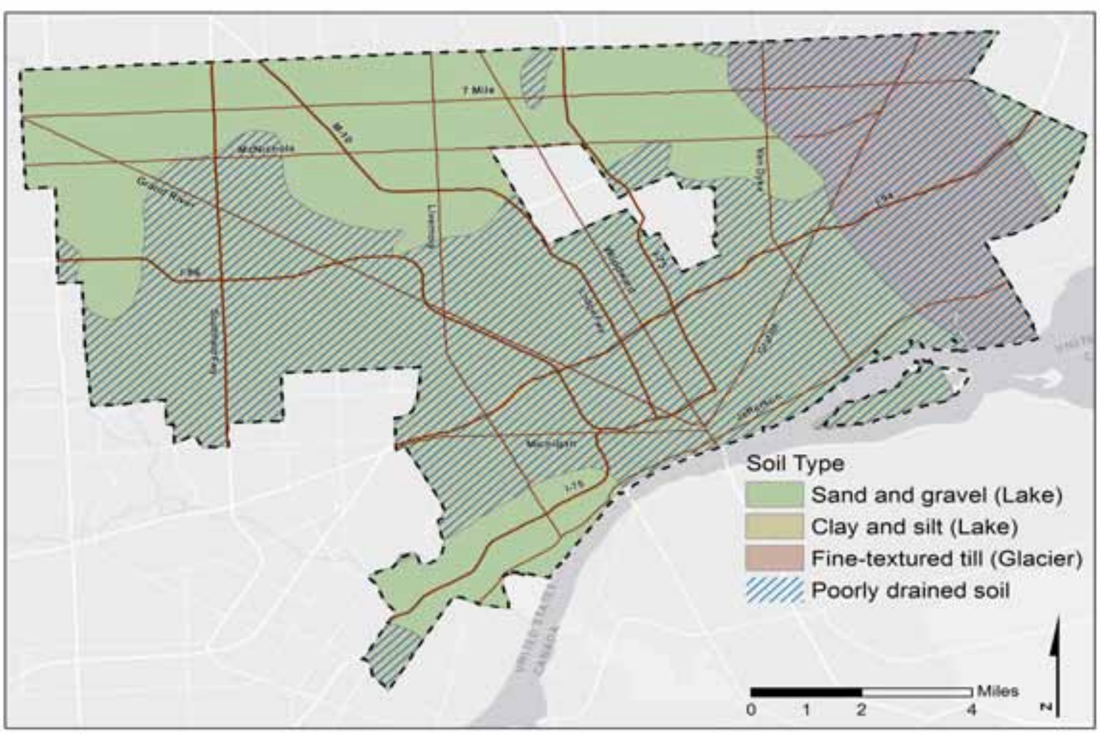
SOUTHEAST MICHIGAN: A TALE OF GLACIATION AND PROXIMITY TO THE GREAT LAKES

Michigan's current landscape was shaped predominantly during the last ice age. The movement of the last ice sheet, known as the Wisconsin Glacier, left the most direct impact with its retreat occuring 14,000 years ago. When the planet warmed and the ice melted, the water would carry the scoured soil and rocks away from the retreating glacier, with finer-grained particles able to travel farther.[1] The Great Lakes themselves are a product of this retreating glacier—large basins that became the repository for much of the melted ice.[2] These historic processes determined many of the characteristics of the current landscape, from soil types to hydrologic flows, and in some regards, the historic forest composition as well.

SURFACE GEOLOGY

Understanding the soil types is crucial in the face of changing climate. Particle size determines the amount of water and nutrients that soil can hold, which affects agricultural viability, forest and plant dynamics, and stormwater management. Generally, larger particles (sand and gravel) have higher rates of drainage due to the greater amount of space between particles, whereas finer soils (silts and clays) retain water for longer periods, and can become saturated quickly. For agricultural purposes, silt soils are ideal for growing crops—they hold water and nutrients, but do not become dense, hard, and brittle like dried clay.[3]

A key impact of these historic geologic processes is Detroit's most common current soil types—soils produced from glacial outwash, and soils derived from deposited lake sediments.



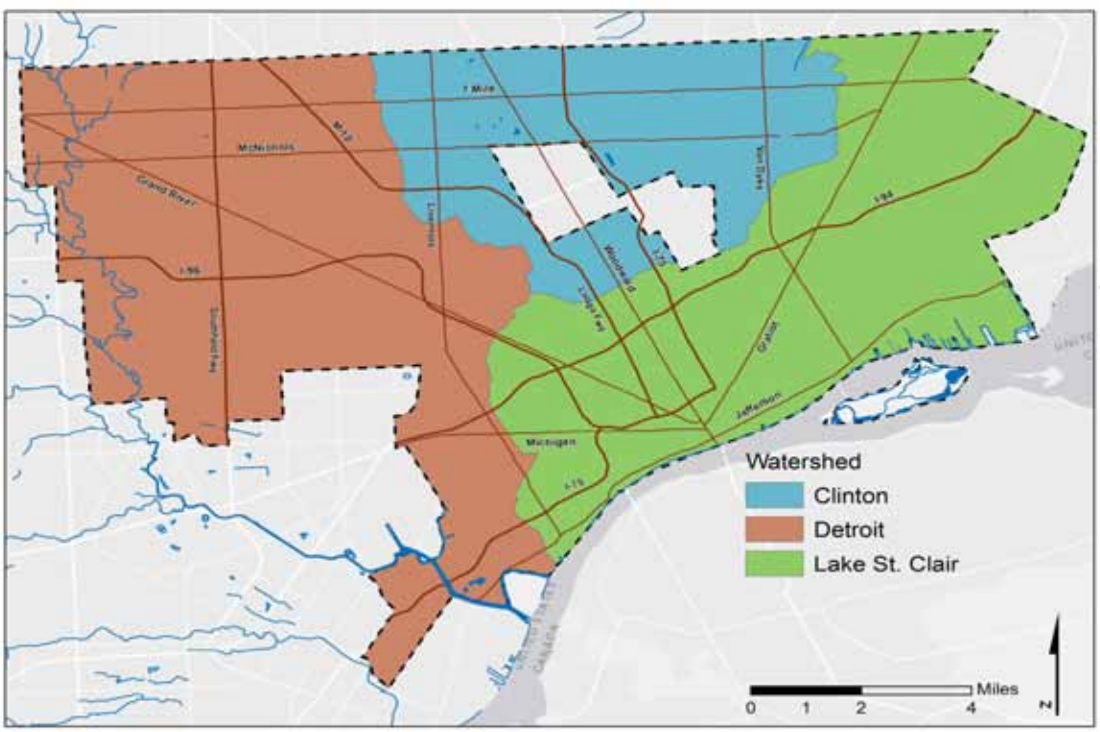
Detroit Soil Types
Source: Michigan Geographic Data Library, Michigan Quarternary Geology Map
Prepared By: University of Michigan Detroit Climate Capstone

Touching briefly on glacial outwash, we see an accumulation of fine-grained material, or till, into ridges that delineate the farthest extent of glaciation. The subtle ridges of accumulated glacial till have over time defined the area's watersheds, dictating the course of rivers and streams, and influence drainage dynamics.[4]

The other surface type that is apparent is derived from the deposition of lake sediments. As the Great Lakes began to fill, they were not always the shape that we know today. In fact one in particular, Lake Maumee, encompassed an area that included part of present-day Lake Erie, Lake St. Clair, the Detroit river, and inland parts of Canada and Michigan. Lake dynamics are such that sediments will accumulate over time, carried by rivers, wind, and erosion to the lake. Sand and gravel tends to accumulate along the outer portion of the lake, while finer silt and clay sediments will settle in the inner, deeper lake areas.[5] Detroit and the surrounding area has a presence of both types, though silt and clay predominate in the sections closer to the Detroit River.

HYDROLOGY

The historic glacial processes played a role in the creation of present day watersheds. The deposited sediments created ridges, essentially boundaries, which charted the course for water to follow. Detroit is placed within the greater context of the Great Lakes watershed, a massive process that moves water, in order, through Lake Superior, Lake Michigan, Lake Huron, the St. Clair River, Lake St. Clair, the Detroit River, Lake Erie, Lake Ontario, and out the St. Lawrence River to the Atlantic Ocean. Locally, however, there are three watersheds falling within the boundary of Detroit, two emptying directly into Lake St. Clair (Lake St. Clair and Clinton watersheds) and the other into the Detroit River (Detroit watershed). Additionally, the Huron watershed to the west of Detroit, plays an important drainage role in the region, passing through Wayne County and emptying into Lake Erie, south of Detroit.[6] Each watershed is further



Detroit Watershed
Source: Michigan Geographic Data Library, Michigan Watersheds
Prepared By: University of Michigan Detroit Climate Capstone

broken down into subwatersheds, which can be useful scales when analyzing the impacts of impervious surfaces and stormwater management practices.

Within Detroit itself, there were a number of streams and rivers that served to drain the area. Many of these streams were subsequently routed into culverts and underground pipes as the city expanded, trying to conceal its stormwater system. Understanding the hydrologic processes of the city will be important as we move forward facing climate change because of the stresses that will be put on the system from increased storm events. With a combined sewer overflow system, additional stress on or relief from the natural drainage system will have impacts on sewage discharges into the Detroit River. One innovative suggestion looks at “daylighting” these streams that have been enclosed by pavement. Opening these waterways could restore some of the historic flows, landscape, and habitat, while also diverting urban stormwater runoff, lessening the chance for a system-wide overflow.[7]

Historical Detroit Watershed
Source: Detroit Water Sewerage Department

FOREST TYPES

The glacial and soil deposition processes, along with broader climate characteristics, also played a role in determining the vegetation makeup of the region. Categorized as the mesic southern forest, pre-settlement Detroit experienced the presence of beech and sugar maple dominant communities. These species do especially well on fine-textured glacial till and sandy lake plains that are well drained, conditions that were previously established in this area. Soils are generally fertile with high nutrient content and soil organism content, due to the decomposition of deciduous leaves and branches. Where drainage is poorer and seasonal pools are common, a wetter habitat was formed, favoring beech and an oak-hickory mix.[8] Along the eastern border of the city, as well as in the southwest, there were historically much wetter, swamp and marsh conditions. To this day, these areas remain more prone to flooding than other parts of the city.

Today, the U.S. Forest Service undertakes a Forestry Inventory and Analysis (FIA) Program to periodically assess the current forest composition as well as develop predictive models. While there is no direct data for the urbanized Detroit metro region, the surrounding areas indicate a fairly high diversity of species, characterized by the historic beech, sugar maple, birch, oak, and hickory, but also a heavy elm and cottonwood presence. Looking into the future, the predictive models tend to emphasize the likelihood for elm and cottonwood to become dominant, with a minor role for oak and hickory. This is largely based on climate modeling processes, where shifting climates may limit a species’ range.[9] For local communities, it will become important to take broader predictions on regional or national forest types. In addition, coupled with knowledge about local topography and hydrology, develop a working list of species that can thrive in different biophysical circumstances.

Source: By Sombraala

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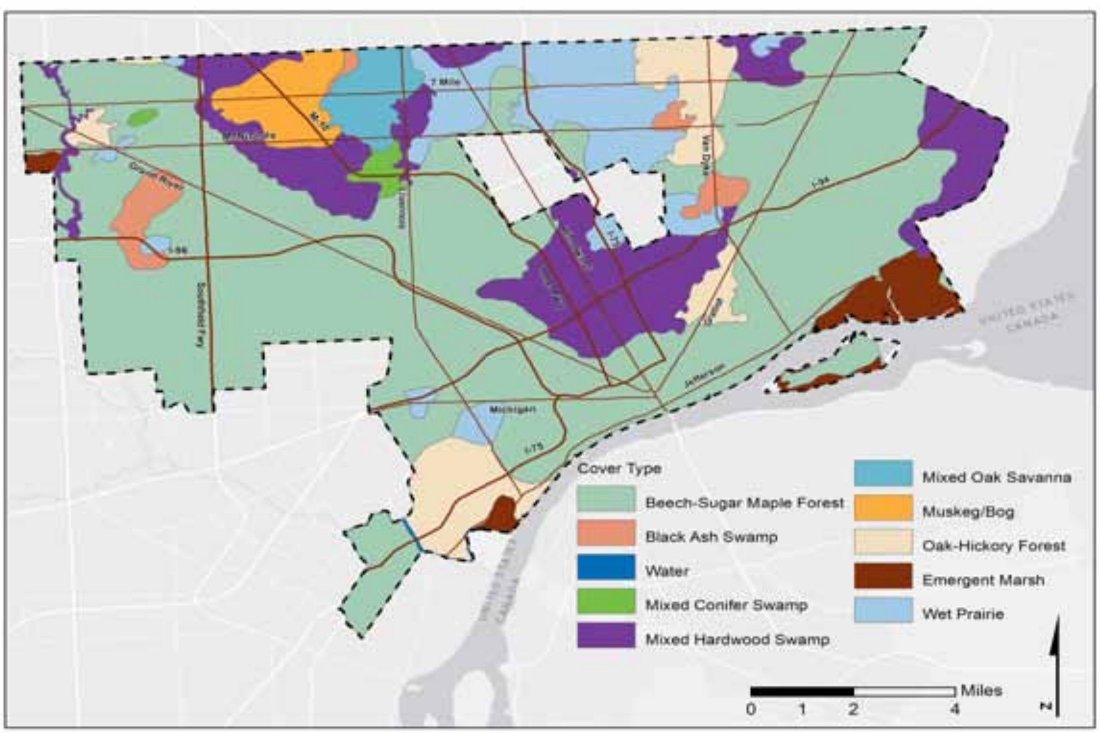


Detroit Historic Vegetation
Source: SEMCOG, Vegetation Circa 1800 Southeast Michigan
Map Prepared By: University of Michigan Detroit Climate Capstone

CLIMATE

WEATHER AND CLIMATE: WHAT IS THE DIFFERENCE?

Although climate and weather are directly related, they are not the same. Weather describes the day-to-day conditions in a specific place, while climate is the accumulation of recorded weather trends in a region over a longer period of time. The distinction between weather and climate is important because it differentiates temporary weather variability from long-term projected trends measured over decades.

While the terms "global warming" and "climate change" are often used interchangeably, climate change more accurately conveys the multitude of impacts caused by the trend of higher global temperatures: increased duration and frequency of drought, increased number of extreme precipitation events, rising sea levels, and ocean acidification.[1] The global climate is sensitive to a number of natural and human caused activities. Natural events that affect the climate include variations in the Earth's orbit, changes in the intensity of solar radiation, the circulation of the oceanic and atmospheric currents, and volcanic activity. Human activities contribute to climate change through GHG emissions. However, other activities such as deforestation and rapid changes in land cover contribute to global climate change.[2]

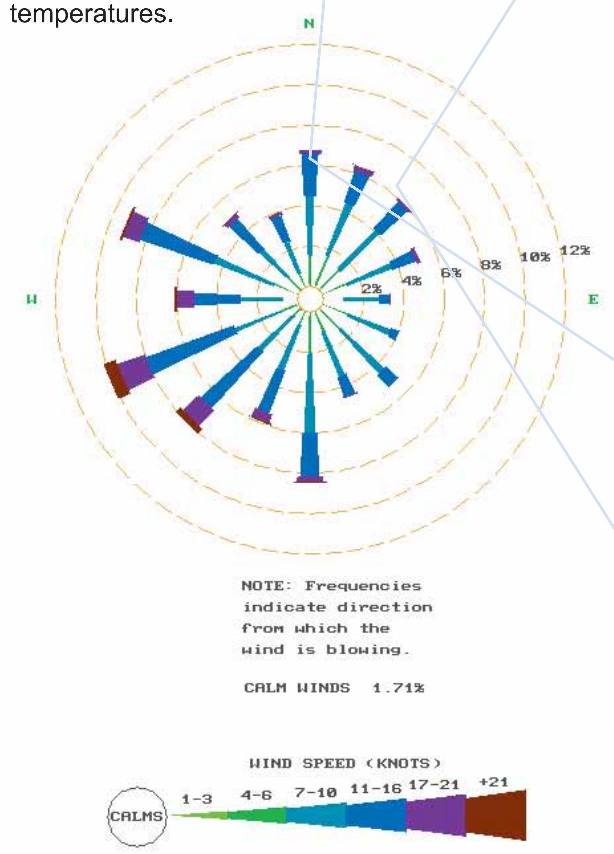
CLIMATE CHANGE DIVISIONS/ GEOGRAPHY

In the United States, climate scientists at the National Climatic Data center use climate divisions as a baseline geography for analysis. Generally, climate divisions are areas that share uniform climate characteristics, and are housed within the boundary of one state. Detroit is located within the Southeast Lower Climatic Division of Michigan (see figure below). This region is bounded by the Ohio border to the south, Lake Huron, Lake St Clair, and Lake Erie to the east, and extends west to include the cities of Flint and Ann Arbor.[3] To predict climate change impacts for a specific region or city, scientists utilize the technique of downscaling. Climate downscaling connects global-scale predictions, such as Atmosphere-Ocean General Circulation Models (GCMs), with regional dynamics to estimate local- or regional-scale information.[4]

Climate Division 10
Source: http://climate.geo.msu.edu/Stations/2102/NARRAT.txt

HISTORIC CLIMATE DATA

Detroit and the rest of the Southeast Lower Climatic Division of Michigan are categorized as a humid continental climate. Humid Continental climates are known for great variances in seasonal temperatures—warm to hot and humid summers, and cold winters. Historically, Detroit's temperatures were generally moderate. In the past, the region rarely experienced prolonged periods of hot, humid weather in the summer or extreme cold during the winter. During the summer months, temperatures from the mid 60s°F through 80s°F were the norm, and occasional easterly winds and local lake breezes from Lake St. Clair moderated temperatures. In the winter, the average daily high temperature range was 23°F to 35°F with an average winter temperature of 27°F. The proximity to Lake Erie and Lake St. Clair was also reflected in winter temperatures.



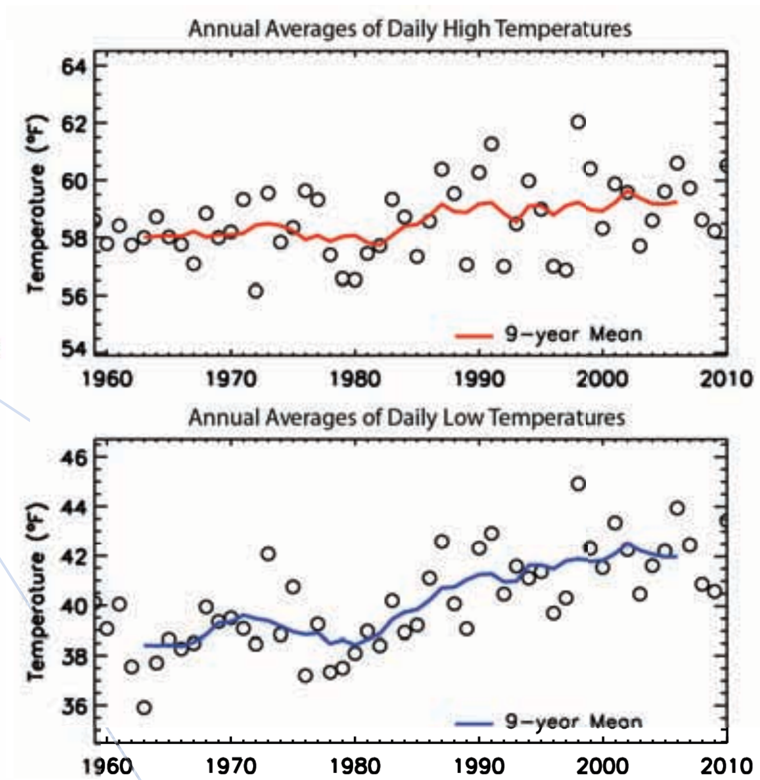
Wind Speed and Direction in Detroit
Source: http://climate.geo.msu.edu/Stations/2102/NARRAT.txt

SEASON	MONTHS	TEMPERATURE
Annual	January-December	48.7 °F
Winter	December-February	26.7 °F
Spring	March-May	47.8 °F
Summer	June-August	70.8 °F
Fall	September-November	57.1 °F

Annual Seasonal Temperature (1958-2012)
Source: Station 202103 National Climate Data Center

Hottest Day on Record	June 25th, 1988	104.3 °F
Hottest Month on Record	July 2011	Ave. Temp. 79.3 °F
Coldest Day on Record	January 21, 1984	-21.1 °F
Coldest Mnth on Record	January 1977	Ave. Temp. 12.8 °F

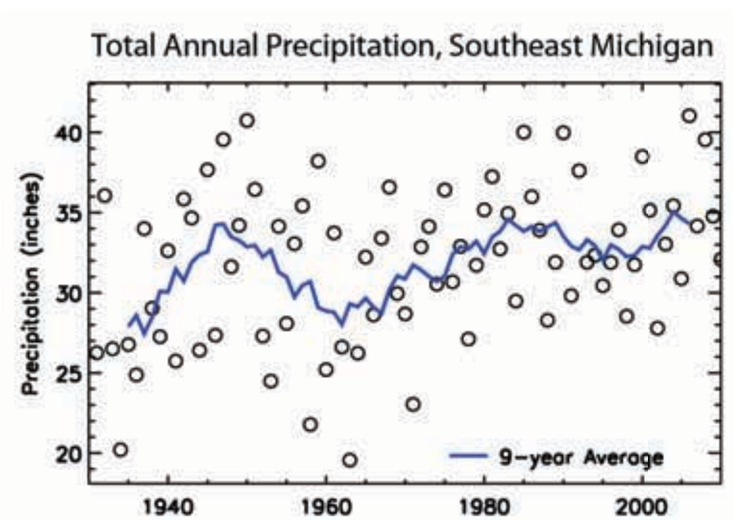
Detroit Temperature Extremes (1958-2012)
(Detroit Proper, not DTW)
Source: Station 202103 National Climate Data Center



Annual Averages of Daily Temperatures
Source: GLISA The Potential Impacts of Climate Change on Detroit, MI

Detroit's annual precipitation averaged 33.58 inches, and was fairly evenly distributed throughout the year. The driest month for Detroit is February, with 1.85 inches of precipitation, and June was the wettest month, with 3.51 inches of precipitation. Summer precipitation came mainly in the form of afternoon showers and thundershowers. Annually, thunderstorms occurred on an average of 36 days. Winter precipitation was generally a mix of sleet and snow, and January was the snowiest month—averaging 11.29 inches of snowfall, for an average snow depth of 6.38 inches.

In terms of extreme weather, while Michigan is shielded from the worst effects of hurricanes, it is located on the northeast fringe of the Midwest tornado belt.[5] Wayne County experienced 27 tornadoes since 1950 while only 4 have crossed into Detroit city limits.[5] The lower frequency of tornadoes occurring in Michigan may be, in part, the result of the colder water of Lake Michigan during the spring and early summer months—the national prime period of tornado activity.



Total Annual Precipitation, Southeast Michigan
Source: GLISA The Potential Impacts of Climate Change on Detroit, MI

DETROIT PRECIPITATION EXTREMES

Greatest Single Day Total	July 28, 1976	4.90 inches
Greatest Monthly Total	July 1878	8.76 inches
Driest Month	Frebruary 1877	0.00 inches

Detroit Precipitation Extremes
Source: Station 202103 National Climate Data Center

TRENDS AND PREDICTIONS

In Detroit, between 1960 and 2010, average annual temperatures have increased by 1.4°F. This warming trend is expected to continue throughout the 21st Century. Although 1.4°F seems like a modest change, small increases in average annual temperature drastically increase the probability of extreme weather, such as heat waves, excessive heat events, droughts, and torrential rains. In particular, excessive heat events, the number of days per year with a high temperature above 90°F, will likely increase. Between 1960 and 1980, Detroit averaged 11 days exceeding the 90°F mark per year. During the later quarter of the century, the number of days exceeding 90°F rose slightly to 12 and to 15 in the first decade of the 2000s. However, by the end of 21st Century, Detroit is projected to experience 36 to 72 days exceeding 90°F per year.

Similar warming trends will affect winter temperatures. Between 1960 and 1980, an average of 50 days had a daytime high of 32°F or lower, an average of 7 days was 0°F or lower, and only 3 years stayed above 0°F. Generally, average winter temperatures are slowly increasing nearer to the freeze-thaw point which poses significant risks to surface and subterranean infrastructure.

Source: Winter Branch CR Artist

The increase in temperatures is expected to bring a rise in precipitation. In the last half century, Michigan experienced an 11% increase in total annual precipitation, and increases in annual precipitation are expected to continue. Precipitation in the summer months is expected to increase slightly, while spring, fall, and winter are expected to see a noticeable increase. While winters will have less snowfalls, they will experience more precipitation in the form of rain. The average number of snowfalls is projected to decrease by 50%. Much like the rise in temperatures, in addition to experiencing more precipitation, Michigan is also expected to experience more frequent and more intense storms, increasing the likelihood of floods.

On the ground, the increases in temperature and precipitation will create a diverse set of challenges for the City of Detroit's municipal departments and its residents. The large number of excessive heat events can exacerbate the symptoms of other diseases, and increase the risk of heat exhaustion, heatstroke, or death. Because of Detroit's combined sewer system, more frequent and more intense precipitation can increase the amount of untreated sewage released into the Detroit and Rouge Rivers. This increases Detroiters' risk and exposure to waterborne diseases. Also, increased precipitation and flooding can cause severe damage to private property and public infrastructure. These and other adverse effects, of climate change will be discussed further in our Vulnerability Assessment section.

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WEATHER EVENTS

The following section summarizes a few of the major weather-related events in Southeast Michigan since the start of the 20th Century. Often, extreme weather events and shifting weather patterns result in catastrophic blows to economic systems and local infrastructure, as well as outbreaks in health-related issues.

FEBRUARY-MARCH, 1900

“SNOWIEST WEEK”

Roughly 30 inches of snow fell over a 6 day period — the 3rd & 4th biggest snowfalls in the 20th century.

WINTER, 1903-1904

“COLDEST WINTER”

This winter ranked as the coldest winter in southern Michigan’s history. The average temperature from December to February was 18.7 degrees.

NOVEMBER, 1913

“WHITE HURRICANE”

Considered to be one of the worst in history, this storm included nearly 5 inches in snowfall and wind gusts over 70 mph. More than 235 sailors lost their lives on the Great Lakes and dozens of ships, including large freighters, sunk.

THE WEATHER— Tonight, fair, colder; Moderate west winds.

The Detroit News

LATEST EDITION

DEATH TOTAL ON LAKES MAY BE 273

WILSON READY TO AID REBELS

GREATEST MYSTERY IN HISTORY OF GREAT LAKES DISASTERS

DISASTER GROWS AS NEW REPORTS COME

DEAD AND MISSING ON GREAT LAKES.

Carruthers	28	Isaac M. Scott	28
Regina	22	Butters	20
McGean	28	Plymouth	7
Wexford	22	Leafield	15
Price	28	Lightship No. 82	6
Argus	26	Nottingham	3
Lafayette	12		
Hydrus	28		
Total			273

Vessel men estimate the financial loss at $3,000,000.

DEATH AND LOSS TOTALS MOUNT; MAY PROVE STORM WORST KNOWN

Mysteries Still Unsolved.

THAT DEPOT LOOP SHOULD BE BUILT

WAITS TILL U.S. ENVOYS QUIT MEXICO

GIVES BLOOD TO BROTHER IN VAIN

SHIP MYSTERY IS NO NEARER A SOLUTION

Source: The Paragraph.com

1930'S (1936)

"DUST BOWL" & "HEAT WAVE"

The 1930s represent one of the dryest periods in Michigan, referred to as the 'Dust Bowl.' This deade includes the driest year in recorded history (1936). The continual, long-standing droughts placed extreme economic pressures on farmers during The Great Depression.
In addition, the 'Heat Wave' of 1936 included 7 straight days of extreme heat, resulting in nearly 400 deaths in Detroit.

Source: HourDetroit.com; Illustrated by Arthur E. Giron

NOVEMBER, 1974

"THANKSGIVING WEEKEND SNOWSTORM"

Recorded as the largest snowstorm of the 20th century, more than 19 inches of snow fell on Southeast Michigan during Thanksgiving weekend.

WINTER, 1976-1977

"COLDEST WINTER EVER"

The Winter of 1976-1977 marks the coldest in Detroit history. Detroit failed to reach 32 °F for 45 consecutive days, resulting in an average January temperature of 12.4 °F (normal averages exceed 24 °F).

SUMMER, 1988

EXTREME HEAT AND DRYNESS

This summer included 39 days in which temperatures exceeded 90 °F, along with 5 days that exceeded 100 °F. In addition, some Michigan cities recorded less than one-inch of rainfall from May through June.

JANUARY, 1994

"COLD OUTBREAK"

This massive cold outbreak resulted in roughly 57 straight hours of sub-zero temperatures, including the coldest day in Detroit history.

MARCH, 1997

ICE STORM

Roughly 2.5 inches of freezing rain, snow & sleet fell in Southeast Michigan, resulting in the 3rd largest blackout in history — roughly 425,000 homes lost power.

JULY 7, 1997

TORNADO OUTBREAK

More than 15 tornadoes were reported across the state — the most in Michigan history. Seven deaths and more than 100 injuries occurred, and total damage to property and crops exceeded $140 million.

Source: UPI.com

WINTER, 1997-1998

"EL NINO"

The average temperature in Detroit during this winter was nearly nine degrees above normal, resulting in only 14.5 inches of snowfall (17.5 inches below normal).

2002

WEST NILE OUTBREAK

More than 115 cases of West Nile occurred in Wayne County, resulting in three deaths. Elderly populations proved to be most vulnerable to the outbreak. As a result, Wayne County granted $200,000 to city and township governments to eradicate the spread of West Nile.

AUGUST, 2003

“BLACKOUT”

As a result of poor regulation and reliability standards, 50 million Americans —I ranging from Michigan to the eastern seaboard — lost power for multiple days. Municipalities rallied in order to cater to vulnerable populations and ensure the safety of its citizens.

Source: Pasty.com

Source: Examiner.com

2009

FLOODING & SEWAGE OVERFLOWS

Extreme weather events resulted in more than 37 billion gallons of sewage overflowing into Southeast Michigan waterways — an increase of 11 billion gallons from the previous year.

2011

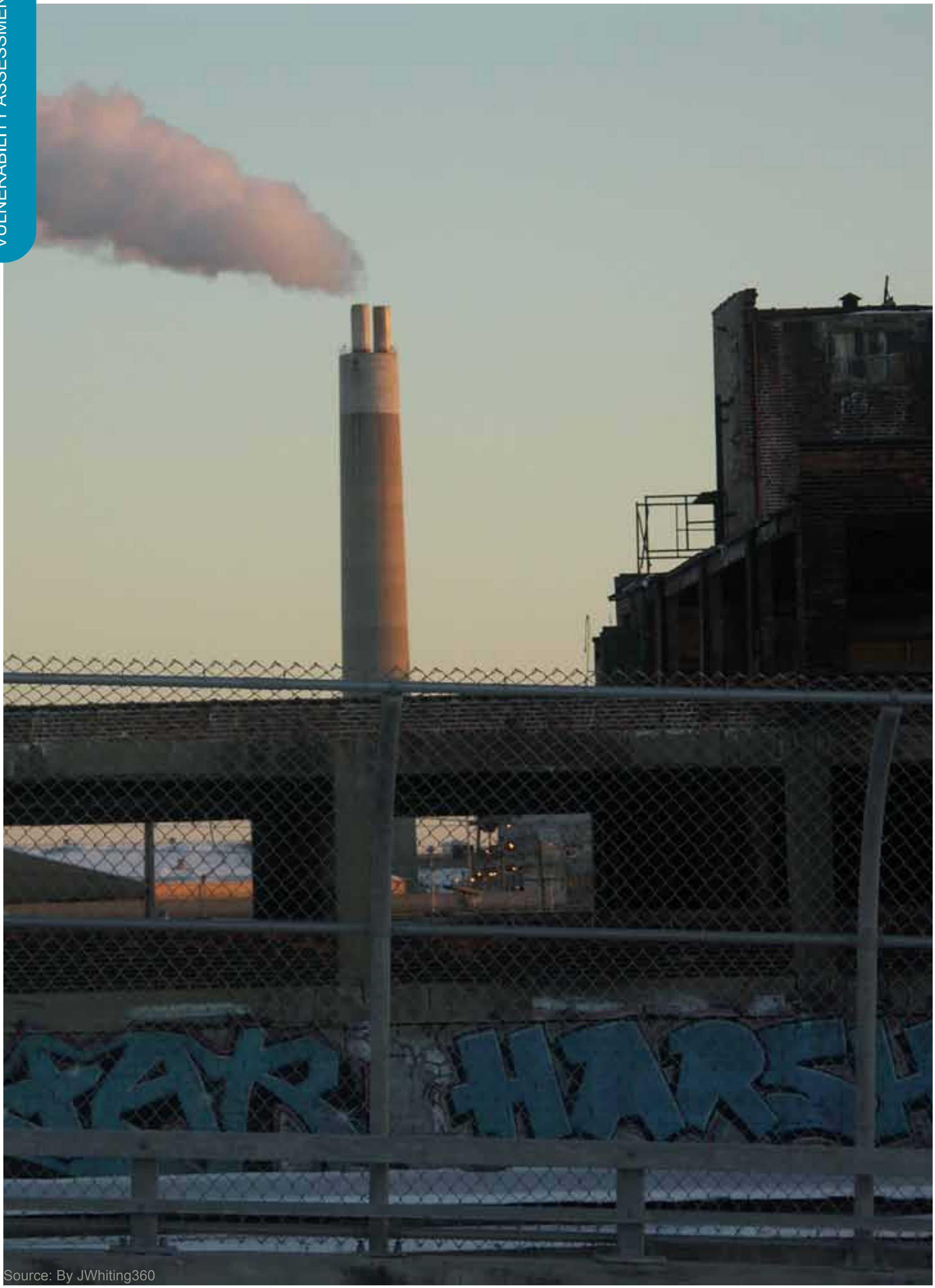
RECORD RAINFALL

Nearly 48 inches of rain fell in 2011. A majority of the rainfall occurred as a result of intense May and September thunderstorms. One storm in May resulted in flooding, as Detroit’s infrastructure could not handle the excess downpour.

2012

WEST NILE OUTBREAK & LYME DISEASE

Michigan recorded roughly 170 cases of West Nile, including 10 fatalities (all of which were elderly patients). Local authorities are also paying attention to a sizable increase in black-legged deer ticks — these ticks are often the primary source of Lyme Disease.



Source: By JWhiting360

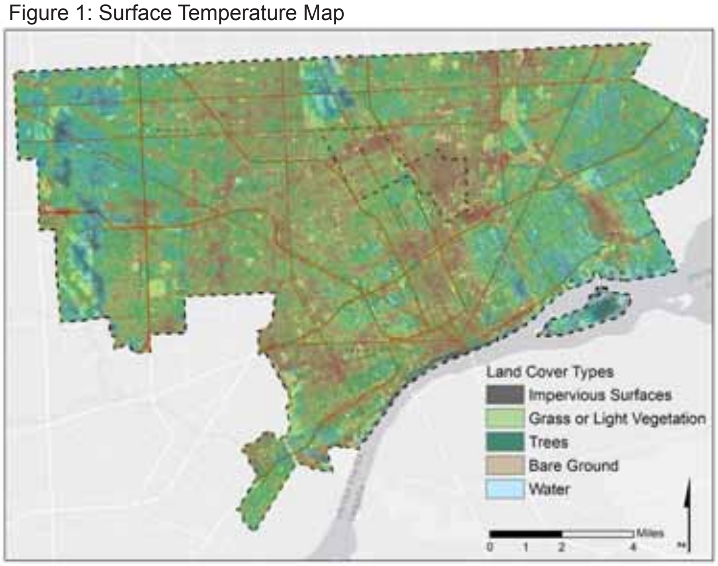
VULNERABILITY ASSESSMENT

Based on the projected changes from the Great Lakes Integrated Science Assessment (GLISA), extreme heat and precipitation are the biggest risks for Detroit. Air pollution, specifically elevated ground-level ozone, will also be a concern with increasing temperatures, but we were not able to quantify air pollution for this assessment. In this section, we will identify areas of high vulnerability pertaining to heat and flooding by quantifying concentrations of exposure and sensitivity in Detroit.

VULNERABILITY ASSESSMENT PROCESS

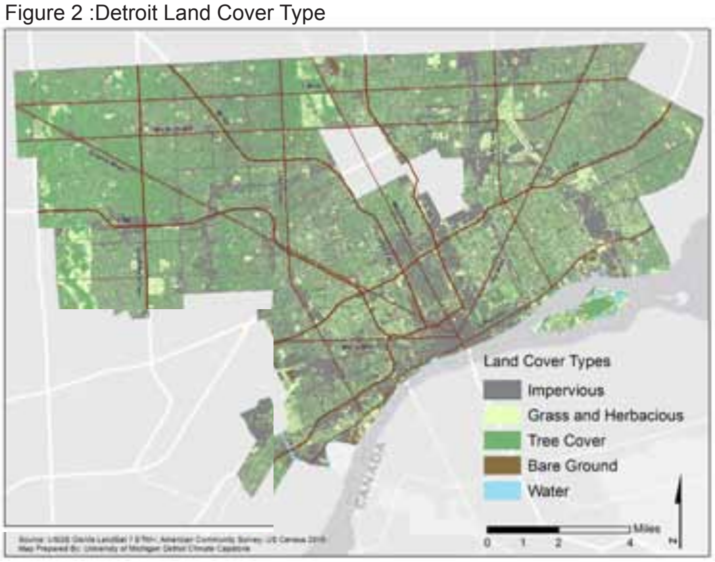
A vulnerability assessment is used to understand and quantify vulnerability. Vulnerability is the combination of biophysical exposures, such as the actual temperature or rainfall change, and sensitivity of a population or system. Sensitivity factors are often human variables such as population demographics. This vulnerability assessment is a geographic overview of concentrations of vulnerability in Detroit. Our assessment used data from the American Community Survey, an ongoing national survey by the U.S. Census Bureau that collects detailed information on housing, income, education, and other population characteristics. We obtained data at the block group level, an area that contains between 600 and 3,000 individuals. This is the smallest geographic level for which demographic data is published. By mapping areas of high exposure and high sensitivity, these assessments can identify areas of high vulnerability. Our methodology will explain the process of how we identified and combined exposure and sensitivity.

Figure 1: Surface Temperature Map



Source:Heat Map by Michael Howe
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 2 :Detroit Land Cover Type



Source: USGS GloVis LandSat 7 ETM+;
American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

HEAT EXPOSURE ASSESSMENT

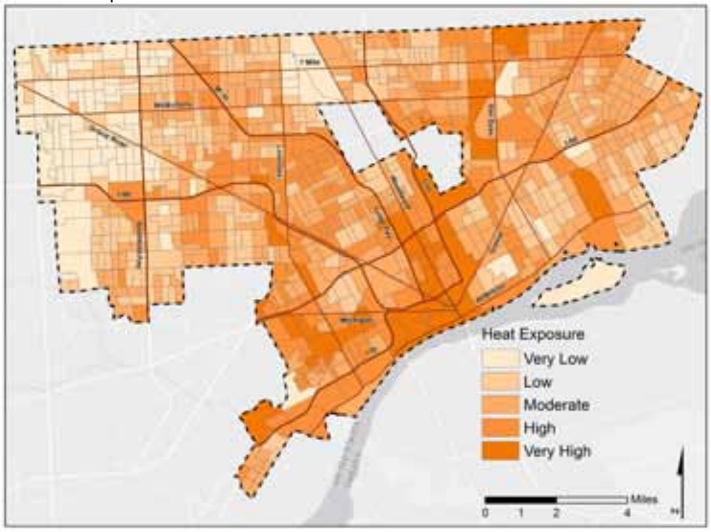
Geographic location within a region can drastically influence the exposure to heat. In Detroit, the average annual temperature from 1980-2010 has increased by 1.4°F, whereas the average annual temperature for Ann Arbor has only increased by 0.2°F over the same period.[1] Although 1.4°F seems like a modest change, a small increase in average annual temperature drastically increases the probability of extreme heat events and droughts. By 2099, Detroit is estimated to experience 36 extreme heat event days per summer, up from 9 days on average between 1975-1995 [2].

Our analysis included two land cover variables that impact effects of extreme heat events: impervious surfaces and tree canopy. Impervious surfaces, such as asphalt and concrete, absorb high amounts of heat and radiate it back into the air, increasing the surface temperatures. Tree canopy and other vegetation exert a cooling influence on the surrounding area. Land use decisions, resulting in the high concentration of impervious surfaces, coupled with disparities in the distribution of tree cover, interact to make certain areas of the city much warmer in summer months; thus, more vulnerable to extreme heat events [3]. This effect is termed the Urban Heat Island effect (UHI effect) [4,5].

Figure [1] shows the surface temperatures in Detroit. [6] This map demonstrates the temperature variation throughout the city, the dispersed character of the UHIs, and highlights how different surface materials absorb and re-radiate solar energy. For example, roads tend to be hotter and therefore create visible lines on the map. The average annual temperatures of UHI areas of Detroit can be 1.8–5.4°F warmer than surrounding areas [7]. However, vegetation cover reduces surface and air temperatures through evapotranspiration and shading, thereby decreasing vulnerability to extreme heat[8].
To analyze local variations in UHI effect we obtained land cover data from the United States Geological Survey Global Visualization Viewer (GloVis) available at usgs.glovis.gov.

As the above maps demonstrate, impervious surface and low tree canopy correspond to location of UHIs within the city. To understand the relative importance of impervious surface and tree canopy, we calculated the percent of each census block group's land cover covered by 1) impervious surface and by 2) tree canopy. Based on research by Coseo and Larsen, areas of impervious surface were weighted by a factor of 7 and areas of tree canopy were weighted by a factor of -2.[9] The two layers were combined to create cumulative heat exposure scores at the block group level, as shown in Figure [3].

Figure 3:Detroit Exposure to Excessive Heat Based on Land Cover by Block Group 2010



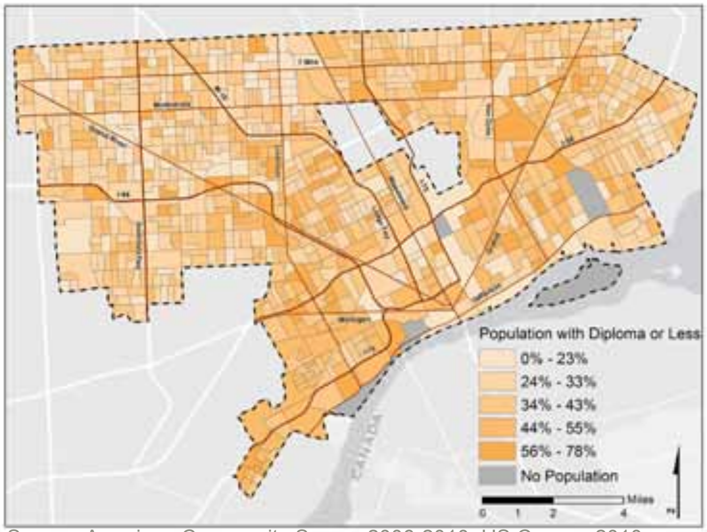
Source: USGS GloVis LandSat 7 ETM+; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

HEAT SENSITIVITY

Our analysis used four primary factors that contribute to increased risk of heat-related illness: residents 65 and older, lower educational attainment, poverty and household access to a vehicle. These four demographic variables measure human sensitivity to extreme heat. The literature used to derive these variables revealed the importance of neighborhood socio-economic positions, or group-level factors, in predicting risk of illness, independent of the influence of the same variable measured at the individual level[10]. For this reason, and due to the difficulty in obtaining individual-level income or health data, we conducted our vulnerability analysis at the census block group level.

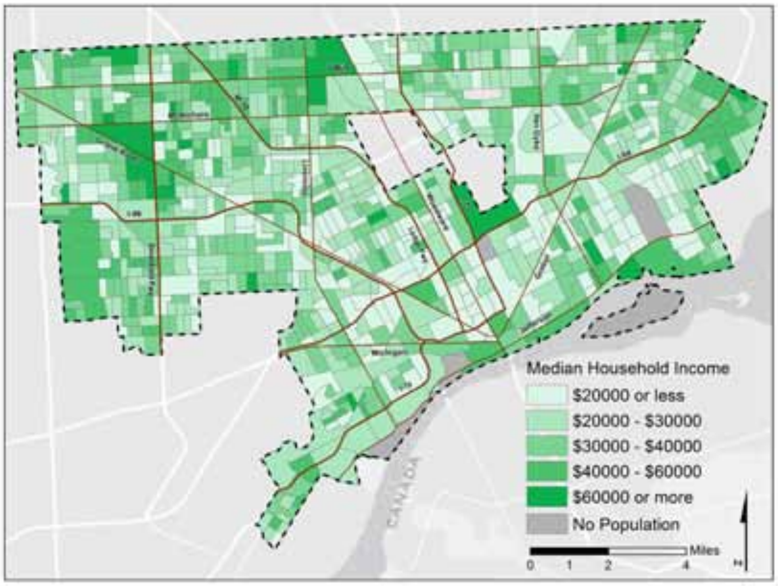
Two indicators of community level socioeconomic status are associated with increased heat-related mortality; these indicators include the percentage of the population without a high school diploma, and the percentage of the population living in poverty.[11] Research demonstrates a link between low educational attainment and poor health.[12] Moreover, specific studies of heat-related deaths in cities across the U.S. find greater mortality rates among individuals with lower levels of education because educational attainment is often a measure of quality of life, occupation and living conditions.[13] Using U.S. Census data obtained from Social Explorer, we calculated the percentage of each census block group holding no more than a high school diploma, as shown in Figure [4].

Figure 4:High School Education or Less by Census Block Group



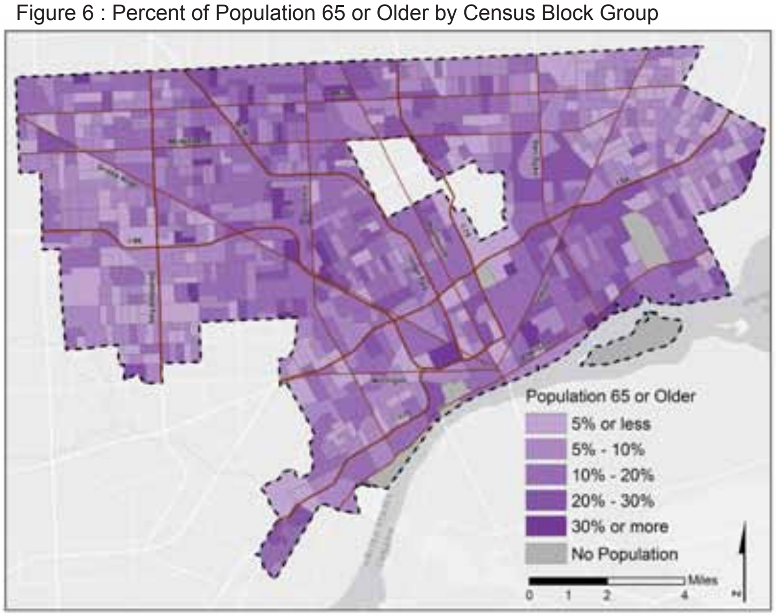
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 5 :Median Household Income by Census Block Group



Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 6 : Percent of Population 65 or Older by Census Block Group



Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

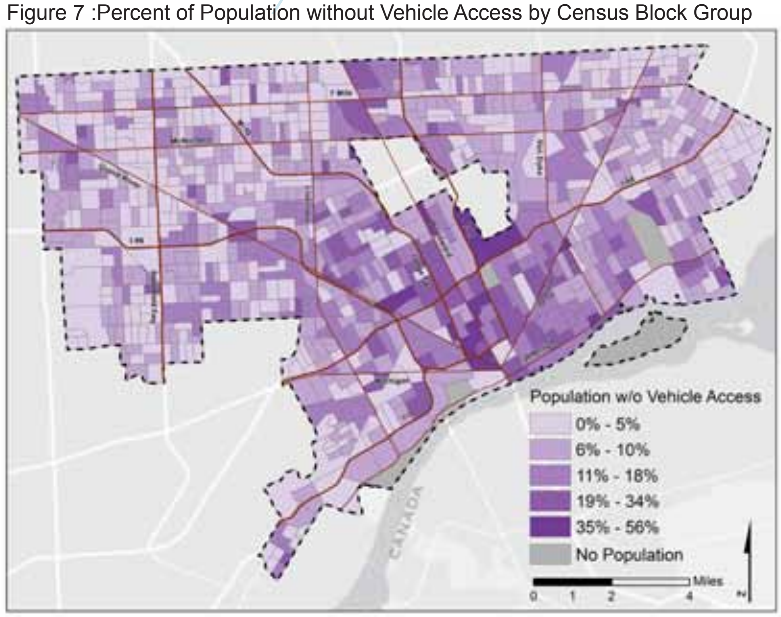
Similarly, wealth mitigates the risk of heat-related death by increasing access to air conditioning and other opportunities to avoid heat. On an individual level, "there is little doubt that poverty leads to ill health," and community levels of poverty have also been demonstrated to play a role in heat-related mortality.[14] Therefore, using census data obtained from Social Explorer, we calculated the median income of each census block group and stratified the census block groups by income level in order to identify the poorest neighborhoods, shown in Figure [5].

A significant body of literature has found old age to be a prominent vulnerability factor during extreme heat, effecting both hospital admission rates and mortality.[15] Since we could not access individual-level age data by household, we calculated the percentage of each census block group over age 65, as shown in Figure [6].

Finally, we included household access to vehicles as a contributing factor in the sensitivity index, since individuals without a vehicle are less able to drive to an air-conditioned cooling center or alternative refuge during extreme heat events. Using census data, we mapped the percentage of households in each census block group that had no vehicle access, as shown in Figure [7].

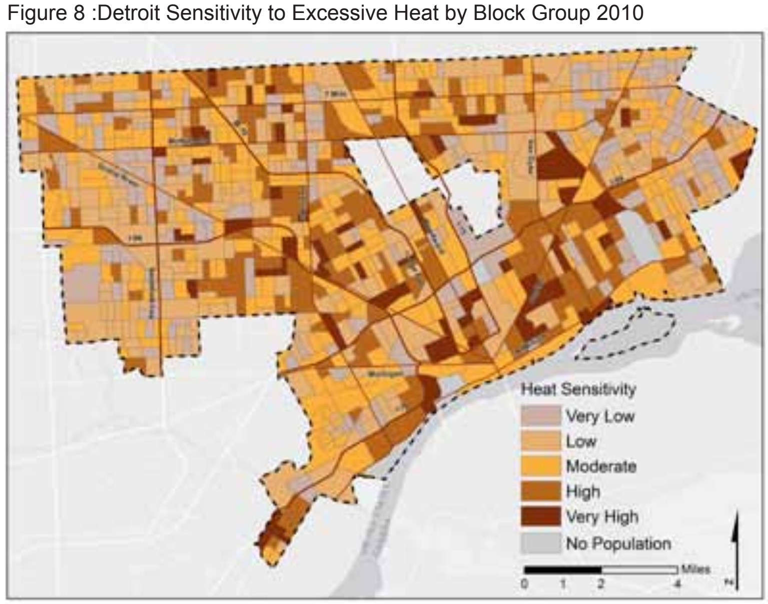
In order to understand the cumulative sensitivity, we calculated a sensitivity index. To do so, we converted the four variables to compatible scales so they could be combined to produce a single index. In order to normalize the variables, we computed the z-scores for each individual variable by subtracting the mean of the sample from each block group's score and then dividing the result by the standard deviation of the sample. This ensures that each of the rescaled variables has a mean of zero and a standard deviation of 1, allowing them to be combined directly. Areas of high sensitivity to extreme heat were geographically dispersed throughout the city, with small clusters in the downtown, southwest, and east sides of the city. The four socio-economic factors were equally weighted.

Figure 7 :Percent of Population without Vehicle Access by Census Block Group



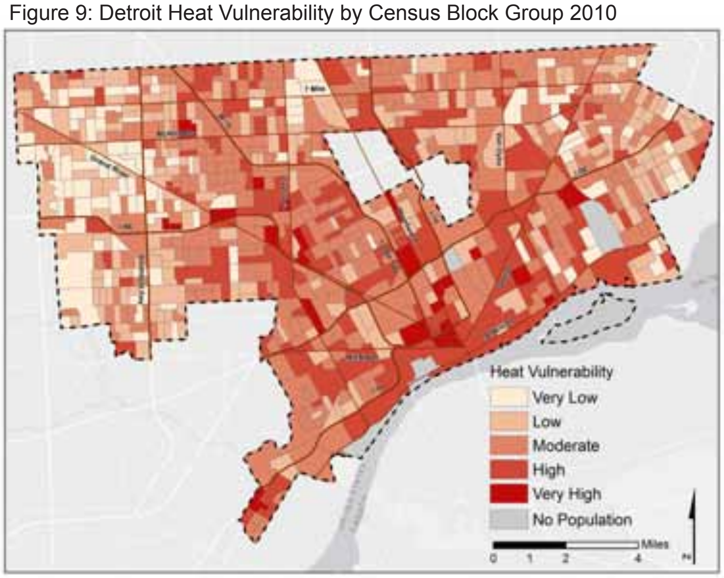
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 8 :Detroit Sensitivity to Excessive Heat by Block Group 2010



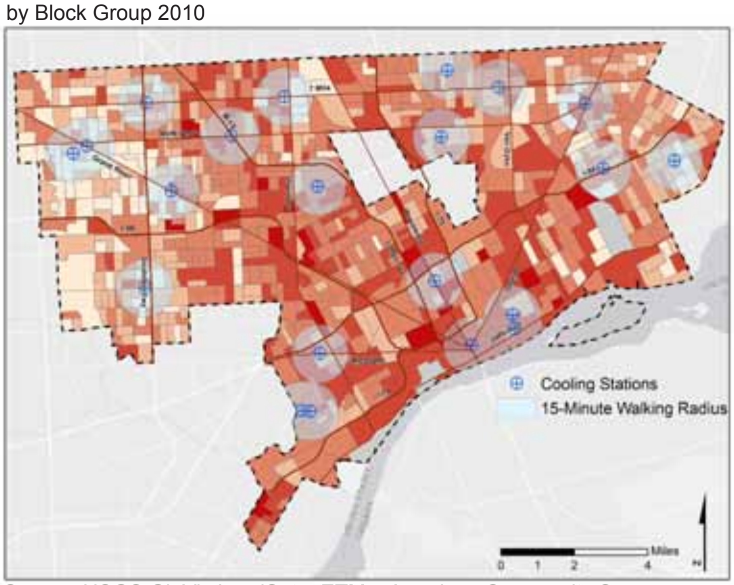
Source: American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 9: Detroit Heat Vulnerability by Census Block Group 2010



Source: USGS GloVis LandSat 7 ETM+;
American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 10 :Detroit Heat Vulnerability and Cooling Center Access by Block Group 2010



Source: USGS GloVis LandSat 7 ETM+; American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

HEAT VULNERABILITY

To identify areas of vulnerability, we created an index to combine our exposure and sensitivity indices.

This vulnerability index identifies the areas of the city where concentrations of exposure and sensitivity create higher risk for residents. Based on this methodology, vulnerability is distributed fairly randomly with notably lower levels in the Northwest portion of Detroit. In general, the most vulnerable census block groups are clustered roughly in the downtown area and the least vulnerable are in the northwest area of the city. Because this is a relative index, the vulnerability index does not represent any sort of absolute risk. Rather, the index identifies the block groups that are more vulnerable in comparison to other block groups in the city.

HEAT VULNERABILITY AND COOLING CENTER ACCESS

The City of Detroit opens facilities such as libraries and recreation centers to serve as cooling centers where residents can seek refuge during extreme heat events. To evaluate how residents are served by Detroit's cooling center network, we determined service areas. We used national working safety standards to determine the appropriate range of cooling center service areas. The Occupational Safety & Health Administration (OSHA) has determined threshold limit values (TLV) for external working conditions. The TLVs are designed to prevent body temperatures from exceeding 100.4° F when experiencing light to moderate exertion. They recommend that during 90° F heat events, each 15 minute period of light activity should be matched by 45 minutes of rest. Therefore, we used 15 minutes of outdoor exposure, while walking, in order to determine each service area. For pedestrians, 15 minutes translates into 0.775 miles, using an average speed of 3.1 mph[16]. We used the Buffer tool, a GIS function, to define an appropriate walking distance. We found that 24.3% of Detroit's land area is within a 15 minute walk of a cooling station. Calculations of the population served by each cooling center reveal that roughly 28.8% of Detroit's population is within a 15-minute walk of a cooling station.

We did not calculate automobile or transit service to cooling centers. While automobiles can often provide the most immediate source of relief, whether by air conditioning in the vehicle or quickest transport to a cooling center, 24 percent of Detroit households do not own a vehicle [17]. Transit also offers an air-conditioned mode of travel, but service times and coverage are limited, an issue further exacerbated by recent spending cuts [18].

Combining the cooling center service areas with the vulnerability map allowed us to determine what percent of Detroit's most vulnerable residents are adequately served. Figure [10] shows the walking service areas overlaid on the vulnerability index map. By selecting the top 20 percent of most vulnerable census block groups, we calculated that only 29.6 percent of the most vulnerable residents are within a 15-minute walk of a cooling station. This service area captures only 24.4 percent of the city.

According to these findings, the city's official response to extreme heat events — cooling centers — is not sufficiently addressing Detroit's needs. Since cooling centers are co-located with existing libraries and recreation centers, and are therefore likely to be a cost-efficient service, we would need to conduct further cost-benefit analysis to determine a recommended relocation strategy. We can, however, recommend opening additional cooling centers to serve more of Detroit's vulnerable population, especially those reliant on walking.

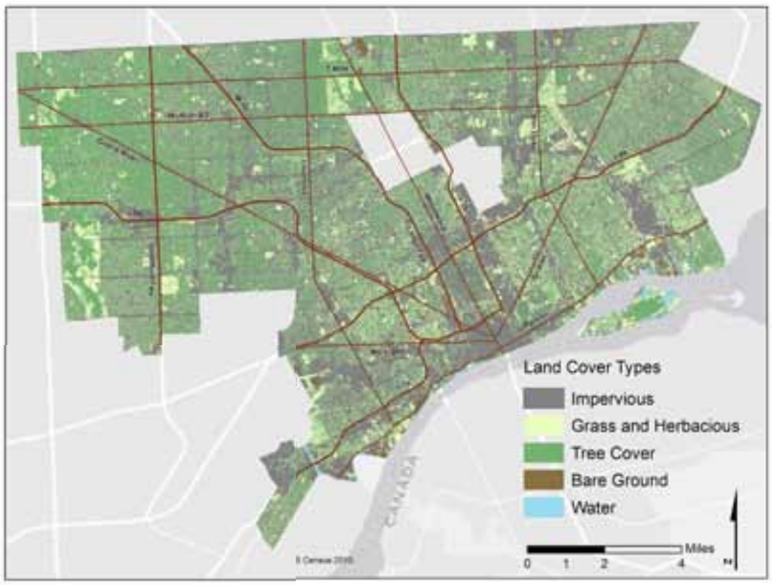
FLOODING: SYSTEM EXPOSURE

Compared to low-lying coastal cities such as New York or New Orleans, Detroit is not at risk from sea level rise or hurricane-induced flooding. Neither is it at risk for landslides of the type that can occur after heavy rainfalls in mountainous areas. However, the projected high volume of precipitation has the ability to overwhelm Detroit's combined sewer system and cause outfalls of untreated sanitary sewage into the waterways. At first glance this appears to be a problem completely for the Detroit Water and Sewerage Department (DWSD). However, after further analysis, our land use decisions are linked to, and have significant impacts on, sewer infrastructure.

When the sewer infrastructure cannot manage the stormwater runoff, excess stormater and sewage is directly discarded into the Rouge and Detroit Rivers. Because the city is serviced by a combined sewer and wastewater system, these discharges also contain untreated sanitary sewage. In 2011, Detroit discharged 7 billion gallons of untreated sewage into the Great Lakes system, making it one of the largest sources of pollution in the Great Lakes system[19]. While DWSD has embarked on significant grey infrastructure projects to address the discharge issue, the DWSD has not pursued green infrastructure projects that seek to deal with onsite stormwater before it reaches pipes. For this reason, our vulnerability assessment has focused on the burden of runoff into the sewer system as the main exposure to flooding.

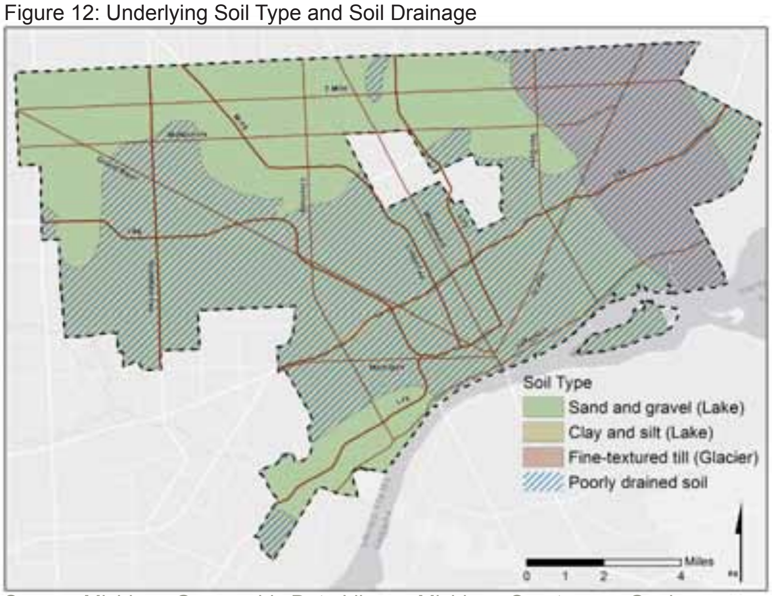
This vulnerability assessment only considered the exposure element of sewer system vulnerability, because we did not have information on the sewersheds' sensitivity factors. Sewershed information is important to obtain for future research and perhaps represents an important future

Figure 11 :Detroit Land Cover Type



Source: USGS GloVis LandSat 7 ETM+;
American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 12: Underlying Soil Type and Soil Drainage



Source: Michigan Geographic Data Library, Michigan Quarternary Geology
Map Prepared By: University of Michigan Detroit Climate Capstone

partnership for the DCAC and DWSD. However, exposure alone provides an excellent idea of what relative levels of burden will be imposed on the system by increased rain events and how these vary across the city by sewer district.

In this instance, exposure is the volume of the runoff from the surface that flows into the sewer system. The manner in which rainwater moves through the combined stormwater/ sanity sewer system is highly dependent upon where it falls. Impervious surfaces by their nature do not readily absorb water, and instead channel water into the sewer infrastructure. To quantify this exposure, called runoff burden, we considered three factors: land cover type, soil drainage type, and slope. The combination of these factors creates a runoff coefficient. This is a score ranging between zero and one that represents the amount of runoff that is generated at a particular site. Zero represents a site that generates no runoff and deals with all rainwater on site while a value of one represents a site that does not retain any water on site.

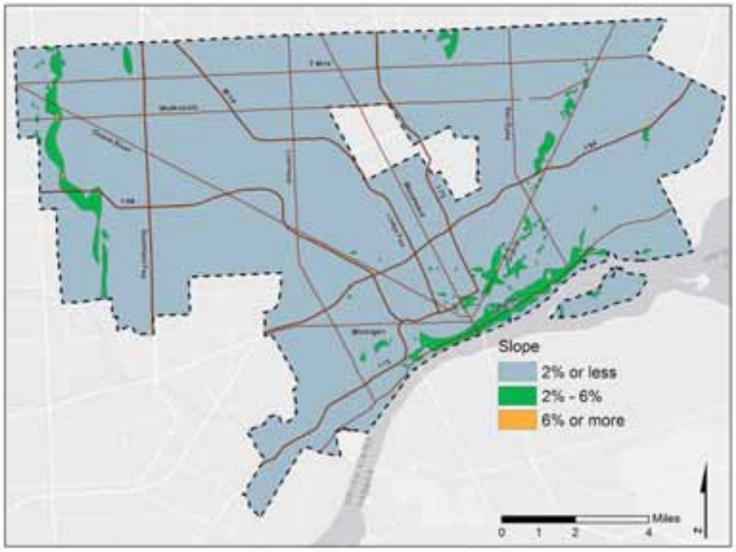
As with the assessment of heat, we utilized a land cover map obtained from the United States Geological Survey Global Visualization Viewer (GloVis) available at usgs.glovis.gov. Land cover was categorized into one of four categories: tree canopy, herbaceous cover, bare ground, or impervious surface. Areas covered by tree canopy contributed the least to runoff and areas covered with impervious surface contributed the most. While grassy and sparsely vegetated areas also have a lower runoff coefficient than tree canopy, bare ground and impervious surfaces contribute heavily with respect to runoff coefficients. These landcover runoff values are based upon standardized engineering tables.

Soil type impacts runoff volumes. In Detroit, three major soil types dominate. These different soil types have different percolation rates. Poorly drained soils (the clays, silts, and fine matter) are unable to remove water quickly, thus giving runoff more opportunity to go somewhere else. Therefore, poorly drained soils have higher coefficients than well drained sandy soils that quickly absorb water. Silt and clay soils are found towards the river and in the east side of the city. Sandy soil, that drains quickly and contributes less to runoff burden, is found primarily in the north and northwest areas of the city.

Slope is another factor that impacts runoff volumes. Areas with higher slopes shed water more quickly. Detroit has relatively little elevation change and therefore minimal slopes. We categorized the minimal slopes into three distinct categories: less than 2 percent, 2 to 6 percent, and greater than six percent. Only a few small areas of the city near the Rouge River in the northwest contain slopes of greater than six percent. The map illustrates how Detroit is a flat city with a gently sloping topography. The highest elevation points occur near M-10 and Eight Mile Road. From these high point, there it a gently slope southward toward downtown and the Detroit River. Most of the city then falls in an area of less than 2 percent slope.

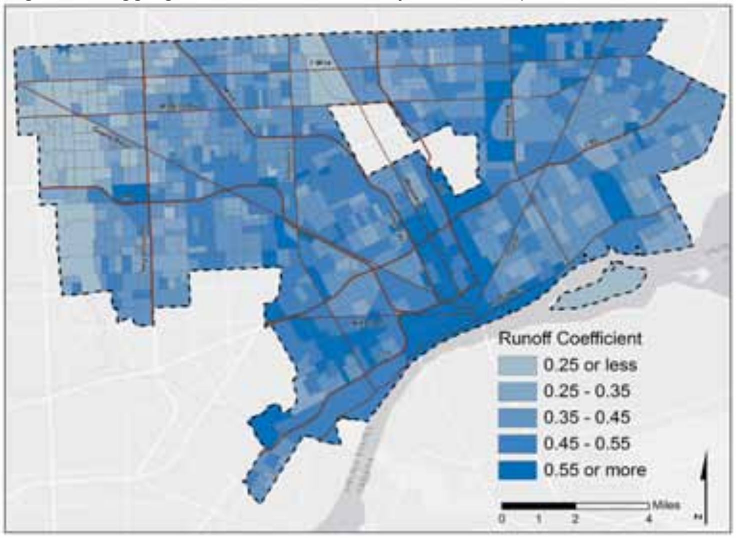
We generated unique land cover combinations based on the three factors — land cover, soil and slope — and determined each combination's relative abundance within each census block group. Based on the relative abundance and associated runoff coefficient for each combination, we created an aggregate runoff coefficient for the each census block group. The highest scores (areas of greatest runoff concern) tended to cluster around the downtown core and in areas of major impervious cover.

Figure 13: Topographical Slope as Percent Change in Elevation



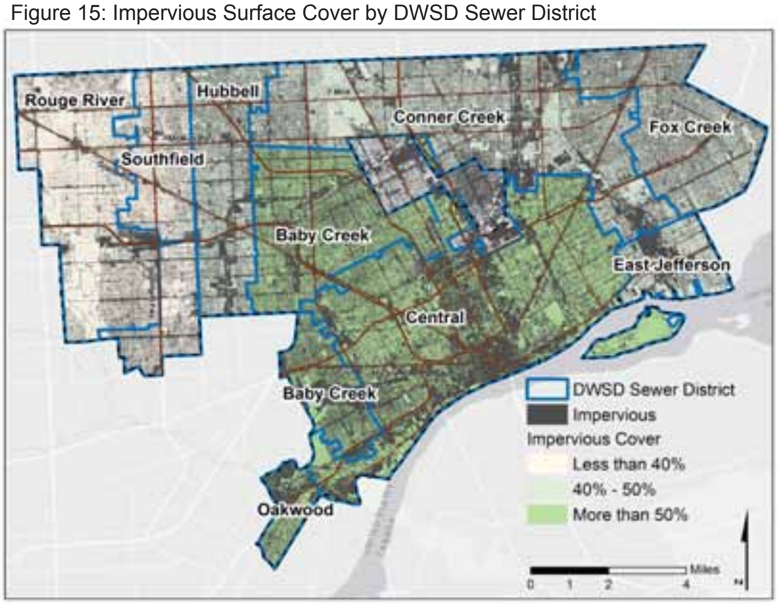
Source: Michigan Geographic Data Library,
Michigan Digital Elevation Model
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 14: Aggregate Runoff Coefficient by Block Group 2010



Source: Michigan Geographic Data Library; Michigan Digital Elevation Model; GloVis Landsat 7 ETM+; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 15: Impervious Surface Cover by DWSD Sewer District



Source: GloVis Landsat 7 ETM+;
US Census 2010; DWSD Wastewater Master Plan
Map Prepared By: University of Michigan Detroit Climate Capstone

However, block groups do not exist in isolation. Each block group's sewershed is part of a larger sewer district. Therefore, it is also useful to analyze the system at the sewer district level.

For instance, if a block group contributes a great deal to runoff burden, but the surrounding block groups do not, then the sewer district will be less likely to become overloaded. However, if that block group is surrounded by block groups that generate large volumes of runoff, then the reference block group is more likely to contribute to flooding.

There are nine sewersheds within the city. Impervious cover is the most predictive variable, due to its sizeable impact on runoff coefficients. Normalizing by the size of the individual sewer districts, we found that the percentage of land cover that is impervious within each sewer district varies widely. The percentage that exists as impervious surface ranges mainly between 40 and 60 percent, with only the Rouge River district in the northwest falling well outside the range (27 %). We added the sewershed-wide value to the individual block group score in an effort to understand the cumulative impact. In general, the most vulnerable areas cluster around the downtown core and around large areas of impervious cover (note SW Detroit). This assessment illustrates the importance of prioritizing on-site stormwater management in sewersheds with higher levels of impervious surfaces.

FLOODING: HOUSEHOLD EXPOSURE

Flood risk also exists at the household level. There are certain areas of the city that are more prone to the effects of flooding, and certain citizens would be impacted disproportionately. The household level analysis comprises the second component of our vulnerability assessment. The household flood risk exposure correlates highly to the household's relative location to floodplains. Household flood risk sensitivity refers to how well a household is prepared for or able to respond to that flood exposure.

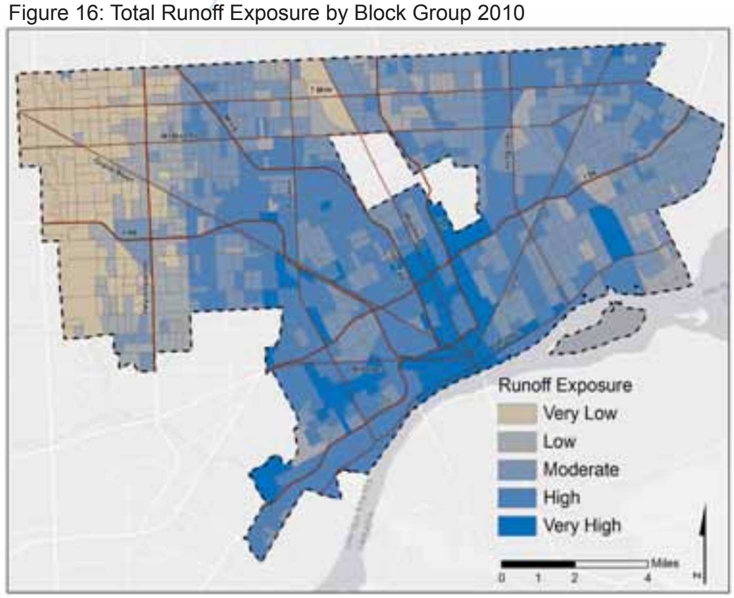
Our exposure assessment used FEMA's maps of 100-year and 500-year flood plains to determine whether a household was in an area of flood exposure. FEMA uses the flood plain maps to denote areas of special hazard and risk in terms of flooding. The terminology of 100-

year and 500-year floods refers to the probability in a given year—that is, an area in a 100-year flood plain has a 1 percent (1 in 100) probability of flooding in any given year. However, many cities are finding that these designated areas are flooding with increased frequency. If this trend persists, the larger 500-year flood plain may in effect become a more relevant area in addition to other low-lying areas. Moreover, areas along the Detroit River may be at increased risk in future years. As Figure [19] shows, areas of flood plain exposure are limited predominantly to two geographic areas: one along the Rouge River in the west, and the other in the southeast alongside Grosse Pointe Park and across from, and on, Belle Isle.

Sensitivity to a given flood exposure was determined by the age of the housing stock and the median household income. Homes built before 1940 used a more porous concrete material for basement construction. Water flows easily and more rapidly into these foundations relative to foundations that were constructed in later years. Additionally, homes that are older may be sensitive in other ways if residents have not had the financial resources to make significant upgrades. By incorporating median household income, we can distinguish older, well-maintained homes from older, at-risk homes. Residents with higher incomes are more likely to renovate their homes to prevent flooding or to repair flood damage. Additionally, flooding that displaces residents from their homes will have a disproportionate effect on low-income households. These households may not be able to afford to miss work or rent a hotel room.

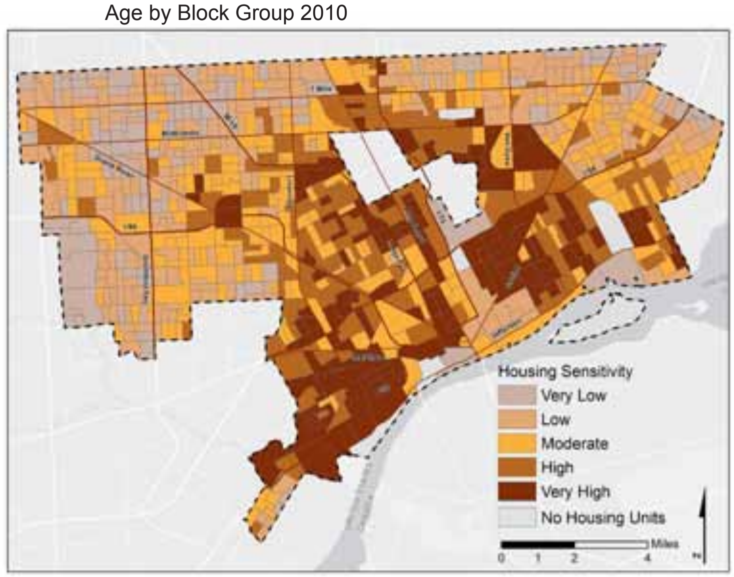
This map of the older housing stock and median household income may also be useful for other DCAC Work Groups that target lower-income housing

Figure 16: Total Runoff Exposure by Block Group 2010



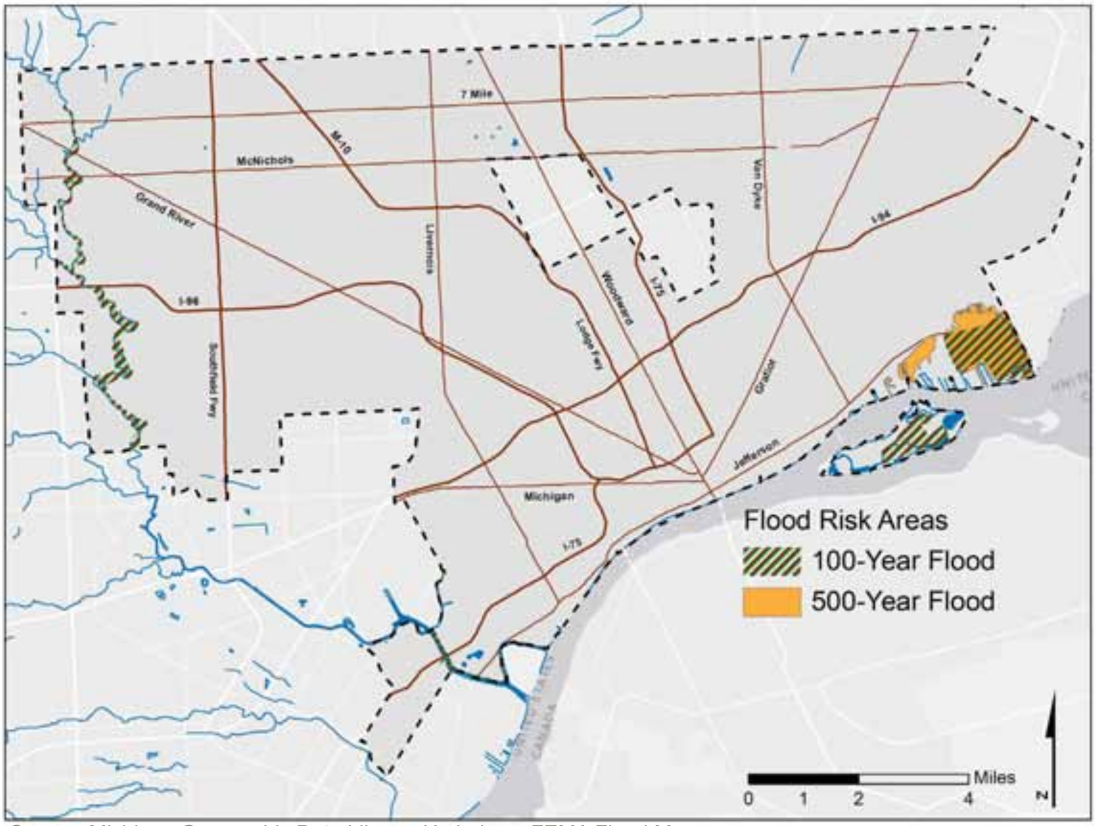
Source: Michigan Geographic Data Library; Michigan Digital Elevation Model; GloVis Landsat 7 ETM+; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 17: Housing Sensitivity Based on Income and Housing Age by Block Group 2010



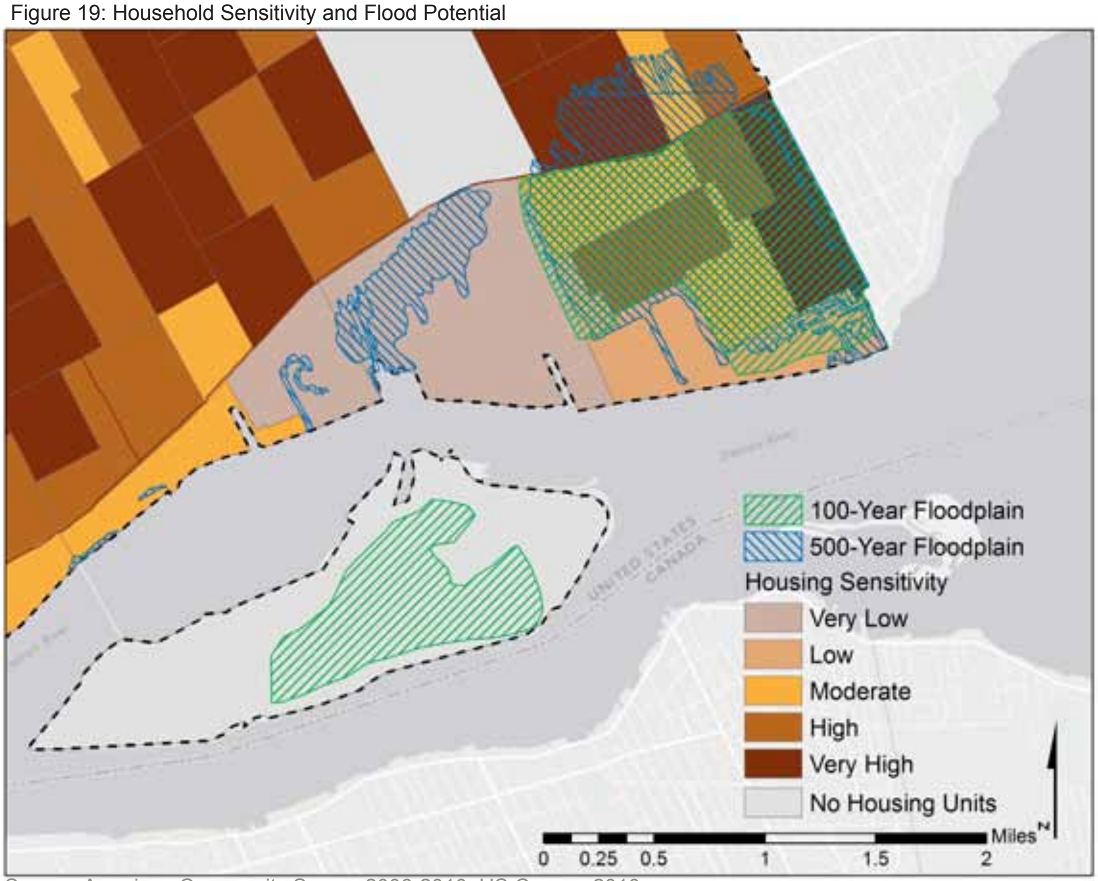
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 18: Flood Risk Hazard



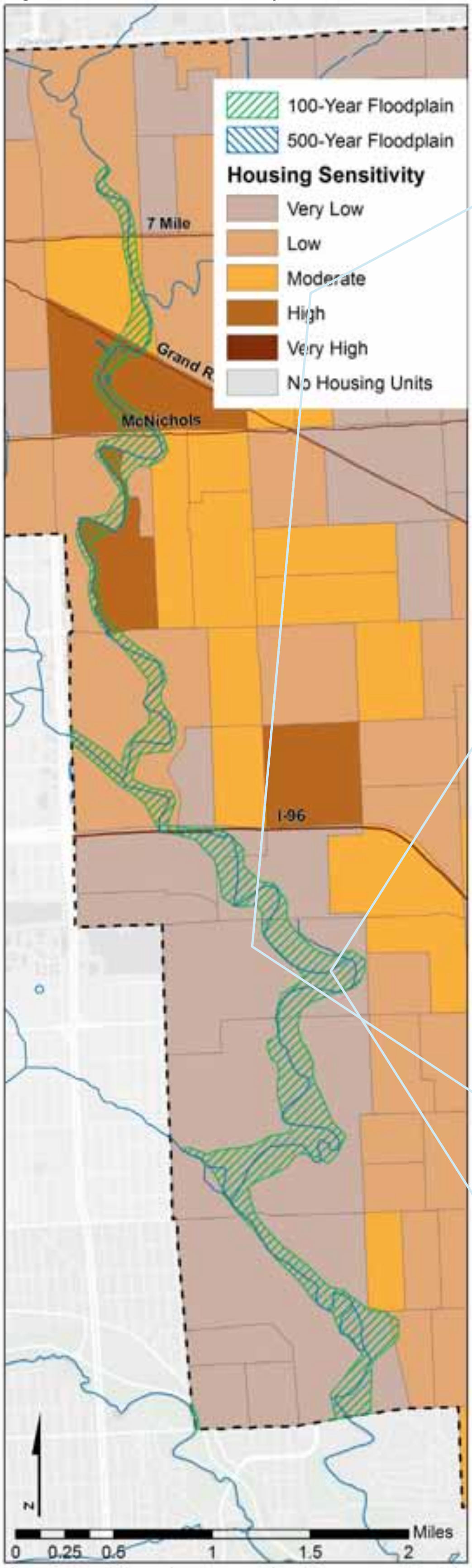
Source: Michigan Geographic Data Library, Hydrology; FEMA Flood Maps
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 19: Household Sensitivity and Flood Potential



Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 20: Household Sensitivity and Flood Potential



Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

By observing the overlap of the flood exposure areas and housing sensitivity, we can identify several block groups that are vulnerable to household flooding risk. We identified two areas of exposure concern. Figure [19] shows the Jefferson-Chalmers area in the east alongside Grosse Pointe Park, and Figure [20] shows the area on the city's west side near the Rouge River. Underlying the floodplain designation in these maps is a map of housing sensitivity using two variables, median household income and the percent of the housing stock built before 1940; these variables were analyzed at the block group level. This comparison is a relative measure, but it shows that even within the small geographic extents of these two maps, some census block groups tare more vulnerable than other nearby census block groups.

VULNERABILITY COMPARISON

When examining the maps of heat vulnerability and system flooding vulnerability, there are clear similarities. Because large areas of impervious surfaces with lower areas of tree canopy are more vulnerable to both extreme heat and runoff burden, many of the same areas of the city appear in both vulnerability assessments. However, this also presents the possibility of strategically locating interventions that address both problems.

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WORK GROUPS

This chapter discusses each Work Group in a detailed fashion. This section outlines specific Detroit-related issues pertaining to each Work Group, as well as a list of possible guidance strategies and indicators. As mentioned, these guidance strategies and indicators serve as a potential foundation for future action. Lastly, each Work Group section provides a list of resources; these resources cite works used in our analysis and provide a basis for further research.

The following encompass the seven Work Groups discussed in this chapter:

- BUSINESSES & INSTITUTIONS
- COMMUNITY PUBLIC HEALTH IMPACTS
- ENERGY
- HOMES & NEIGHBORHOODS
- PARKS, PUBLIC SPACE & WATER INFRASTRUCTURE
- SOLID WASTE
- TRANSPORTATION

BUSINESSES & INSTITUTIONS

Because of the varying size and scope of Detroit's businesses and institutions, the definition of "vulnerability" (as it pertains to these organizations) focuses on risk. Climate change often intensifies the risks normally associated with business operations, such as market, financial and supply-chain risk. Therefore businesses and institutions must address vulnerability and implement adaptation strategies, not just because of reputational gains, but because climate change can drastically affect consumption, operations and logistics. The following chart illustrates climate change's impact on risk factors for local businesses and institutions:

RATIONALE FOR GUIDANCE STRATEGIES

The two primary guidance strategies pertaining to Businesses and Institutions include:

1. Review and improve current business practices
2. Create sustainable green markets

Reviewing and improving current business practices ranks as a primary focus because it's effects are immediate and easily transformed. In order to make gains in eco-efficiency, firms and organizations must evaluate and catalogue ongoing practices. Upon the completion of this internal evaluation, firms and organizations can institute green programs. This strategy targets a broad array of firms and organizations, ranging from large-scale manufacturers to mom-and-pop retail stores and restaurants.

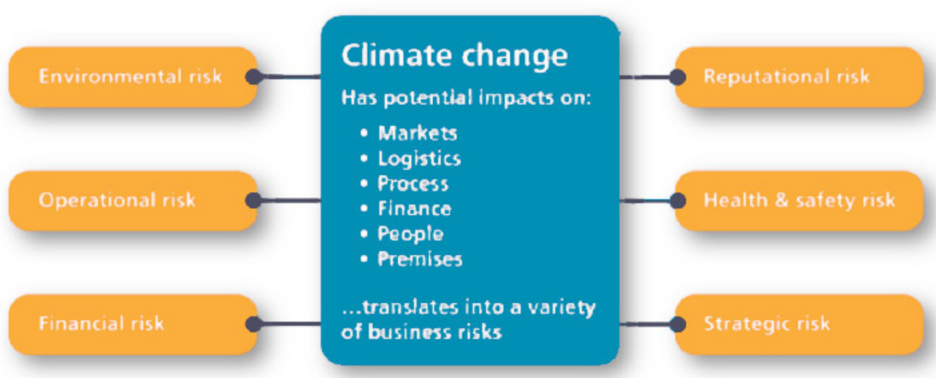

Figure 1 - Risks associated with climate change; Source: UKCIP

This section focuses on guidance strategies for Businesses and Institutions. These guidance strategies serve as an aid for the Work Group chair and members as they address vulnerabilities and risk factors associated with climate change. Moreover, these guidance strategies engage a wide range of businesses and institutions ranging from grass roots organizations and "mom-and-pop" stores to large conglomerates. This section provides options and avenues for Work Group members to explore ideas in an effort to mitigate the impact of climate change. In addition, this section outlines a few actions that will ensure the long-term sustainability of the project.

Secondly, creating sustainable green markets is crucial to the long-term sustainability of this Work Group. This strategy focuses on policy reform, regulatory action, capital attraction and capital investment. This guidance strategy focuses on the review and update of current environmental policy in order to determine areas of opportunity for capital investment. In addition, this strategy focuses on leveraging local incubators and accelerators as key assets in attracting venture capital and seed funding. The combination of these two guidance strategies address current vulnerabilities and build the foundation for future progress.

GUIDANCE STRATEGY #1 - REVIEW & IMPROVE CURRENT BUSINESS PRACTICES

This guidance strategy focuses on engaging current market movers within Detroit, as well as providing the foundation for future climate adaptation efforts. This section discusses potential "actions" and programs that will enhance current systems. Moreover, the indicators provide a framework for measuring the success of each action.

The following actions provide the foundation for the first guidance strategy:

1. Identify market movers and environment-oriented organizations
2. Engage and contact businesses and organizations
3. Partner with colleges and universities
4. Develop website for businesses and institutions to learn about green practices
5. Formulate and distribute "Green" checklist and survey for broad range of businesses
6. Create and distribute 'preparedness' checklist for climate emergencies
7. Leverage checklist and survey data for Green Certification program

The first three actions focus on building a strong coalition around climate action. By identifying and engaging key organizations and institutions, this Work Group can move forward in a cohesive, sustained fashion. The fourth action step builds upon the community engagement process by leveraging technology. More specifically, an internet presence provides a platform for awareness, education and consensus building with regard to businesses, institutions and climate action.

Actions five and six motivate businesses and institutions to analyze existing practices. Step five deals specifically with outlining a guide for organizations to reflect upon current behaviors; upon completion of this checklist and survey process, companies will have a heightened

DEFINITION

GREEN JOBS
Produce ("supply") goods or services that result in: generating and storing renewable energy, recycling existing materials, energy efficient product manufacturing, distribution, construction, installation, and maintenance, education, compliance, and awareness, and natural and sustainable product manufacturing

ENVIRONMENTAL RISK
Vulnerable aspects of organizations that are exacerbated by climate change; Factors of production and capital flows are influenced dramatically by extreme weather events and changing climate conditions

Source: By Michigan Municipal League

sense of awareness with regard to company practices and climate action. Step six focuses on extreme weather events and the preparedness of businesses and institutions. As the propensity for extreme weather events increases, organizations must prepare for these events by developing thorough "game plans."

The last action deals specifically with leveraging data compiled through steps five and six in order to create an independent agency. This agency would monitor businesses and institutions in their pursuit of green practices and adaptation policies. In some examples, cities created an independent entity that monitors these business practices and rewards environmentally conscious organizations with specific certifications. The primary goal of this type of program focuses on the idea of creating a strong social contract between the organizations and the community.

As mentioned, the actions for the first guidance strategy requires indicators — these indicators serve as metrics with which we can measure success. Some key indicators for the first guidance strategy are listed below:

1. Number of program participants
2. Website hits and social media presence
3. Receipt of grant money and philanthropic donations
4. Presence of coalition in community

The first indicator measures the number of program participants, especially with regard to businesses partaking in the checklist process for existing practices and climate preparedness. Although this indicator is basic in nature, it provides a good sense of momentum associated with the Work Group's efforts.

The second indicator resembles the first, as it quantifies activity related to the Work Group's internet presence. Similarly to the first indicator, an increase in unique visitors to the Work Group's internet platforms indicate an increase in community interest.

The third and fourth indicators deal with the Work Group's ability to generate capital and influence. The receipt of grant funding and philanthropic donations allows for greater investment into the Work Group's efforts, as well as recognition amongst community members. In addition to funding, the DCAC's presence within the community further indicates the success of the Work Group's efforts. Measuring the Work Group's presence within the community may simply include the DCAC's ability to meet with City officials and other leaders with regard to business development and land use decisions.

AS THE PROPENSITY FOR EXTREME WEATHER EVENTS INCREASES, ORGANIZATIONS MUST PREPARE FOR THESE EVENTS BY DEVELOPING THOROUGH "GAME PLANS."

STRATEGY #2 - CREATE SUSTAINABLE GREEN MARKETS

The guidance strategy centers on the identification and pursuit of market opportunities pertaining to green ventures. This guidance strategy focuses on a two-prong approach. The two prongs of this guidance strategy include:

1. Implement "Green Procurement" process
2. Attract green social ventures and promote entrepreneurship

The first prong deals specifically with procurement. Procurement processes refer to rules and regulations pertaining to the acquiring of goods and services. Typically, procurement processes focus on the manufacturing and distribution components of the supply-chain. A prime example of a local green procurement process involves Detroit Diesel's voluntary participation with the Environmental Protection Agency (EPA) in order to improve energy efficiency. Detroit Diesel's initial investment into property, equipment and manufacturing processes led to long-term gains. The company is currently a market leader in green manufacturing and continually receives recognition for their efforts.

Implementing green procurement practices involves conducting a Strengths/Weaknesses/ Opportunities/Threats (SWOT) analysis and determining the key market opportunities. The identification of these market opportunities is crucial with regard to the pursuit of policy reform as well as the encouragement of green procurement.

The following indicators pertain to green procurement:

1. Identify a market opportunities with regard to green procurement
2. Complete independent study on economic impact of green procurement implementation
3. Complete study describing capital requirement for green procurement process

The first step refers to the necessary analysis required for identifying market opportunities and outlining potential strategies for implementation. Although this indicator is not measured quantitatively, it requires thorough discussion and continual engagement. Once market opportunities are identified, the second indicator serves to support the pursuit of such opportunities. An economic and fiscal impact study informs whether the pursuit of such market opportunities results in a positive outcomes for local employment. Such outcomes are often a key selling point with regard to receiving funding, incentives and political support. Lastly, the third indicator refers to capital requirements necessary for green procurement. Studies explaining the costs and benefits of green procurement aim to further encourage the involvement of the business community.

Similarly to the first strategy, the second strategy — attracting green social ventures and promoting social entrepreneurship — employs a two-prong approach. The first prong focuses on attracting green venture capital groups. Organizations such as the Green Garage already exist within Detroit in order to foster incubation. This particular strategy seeks to attract capital in order to aid in the launch and scaling of these businesses.

Source: By Kevin.Ward

The second prong relates to the establishment of social entrepreneurship programs within Detroit. Through leveraging partnerships with institutions of higher learning and local businesses, the Work Group can create an environment that promotes talent attraction and development.

The following indicators pertain to attraction of green venture capital and promotion of social entrepreneurship:

1. Monitor total venture capital investment
2. Measure number of environmentally-oriented start-ups
3. Monitor venture-backed jobs in Detroit
4. Ensure ventures stay in Detroit and do not relocate

The first three indicators provide a simple, effective measure with regard to the attraction and sustainability of venture capital. The Work Group can identify venture capital groups investing in green business by the number of groups that have already invested in green ventures (or in the process of). Moreover, the number of start-ups and jobs associated with these green ventures provides a way in which the Work Group can measure the sustainability of these pursuits.

Lastly, the creation of a sustainable, flourishing green economy must focus on the retention of green ventures. By collaborating with start-ups and economic development agencies, the Work Group can create an environment conducive to the long-term success of the green economy. Examples of such collaboration include creating a network for green businesses within Detroit, as well as streamlining regulatory processes for green businesses.

RESOURCES

Bizdom.
<bizdom.com>
Bizdom is an entrepreneurship accelerator that helps entrepreneurs launch, fund, and grow innovative, tech-based startups in Detroit and Cleveland.

Detroit Creative Corridor Center.
<detroitcreativecorridorcenter.com>
The Detroit Creative Corridor Center is designed to support the growth of Detroit's creative economy by delivering business acceleration and attraction services and developing signature programming tailored specifically to creative professionals' needs.

Detroit Diesel. May 6 2009. "Detroit Diesel Launches New Green Initiatives." <http://www.demanddetroit.com/pdf/press/pr-2009-05-06a.pdf>

Detroit Venture Partners.
<detroitventurepartners.com>
Detroit-based venture capital firm that invests in early-stage technology companies.

Green Garage Detroit. <greengaragedetroit.com>
Mid-town based business enterprise that is committed to the sustainability of Detroit.

Greening of Detroit. <greeningofdetroit.com>
The Greening of Detroit is a 501(c) (3) not "for" profit organization established in 1989 to guide and inspire the reforestation of Detroit. In 2006, a new vision was established, expanding The Greening's mission to guide and inspire others to create a 'greener' Detroit through planting and educational programs environmental leadership, advocacy, and by building community capacity.

United Kingdom Climate Impact Programme.
"Climate Adaptation Wizard." <http://www.ukcip.org.uk/wizard/>


Source: By Daviddje

COMMUNITY PUBLIC HEALTH IMPACTS

Public health works to prevent disease, injury and death, and promote well being for individuals and communities. Because the effects of climate change will worsen many existing health problems, and create potential new ones, the field of public health is working to identify factors that make people more sensitive to these negative effects.

DETROIT CONTEXT

Not all negative effects of climate change will manifest in Detroit, nor will all be equally dramatic. The leading causes of death in Detroit in 2007-2008 were heart diseases, cancers, cerebrovascular diseases, assault, and accidents.[1] While climate change does not directly cause cardiovascular or respiratory diseases, heat and poor air quality exacerbate them.[2] Additionally, severe weather that displaces people from their homes, jobs, and communities can have negative secondary effects and even cause problems of mental health or chronic stress.[3] Each of these issues affects children; additionally, children suffer disproportionately from environmental pollution, such as air pollution or lead paint in the home.[4] Because the city has a high proportion of low-income residents, any change in food prices due to shortages will have a disproportionately negative impact on the community.

DEFINITION

PUBLIC HEALTH

“Public health works to prevent disease, injury and death, and promote well being for individuals and communities.” (Source: American Public Health Association)

EXTREME HEAT EVENTS (EHE’s)

Refers to unusually hot temperatures and/or high humidity readings compared to the typical regional average for that season.An EHE occurs when the daytime high is above 90*F and the nighttime low temperature remains high limiting relief from the heat. (Source: EPA)

VULNERABILITY

The main biophysical exposures that influence public health are extreme heat, extreme cold, air quality, water quality, flooding or extreme weather events, insect-borne disease, and increase in food prices. Since vulnerability is comprised of biophysical exposures and sensitivity, public health efforts should target its emergency and preventive strategies at the most sensitive population. There are two main groups of factors that increase sensitivity. Physical factors include age (such as the very young or very old), disease, and physical mobility or disability. Social factors that increase vulnerability include poverty, language barriers, social isolation, lack of education, and transportation access, such as having access to a vehicle.

RATIONALE

The main danger from increased heat is not an increase in temperature but the frequency of extreme heat events (EHEs)[5], sustained high temperatures over a period of days. Cities with low-density land use spread over large areas, such as Detroit, “have been associated with enhanced surface temperatures”[6], intensifying the risk of EHEs. The projected increase in EHE days will cause Detroit to experience a four-fold increase by the end of the 21st century, from 9 to 36 days[7]. According to the National Oceanic and Atmospheric Agency, “Cities in the northeastern and midwestern United States have the strongest weather mortality relationships, because weather variability, rather than heat intensity, is the single important factor in defining human sensitivity to heat”[8]. This may occur because people don’t know how to cope with temperature extremes they are unfamiliar with or do not perceive themselves as vulnerable to this risk[9].

Extreme heat is dangerous to those who are very old, very young, homebound, lack air conditioning, are socially isolated, or who suffer from chronic physical or mental illness[10]. With an increase in extreme heat events, there will be an increased risk of heat-related deaths and exacerbation of illnesses[11]. Additionally, the high electricity demand for air-conditioning during a heat event increases the risk of brownouts and power outages, further isolating potentially vulnerable groups. People who suffer health effects as a result of heat may survive the EHE itself but succumb in the two-week period following the event.

Greenhouse gas emissions also have chemicals (NOCs and VOCs) that are ozone precursors, meaning that they interact with heat and chemically transform into harmful ozone particles. "Higher temperatures hasten the chemical reactions that lead to ozone and secondary particle formation"[12]. With higher ground-level temperatures, these reactions will happen more, leading to a decrease in air quality and an increase in harmful effects on people's respiratory function.

Breathing ozone "can cause inflammation in the deep lung as well as…decreases in lung function".[13] Exposure to ozone and other airborne pollution can increase respiratory illness, asthma attacks, asthma-related hospital visits, and even premature death. People who spend more time outdoors, such as children and laborers, will have greater exposure and therefore greater risk.

There may be fewer deaths from exposure, because winter temperatures overall will be warmer. However, there may be more frequent extreme winter precipitation events, such as blizzards and ice storms. While everyone may suffer the same exposure to a severe weather event, not all people are vulnerable in the same way. Blizzards and other storms that block roads and isolate people pose a specific hazard to older people and those with chronic health conditions who will be cut off from help. Homeless individuals will be at greater risk of death from exposure when an event comes on suddenly. Additionally, low-income people may suffer damage to their homes or lose income

DEFINITION

VOCs and NOx

"Volatile organic compounds (VOCs) and nitrogen oxide (NOx) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC." (Source: EPA)

OZONE PRECURSORS

Ground level ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC). These chemical reactions are accelerated by heat.

APPARENT TEMPERATURES

Calculation of what people perceive as the temperature in hot and humid conditions. (Source: National Oceanic and Atmospheric Administration)

Source: By josephhleenovak

from missing work. Potential power outages associated with storms may compound these difficulties.

Extreme precipitation events can flood the sewer system with a high volume of water in a short period of time. Overflow of the combined sewer system can release untreated sewage into local rivers and streams, causing a hazard to human health. The current combined sewer system may have inadequate capacity to absorb and process the volume of water runoff from an extreme precipitation event. This could lead to sewer overflow, water contamination with sewage, and water contamination from surface runoff. Children, the elderly, pregnant women, and those with compromised immune systems are especially at risk for waterborne diseases [14].

While Detroit will likely not experience the type of flooding seen in coastal cities such as New York, extreme precipitation could nevertheless have negative effects on residents. Flooding of homes and neighborhoods could be costly for homeowners and displace residents, causing homelessness and disrupting the fabric of the community.

Changing temperatures will push back first frosts later in the fall and last frosts earlier in the spring, lengthening the season for insects. Since 2002, Michigan has seen the emergence of insect-borne diseases such as West Nile, Lyme disease, and Equine Encephaly. Additionally, flooding or heavy rainfall can create breeding grounds for these insects. Resulting in an increase in infected insects and an increased risk of human exposure. Nearly all individuals in Michigan who have died from West Nile virus have been sixty-five or older.

While Michigan is better positioned to withstand drought than other regions of the country, food shortages caused by droughts during the growing season increase the price of food. Such price increases, even small ones, disproportionately impact low-income people. If drought increases the price of fresh foods, residents may turn to less healthy, processed foods to stretch their budgets. One final factor to consider is the extreme vulnerability of homeless people to all of these impacts. They have the least financial resources to deal with any effects of heat and flooding, and because they spend more time outdoors, they are extremely sensitive to physical exposures to heat, air quality, and flooding.

DEFINITION

SYNDROMIC SURVEILLANCE

Michigan's Syndromic Surveillance System facilitates rapid public health response to outbreaks of illness and other public health threats by using real-time detection through automatic data collection and other tools. (Source: Michigan Department of Community Health)

URBAN HEAT ISLANDS (UHI)

UHI is defined as increased surface and air temperatures in urban areas relative to surrounding suburban and exurban areas. UHI patterns vary by region, occur in more dispersed pattern than once thought, may increase or decrease over time, and are most problematic during warm weather.

ALL HAZARDS PLAN

Plan to address all aspects of emergency preparedness, from security to natural disasters. Detroit's Office of Public Health Emergency Preparedness coordinates its All-Hazards Plan.

HEAT HEALTH WARNING SYSTEM

Tool developed by National Oceanic and Atmospheric Administration for statistical analysis of heat threats for specific regions to allow for better forecasting of extreme heat and improve the public health response.

INDICATORS AND STRATEGIES

The following provides indicators, potential strategies, and potential goals for each public health issue.

Heat

Indicators

- Number of heat-related deaths
  Work with Medical Examiner to explore how ICD codes used to indicate cause of death could be used as a tool to track heat-related deaths
- Number of potentially heat-related deaths
  Track deaths relative to baseline in the two-week period after an extreme heat event
- Number of cooling centers open during an extreme heat event
- Ground-level apparent temperatures (heat index) throughout the city and in known heat islands
- Percent of tree canopy coverage in known heat islands
- Number of heat-related hospitalizations and emergency room visits during extreme heat events
- Average distance to refuge cooling station for residents
- Numbers of people using refuge cooling stations

Potential Strategies and Goals

- Goal: Reduce heat-related deaths and illnesses
- In the short term, public health strategies use cooling centers to prevent heat-related deaths and illnesses. However, while use of air conditioning saves lives now, it increases greenhouse gas emissions and thus worsens climate change in the long term. Long-term strategies that actually cool the built environment and mitigate the urban heat island effect should be the ultimate goal.
- Create or update the City's heat wave response plan, based on other municipal response plans[15]
- Increase number of residents with working air conditioning (in conjunction with energy-efficiency measures)
- Improve access to cooling centers, both in terms of number of stations and geographic distribution
- Improve residents' awareness of cooling centers through outreach strategy
- Increase awareness of vulnerable populations about risks of heat illness
- Work with state Syndromic Surveillance to better track heat-related hospitalizations and deaths
- Decrease ground-level temperatures in known urban heat islands (UHI) by increasing tree coverage and converting impervious materials to vegetative coverage
- Implement green-roof or white-roof initiative to reflect instead of absorb heat
- Incorporate climate projections into All Hazards Plan
- Reach out to home services such as Meals on Wheels, other senior services, to contact isolated or homebound individuals
- Work with apartment buildings and neighborhoods organizations to institute block or floor captains to check on residents
- Implement Heat Health Warning System when possible, based on NOAA Heat/ Health Warning System, to forecast excessive heat

Source: By CR Artist

Air Quality

Indicators

- Frequency of ozone action days
- Ground level ozone and particulate matter in known "hot spots"
- Frequency of respiratory illness during ozone action days or heat days as measured in hospital/emergency room admissions

Potential Goals and Strategies

- Work with industry to reduce toxic release of ozone precursors
- Identify proximity of power plants, incinerator, toxic release facilities to dense residential areas or school
- Aggressively prevent truck and other heavy traffic from residential areas
- Create vegetative buffers or other filters between residential and highway
- Track admissions for respiratory illness for early warning and action
- *Many other strategies to address climate change in other areas (such as switching to renewable sources of energy, encouraging biking rather than driving) will also have positive effects on public health.*

DEFINITION

OZONE ACTION DAYS

Days that ground-level ozone exceeds acceptable levels for human health. Breathing in ground level ozone can harm our health. Even relatively low levels of ozone can cause health effects. People with lung disease, children, older adults, and people who are active outdoors may be particularly sensitive to ozone. (Source: EPA)

Exposure and Cold-Related Deaths

Indicators

- Number of cold-related deaths
- Number of people taking advantage of warming shelters
- Number and duration of winter power outages

Potential Goals and Strategies

- Outreach to homeless population, homebound and elderly in anticipation of a severe storm and immediately after
- Increase awareness of warming shelters or other resources

Water Quality

Indicators

- Capacity of water treatment systems
- Instances of combined sewer outflow release
- Coverage of absorptive vegetation
- Instances of water-borne illness

Potential Goals and Strategies

- Increase public information on frequency and location of sewer outflows
- Increase techniques to absorb water and reduce runoff into sewer—swales, vegetation.
- Incentivize homeowners to reduce runoff by crediting their sewer bill when they implement rain barrels, other on-site collection and absorption techniques
- Work with hospitals to better track admission for possible water-borne illnesses
- Additional techniques from the Parks, Open Spaces and Water Infrastructure group will also benefit human health by improving water quality

Flooding

Indicators

- Number of roads impassable from flooding
- Number of homes damaged from flooding
- Number of people displaced from flooding

Potential Goals and Strategies

- Work with Parks, Open Spaces, and Water Infrastructure to prevent flooding
- Work to increase awareness of flood insurance in areas with high water table or low elevation
- Collaborate with Homes and Neighborhoods work group to change landscaping and other techniques to divert water from homes

Insect Borne Disease

Indicators

- Number of infected insects tested relative to same time previous year
- Number of people admitted for insect-borne
  diseases over same time previous year
- Measure public awareness of symptoms and how to detect
- Measure medical community awareness of symptoms

Potential Goals and Strategies

- Continue education to medical community about recognizing symptoms
- Continue education to vulnerable populations about recognizing symptoms
- Drain flooded areas
- Employ larval insecticide in heavily infested areas
- Secure homes with screens, bed nets to keep out insects

Source:By CR Artist

Food Price Changes

Indicators

- Percent change in price of staple foods, normalized for inflation
- Percent change in price of fruits and vegetables, normalized for inflation
- Percent change in residents using food pantries
- Percent change in residents who report greater food insecurity

Potential Goals and Strategies

- Support access to community gardens, urban farms, and other sources of food for residents
- Publicize food pantries and similar resources during times of high food prices

Source: Michigan Municipal League

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ENERGY

Energy consumption pervades every aspect of our modern world and is a major hurdle toward building a more sustainable and resilient community. The U.S. Department of Energy divides energy use into five sectors: residential, commercial, industrial, transportation and utilities. The DCAC can operationalize these sectors as (1) built environment energy consumption, and (2) energy supply and distribution. A serious effort to impact the DCAC's stated goals to reduce greenhouse gas emissions for the sustainability and well-being of the City of Detroit, and increase the resilience of the city's social, built and natural environments, must cast a broad net. Strategies and indicators for each sector encompass aspects of both climate mitigation and adaptation. To approach the tasks as outlined by the DCAC Workgroup Guide, the following general approach should inform and guide the process:

1. Coordinate with other work groups (Neighborhoods, Transportation, Parks, etc.) to develop cross-linked indicators that impact energy use.
2. Seek mitigation strategies to reduce overall energy consumption per capita or per unit of economic activity
3. Approach climate adaptation by minimizing energy distribution vulnerabilities.

DETROIT CONTEXT

In a warming climate, reliable energy delivery becomes crucial as Detroiters use more electricity for air conditioning. If the region's average annual climate warming trends continue by the predicted 1.4°F, the associated demand for energy used for cooling will increase by about 5-20 percent.[1,2] Meeting increases in this peak demand could require investments in new energy infrastructure. For example, based on a 6°F to 9°F temperature increase in summer, climate change could increase the need for additional electric generating capacity by roughly 10-20 percent by 2050 in the region.[3] This would require a significant additional investment to upgrade and repair infrastructure. Likewise, the age of housing stock affects the efficiency of home energy use, requiring significant upgrades to weatherize houses and decrease unnecessary home energy use.

ENERGY VULNERABILITY

Energy vulnerability focuses on threats posed by extreme weather events associated with climate change that can disrupt infrastructure services. These disruptions often cascade across energy infrastructure, compounding both the geographic extent and complications of restoring service. For example, the 2003 Northeast blackouts were compounded due to infrastructure failures at multiple points throughout the Northeast and Midwest. As successive systems failed, the increased burden overwhelmed associated infrastructure. Such events threaten public health and local economies, especially in areas where human populations and economic activities are concentrated in urban areas. Implications of climate change for energy infrastructure vulnerability in Detroit include:

1. Extreme weather events (flooding, severe weather, etc.) associated with climate change will increase disruptions of energy delivery.[4]
2. Less extreme weather events associated with climate change such as extended warm weather, freeze-thaw cycles, or freezing rain, occurring in rapid succession can also damage or overwhelm energy delivery infrastructure.[5]
3. Disruptions of services in one infrastructure will almost always result in disruptions in one or more other infrastructures, especially in urban areas, triggering serious cascading infrastructure failures. For example, if electricity supply is disrupted, storm water systems without sufficient backup systems will consequently fail.[6]

4. These risks are greater for infrastructure that is already stressed by age or by demand levels that exceed what they were designed to deliver.

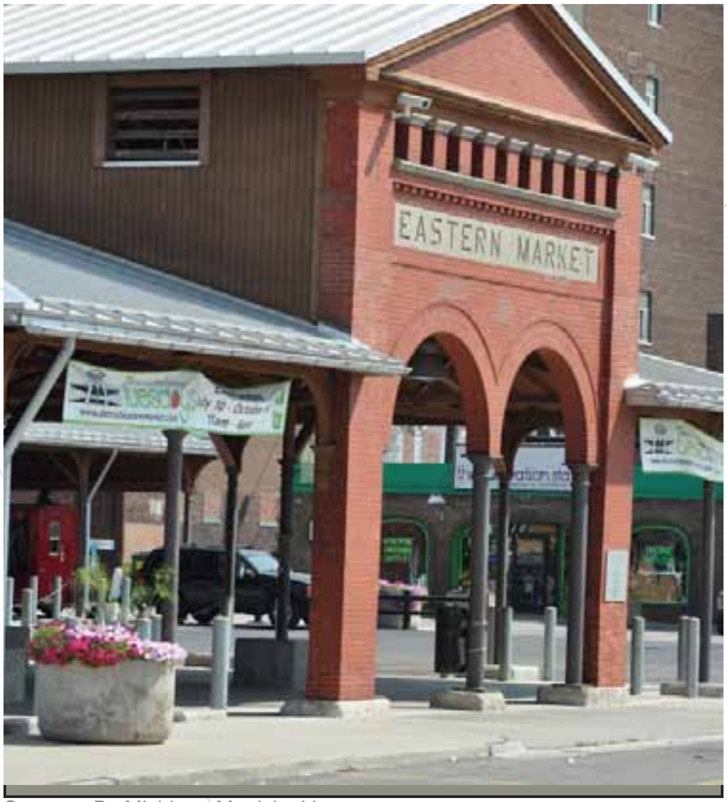
GOALS FOR OPERATIONAL AREAS

This document identifies five potential goals concerning Detroit's energy operational areas. Subsequently, this report provides a mitigation or adaptation rationale for each goal, as well as some potential strategies, and indicators that might be used to measure progress toward the goal.

1. Reduce the energy consumption of residential dwellings by 25 percent per household per unit of Gross Metropolitan Product (GMP), a measure of regional economic activity.
2. Reduce the total energy use of all commercial and industrial buildings by 10 percent per unit of GMP.
3. Develop local policies to ensure that new buildings and major renovations can adapt to the changing climate.
4. Produce 5 percent of the total energy used within Detroit from local (<50 miles) renewable sources and district (distributed) energy systems
5. Increase the capacity factor of cleaner fossil fuel energy generation such as natural gas.

STRATEGIES FOR OPERATIONAL AREAS

Mitigating energy vulnerability will require a multifaceted approach that impacts both energy generation (supply-side) and energy use (demand-side). Supply-side strategies seek to increase the reliability of energy supply by focusing on production, transmission, or distribution of energy. Demand-side policies manage the demand for energy in various ways. Most important are efficiency improvements that keep end-use demand levels constant while minimizing the energy lost during generation and transmission. For example, energy efficient retrofits and appliances such as refrigerators with more insulation and smaller, more efficient motors, and compact fluorescent light bulbs that displace incandescent bulbs are two common examples of ways to reduce energy consumption. Also important are conservation efforts that encourage users to accept lowered-use service levels, especially when they do not diminish quality of life. Examples include turning thermostats slightly lower during the winter and slightly higher during the summer, and turning off lights or using timers when possible.



Sources: By Michigan Municipal League

DEMAND-SIDE STRATEGIES

1) & 2) Reducing Building Energy Consumption

Buildings are the single largest contributor to carbon emissions in the United States. The commercial and residential building sector accounts for 39 percent of carbon dioxide (CO_2) emissions in the United States per year, more than any other sector.[7] Similarly, over the next 25 years, CO_2 emissions from buildings are projected to grow faster than any other sector, with emissions from commercial buildings projected to grow the fastest at 1.8% per year through 2030.[8] Reducing carbon emissions from building energy use requires two approaches:
1) improve energy efficiency of existing structures; and 2) improve energy efficiency of new construction.

Energy conservation can improve carbon mitigation, comfort and cost of living. A study on Federal Energy Management practices details that American households could save 46.4 quadrillion British Thermal Units (BTUs) of energy and over $56 billion in consumer energy bills annually in the year 2020 by implementing energy conservation techniques, such as weatherization, and efficient technologies.[9] Due to the high share of natural gas and electricity use in the building sector, percentage reductions in consumption of these energy resources could be even greater. The report's policy recommendations could reduce total projected electric generating capacity and natural gas consumption (including gas consumed for electricity consumed in buildings) by well over 10 percent per year. Deploying energy-efficient technologies in end-use facilities and minimizing losses in power generation, transmission and distribution can help counteract the increased demand on and decreased output of power plants due to higher temperatures. This will eliminate the need for approximately 320 average-sized (400 MW) power plants.

3) New Building and Major Renovation Construction Standards

New building construction and renovation is another key area of prioritization. Buildings have a design life ranging from 50-100 years during which they continually consume energy and produce CO_2 emissions. If half of new commercial buildings were built to use 50 percent less energy, it would save over 6 million metric tons of CO_2 annually for the life of the buildings.[10] The U.S. Green Building Council projects demand for new construction to be approximately 1.5 million new buildings annually through 2015. Energy efficiency in new construction standards could protect buildings against predicted changes in weather patterns by ensuring that site orientation, insulation and windows are appropriate for expected climate conditions. Similarly, other strategies such as reducing impervious surface cover on sites and using light-colored materials on flat surfaces such as parking lots and rooftops can help reduce ambient air temperature, further reducing energy use for cooling.

SUPPLY-SIDE STRATEGIES

4) Renewable and Distributed Energy Generation

A final area to impact energy consumption is to reduce the carbon intensity of energy generation, primarily by increasing distribution of electricity from alternative sources such as solar and wind power and minimizing transmission loss by decreasing the distance between energy production and consumption. Utilities can minimize energy loss during distribution by siting power sources closer to their final end use. This reduces the distance that current must travel before it reaches its final destination, and thus decreases the energy lost during transmission.

Similarly, generating energy from many small sources, called distributed generation can provide secure electricity for large consumers

Source:By Project Public Spaces

and reduce vulnerability to grid outages in extreme weather. In general terms, district energy systems provide for the heating and hot water needs of a community of buildings, which are connected through a network of pipes under the streets that carry hot water from a centralized energy plant. District energy can also provide cooling services, through the use of a similar piping infrastructure with chilled water. Combined heat and power (CHP) plants capture and use the heat created during electricity generation, making them much more efficient. Rather than being released into the air above the plant, this captured energy can heat nearby buildings.

5) Increasing Natural Gas Capacity Factor

Capacity factor is a measure of how often an electric generator runs for a specific period of time. It compares how much electricity a generator actually produces with the maximum it could produce at continuous full power operation during the same period. Increasing capacity factor of natural gas and decreasing that of coal is a viable strategy for reducing the environmental footprint of energy generation. Utilities can utilize low-emission fossil fuels, such as natural gas, to satisfy constant base-level demand and supplement with renewable sources to meet periods of higher, or peak-level, demand. Some renewable sources generate power in a highly variable way. Utilities have no control over whether the sun shines or the wind blows, so it is not feasible to rely solely on these modes of generation to satisfy the base-level energy use that exists 24 hours a day. For instance, there will be some level of electricity demand throughout the night, but it will increase sharply early in the morning as residents awake and start their day.

POTENTIAL INDICATORS

No.	Indicator	Description
E-1	Energy Use by Sector: Residential	Total GJ of energy consumed annually for residential use per household.
E-2	Energy Use by Sector: Commercial	Total GJ of energy consumed annually for commercial use per commercial property.
E-3	Energy Use by Sector: Industrial	Total GJ of energy consumed annually for commercial use per inducstrail property.
E-4	Energy Use by Sector: Transportation	Total GJ of energy consumer annually for fleet and grounds vehicles and equipment per VMT.
E-5	Energy Mix	Percent of total enrgy production by production type (Coal, Natural Gas, Nuclear, Renewables, etc.)
E-6	Local Energy Sources	Total GJ of energy (for same uses as E-1, E-2, E-3) consumed annually by city produced within the city limits.
E-7	Energy Use-Buildings (GJ/Sq ft.)	Total GJ or energy (for same uses as E-1, E-2, E-3) consumer annually produced by renewable sources within 100 miles of city limits.
E-8	Reduction in Energy consumption (% Change)	Total GJ of energy (of all types) consumed annually per gross square ft.
E-9	Energy Use- Commuter transport (GJ/capita)	Total energy (of all types) consumed in GJ each year for commuter transportation/ Total number population in that year
E-10	Reduction in energy consumption (% Change)	Total change in energy consumption in GJ for buliding, commuting, and fleet/grounds vehicle uses in current year over previous year.
E-11	CO_2 Equivalent: All energy uses (Tons/capita)	Total CO2 equivalent (in tons of CO2) emitted annually by the campus for building, commuting, and fleet/grounds vehicle uses .Total population.

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(http://www.cee1.org/eval/db_pdf/964.pdf)

Climate Change and Infrastructure, Urban Systems, and Vulnerabilities: Technical Report for the U.S. Department of Energy (http://www.esd.ornl.gov/eess/Infrastructure.pdf)

Commercial Building Energy Consumption Survey (CBECS)
(http://www.eia.gov/consumption/commercial/)

Energy Information Administration: State of Michigan Profile-Energy Consumption by Sector
(http://www.eia.gov/beta/state/?sid=MI)

Energy Information Administration: State of Michigan Profile - Environment Profile & Consumption Profile
(http://www.eia.gov/beta/state/data.cfm?sid=MI#Environment)

Energy Information Administration: Electricity Detailed Data Files
(http://www.eia.gov/cneaf/electricity/page/data.html)

Energy Information Administration: Consumption and Efficiency Data Files
(http://www.eia.gov/consumption/data.cfm#rec)

EPA Greenhouse Gas Equivalencies Calculator
(http://www.epa.gov/cleanenergy/energy-resources/calculator.html)

National Renewable Energy Lab – Dynamic Maps, GIS Data, and Analysis Tools for Energy Siting
(http://www.nrel.gov/gis/)

United States Bureau of Economic Analysis – Regional Gross Domestic Product (GMP)
(http://www.bea.gov/iTable/iTable.cfm?ReqID=70&step=1&isuri=1&acrdn=2)

US Department of Transportation – State Facts and Figures
(http://gis.rita.dot.gov/StateFacts/)

Source:

HOMES & NEIGHBORHOODS

The development of community-based initiatives and climate education within Detroit can reduce the direct impacts of climate change on homes and neighborhoods.   By bringing the community together to decrease utility bills and increase sustainability, residents can reduce vulnerability while improving quality of life.

We define vulnerability as exposure to biophysical hazards paired with sensitivity. Sensitivity refers to the degree to which a community is harmed by the given exposure. The biophysical hazards that influence homes and neighborhoods include extreme heat, extreme cold, flooding, weakening infrastructure, low neighborhood density, and low tree canopy. In order to reduce vulnerability, homes and neighborhoods should target strategies towards sensitive populations such as elderly residents and low-income families.

DETROIT CONTEXT

DCAC is a grassroots effort that requires community involvement in order to be successful. Community involvement is of particular importance for the Homes and Neighborhoods Work Group. One method to make climate change concerns interesting to residents is through potential energy savings. With approximately 44% of Detroit residents living beneath the poverty level, energy efficiency can save money and increase comfort. Such strategies, could address multiple issues of housing quality and poverty.

ENERGY EFFICIENCY AND HOUSING CONDITION

According to the U.S. E.P.A., most buildings waste up to 30% of the energy they consume due to inefficiencies.   The likelihood of inefficient heat and cooling systems, older, inefficient appliances, and drafty windows and doors with insufficient insulation is greatest among older homes in lower-income areas. While some programs in Detroit approach this issue, these programs target specific areas of the city, leaving many residents without access to the benefits of these programs.

Short Term Priorities

1. Empower residents to take action and utilize existing programs by increasing awareness of programs and action steps
2. Decrease energy usage in residences through energy efficiency and weatherization programs
3. Reduce UHI

Long Term Priorities

1. Promote alternative uses of failing structures
2. Promote compact development

Goal: Empower residents to take action and utilize existing programs by increasing awareness of programs and action steps

Strategy: Create community involvement through educational programs that are affordable, accessible and empowering.

Educational programs have been shown to have a positive influence on youth, empowering them to contribute to their community while building leadership and team building skills. School systems can foster programs run by volunteers and parents during after school hours. The “Climate Change Youth Action Guide” is a resource that can start informing youth on issues around climate action and help empower them to make a change. In addition to youth programs, leadership positions for residents within the community should be developed and provided with basic resources to initiate community projects. Additionally, programs should encourage participation between the different neighborhoods in Detroit.

Actions:

1. Identify partnership organizations around youth education and programming
2. Develop school and community based educational programs throughout the City for youth
3. Initiate development of neighborhood based climate alliances
4. Establish a Community Recognition Program which will include small project grants
5. Develop Detroit Climate Website with information on available programs and blog space to promote neighborhood projects

Potential Indicators:

- Number of programs developed in schools
- Number of youth in these programs
- Number of views on website and those posting on website
- Number of communities applying to Community Recognition Program

DEFINITION

WEATHERIZATION

The practice of protecting a building and its interior from the elements, particularly from sunlight, precipitation, and wind, and of modifying a building to reduce energy consumption and optimize energy efficiency.

COMPACT DEVELOPMENT

Building in a more compact way to reduce development costs and provides density that can be efficiently served by transit. There are several forms of compact development including mixed-used development, where by integrating different uses such as residential, office, and shopping daily vehicle trips can be reduced.

Source: By Ellenm1

Goal: Reduce Residential Energy Bills

Strategy: Combine with existing programs to weatherize residences, decrease energy consumption, and use energy efficiently.

While many smaller programs exist in the City of Detroit, the lack of public awareness and communication between programs prevents full participation. While reducing energy consumption in homes reduces the amount of greenhouse gases in the atmosphere, it more importantly reduces residents' energy bills. Many residents are below the national poverty level and excessive energy bills can lead to utility shut offs. Residents need assistance in long-term solutions in order to reduce utility bills.

Actions:

1. Develop programs to reduce energy leakage and promote energy efficient systems in buildings
2. Weatherization of existing residences to resist sunlight, wind and precipitation to reduce heating and cooling costs
3. Improve air quality in residences through lead paint abatement
4. Work with Detroit energy companies to enhance comprehensive home energy assessments programs and subsidize installation of energy saving appliances and light bulbs.
5. Develop a "Green Lease" program to promote energy saving renovations of rental units.
6. Develop website and create a toolbox of existing programs

Potential Indicators:

- Number of homes utilizing programs developed
- Amount of reduction in energy bills
- Number of green leases in the city
- Service area of programs

Goal: Decrease Urban Heat Island effect in neighborhoods

Strategy: Increase reflective and pervious surfaces in neighborhoods and minimize rainwater runoff into stormwater system

Through the vulnerability assessment conducted, we saw that temperatures varied throughout the city by up to 7°F. This variation is mainly due to large areas of impervious surfaces and insufficient tree canopy. Warmer temperatures in homes decrease human comfort and increase utility costs due to increased water and air conditioner usage. As temperatures rise, it can have negative effects on vegetation as well, further increasing the vulnerability of the area. By utilizing strategies such as reflective roofs, tree canopies and pervious surfaces, we are able to reduce CO2 in the air, allowing for cooler temperatures and greater human comfort.

Actions:

1. Establish building codes for future developments to increase reflectivity of roofs (cool roofs)
2. Subsidize costs of reflective shingles for home owners
3. Develop neighborhood tree canopy plans through partnerships with Greening of Detroit and other community-based organizations
4. Promote pervious driveway surfaces throughout the city
5. Promote rain barrel usage in residential areas for outdoor watering purposes
6. Remove unused impervious surfaces on former industrial sites.

Potential Indicators:

- Number of residences with reflective shingles
- Number of trees planted
- Number of driveways changed to pervious surfacing
- Amount reduction of storm water
- Removal of impervious - percent impervious

Source: By jessicareeder

Goal: Promote alternative uses for failing structures

Strategy: Decrease the amount of abandoned failing structures to increase public safety, community involvement and prepare for dense, sustainable living in the future.

Actions:

1. Deconstruct unstable structures
2. Incentivize community involvement through neighborhood community development grants
3. Establish protocol for cleaning site after building removal

Indicator:

- Number of buildings deconstructed
- Number of buildings redeveloped
- Number of neighborhood proposals for developments

DEFINITION

GREEN LEASE

A lease that incorporates ecologically sustainable development principles to ensure that the use and operation of a building minimizes the impact on the environment.

COOL ROOF

A roof with reflective (white or light-colored) surface off of which sunlight will bounce. A cool roof also has high emissivity, which means it easily releases heat.

Goal: Establish future neighborhood development as compact, efficient, and community based

Strategy: Establish new policies and rezone neighborhoods for mixed-use residences and compact design.

Through the development of compact community development, we are able to reduce GHG emissions by reducing vehicle dependency and energy consumption. By increasing density we are able to improve public safety, promote sustainable living and develop community initiatives.

Actions:

1. Working with neighborhood leaders and city officials and determine areas to be rezoned for mixed use and compact development
2. Develop incentives for developers to build mixed use structures
3. Develop neighborhood infill strategies to maximize livability

Indicators:

- Number of new projects with neighborhoods
- Number of empty housing units in neighborhood

RESOURCES

Greening of Detroit

Greening of Detroit's mission is to guide and inspire others to create a 'greener' Detroit through planting and educational programs environmental leadership, advocacy, and by building community capacity.

Website: www.greeningofdetroit.com

Warming Training Center

WARM Training Center is a non-profit organization that promotes the development of resources efficient, affordable, healthy homes and communities through education, training, and technical assistance. WARM's services include: education, technical assistance, green jobs training, and resources.

Website: www.warmtraining.org

DTE Energy

The DTE Energy website offers many resources and tips for reducing energy in residences along with information on rebates for energy saving appliances. For those eligible, DTE offers home energy consultations free of charge. This includes installing fluorescent light bulbs, water-saving faucets and water heater pipe wrap.

Website: www.DTEEnergy.com

ClearCorps Detroit

Creating healthy homes in Detroit through four main programs. Healthy Homes Detroit addresses asthma, lead, and home safety issues through products, education, and repairs. The Lead Safe Homes Program abates lead hazards from homes in Detroit. Lead Talk educates on lead poisoning prevention, and targets families whose children have low to mid lead levels. The Education and Outreach program works with health fairs, Head Starts, and schools to bring information and resources about lead poisoning to both parents and children.

Website: http://clearcorpsdetroit.org/

Climate Change Youth Guide to Action.

A resource guide for youth to take action in climate change.

Website: www.climate.takingitglobal.org

Cool the Earth

Free program that introduces climate change to k-8 students and is run by parental volunteers over a 2 month period for a total of 12-16 hours.

Website: www.cooltheearth.org

Youth Climate Pledge

A pledge for youth to be dedicated to climate change and have their actions in home, school, community and country reflect it.

Website: www.thepeoplespeak.org/activities/youth-leadership-summit/youthclimatepledge.html

Redwood Climate Community Action Plan

The plan discusses goals and strategies for engaging youth. It includes many programs initiated but also the Verde Youth Ambassador Program, after school enrichment classes, and the Green Jobs Corps. As the city itself has a population of approximately 70,000 people, many of the initiatives are community based programs.

Website: http://www.redwoodcity.org/manager/initiatives/climate%20protection/Verde/Final%20CCAP%20Documents/CCAP_Final_3-25-10.pdf

Oakland Climatic Action Coalition: A Toolkit to Create Climate Action in Your Community

This coalition helped to write and pass some of the boldest plans in the country and had unprecedented community participation.
It has shown how youth took a role in community meetings, including dancing and acting to promote their message.

Website: http://ellabakercenter.org/toolkit-create-climate-action-in-your-city

Source: By Jarred Henderson, Detroit Free Press

PARKS, PUBLIC SPACE & WATER INFRASTRUCTURE

The effects of climate change will have direct implications for how Detroit's natural systems function, and how we choose to manage them. Increased temperatures and changing precipitation patterns are two elements that are consistently identified by Great Lakes climate scientists.[1] Even with this knowledge, some actions can be taken that will immediately help improve the functioning of our natural systems. These actions should seek to mitigate emission totals and increase the adaptive capacity of city environments. Finally, it will be important to forge collaborative relationships among residents, businesses, and organizations to track progress and build momentum.

Both the heat and flood vulnerability assessments have direct impacts for the Parks, Public Space, and Water Infrastructure Work Group, which should consider the following:

- How climate change impacts the quantity and quality of Detroit's natural resource systems
- How Detroit's natural resource systems can be utilized to combat the vulnerabilities that arise due to climate change

While Detroit may face many challenges from climate change, the city also is uniquely poised to increase its resiliency. Abundant open space and largely vacant areas can be assets to be used to mitigate climate and its effects. Taking an expansive view of the workgroup, large open spaces in the city should be incorporated into the larger parks and public space picture.

To complete the workgroup tasks as outlined by the DCAC Workgroup Guide, the following approach should inform and guide the process.

1. **Build understanding:** Continue to identify how climate change is impacting Detroit's natural systems, especially noting the spatial patterns that emerge.
2. **Focus on mitigation and adaptation:** Mitigation strategies are often easier to justify financially, and have built-in adaptation benefits; however, this workgroup is especially suited to pursue aggressive adaptation-related goals and strategies.
3. **Build collaborative relationships:** Existing data gathering and outreach efforts can help maximize the workgroup's effectiveness. Residents, businesses and organizations should be involved and help to implement strategies. Additionally, DCAC can be more productive when workgroups come together around a common issue.
4. **Focus on "no regret" actions in the short term**: Certain actions will be beneficial regardless of the level of change that Detroit will eventually experience. Similarly, actions that have cross-cutting benefits with other workgroups, and should be higher priority. Long-term actions and strategies should be periodically reevaluated as climate impacts become better understood.

GOALS

This report identifies five goals, covering five topic areas concerning Detroit's parks, public space, and water infrastructure. Subsequently, this report provides a mitigation and adaptation rationale for each goal, as well as some potential strategies, and indicators that might be used to measure progress toward the goal.

1. Maximize the urban tree canopy, with special consideration for urban heat islands and changing precipitation patterns.
2. Minimize Combined Sewer Overflow (CSO) events and flood insurance claims.
3. Encourage production of local agriculture on publicly owned land as well as on vacant open space within existing neighborhoods.

4. Ensure an adequate water supply for city residents and services.
5. Expand access to Detroit's parks, public space and water resources.

This is by no means an exhaustive list of workgroup goals, but represents five areas that are especially well-suited given Detroit's characteristics and anticipated climate impacts.

1. ***Maximize the urban tree canopy, with special consideration for urban heat islands and changing precipitation patterns.***

From the mitigation perspective, trees take up CO2. Which lessens the city's overall emissions. Trees also play an important adaptive role through the provision of shade. Trees significantly lessen the urban heat island (UHI) effect, and this same canopy also intercepts rainwater, reducing the amount of runoff.[2]

DEFINITION

URBAN HEAT ISLAND

UHI is defined as increased surface and air temperatures in urban areas relative to surrounding suburban and exurban areas. UHI patterns vary by region, occur in more dispersed pattern than once thought, may increase or decrease over time, and are most problematic during warm weather.

URBAN FOREST

The layer of leaves, branches and stems of trees that cover the ground when viewed from above. The urban forest includes trees on both public and private land.

IMPERVIOUS SURFACE

An impervious surface is any surface that does not allow water to soak into the ground. When water from rain and snowmelt washes off a piece of property, it flows into a storm drain system and eventually into the Huron River. Impervious or hard surfaces on the property such as roofs, driveways, and patios, do not absorb the water and contribute to stormwater runoff.

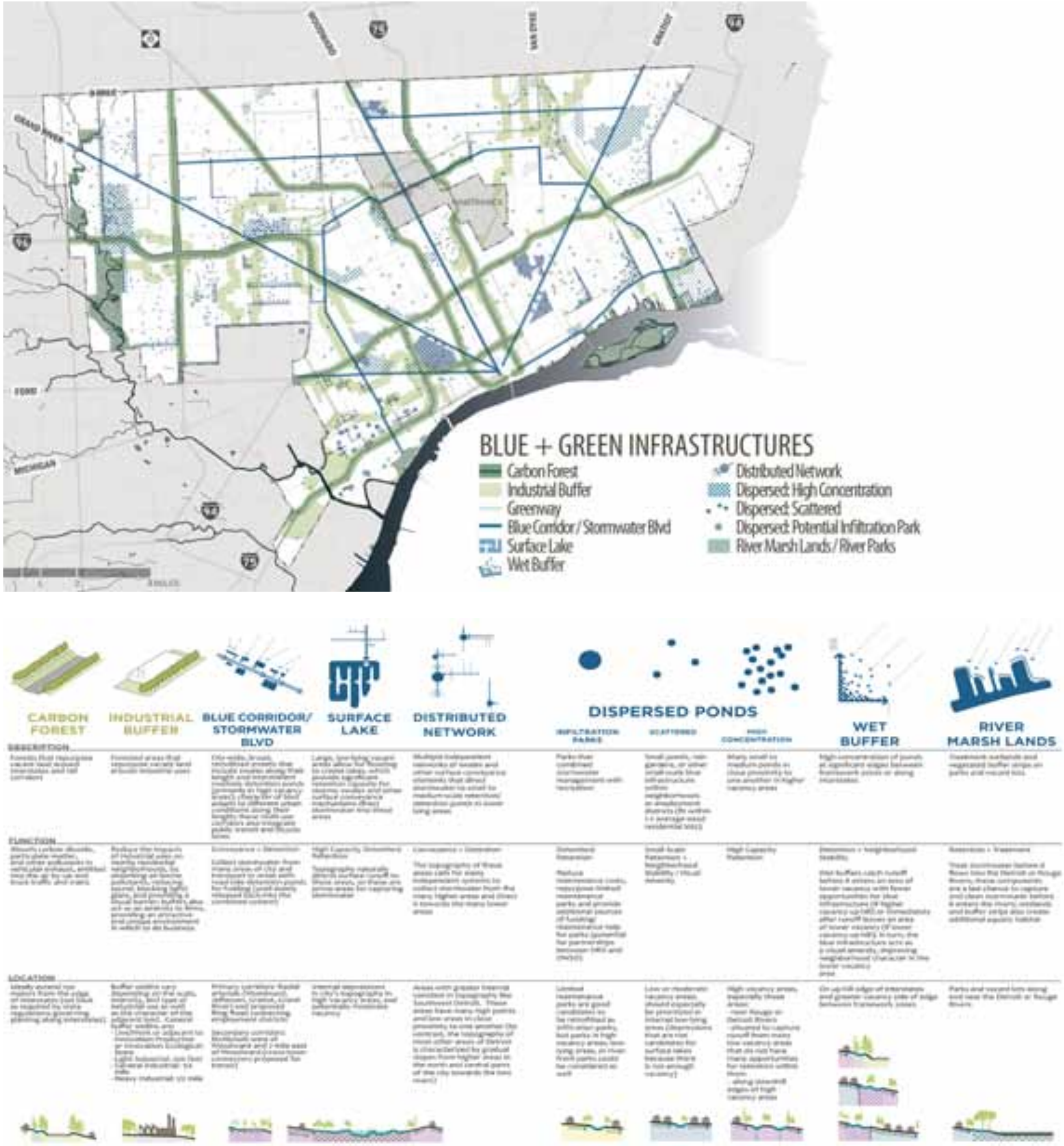
Mitigation

For trees to have the greatest mitigating effect on carbon emissions, strategies should maximize coverage. The organization American Forests recommends cities achieve a 40% urban forest cover. Detroit is currently at about 31% canopy cover, and lost about 3% cover between 2005 and 2009.[3] The DCAC should prioritize increasing tree canopy percentage. Some potential locations for increasing this percentage were identified through the Detroit Works Project.[4] These "carbon forests" and "industrial buffers" concentrate trees around highways and industry in order to absorb CO2 and other air pollutants. In the long term, stakeholders should consider programs that incentivize residents and business owners to plant and maintain trees. Trees are especially effective along buildings' southern faces, which receive the most direct sunlight, and would therefore have the most impact on cooling costs and energy use.[5]

Adaptation

Adaptation strategies should use trees to alleviate urban heat island and stormwater effects caused by climate change. Increasing Detroit's urban canopy will provide benefits, however, certain locations may warrant prioritization. The workgroup should likely consider the following characteristics when prioritizing, as highlighted in this report's Vulnerability Assessment:

- Land Use Type: Distinguishing between residential, commercial, industrial, and institutional land uses
- Impervious Surface Cover: A factor that contributes to UHI, the workgroup could use trees to lessen the heat impacts in especially susceptible areas
- Demographic Characteristics of Concern: Elderly and youth populations, poverty, education levels, housing without air-conditioning, chronic health problems
- Current Park Locations: Parks themselves could be targets for



The Detroit Works Project has identified a number of blue-green infrastructure strategies and potential locations for these projects throughout the city.
Source: "City Systems" Detroit Works Project: Long-term planning. http://detroitworksproject.com/planning/strategies/city-systems/

increased tree cover, in addition to the streets within a certain radius, for example a tenth-mile

- Sewer District: There may be flood-prone areas or overburdened sewer districts that would benefit from increased stormwater retention

Additionally, changing climates will also result in changing species composition, as many trees expand their ranges northward. With natural systems in flux, Detroit will want to position their resources to be well equipped for this change. Some considerations include:

- Preferred Species List: Certain trees may do better in this region in the future, these species could be promoted.
- Maintaining a Level of Diversity: Systems in flux can be especially vulnerable to invasive species and diseases. Ensuring a diversity of plant life will help to minimize negative impacts should a certain species fall into decline.

Indicators to Track Progress

- Urban Tree Canopy percentage to go further: public vs. private cover, cover by species, cover by land use type, canopy coverage in especially highly impervious/high heat areas (Extent/Minimizing vulnerability/Access)

- Number of Trees Planted per Year (Extent)
- Number of Citizen Volunteer Pruners (Maintenance/Community Engagement)

2. Minimize Combined Sewer Overflow (CSO) events and flood insurance claims.

Detroit has a combined sewer system, sending both wastewater and stormwater through the same retention and processing facilities. During periods of intensive rainfall the system often reaches its full capacity, and the city is forced to release untreated water into the Rouge and Detroit Rivers. During 2011, Detroit discharged around 7 billion gallons of untreated wastewater through outfalls located on the rivers, and while 2011 was a particularly wet year, it may be representative of future conditions.[6] The Detroit Water and Sewerage Department (DWSD) has embarked on an extensive capital improvements plan to address the shortcomings of the system and expand its capacity, which have certainly helped to reduce Combined Sewer Overflow (CSO) discharges in the last two decades.[7] However, the system needs to find other means to address the precipitation volumes that come with intense storms.

Mitigation

For mitigation reasons the workgroup will want to examine how to minimize the volume of water that must be processed by wastewater treatment plants. This will allow the DWSD to save energy. The workgroup should then prioritize strategies that lessen the volumes of stormwater runoff, dealing with rainwater on-site, rather than allowing it to contribute additional volume to the system. Other cities have focused on strategies that minimize the amount of paved, impervious surface, and instead provide areas where rainwater can collect and naturally filter back into groundwater.

DEFINITION

WASTEWATER

Used, dirty water that goes through the drains and toilets of homes, businesses, industry, and institutions; also known as sewage.

STORMWATER

Water from rain, snow, sleet, hail, that flows across the ground and pavement or when snow and ice melt.

OUTFALLS

The point, location, or structure where wastewater or drainage discharges from a sewer, drain, or other conduit.

COMBINED SEWER OVERFLOW (CSO)

A sewer system discharge (and major pollution concern) containing not only stormwater but also untreated human and industrial waste, toxic materials, and debris.

Secondly, Detroit currently incinerates its sludge waste in old, outdated incinerators that contribute to poor air quality and produce GHGs. The workgroup should investigate utilizing the waste as a source of energy, or turning the waste into an input for larger scale composting operations. Also, the workgroup should investigate increased pollution controls for the current incinerator.

Adaptation

Adaptation strategies would seek to use existing open space to alleviate the stormwater runoff burden from climate change. Discharge events are undesirable from public health and riverfront development perspectives. Some factors to consider when looking to minimize impervious surface cover and maximize the functional efficiency of the stormwater system may include:

An example of Low Impact Design, which incorporates bioretention swales into otherwise impervious parking lots.
Source: http://www.water-research.net/images/biorentionparking.jpg

DEFINITION

LOW IMPACT DESIGN

An approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product. (Also Low Impact Development.)

An aerial view of Detroit's Wastewater Treatment Plant, adjacent to Zug Island in southwest Detroit.
Source: Environmental Protection Agency

WASTEWATER TREATMENT PLANTS

In general, a facility designed to treat wastewater before discharging back into a water body. The Detroit facility is the largest single-site wastewater treatment facilities in the United States. Originally, it was only intended to provide primary treatment, which screens out solids and chlorinates the wastewater. However, the plant was upgraded in the 1960s to provide secondary treatment, which is a more rigorous screening and treatment process that disinfects biodegradable solids, producing an even cleaner product. Currently, the plant serves about 35% of Michigan's total population, with a service area of 946 square miles, extending far beyond just Detroit's boundary.[8]

- Spatial, demographic, and geographic characteristics—identify patterns within the city, and seek to promote a healthy balance of impervious and pervious surfaces that is consistent with underlying flood and population characteristics. Similarly, especially flood-prone areas may demand prioritized attention, to develop strategies that alleviate some of this potential.
- New development: whether it is new construction or development on an existing facility, the city may look to incorporate recommended or minimum Low Impact Design guidelines into project development.
- Concentrations of impervious surfaces: there may be some facilities that have a large impervious surface footprint, and are thus contributing more heavily to the stormwater burden. Programs could incentivize these users to minimize the impervious cover on their property.

- Historic hydrologic flows: While Detroit had a number of creeks historically, these have largely been incorporated into the sewer drainage system of pipes and culverts. Daylighting is a technique that reverses this process, and subsequently converts a large portion of the land immediately adjacent to the creek back to natural land cover, helping to minimize the amount of total runoff.

Indicators to Track Progress

- Number of Combined Sewer Overflow (CSO) events or volume discharged
- Number of Low Impact Design projects
- Incidence of flooding or flood-insurance claims
- Percent or square footage of impervious surface removed or converted

3. Encourage production of local agriculture on publicly owned land as well as on vacant open space within existing neighborhoods.

Although estimates vary, and have at times been exaggerated, there is a reasonable assumption that there are around 20 square miles of vacant land in Detroit.[9] This open space resource can be apportioned in a variety of ways, and local agriculture could represent one potential use that also serves to address some climate change planning concerns.

Mitigation

There are two relevant factors that connect the food we eat to carbon emissions. First, the energy expended in the transport of food from grower to table is substantial and can be lessened by connecting the city to a local agriculture base. However, research shows that transportation only represents about 11% of total associated emissions.[10] The remainder is attributed to production itself, with red meat and dairy being more carbon-intensive than grains, chicken, eggs, fish, and vegetables.[11] Where possible, promotion of certain dietary alternatives can result in both fewer carbon emissions and a healthier population.

An aerial view of the Earthworks Urban Farm, an extension of the Capuchin Soup Kitchen spread over 20 lots on two city blocks.
Source: Food Urbanism

Adaptation

The impacts of climate change will affect the world's food producers, and periodic food shortages and price increases may become more frequent. Michigan has a very suitable agricultural climate, and Detroit in particular has a suitable amount of land in which to cultivate crops. The city can use this resource base as a way to insulate itself from the changing pressures of a global market.

Strategies to consider may look to:

- Expand the level of local production: Identify suitable areas in the city for agriculture and create networks of support for local growers
- Connect growers to healthy compost and soil, seed suppliers, finding unaddressed niches in the market, and local markets, churches, and institutions, and finally to consumers, making sure residents have access to locally produced food.
- Amend city policies and ordinances to allow for a wider range of agricultural activity, perhaps placing a limit on carbon-intensive practices such as raising livestock for meat or dairy

Indicators to Track Progress

- Local grower representation at farmer's markets (Extent of industry)
- Acreage dedicated to local agriculture or tonnage of food produced (Extent of industry)

- Number of local food-to-school or – business, etc. programs (Connectivity)
- Number of local markets or duration of time residents have access within new council districts, or census tracts (Access/Connectivity)

4. Ensure an adequate water supply for city residents and services.

Ensuring the availability of a clean and plentiful water supply will become more difficult facing climate change. However, proximity to the Great Lakes benefits Detroit, and there is no danger from sea level rise. However, a recent report from the U.S. Army Corps of Engineers indicates that the Great Lakes system has the potential to hit a record low depth this year.[12] The implications of water level change could extend beyond municipal water users, also impacting ship ports and navigation, and property owners along the river and lakeshore, where newly exposed vegetation could lead to increased property maintenance or undesirable decaying plant material.

Mitigation

Energy inputs are required at several important stages in the life cycle of water. Initially, water must be pumped from the source location to the treatment facility. Once there, these facilities use energy to pump water through the system and treat it. It then requires energy to transport the water to the end users, who also use energy in heating, cooling, filtering, pressurizing, and circulating processes.[13] Inefficiencies at any point in the system present opportunities for improvement and a lessening of carbon emissions. Some areas that the workgroup may want to explore further include:

The St. Clair River, in May 2001, experienced water levels that were a foot below average, making it easier for phragmites and other invasive plants to grow and spread.
Source: NOAA via http://greatlakesecho.org/wp-content/uploads/2012/07/StClairRiver2.jpg

- Source water quality: Detroit discharges treated wastewater, and has sewer outfalls, along the Detroit River, one of the water source intakes. To ensure higher quality water for the entire system, however, a regional approach should be encouraged among all DWSD communities to lessen runoff pollution.
- Distribution efficiency: A report on drinking water in Detroit indicated that aging infrastructure in the city costs residents 35 billion gallons and $23 million each year.[14] DWSD initiated a capital improvement plan to address these concerns, and the workgroup may want to develop strategies and partnerships that help the city achieve their goals identified in the plan.
- End user conservation: Crossing into the realm of the Homes and Neighborhoods workgroup, efficiency can be promoted through appliance and technological fixes, but this workgroup could also look to promote conservation behaviors among residents and businesses.

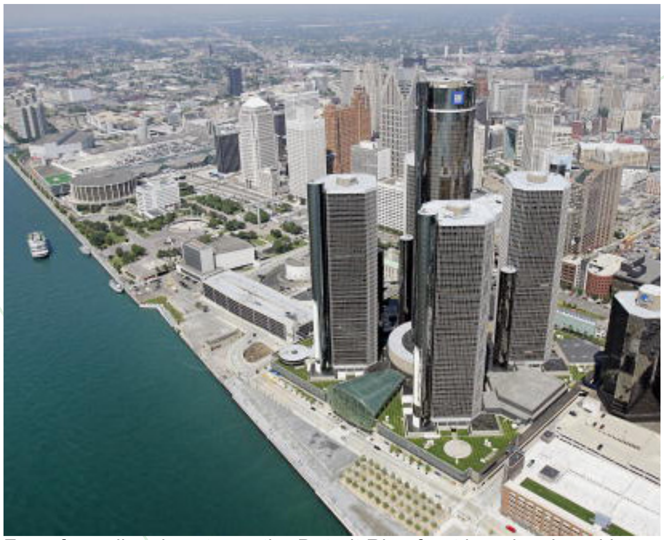
Adaptation

Increased variability in precipitation and potentially lower lake levels could negatively impact many users. The workgroup should seek to identify strategies that both identify these user groups and make them better prepared for variable conditions. Some groups that might warrant further exploration include:

- Large quantity non-human users: Whether a parks department or school needs to water a field, or local agriculture growers depend on a fairly high level of water use, drought conditions could impact their ability to maintain their product. Helping these groups maintain reserve water supplies in onsite rain barrels or tanks can help to insulate them from the fluctuations of variable water supply.
- River/Lake-level dependent users: Shipping, industry, and recreational boat users need to be adequately informed about the potential threats to their activities imposed by lower lake levels. In addition to public awareness, there may be programs or activities that will help make boat facilities better suited to lower water levels. As a second group, property owners along the lake should understand the changes that may occur to their property, what their responsibilities are, and if there are maintenance activities that help or damage the ecological functioning of the river system.

Indicators to Track Progress

- Per capita water use
- Energy used to treat drinking water
- Percent of Water Conservation outreach programs
- Percent of installed onsite water storage systems, like barrels/tanks



For a few miles downtown, the Detroit Riverfront has developed into a vibrant place, offering both natural amenities and entertainment opportunities for residents.
Source: Jeff Haynes/AFP/Getty Images via http://cbsdetroit.files.wordpress.com/2011/05/detroit-riverfront.jpg

5. Expand access to Detroit's parks, public space and water resources.

Detroit has a huge asset in its abundant open space and riverfront, however access to these resources varies throughout the city. There are several functioning greenways with plans to increase connectivity throughout the city. Likewise, Detroit has taken steps to reclaim its riverfront, developing it for recreational and pedestrian access. The workgroup should seek ways to support these efforts.

Mitigation

Improving access and connectivity among parks and open space areas of the city will help to reduce vehicle miles. A natural ally in this effort will be the transportation workgroup.

Adaptation

Having a large and well-connected park and open space system will help residents find respite on extreme heat days. In this manner, the workgroup can seek to increase canopy cover along greenways and trails to maximize their adaptive potential.

Indicators to Track Progress

- Miles of trail (total and/or connected)
- Tree canopy cover along trails and riverfront

RESOURCES

Detroit Works Project: Blue-Green Infrastructure Overview (http://detroitworksproject.com/planning/strategies/city-systems/)

Detroit Water and Sewerage District: Wastewater Master Plan (http://www.dwsd.org/pages_n/system_plans.html)

EPA: Climate Change Vulnerability Assessments: Four Case Studies of Water Utility Practices (http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=233808)

EPA: Green Infrastructure (http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm)

EPA: National Water Program 2012 Strategy: Response to Climate Change (Public Draft) (http://water.epa.gov/scitech/climatechange/2012-National-Water-Program-Strategy.cfm)

EPA: A Screening Assessment of the Potential Impacts of Climate Change on Combined Sewer Overflow (CSO) Mitigation in the Great Lakes and New England Regions (http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=188306)

Center for Clean Air Policy: The Value of Green Infrastructure for Urban Climate Adaptation (http://ccap.org/resource/the-value-of-green-infrastructure-for-urban-climate-adaptation/)

SEMCOG: Low Impact Development Manual for Michigan (http://www.semcog.org/lowimpactdevelopment.aspx)

Source: By Cletch

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SOLID WASTE

A well-managed waste stream can generate economic development and improve the quality of life and livability of a city. Moreover, when managed a certain way, a solid waste stream can have a significant mitigation effect on GHGs—lowering GHGs in a direct and indirect manner.

DETROIT CONTEXT

Adaptation efforts will not affect the Solid Waste workgroup, as climate change does not increase Detroit's vulnerability to solid waste issues. After all, the garbage is still picked up in warmer cities like Dallas, San Antonio, and Oklahoma City. This group will focus on mitigation and has a difficult task ahead, as Detroit has not kept up with the latest trends in waste management. The city is home to the nation's largest waste-to-energy incinerator, which a produces GHGs, decreases air quality, and places a negative incentive on the implementation of city-wide recycling programs.[1] Currently Detroit does not have a comprehensive curbside recycling program. Curbside recycling is conducted in three neighborhoods and drop-off stations run by community organizations such as Recycle Here are available throughout the city.

In reforming its solid waste practices, Detroit faces three key challenges. First, the financial position of the city makes any capital-intensive improvements a difficult proposition. Second, the city's continued population loss and lack of density make curbside pick-up for trash or recycling too expensive in certain neighborhoods. Finally, while many cities use enforcement programs and fines to augment their recycling programs, a similar program in Detroit would be ineffective given the city's high unemployment and poverty rates, and would place an unfair burden on the city's most vulnerable residents. On the positive side, because Detroit is so far behind the rest of the field, it also has the opportunity to learn from and avoid the mistakes of other cities.

HOW DO THE IMPACTS (DIRECT AND INDIRECT) WORK?

Solid waste has two impacts on environmental mitigation—direct and indirect. Detroit's incinerator is an example of a direct impact. Trash is trucked in and used as fuel to produce energy. Burning fuel for the trucks and burning trash in the incinerator produces GHGs. In sum, direct impacts are GHGs produced during the waste collection process. The solid waste stream has the opportunity to indirectly mitigate greenhouse gasses as well. For example, when paper is recycled, less energy and GHG's are produced compared to manufacturing new paper, and less trees are cut down, augmenting the carbon cycle.[2] With this multifaceted impact in mind, sound solid waste management can have a comprehensive effect on a society's mitigation efforts. Finally, the best solid waste is the waste that never makes it into the waste stream in the first place. When Detroiters compost at home, the city does not have to send trucks out to pick up bags of yard waste. All of these efforts combined, large or small, can mitigate GHGs.

Exactly how a solid waste strategy affects the environment is complex and difficult to quantify, as each solution creates their own impacts, and can create its own environmental impacts beyond the production of GHGs. For example, while landfills may produce less heavy metal air pollution than incinerators, landfills can emit methane gases, contaminate water supplies, and trucks to expend fuel when heading to and from the landfill. Incinerators, on the other hand, may generate energy, but their contributions to poor air quality and emissions of heavy metals can cast a pall over nearby neighborhoods, and their need for trash to burn can de-incentivize recycling programs. Consequently, it is important to consider each facet of solid waste in a broad lens to ensure that all issues are considered.

GOALS

The DCAC should consider citywide, "top down" reforms in conjunction with "bottom up" grassroots, community based efforts to successfully mitigate the GHG effects of Detroit's solid waste stream. Broadly, the suggested goals are to decrease GHGs produced directly by the waste stream during the collection and disposal process, and increase the opportunity for indirect mitigation effects through recycling, composting, education, and conservation efforts. Also, the DCAC should consider the economic development effects of recycling with an emphasis on creating jobs.


Source: Rebecca Cook Metro Times

GUIDANCE STRATEGIES

The Incinerator

Key Indicator: Percentage of City of Detroit waste incinerated

All discussions of solid waste policy in Detroit begin with the Greater Detroit Resource Recovery Authority's incinerator. It is the largest waste-to-energy incinerator in the United States, and over twenty years after its construction, it remains controversial. For incinerator advocates, the facility is good the environment—it saves landfill space, recycles heavy metals, and produces steam for the Downtown Detroit steam loop. Critics are quick to point out the high amount of carcinogens and heavy metals emitted through the facility's smoke stack. The facility is also criticized for its high amount of CO_2e emissions (over 414,064 metric tons of CO_2e gasses for the year 2010 alone), and note that energy generated by burning trash is inefficient compared to the energy saved by recycling. [3]

Critics argue that the incinerator's demand for fuel deemphasizes the need to recycle, and see a close connection to the city's poor recycling efforts and the presence of the incinerator. Because the City of Detroit does not own the facility, it cannot close the incinerator directly. However, if the City of Detroit reduces or eliminates its waste contribution, it could make operating the incinerator financially difficult, and eventually force its owners to close the facility.

Recycling

Key Indicators:Percentage of waste recycled; Percentage of city with curbside recycling;Revenue generated from sold recycled materials

Recycling in Detroit is in its nascent stages—just three neighborhoods offer curbside recycling. This needs to change. Today, many cities make it easy for residents to recycle. Instead of placing recyclables in a small bin that is sorted at the curb by a recycling truck operator, cities now are switching to a single-stream recycling policy. All recyclables (newspapers, soup cans, shampoo bottles, etc.) are placed in one large can, usually the same size as a trash can, and collected on the same day as the trash—then sorted at a large, central facility. Recycling efforts are also accompanied by a concerted education effort, and sometimes reward programs. Programs like Recyclebank allow residents to accumulate points that are redeemed for coupons, or can be donated to charities for participating in recycling efforts.[4]

Some cites, such as New York, also levy fines on residents that do not comply with regulations, but given Detroit's current state of affairs, this may not be a wise course of action. Other cities operate a "pay as you throw" scheme, where residents pay a fee for trash collection, while recycling and composting is free, which encourages residents to recycle. Because Detroit already charges a fee for trash pick-up, the city could easily recalibrate the fee in a manner that encourages recycling—charging more for trash cans and less for recycle bins.

Yard Waste

Key Indicators: Percentage of yard waste composted

One of the largest portions of the waste stream is actually yard waste—an estimated 13.4% nationwide.[5] Detroit does collect yard waste separately from the rest of waste stream, and composts this yard waste through a contractor. This compost yield should be made available to Detroit residents and Detroit's growing urban gardening movement. A simple education or marketing plan could help move this program forward. This is a positive step, but Detroit can and should do more to prevent yard waste from reaching the regular waste stream.

Outreach and education efforts, and measures that simplify yard waste collection, such as providing a separate different color waste can for residential yard waste can encourage residents to keep yard waste out of the normal waste stream. With Detroit's single-family home build-out pattern, stakeholders could easily develop an at home compost program. This is a real opportunity for Detroit to prevent yard waste from entering the waste stream in the first place, and reduce waste collection costs for the long term. This also allows the community to "buy in" to the community's waste management program.

When analyzing Detroit's solid waste stream, the DCAC should keep these indicators in mind:

- Pounds of solid waste per capita
- Percentage of waste collected recycled
- Percentage of waste collected incinerator or landfilled
- Percentage of yard waste composted
- Revenue generated from sold recycled materials

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Source: Voice of Detroit

RESOURCES:

For the Solid Waste group, the best resources are the plans and actions of other cities.

Edmonton, Alberta

One of the most comprehensive waste management policies belongs to the City of Edmonton, Alberta, Canada. Edmonton takes a comprehensive approach to waste management, recycling and composting a high percentage of its waste. The goal of their operation is to recover as much waste as possible through composting and recycling. Edmonton also provides recycling opportunities for more challenging materials such as electronic waste, operating drop off stations throughout the city.

See http://www.edmonton.ca/for_residents/garbage_recycling/edmonton-waste-management-centre.aspx for details.

New York, New York

Despite the logistical challenges of high-rise buildings and high population density, the City of New York operates a comprehensive recycling program. New York also has a high population of renters, much like Detroit, and requires landlords to provide recycling space and containers, and requires residents to keep recyclebles out of the standard garbage.

See http://www.nyc.gov/html/nycwasteless/html/recycling/recycle_what.shtml for more information.

Western Springs, Illinois

The Village of Western Springs, Illinois, operates a simple yet effective pay-as-you throw program. Residents pay a set fee for trash cans, and can “trade up” for two or three if necessary. Also, if residents do not want to pay for an extra can year round, but have a week where they produce extra trash, they can place a pre-paid sticker on their trash bags, and the trash will be picked up. If trash is in excess of the pre-paid amount, residents are retroactively charged a fee. Recycling and yard waste pick-up is free.

See http://www.wsprings.com/living/recycling.asp for more information.

TRANSPORTATION

CLIMATE CHANGE VULNERABILITY & TRANSPORTATION

Transportation is a critical system within Detroit that has significant implications for both climate mitigation and adaptation. Extreme weather events disrupt transportation systems as a result of flooding, downed power lines, power outages and icing on the roads. Consequently, extreme weather events make it difficult for local economies to function properly and emergency response vehicles to service the city in times of need.

Vulnerability in terms of transportation is related to both the physical infrastructure system and the ability of residents in Detroit to access transportation modes. The physical infrastructure is vulnerable to flooding, increased freeze-thaw days as well as the increased heat. Though the social aspects of transportation vulnerability are not directly related to climate change they are related to how residents are able to access the resources they need to cope with climate change. For example, an extreme weather event can make even the shortest walking or biking trip inhospitable.

Opportunities to mitigate the effects of climate change include diversifying transportation. This diversification requires lessening Detroit's dependence on carbon-based modes such as gas and diesel consuming personal vehicles, trucks and public buses. More sustainable modes of transportation offer safe and comfortable alternatives to personal vehicle use. A few options of sustainable transportation include improved public transit and reliability, improved bicycle and pedestrian infrastructure and neighborhood-based car sharing. In addition, this diversity in transportation modes can help Detroiters lessen the economic burden associated with rising oil prices.

PRIORITY CONCERNS FOR TRANSPORTATION IN DETROIT

For the purposes of the DCAC, sustainable transportation can be defined as transportation options that decrease dependence on personal vehicle transportation and reduce the use of carbon-based fuels. The key to the DCAC's future success relies on collaborating with existing sustainable transportation and community efforts across the city. This collaboration could become the foundation for the short-term efforts for promoting sustainable transportation. In addition to the short-term opportunities, the DCAC should simultaneously advocate for long-term sustainable transportation solutions that address land-use and economic challenges within the city's fabric.

Many opportunities exist for transportation and climate adaptation in Detroit. Major opportunities exist with regard to collaborating with current neighborhood planning efforts. In addition, catalyzing and promoting Transit Oriented Development (TOD) is an exciting opportunity for the community; pursuing TOD can be done through a variety of methods discussed further on page 86. Lastly, many progressive climate action plans, such as The City of Grand Rapids and their Green Grand Rapids report, couple transportation and land-use planning. Though this integrated approach requires major public sector influence, the DCAC, as a long-term goal, can leverage existing community relationships in order to educate and advocate for an integrated approach.

WORK GROUP PRIORITIES & CHALLENGES

For Detroit, developing a sustainable transportation system will be an ongoing challenge, due to the scale of the city, low population density across some areas, the strong status quo of the automobile and lack of regional participation in pubic transit.

As the DCAC looks toward the future and works toward developing a community based grass roots climate action plan, some primary challenges for the long and short term include:

1. Accessibility, connectivity and diversity of transit options
2. Reliability of existing transit options
3. Safety and comfort of non-motorized transportation
4. Air quality concerns for non-motorized transportation users
5. Automobile dependency
6. Volatile oil prices in the long-run

The DCAC's priority for short-term development of sustainable transportation goals in Detroit should connect with existing efforts. This collaboration reduces any potential duplication of existing programs or services such as working with existing Safe Routes to Schools initiatives or TOD advocacy. Simultaneously the DCAC can identify and promote long-term sustainable transportation goals based on community needs and the vulnerability assessment; long-term efforts may require development of additional initiatives, programs and capital for successful implementation.

DEFINITION

SUSTAINABLE TRANSPORTATON

Transportation options that decrease dependence on personal vehicle transportation and reduce the use of carbon-based fuels.

Source: By Michigan Municipal League

The following are short-term priorities for transportation advocates in Detroit:

1. Improve reliability of existing transit options in Detroit
2. Improve safety and comfort of non-motorized transportation
3. Identify opportunities for synergies and improvements

The following are long-term priorities for transportation advocates in Detroit:

1. Improve accessibility, connectivity and diversity of transit options in Detroit
2. Address air quality issues for non-motorized transportation users
3. Promote a culture of sustainable transportation in Detroit
4. Promote infill development along established transit corridors

DIVERSITY IN TRANSPORTATION MODES CAN HELP DETROITERS LESSEN THE ECONOMIC BURDEN ASSOCIATED WITH RISING OIL PRICES.

POTENTIAL GOALS AND INDICATORS FOR TRANSPORTATION

The suggested goals and strategies discussed in this section were derived from review and research of other successful climate action plans across the U.S. and Canada. These suggested goals and strategies supplement the aforementioned short-term and long-term priorities. Recognizing the unique position of the DCAC as a community grassroots planning effort, the following goals were chosen with consideration for Detroit's physical and social structures:

1. Decrease vehicle miles traveled (VMT)
2. Increase safety & comfort of non-motorized transportation
3. Increase connectivity, accessibility and ridership (when operational) of the bus rapid transit system
4. Increase alternative fuel use in fleet vehicles
5. Increase efficiency of fleet vehicles routes
6. Promote TOD

Each goal includes strategies and indicator(s). The strategies help guide stakeholders with regard to the achievement of the aforementioned goals. The indicator(s) gauge progress with regard to each goal by offering measurable data points.

DEFINITION

TRANSIT ORIENTED DEVELOPMENT

"Moderate and high-density housing, along with complementary public uses, jobs, retail and services, [that] are concentrated in mixed-use developments at strategic points along the regional transit systems." (source: Peter Calthorpe)

Goal #1: Decrease Vehicle Miles Traveled (VMT)

Strategy: Combine with existing organizational efforts to promote the Woodward Corridor BRT and develop additional multi-modal transit opportunities within the BRT service area.

Strategy: Promote non-motorized transportation opportunities.

The following indicators help monitor reductions in VMT:

1. Decrease per-capita VMT
2. Increase transit ridership

Goal #2: Increase safety and comfort of non-motorized transportation

Strategy: Combine with existing organizational efforts to identify key nodes of concentration to maximize the impact of physical implementation. Advocate for reduced vehicle speeds on selected thoroughfares, as vehicle speed and pedestrian safety are linked, according to a report on walkability in urban thoroughfares by the Institute of Transportation Engineers.[1]

The following indicators relate to increasing the safety and comfort of non-motorized transportation:

1. Increase foot traffic at key nodes.
2. Increase bicycle use/trips per capita
3. Increase implementation of complete streets in key areas.
4. Increase in the cooperation and implementation of safe routes schools in the City of Detroit.(27 participating schools currently)
5. Increase percentage of children per school that have access to safe routes.

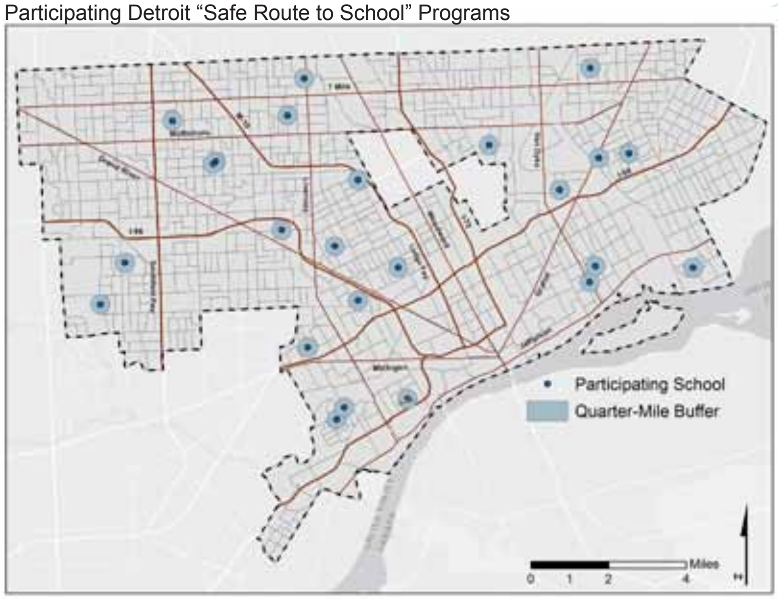
Goal #3: Increase connectivity, accessibility and ridership (when operational) of the bus rapid transit system

Strategy: Support existing organizational efforts to coordinate key nodes of concentration to and improve the connectivity of the bus rapid transit system by improving the multi-modal connectivity.

The following indicator measures increasing productivity and efficiency of a bus rapid transit system:

1. Increase ridership

Participating Detroit “Safe Route to School” Programs



Source: Detroit Safe Routes Participating Schools <http://www.saferoutesinfo.org/>
Prepared By: Univiersity of Michigan Detroit Climate Capstone

Goal #4: Increase alternative fuel use in fleet vehicles

Strategy: Combine with existing organizational efforts to identify key users of fleet vehicles and encourage the conversion of fleet vehicles to alternative fuel sources, in addition to developing alternative refueling infrastructure.

The following indicator pertains to increasing the use of alternative fuels within vehicle fleets:

1. Increase percentage of fleet vehicles using alternative fuels.

SEVERAL PROGRAMS AND EFFORTS PERTAINING TO SUSTAINABLE TRANSPORTATION AND SAFETY CURRENTLY EXIST, SOME ALREADY HAVE ADVOCACY IN DETROIT.

Goal #5: Increase efficiency of fleet vehicle routes

Strategy: Combine with existing organizational efforts to identify key users of fleet vehicles and encourage the optimization of fleet routes. Provide assistance in route analysis and streamlining routes for maximum efficiency.

The following indicator pertains to increasing the efficiency of fleet vehicle routes:

1. Increases efficiency in fleet vehicle routes. (Efficiency being measured in fuel gallons consumed/tons of cargo delivered or fuel gallons consumed/ hour of operation.)

Goal #6: Promote Transit Oriented Development (TOD)

Strategy: Combine with existing organizational efforts to identify key nodes of concentration to maximize the impact of physical implementation of TOD. Lobby the city to update zoning for TOD developments and decrease parking requirements for proposed TOD developments. Where applicable, engage landholders to consolidate properties and catalyze developers.

The following indicators pertain to the promotion of transit-oriented development:

1. Increase in TODs in the City of Detroit
2. Increase in areas zoned for TOD

INNOVATIVE AND SYNERGISTIC PROGRAMS RELATED TO TRANSPORTATION

As mentioned several programs and efforts pertaining to sustainable transportation and safety currently exist, some already have advocacy in Detroit. The programs listed below were highlighted because their relationship to transportation, climate change and sustainability. The programs can play an integral role in the strategic implementations of Work Group plans. A couple of the listed programs are established initiatives that have planning implementation funding available through various state and federal sources. Additional information on these programs is provided in the transportation resources list at the end of this section.

Safe Routes to Schools: Safe Routes can be a community-initiated effort to increase the number of students who walk or bicycle to school. As part of this effort the program also addresses safety concerns and initiatives for improving the overall walkability of the routes to schools. To assist in the planning and design of the program and the physical improvements to sidewalks and infrastructure that improve the access to schools federal funding is available and distributed through the state Safe Routes to School Coordinator. Detroit's regional Coordinator is Linda Patrick lpatrick@michiganfitness.org.

Source: Complete Streets from Toole Design Group

Complete Streets: As defined by Smart Growth America, "the Complete Street movement aims to develop integrated, connected networks of streets that are safe and accessible for all people, regardless of age, ability, income, ethnicity, or chosen mode of travel." Complete Streets seeks to integrate walking and bicycling into the status quo of the transportation system and provide accessibility to employment opportunities and educational institutions, in addition to giving independence from carbon-based fuels and the economic benefits that can bring. Complete Street policies are encouraged by Michigan legislation and funding sources are available for a variety of programs.

Transit Oriented Development (TOD): Peter Calthorpe a leader in TOD defines it as: "moderate and high-density housing, along with complementary public uses, jobs, retail and services, [that] are concentrated in mixed-use developments at strategic points along the regional transit systems." Interest in TOD has already been active in Detroit surrounding the Woodward Corridor planning efforts. The Downtown Detroit Partnership, Detroit Economic Growth Corporation and Midtown Detroit Inc. have formed a partnership that meets monthly to engage TOD planning issues.

Clean Cities: The Clean Cities program is a program developed through the U.S. Department of Energy (DOE). According to DOE Clean Cities is dedicated to "advancing the nation's economic, environmental and energy security by supporting local actions to reduce petroleum consumption in transportation." The Clean Cities coalition "brings together stakeholders in the public and private sectors to deploy alternative and renewable fuels, idle-reduction measures and fuel economy improvements." Funding for these supported initiatives is available and Detroit is already established as apart of the nearly 100 cities within the Clean City network. The Clean Cities Coordinator for Detroit is Matt Sandstorm matt@cec-mi.org.

Woodward Corridor Initiative: The Woodward Corridor Initiative is one of several organizations supporting the development transit and investment along the Woodward Corridor in Detroit. They are supportive of TOD strategies and are active in advocacy for the integration of mixed-use development at strategic points. As an organization they have propelled development efforts forward and aided in concentrating growth around midtown even when the transit proposals for the corridor have stalled.

SOURCES

1. Bochner, Brian, James M. Daisa P.E., and Beverly Storey. "Walkable Urban Thoroughfares: From Concept to Recommended Practice." Institute of Transportation Engineers.ITE Journal 81.9 (2011): 18-24.

RESOURCES

Accelerating Bus Rapid Transit: A Resource Guide for Local Leaders

This resource guide was prepared for a workshop held in Cleveland, OH on March 24, 2012. The guide is a compilation of case studies for best practices for implementing Bus Rapid Transit (BRT) systems. It provides clear examples and references to tools for implementation including: making the case for BRT, fostering collaboration and finding creative financing.

Webpage:
http://sustainablecommunitiesleadershipacademy.org/workshops/accelerating-bus-rapid-transit

PDF Document:
http://sustainablecommunitiesleadershipacademy.org/resource_files/documents/Resource-Guide-Bus-Rapid-Transit-v1.pdf

Complete Streets: Local Policy Workbook

This is a guidebook that serves as a starting point to begin development of Complete Streets policies. The guide encourages local leaders to examine their own community's needs, visionand goals and incorporate a broad group of local stakeholders.

PDF Document:
http://www.smartgrowthamerica.org/documents/cs-local-policy-workbook.pdf

Funding in Michigan:
http://library.michigantrails.org/wp/wp-content/uploads/Complete-Streets-Funding-for-Michigan-2011.pdf

Webpage:
http://www.smartgrowthamerica.org/guides/complete-streets-local-policy-workbook/

Safe Routes — Getting Results: Safe Routes To School (SRTS) Programs That Increase Walking and Bicycling to School

This is a guide to developing Safe Routes programs; it features communities across the U.S and identifies how they overcame their barriers to developing Safe Routes programs. It also includes a useful guide on how to measure student walking and bicycling numbers.

Document:
http://www.saferoutesinfo.org/sites/default/files/resources/srts_gettingresults_walkbike.pdf

Webpage:
http://www.saferoutesinfo.org/

Designing Walkable Urban Thoroughfares; A Context Sensitive Approach

This report was developed to help improve mobility choices and community character through the commitment to creating and enhancing walkable communities. This report uses case studies and design options to guide the community through the urban planning and design process.

Journal Article:
Bochner, Brian, James M. Daisa P.E., and Beverly Storey. “Walkable Urban Thoroughfares: From Concept to Recommended Practice.” Institute of Transportation Engineers.ITE Journal 81.9 (2011): 18-24.

Full Report:
Daisa, James. M. and Brian S. Bochner. “Designing Walkable Urban Thoroughfares; A Context Sensitive Approach” Institute of Transportation Engineers. 2012

Webpage:
http://www.ite.org/emodules/scriptcontent/Orders/ProductDetail.cfm?pc=RP-036A-E

Livability Solutions: coalition helping communities succeed

Livability Solutions is a coalition of organizations across the country that provides communities assistance to achieve livability, sustainability, placemaking and smart growth goals. They have a verity of resources listed on their webpage as well as periodic grant opportunities.

Webpage:
http://livabilitysolutions.org/?page_id=7

Sustainable Urbanism: Urban Design With Nature By Douglas Farr

This is a book off articles and case studies that address issues of sustainable urbanism The book gives structure to issues of leadership, implementation and advocacy for sustainable issues.

Farr, Douglas. Sustainable Urbanism: Urban Design With Nature. Hoboken, N.J.: Wiley, 2008.

Transportation and Climate Change Clearinghouse—Climate Change Impacts

This annotated list of resources on the impacts of climate change on transportation infrastructure is continually updated.

Department of Transportation, 2010
Webpage: http://climate.dot.gov/impacts-adaptations/forcasts.html

Regional Climate Change Effects: Useful information for transportation agencies

This report provides the transportation community (including highway engineers, planners, NEPA practitioners) with digestible, transparent, regional information on projected climate change effects that are most relevant to the U.S. highway system. This information informs assessments of the risks and vulnerabilities facing the current transportation system, and can inform planning and project development activities.

Federal Highway Administration, 2010
Webpage: http://www.fhwa.dot.gov/hep/climate/climate_effects/effects00.cfm

CONCLUSION

As of December, 2012, DCAC is in the early stages of developing a community-led climate action plan for Detroit. As part of this process, graduate students from the University of Michigan's Urban and Regional Planning Program, in partnership with DCAC, developed a vulnerability assessment in late 2012 to identify the spatial distributions of social disadvantage and environmental hazards that may inform decision-makers how best to prioritize adaptive strategies.

Results of the vulnerability assessment can be used to identify key geographic areas and populations within the city that are recognized to be most vulnerable to the potential effects of climate change. However, the greatest strength of the vulnerability analysis will be when it is integrated with the expertise and contextual knowledge of the DCAC members and community residents. Then it can be used as a tool to carefully target further efforts including: additional research, ground-truthing, community outreach and ultimately prioritizing strategies for climate change adaptation efforts.

The vulnerability analysis focused on identifying the physical areas in the city that have the highest risk of negative impacts related to heat and rainfall events. These impacts were chosen based on GLISA's identification that heat and rainfall would have the greatest climate change effect on Detroit. Current scientific literature also identifies that certain populations have a greater level of sensitivity to heat or flooding events. As a result of this research, an overlay of the socio-economic demographics was added to help prioritize the populations that may experience the greatest vulnerability.

The overall findings show that areas with the highest heat intensity and potential for a sewer system overload during a rain event contain a high percentage of impervious surfaces and a low percent of tree coverage. To help prioritize adaptation strategies within the city, the results of the vulnerability analysis were mapped at a relative scale, meaning the areas that are identified to have the highest vulnerability are relative only to those with lower vulnerability within Detroit, and are not compared to other cities.

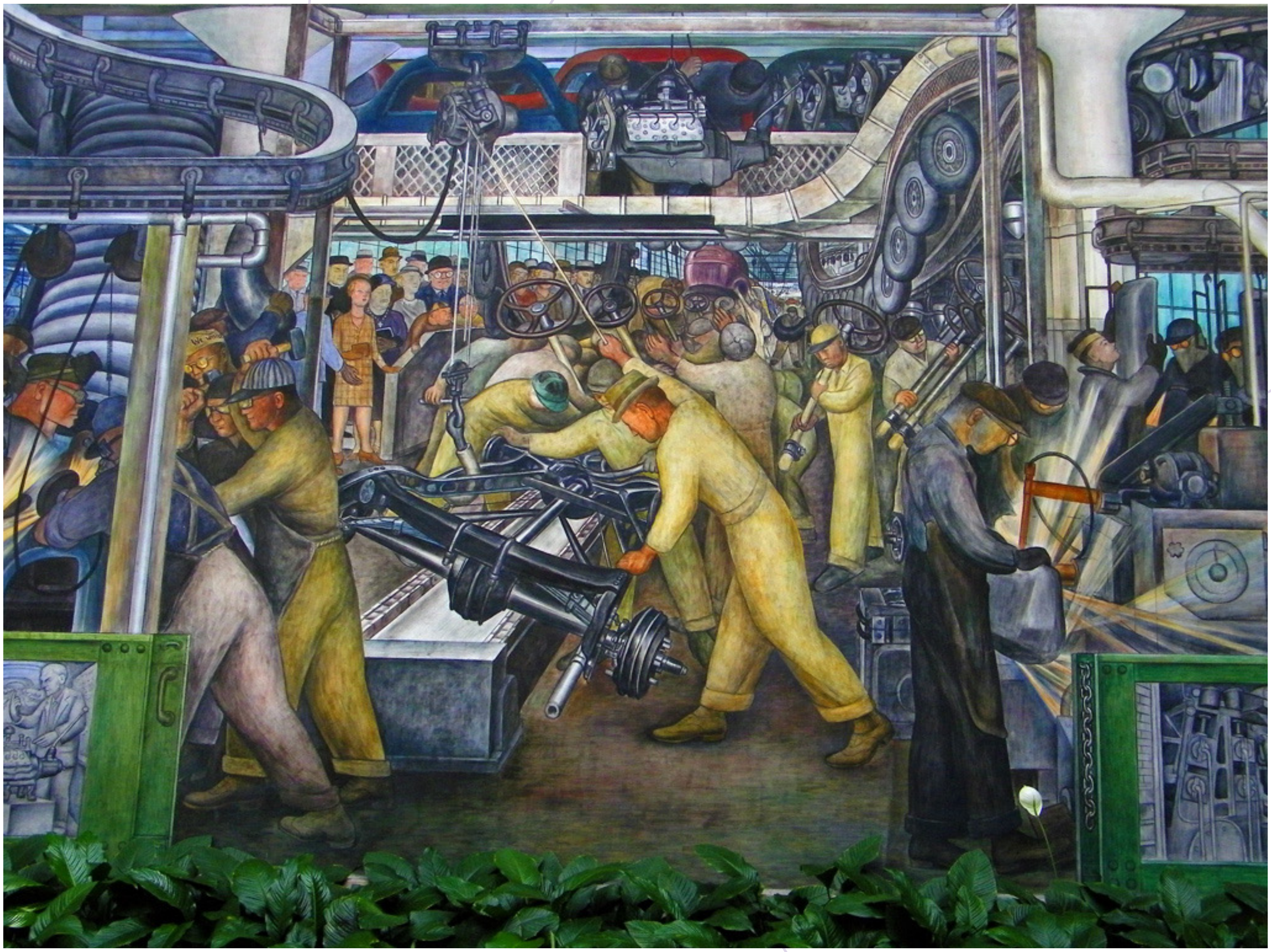
Areas identified as having very high levels of heat vulnerability are dispersed throughout the city. Downtown, Midtown and the Grand River and Gratiot corridors are predominantly identified as moderate to very high vulnerability due to their generally low tree cover and impervious physical characteristics.

Our flooding vulnerability analysis has two components: sewersheds and households. As climatologists warn that intensity and frequency of precipitation events will increase, it is important to identify what areas of the city have the most stormwater runoff. Similar to the heat analysis, the results showed that the areas most vulnerable to sewer systems overload are those with the highest percent of impervious surface and the lowest percent of tree cover. Again, these areas are concentrated predominantly in the Downtown and Midtown areas of Detroit. At the household level, the flooding vulnerability analysis focused on exposure according to location within the floodplain and sensitivity according to the age of the housing stock and the median household income. The results showed a limited flooding risk located only along areas adjacent to the Rouge and Detroit Rivers.

Moving forward in 2013, the DCAC and its work groups should identify both long-term and short-term priorities for addressing vulnerabilities within the city. Short-term recommendations could include, for example: carefully considering the distribution of the city's designated cooling center locations. Our findings encourage increasing the number of official cooling centers, and adding mobile cooling centers when necessary.

Longer-term, DCAC should develop a strategy that prioritizes planting and pavement removal in the areas that have been identified as the most vulnerable to heat events. Minimizing impervious surface cover and maximizing vegetative cover and tree canopy throughout the city will have positive benefits for reducing the UHI effect and reducing the likelyhood that overloaded sewer/stormwater systems will release untreated wastewater into the city's receiving waters.

Climate change adaptation for Detroit will require collaboration among the city's residents, organizations and institutions to effectively share knowledge, resources, and prioritize actions. The vulnerability assessment contained in this document serves as a starting point to begin a larger community conversation.



Source: By Maia C.

GLOSSARY

Adaptation: The “adjustment of human or natural systems in response to actual and/or anticipated climate change” (Larsen et al, 2013; Blanco et al, 2009).

Albedo: Albedo is how much of the incoming solar radiation is reflected as shortwave radiation. Measured from 0 - 1.0, 0 represents 100% complete absorption of all shortwave radiation and 1.0 represents 100% complete reflection of all shortwave radiation

All Hazards Plan: Plan to address all aspects of emergency preparedness, from security to natural disasters. Detroit’s Office of Public Health Emergency Preparedness coordinates its All-Hazards Plan. (Source: Detroit Department of Public Health)

American Community Survey: The American Community Survey (ACS) is an ongoing survey that provides data every year -- giving communities the current information they need to plan investments and services. Information from the survey generates data that help determine how more than $400 billion in federal and state funds are distributed each year. (Source: Census.gov)

Anaerobic Digestion: A biological process that produces a gas principally composed of methane (CH_4) and carbon dioxide (CO_2) otherwise known as biogas. These gases are produced from organic wastes such as livestock manure, food processing waste, etc. (Source: California Energy Commission)

Apparent Temperature: Calculation of what people perceive as the temperature in hot and humid conditions. (Source: National Oceanic and Atmospheric Administration, http://www.ncdc.noaa.gov/societal-impacts/apparent-temp/)

Biophysical: The biological and physical elements that help characterize a place, specifically underlying geology and soils, forest and vegetative cover types, climate, hydrology, and species diversity.

Blue-Green Infrastructure: Uses vegetation, soils, and natural processes to manage water and create healthier urban environments.
At the scale of a city or county, blue-green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, blue-green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water. (Source: EPA Green Infrastructure http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm)

Brownfield: Real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. (Source: EPA.gov)

Census Block Group: The smallest unit of Census geography in which the Census publishes household level data. A block group is smaller than a Census tract yet larger than a Census block and generally contains between 600 and 3,000 people. (Source: American Fact Finder Glossary)

Climate: Climate is the accumulation of recorded weather trends in a region over a long period of time.

Climate Change: The multitude of impacts caused by the trend of higher global temperatures: increased duration and frequency of drought, increased number of extreme precipitation events, rising sea levels, and ocean acidification. (Pew Center)

Climate Projection: A model of climate patterns combined with GHG emission scenarios that projects the expected climate change outcomes.

Coniferous: Mostly evergreen trees and shrubs having usually needle-shaped or scalelike leaves and including forms (as pines) with true cones and others (as yews) with an arillate fruit.

Cool Roof: Reflects the sun's heat and emits absorbed radiation back into the atmosphere. The two basic characteristics that determine the 'coolness' of a roof are solar reflectance (SR) and thermal emittance (TE). (Source: CoolRoofs.org http://www.coolroofs.org/HomeandBuildingOwnersInfo.html)

Cooling Center: A temporary air conditioned public space set up by local authorities to provide relief from the heat. (EPA, http://www.epa.gov/aging/resources/climatechange/extremeheatevents.htm)

Combined Sewer Overflow (CSO): A sewer system discharge (and major pollution concern) containing not only stormwater but also untreated human and industrial waste, toxic materials, and debris. During periods of heavy rainfall or snowmelt, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies. (Source: EPA http://cfpub.epa.gov/npdes/home.cfm?program_id=5)

Combined Stormwater System: Sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. (Source: EPA http://www.epa.gov/compliance/monitoring/programs/cwa/csos.html)

Compact Development: Building in a more compact way to reduce development costs and provides density that can be efficiently served by transit. There are several forms of compact development including mixed-used development, where by integrating different uses such as residential, office, and shopping daily vehicle trips can be reduced.

Compost: Decayed organic material used as a plant fertilizer.

Deciduous: Trees and shrubs that are wood plants and shed leaves annually,

Demand-Side Management: Manage the demand for energy in various ways that keep end-use demand levels constant.

Eco-Efficiency: Reducing the amount of resources, waste and pollution needed to provide the same good or level of service.

Effluent: An outflow from a sewer or sewage system.

Emissivity: Ratio from 0 - 1.0. An emissivity of 1.0 indicates that pavements are very effective at storing heat energy and releasing it slowly.

Environmental Risk: Vulnerable aspects of organizations that are exacerbated by climate change; Factors of production and capital flows are influenced dramatically by extreme weather events and changing climate conditions.

Extreme Heat Event (EHE): refers to unusually hot temperatures and/or high humidity readings compared to the typical regional average for that season. Generally, an EHE occurs when the daytime high is above 90*F and the nighttime low temperature remains high limiting relief from the heat. (EPA, http://www.epa.gov/heatisland/about/heatguidebook.html)

Flood Plain: A land area immediately adjacent to a river, stream, or creek. It is an area that may be covered with water after heavy rainstorms. The floodplain collects and holds the excess water from storms, allowing it to be released slowly into the river system and to seep into groundwater aquifers, the underground layers of soil, gravel, or porous stone that yield and carry water. Floodplains, along with wetlands and shorelines, are considered to be critical areas for a river and its watershed. (Source: Huron River Watershed Council)

Flood Risk: Usually expressed through a map, highlights areas that are more likely to flood and has a corresponding insurance rate. Risk is based on a number of factors: rainfall, river-flow and tidal-surge data, topography, flood-control measures, and changes due to building and development. (Source: FloodSmart.gov http://www.floodsmart.gov/floodsmart/pages/flooding_flood_risks/ffr_overview.jsp)

Geographic Information System: Software for analyzing and representing spatial data.

Greenhouse Gas (GHG): Gases that trap heat in the atmosphere often emitted as a byproduct of fossil fuel combustion. The most common are Carbon Dioxide (CO2), Methane (CH4), and Nitrous Oxide (N2O). (EPA, http://www.epa.gov/climatechange/ghgemissions/gases.html)

Greenway: A network of open spaces and trails for walking, jogging, biking and roller-blading that links neighborhoods and destinations such as parks, schools, libraries and shopping areas. (Source: Conner Creek Greenway http://www.connercreekgreenway.org/conner-creek-greenway/)

Green Jobs: Green jobs produce (“supply”) goods or services that result in: generating and storing renewable energy, recycling existing materials, energy efficient product manufacturing, distribution, construction, installation, and maintenance, education, compliance, and awareness, and natural and sustainable product manufacturing. (Source: State of California, Employment Development Divisions & Labor Market Information Division)

Green Lease:A lease that incorporates ecologically sustainable development principles to ensure that the use and operation of a building minimizes the impact on the environment.

Green Procurement: Environmentally sustainable rules and regulations that focus on efficiencies with regard to the acquisition of goods and services. (Ex: Detroit Diesel)

Heat/Health Warning System: Tool developed by National Oceanic and Atmospheric Administration for statistical analysis of heat threats for specific regions to allow for better forecasting of extreme heat and improve the public health response.

HVAC: Heating, ventilation and air conditioning systems. Used to provide heating and cooling services to buildings.

Herbaceous: Having the texture, color, etc. of an ordinary foliage leaf. i.e. shrubs and other low-growing plants.

Impervious Surface: An impervious surface is any surface that does not allow water to soak into the ground. When water from rain and snowmelt washes off a piece of property, it flows into a storm drain system and eventually into the Huron River. Impervious or hard surfaces on the property such as roofs, driveways, and patios, do not absorb the water and contribute to stormwater runoff. (Source: City of Ann Arbor, a2gov.org)

Incineration: The process of combusting waste material. Incineration is used to reduce the amount of waste headed to landfills, and/or produce energy.

Indicator: An instrument to measure the direction and proportion of progress.

Lead Abatement: Lead abatement is an activity designed to permanently eliminate lead-based paint hazards. (Source: EPA.gov)

Low Impact Design: Approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product. (Also Low Impact Development.) (Source: EPA http://water.epa.gov/polwaste/green/index.cfm)

Mitigation: Strategies that focus on reducing GHG emissions from human activity and promote the use and development of non-fossil fuel energy sources

Normalized: A method of accounting for changes in activity level such as population changes or changes in economic flows.

Outfall: The point, location, or structure where wastewater or drainage discharges from a sewer, drain, or other conduit. (Source: http://www.owp.csus.edu/glossary/outfall.php)

Ozone Precursors: Ground level ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC). These chemical reactions are accelerated by heat.

Ozone Action Day: Days that ground-level ozone exceeds acceptable levels for human health. Even relatively low levels of ozone can cause health effects. People with lung disease, children, older adults, and people who are active outdoors may be particularly sensitive to ozone. (Source: EPA, http://www.epa.gov/air/ozonepollution/basic.html)

Pay-As-You-Throw: A policy of charging residents for refuse collection based on amount.

Pervious Surface: Surfaces that allow rainwater to pass through them and soak into the ground instead of flowing into storm drains. (Source: Oregonmetro.org)

Positive Drainage: Soil around building slopes away from building to move water away from building

Public Health: Public health is the practice of preventing disease and promoting good health within groups of people, from small communities to entire countries. (Source: American Public Health Association)

R-Value: Measure of the thermal resistance to heat flow of a given material. A high R-value indicates a good insulative property.

Runoff: The draining away of water (or substances carried in it) from the surface of an area of land, a building or structure, etc.

Sensitivity: Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate- related stimuli. The effect may be direct e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise). (IPCC 3rd Assessment Report)

Service Area: A geographic zone based on access to particular amenity or service.

Sewer District: Sewer drainage areas defined as the city developed, with no formal legal boundaries. Boundaries are determined in order to minimize the number of inflow points into the DWSD collection system. (Source: DWSD Wastewater Master Plan)

Single Stream Recycling: Policy of collecting recycling goods in one container and sorting at a central facility. This is in contrast to the previous method of requiring residents or collectors to sort recyclables on the side of the curb.

Social Entrepreneurs: Social entrepreneurs are individuals with innovative solutions to society's most pressing social problems. (Source: Ashoka)

Stormwater: Water from rain, snow, sleet, hail, that flows across the ground and pavement or when snow and ice melt. (Source: Stormwater Coalition http://www.stormwatercoalition.org/html/ti/index.html)

Supply Side Management: Increases the reliability of energy supply focusing on production, transmission, or distribution of energy.

Sustainable Transportation: Transportation options that decrease dependence on personal vehicle transportation and reduce the use of carbon-based fuels.

Syndromic Surveillance: Michigan's Syndromic Surveillance System facilitates rapid public health response to outbreaks of illness and other public health threats by using real-time detection through automatic data collection and other tools. (Source: Michigan Department of Community Health, http://www.michigan.gov/mdch/0,4612,7-132-2945_5104_31274-107091--,00.html)

Thermal Envelope: Parts of a building that enclose conditioned spaces, including exterior walls, roof, and floors.

Transit-Oriented Development: "Moderate and high-density housing, along with complementary public uses, jobs, retail and services, [that] are concentrated in mixed-use developments at strategic points along the regional transit systems." (source: Peter Calthorpe)

Tree Canopy: The upper layer of deciduous trees that provide shade.

Urban Forest: The layer of leaves, branches and stems of trees that cover the ground when viewed from above. The urban forest includes trees on both public and private land. (Source: Center for Watershed Protection)

Read more: Definition of Urban Tree Canopy | eHow.com http://www.ehow.com/about_6578907_definition-urban-tree-canopy.html#ixzz2Fd5UZfeh

Urban Heat Island - UHI is defined as increased surface and air temperatures in urban areas relative to surrounding suburban and exurban areas. UHI patterns vary by region, occur in more dispersed pattern than once thought, may increase or decrease over time, and are most problematic during warm weather.

VOCs: "Volatile organic compounds (VOCs) and nitrogen oxide (NOx) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC." (Source: EPA, http://www.epa.gov/iaq/voc.html)

Vulnerability: The degree to which a system is susceptible to, and unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (Ontario Expert Panel on Climate Change Adaptation 2009)

Waste-to-Energy(WtE):Process of creating energy in the form of electricity or heat from the incineration of waste source. WtE is a form of energy recovery. Most WtE processes produce electricity directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels.

Waste Stream: Refers to total amount of waste produced by a particular area.

Wastewater: Used, dirty water that goes through the drains and toilets of homes, businesses, industry, and institutions; also known as sewage. (Source: WaterWise http://www.waterwise.co.za/export/sites/water-wise/water/wastewater/posters/downloads/Wastewater.pdf)

Wastewater Treatment Plant: In general, a facility designed to treat wastewater before discharging back into a water body. The Detroit facility, is the largest single-site wastewater treatment facilities in the United States. Originally, it was only intended to provide primary treatment, which screens out solids and chlorinates the wastewater. However, the plant was upgraded in the 1960s to provide secondary treatment, which is a more rigorous screening and treatment process that disinfects biodegradable solids, producing an even cleaner effluent. Currently, the plant serves about 35% of Michigan's total population, with a service area of 946 square miles, extending far beyond just Detroit's boundary. (Source: DWSD http://www.dwsd.org/pages_n/facilities_wastewater.html)

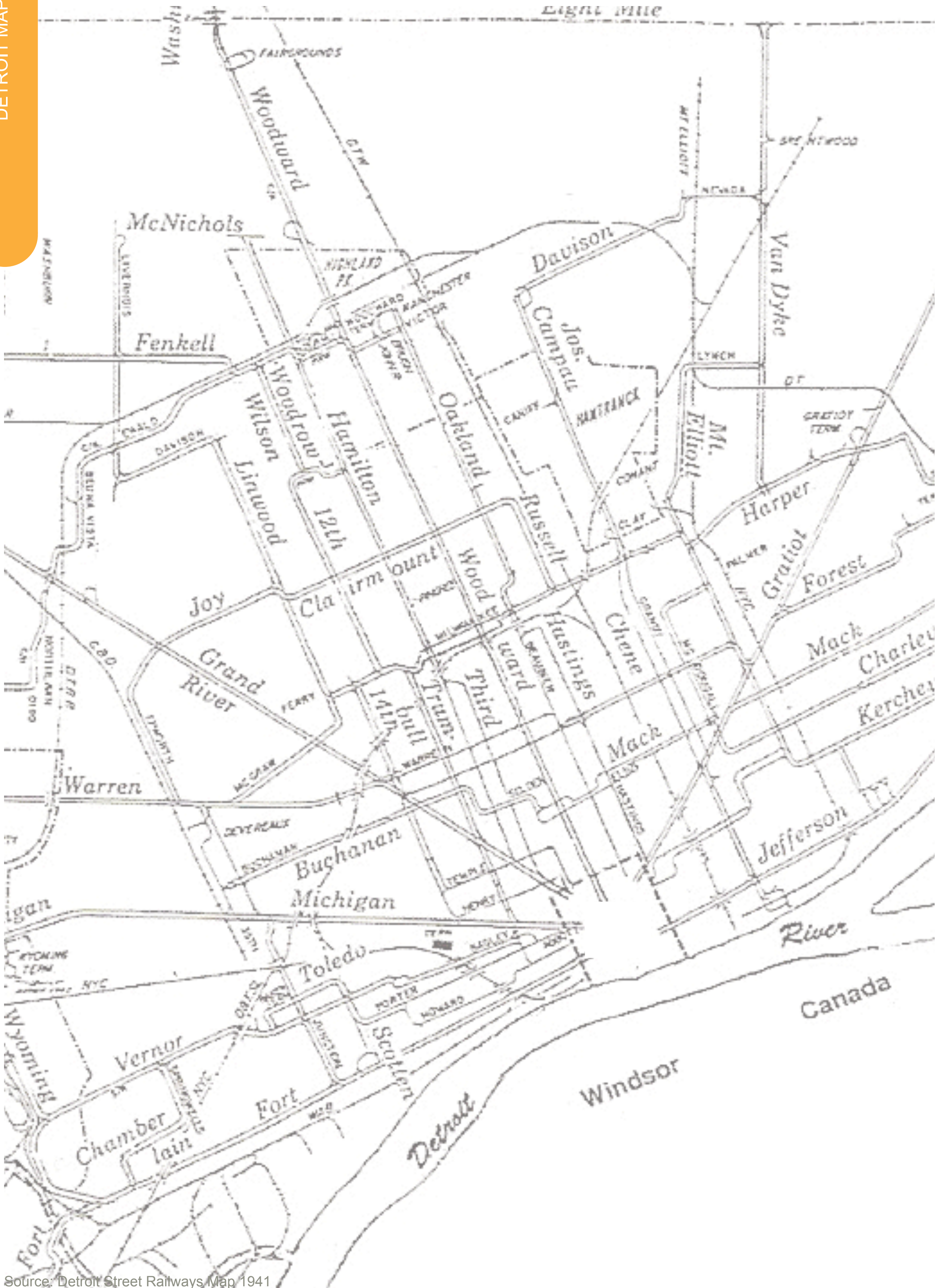
Watershed: Region within which water flows into a specified body such as a sea, river, lake or ocean

Weather: Weather describes the day-to-day conditions in a specific place, including the temperature, precipitation and cloud cover.

Weatherization: The practice of protecting a building and its interior from the elements, particularly from sunlight, precipitation, and wind, and of modifying a building to reduce energy consumption and optimize energy efficiency. (Source: http://www.waptac.org/)

Whole House Fan: Type of fan, or exhaust system commonly venting into a building's attic, designed to pull hot air out of the building.

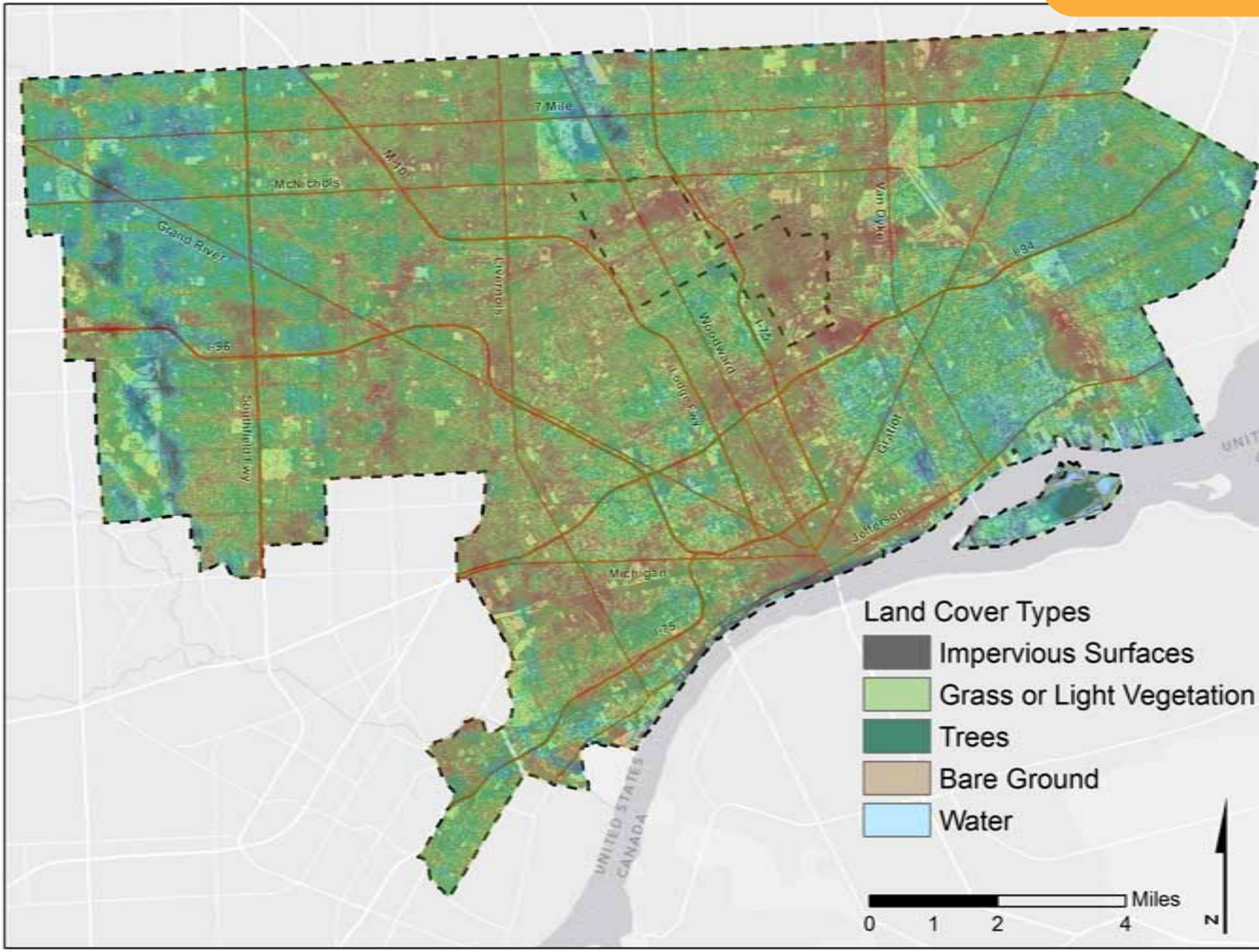
Yard Waste: Biodegradable waste that stems directly from plant matter, such as grass clippings and leaves.



Source: Detroit Street Railways Map 1941

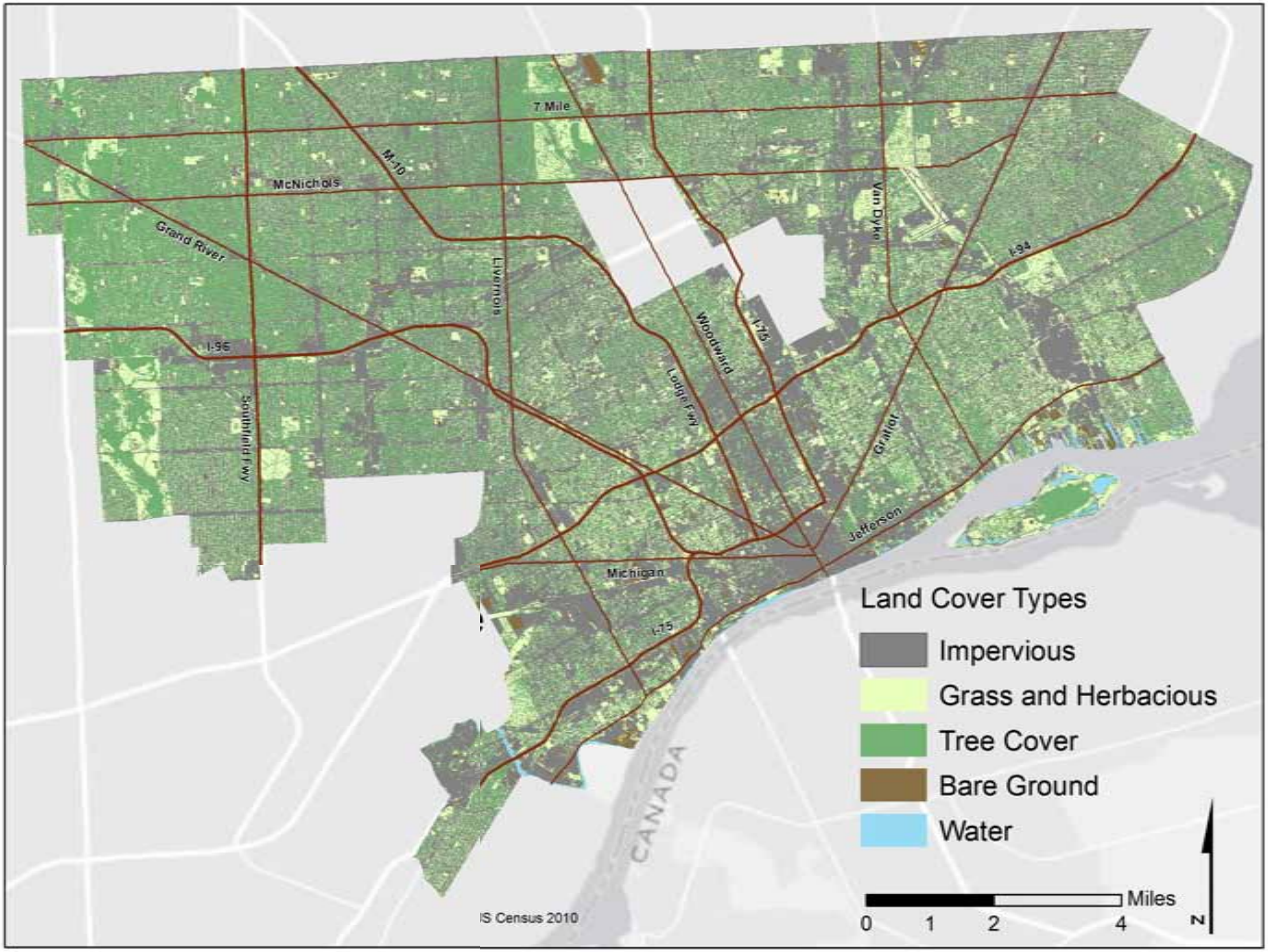
DETROIT MAPS

Figure 1: Surface Temperature Map



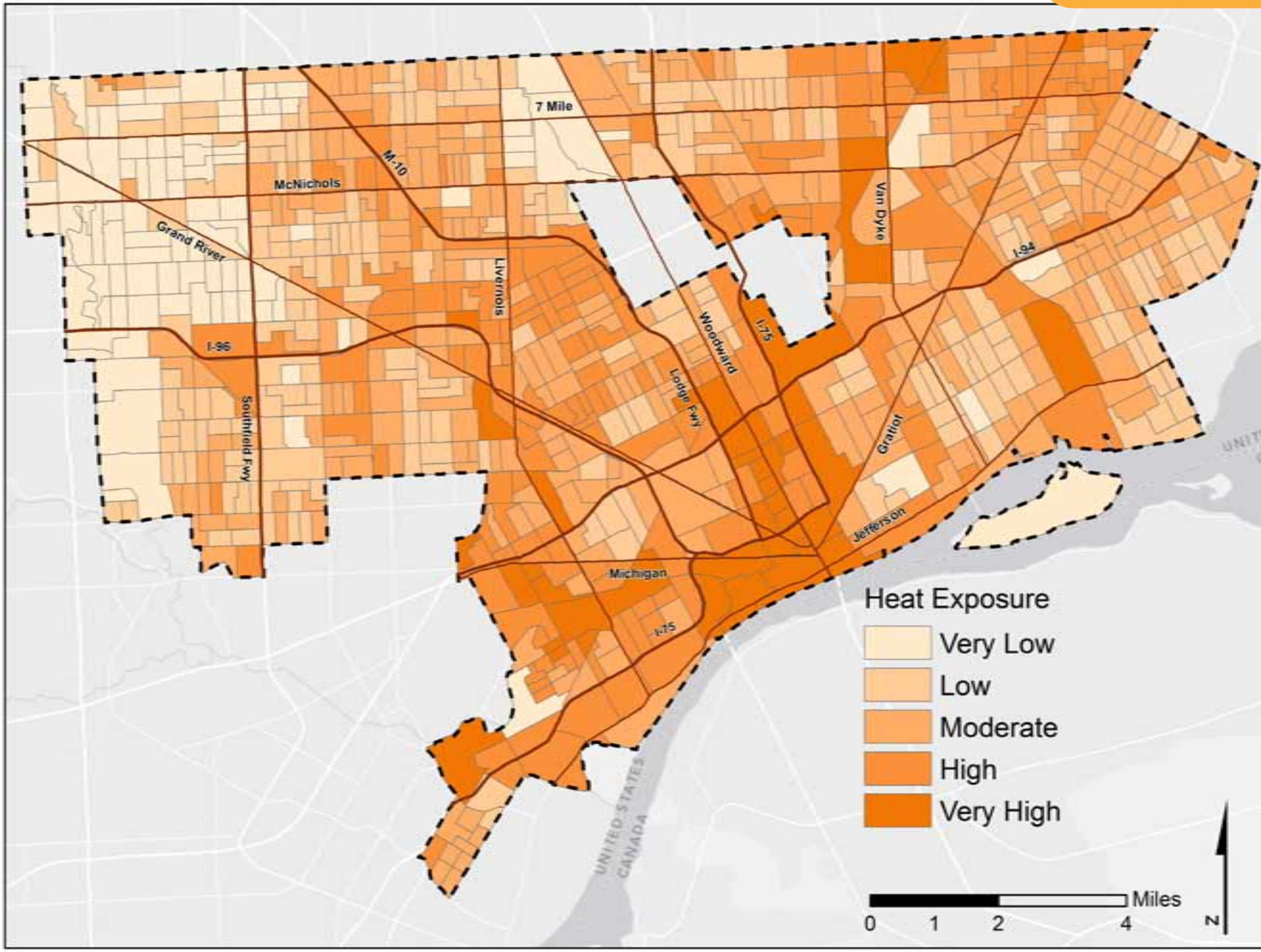
Source:Heat Map by Michael Howe
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 2: Detroit Land Cover Type



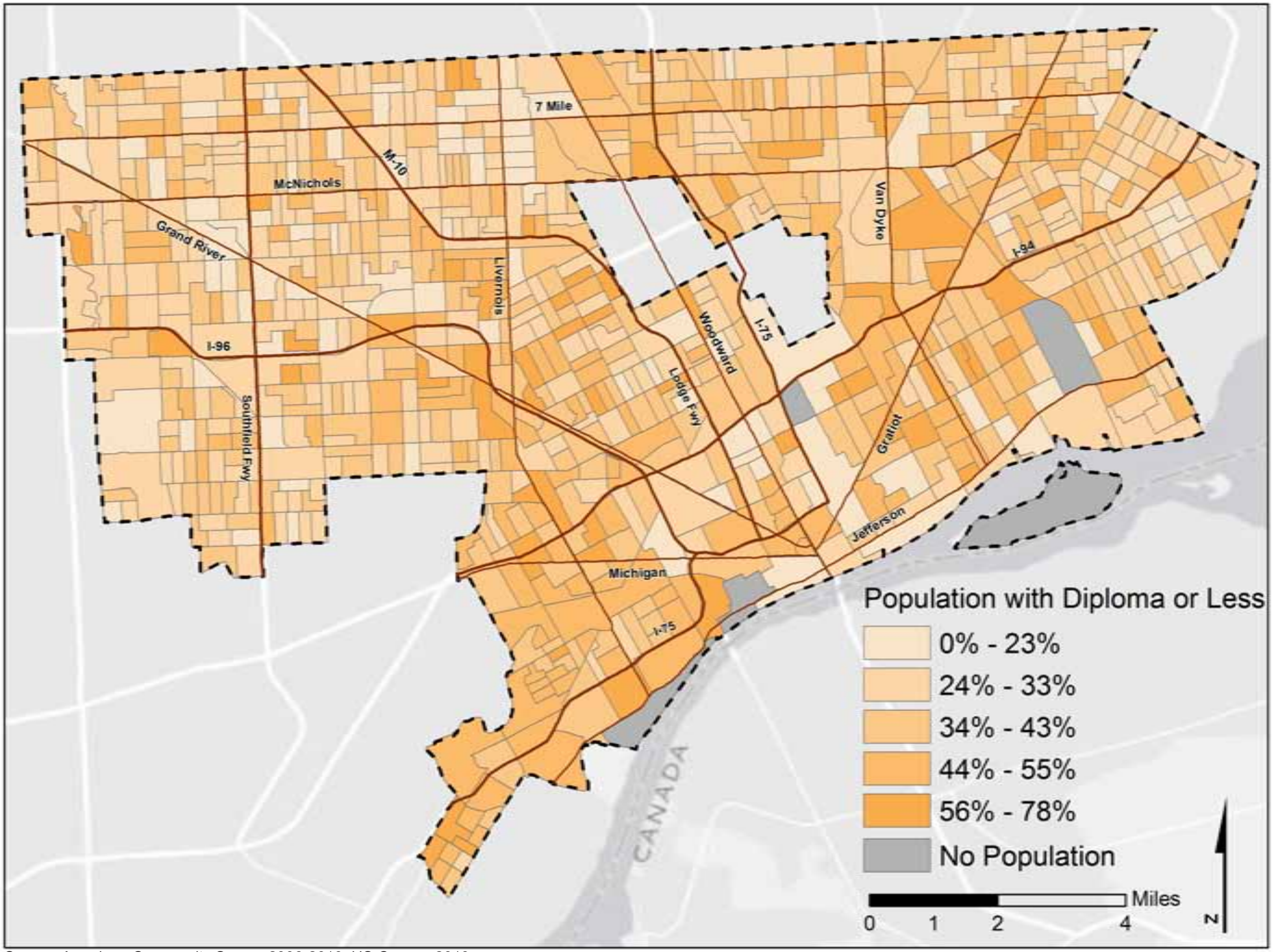
Source: USGS GloVis LandSat 7 ETM+; American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 3:Detroit Exposure to Excessive Heat Based on Land Cover by Block Group 2010



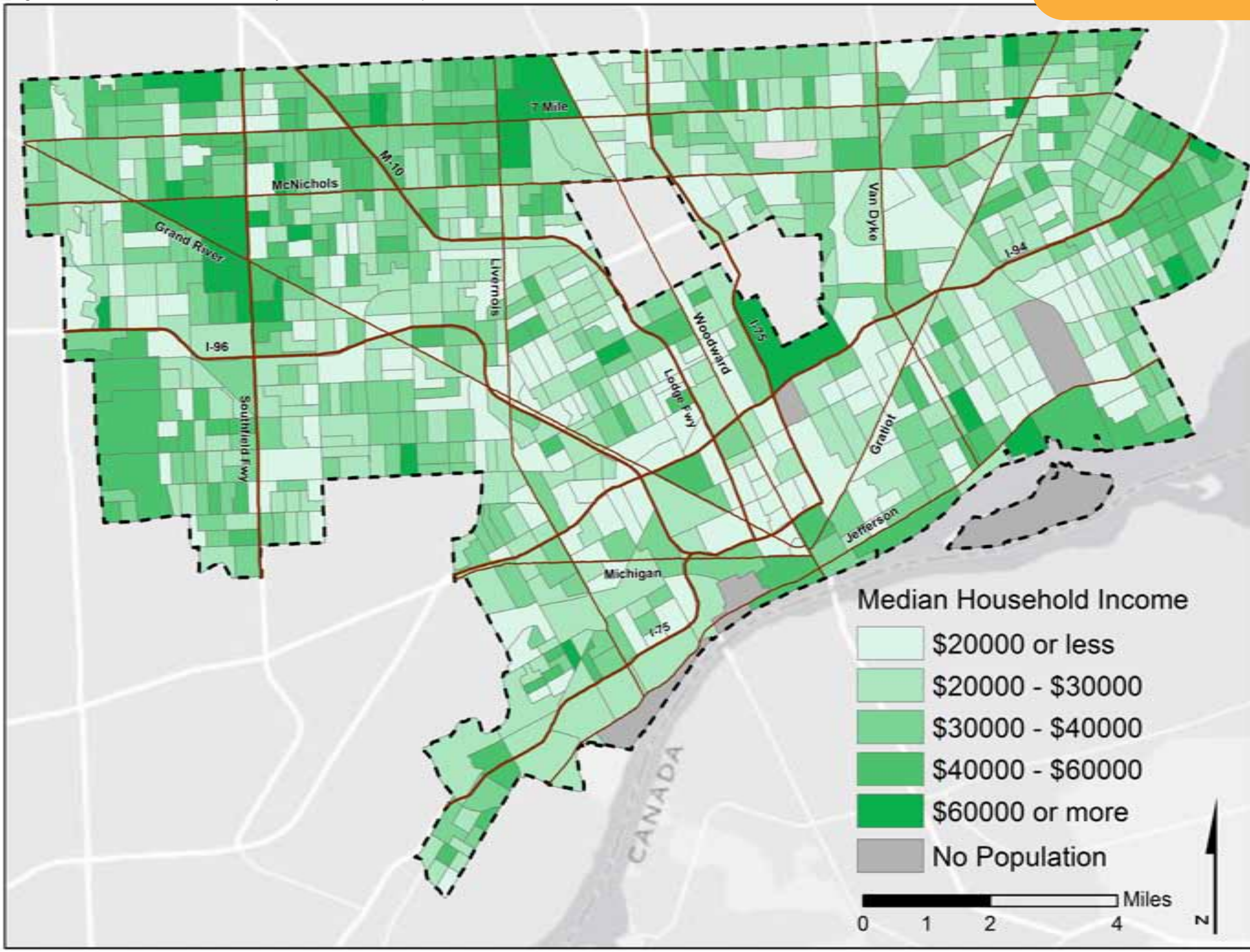
Source: USGS GloVis LandSat 7 ETM+; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 4:High School Education or Less by Census Block Group



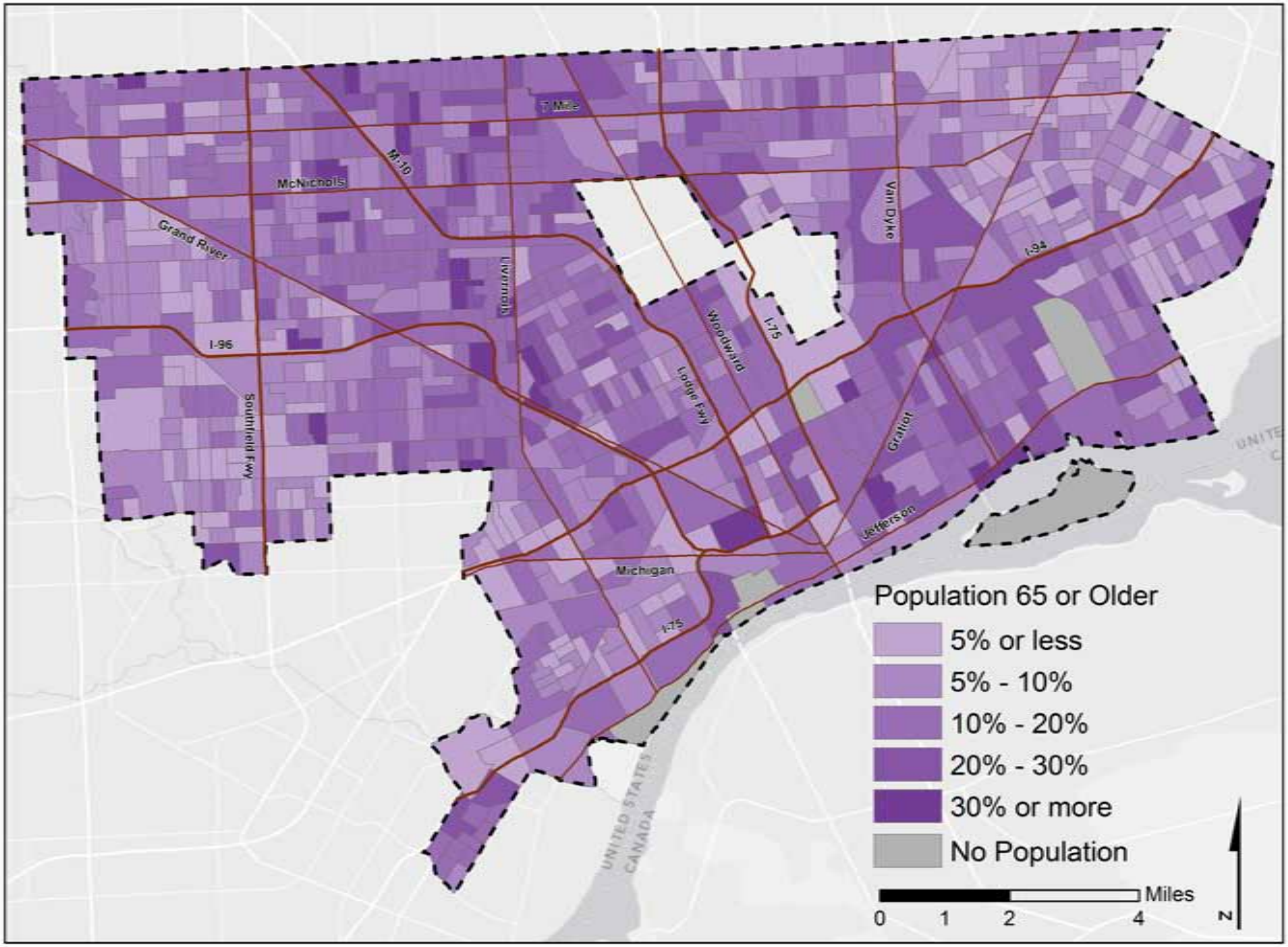
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 5: Median Household Income by Census Block Group



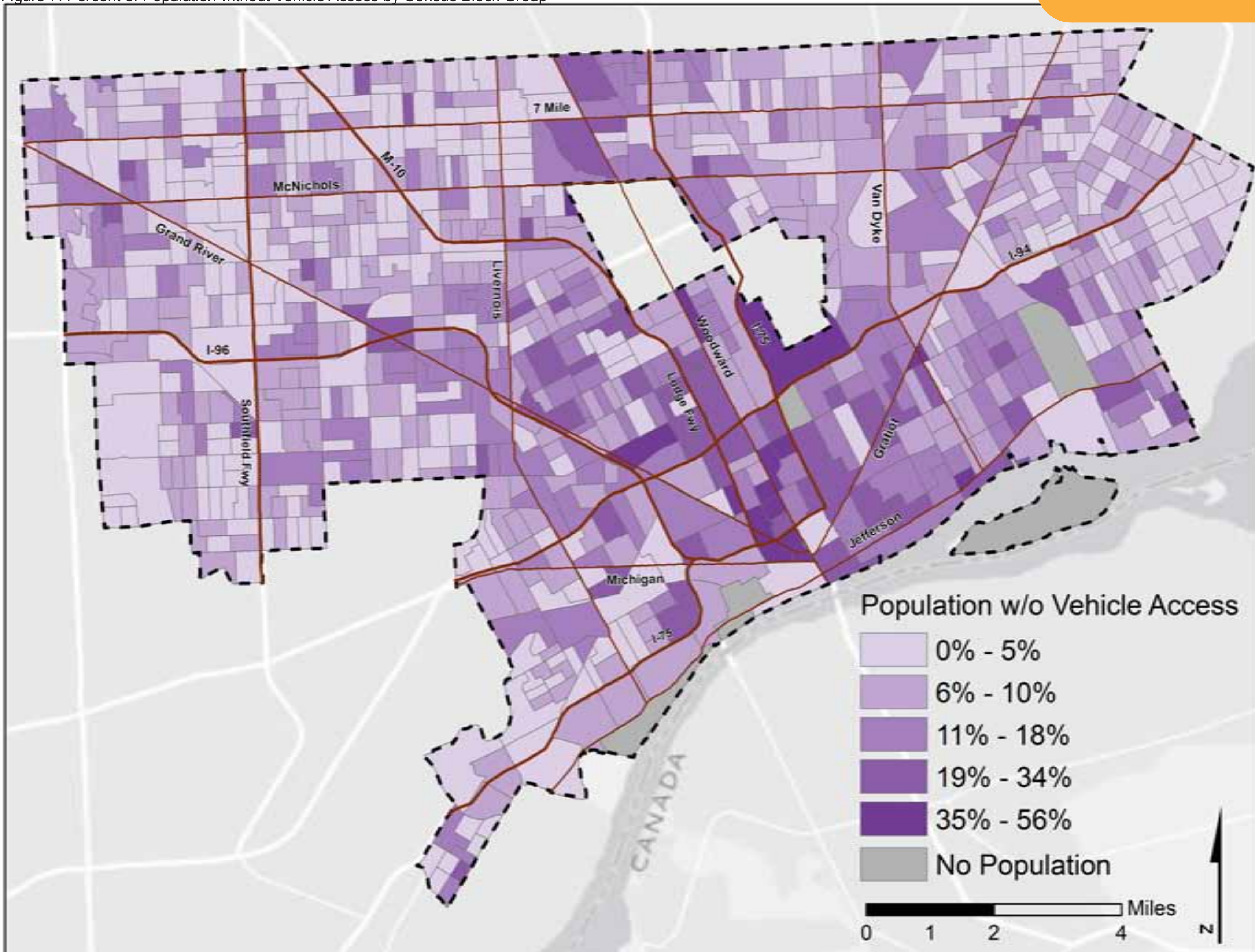
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 6: Percent of Population 65 or Older by Census Block Group



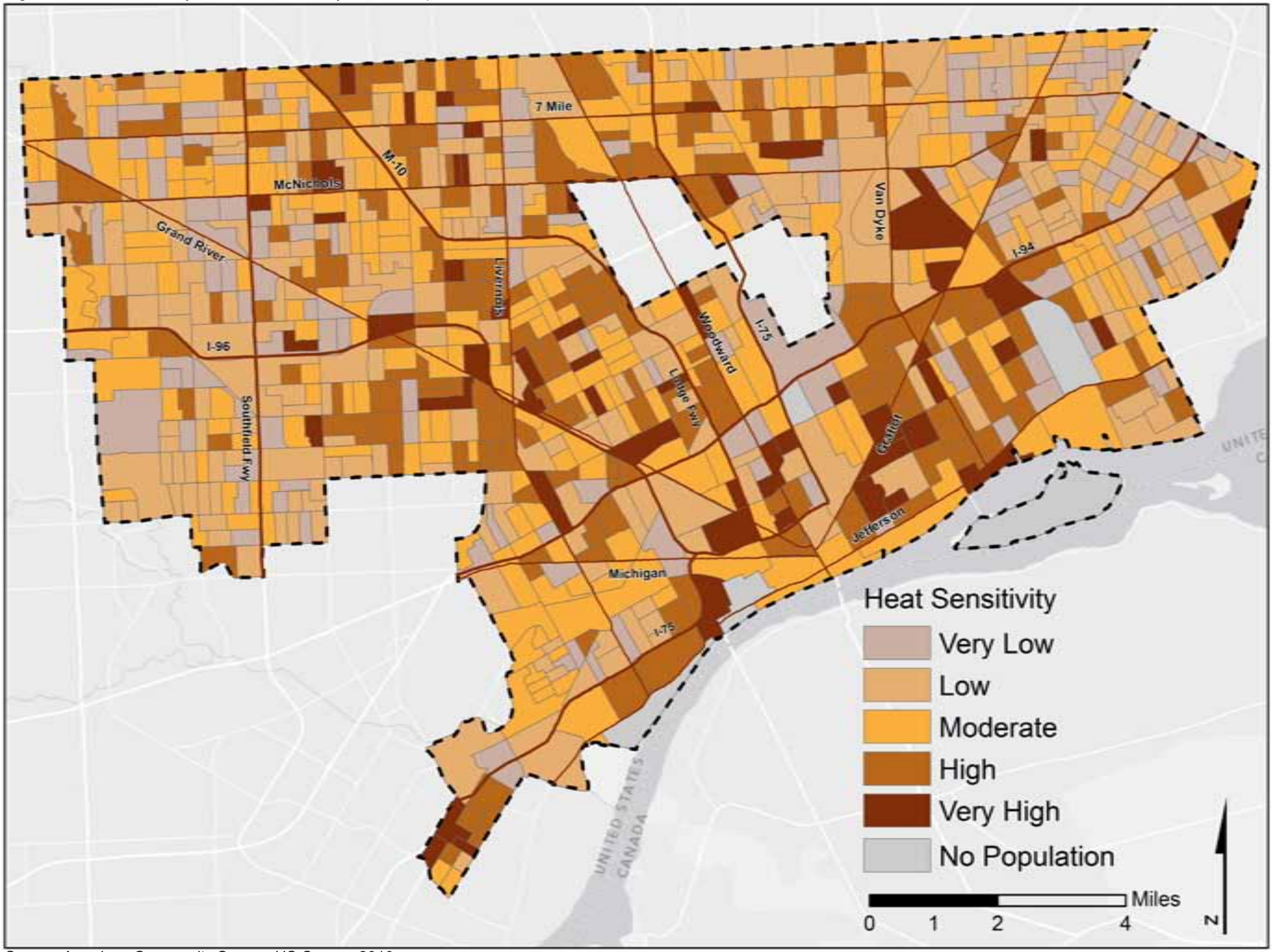
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 7: Percent of Population without Vehicle Access by Census Block Group



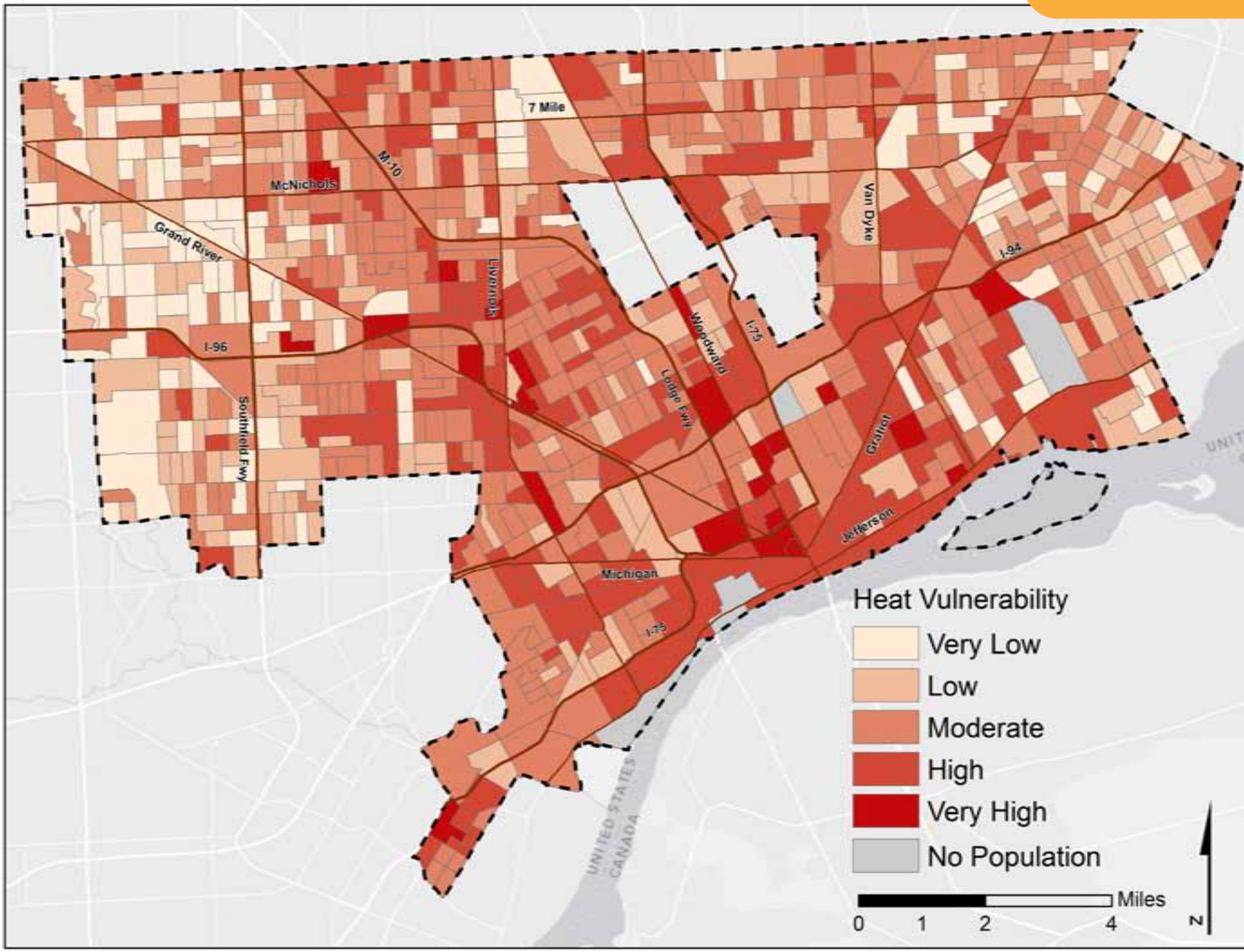
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 8 :Detroit Sensitivity to Excessive Heat by Block Group 2010



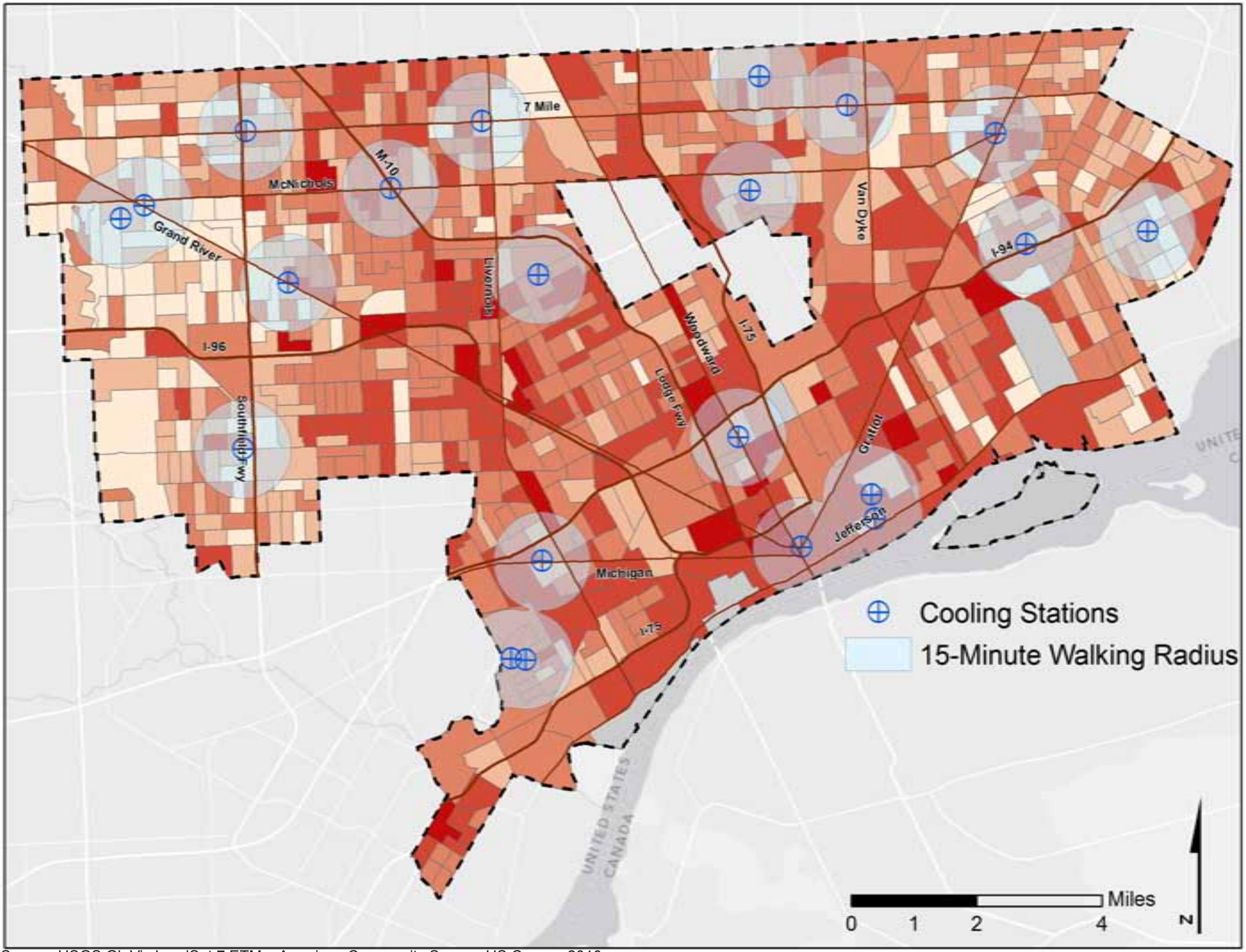
Source: American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 9 :Detroit Heat Vulnerability by Census Block Group 2010



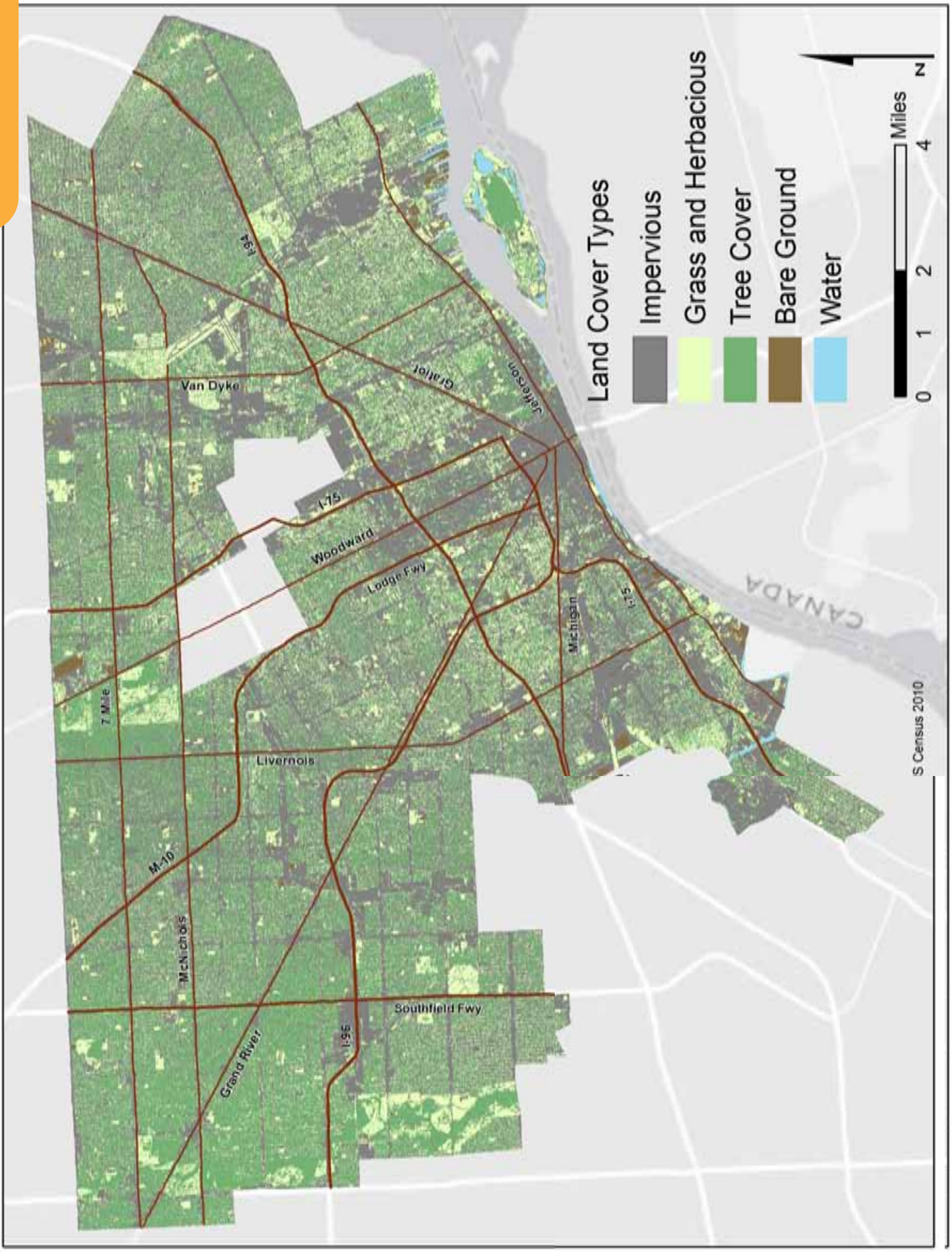
Source: USGS GloVis LandSat 7 ETM+; American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 10 :Detroit Heat Vulnerability and Cooling Center Access by Block Group 2010



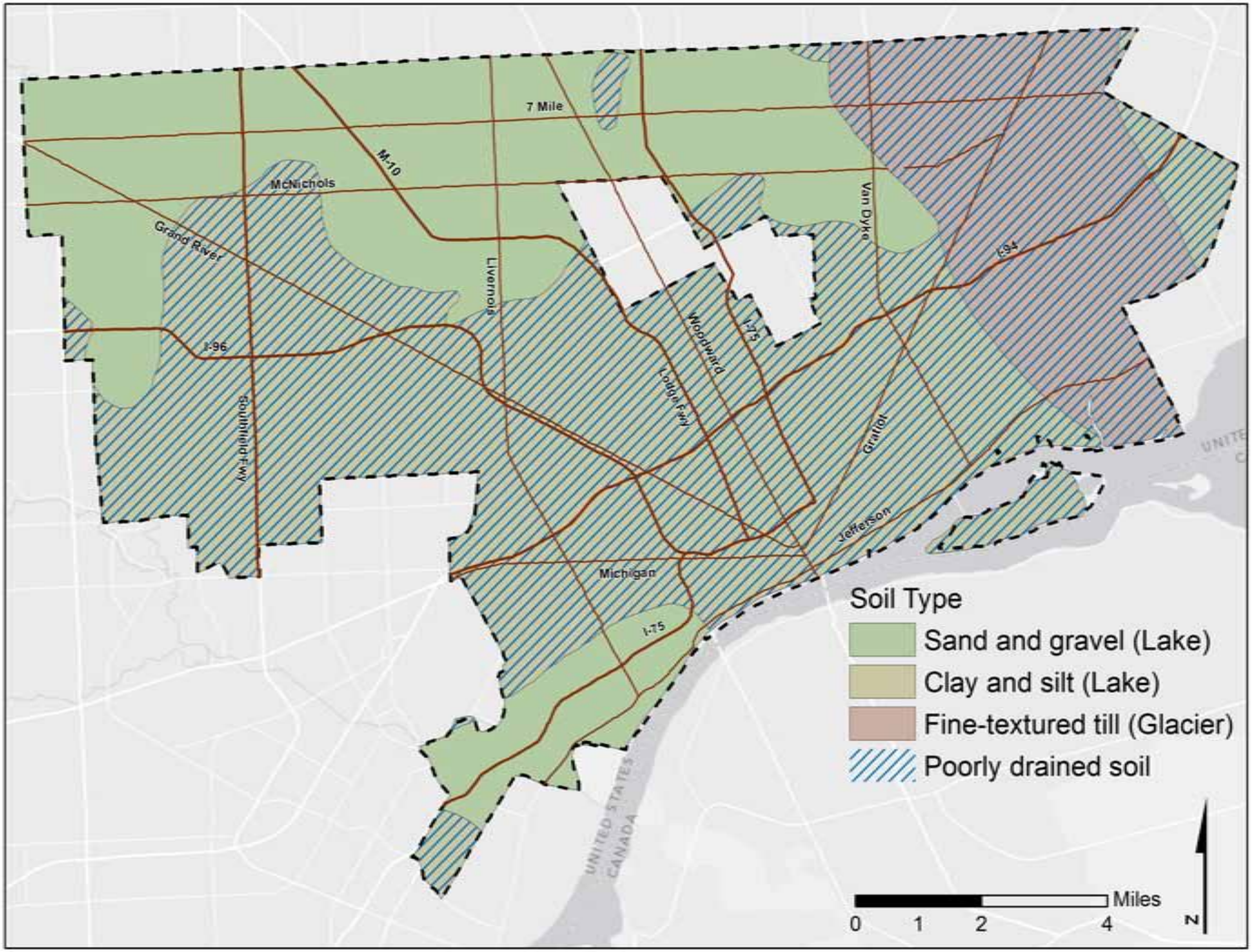
Source: USGS GloVis LandSat 7 ETM+; American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 11 :Detroit Land Cover Type



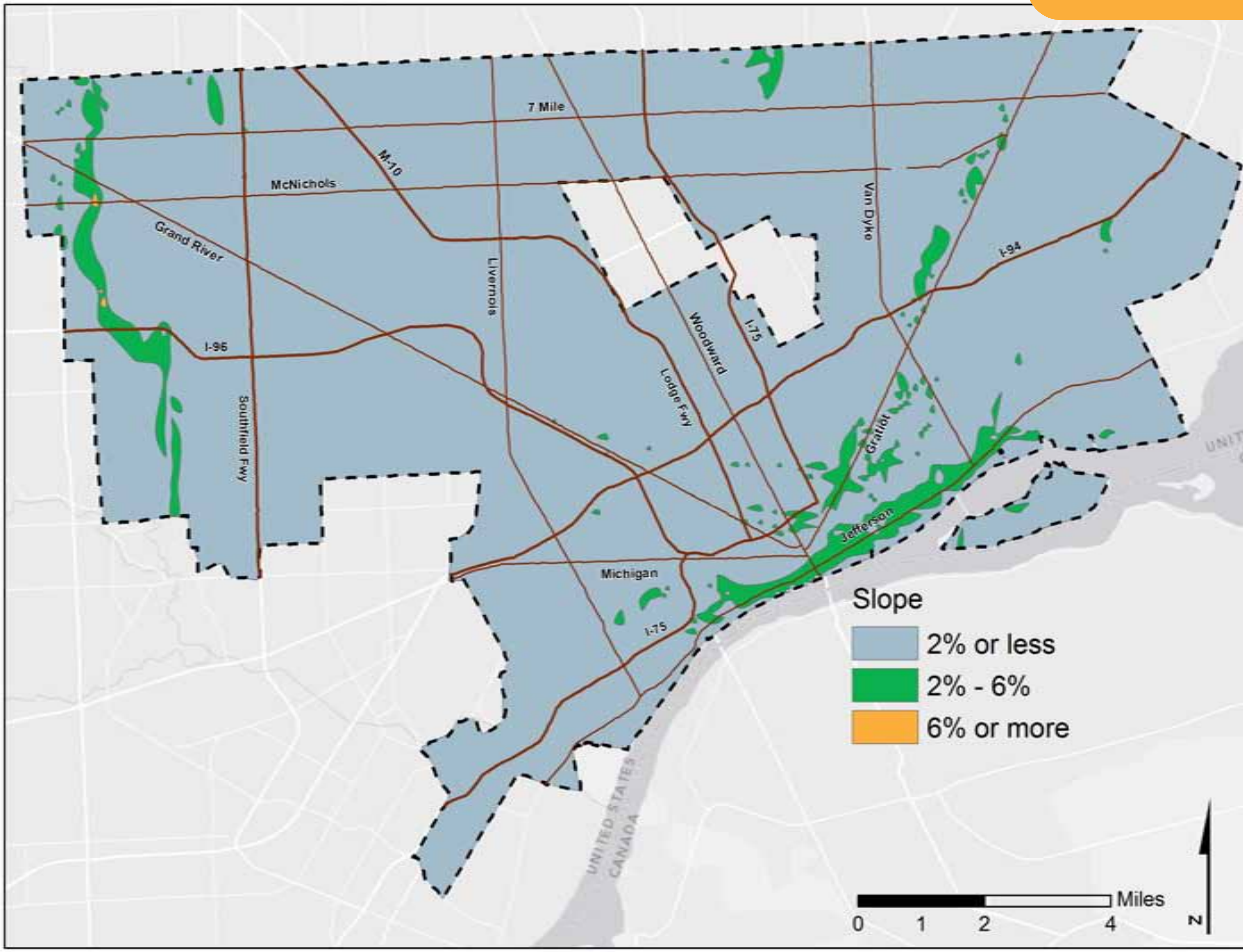
Source: USGS GloVis LandSat 7 ETM+; American Community Survey; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 12: Underlying Soil Type and Soil Drainage



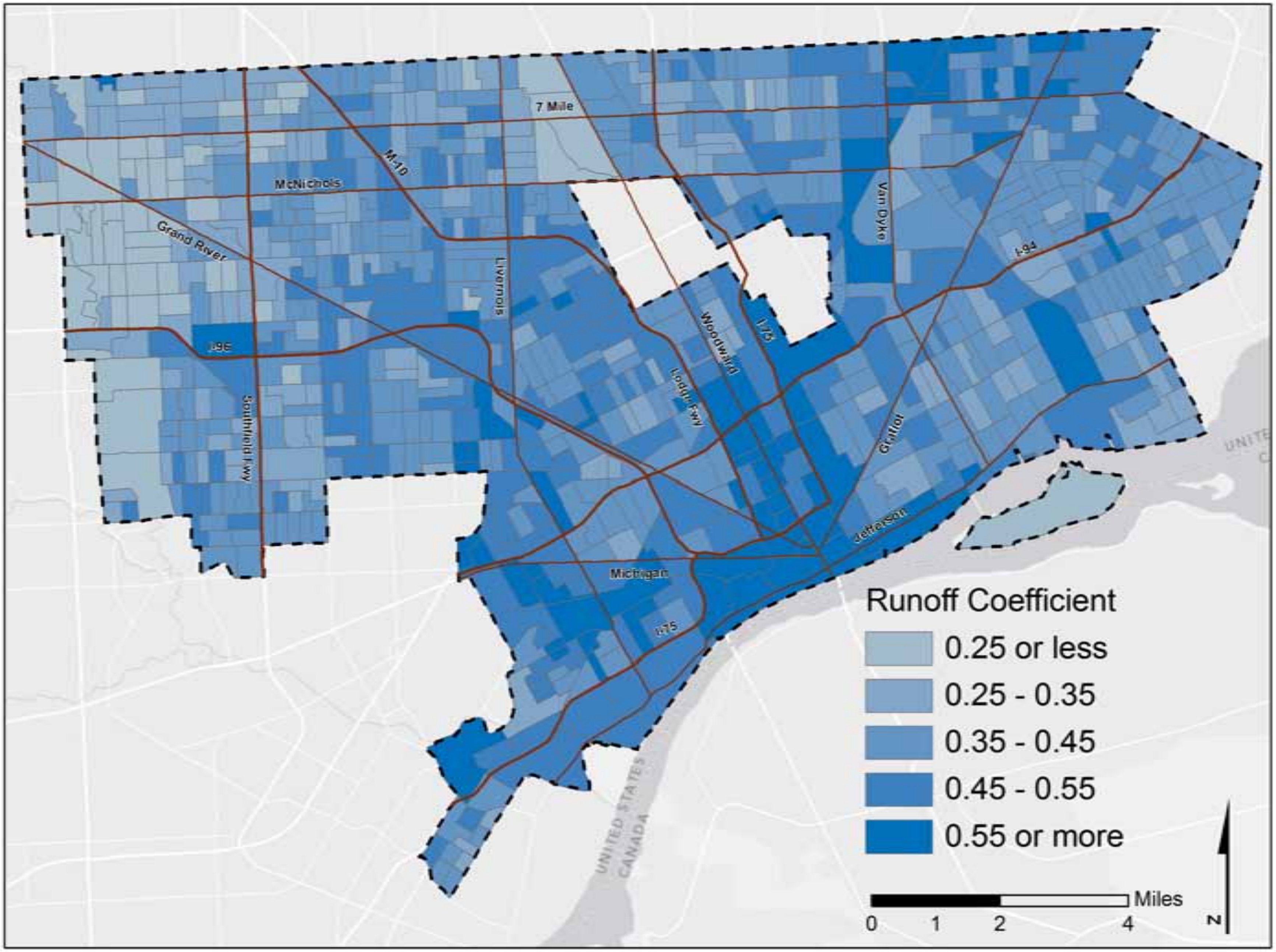
Source: Michigan Geographic Data Library, Michigan Quarternary Geology
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 13: Topographical Slope as Percent Change in Elevation



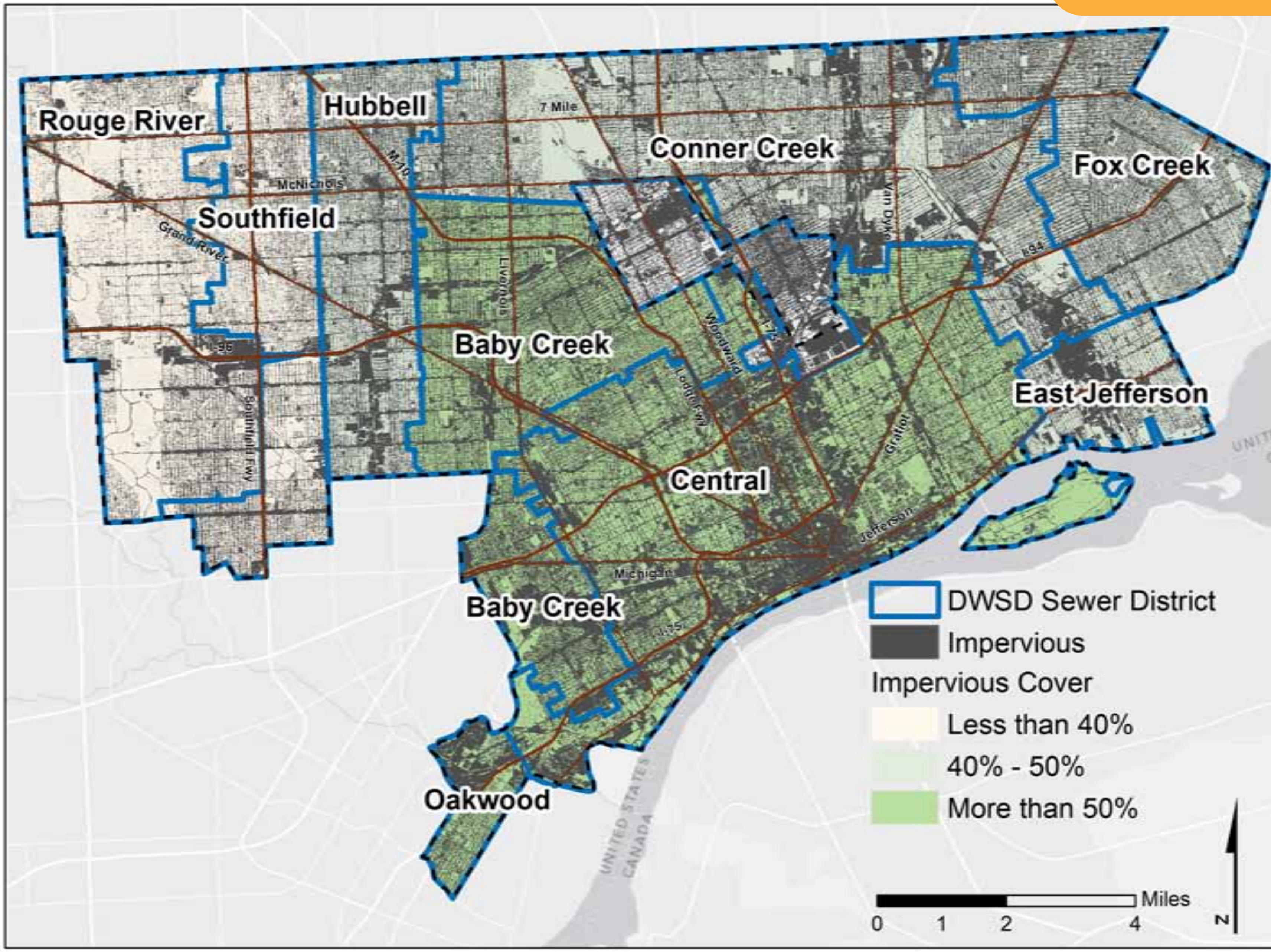
Source: Michigan Geographic Data Library, Michigan Digital Elevation Model
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 14: Aggregate Runoff Coefficient by Block Group 2010



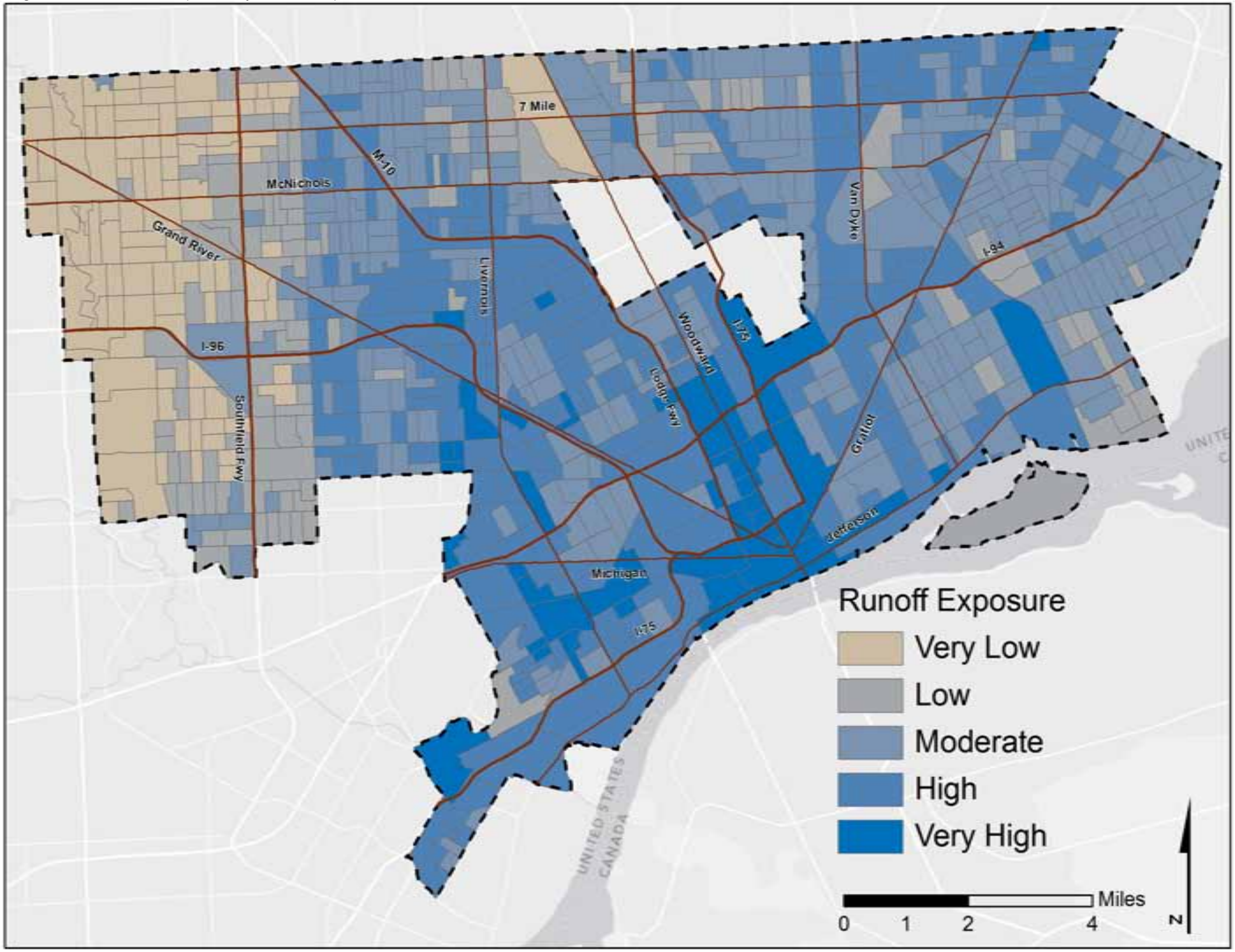
Source: Michigan Geographic Data Library; Michigan Digital Elevation Model; GloVis Landsat 7 ETM+; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 15: Impervious Surface Cover by DWSD Sewer District



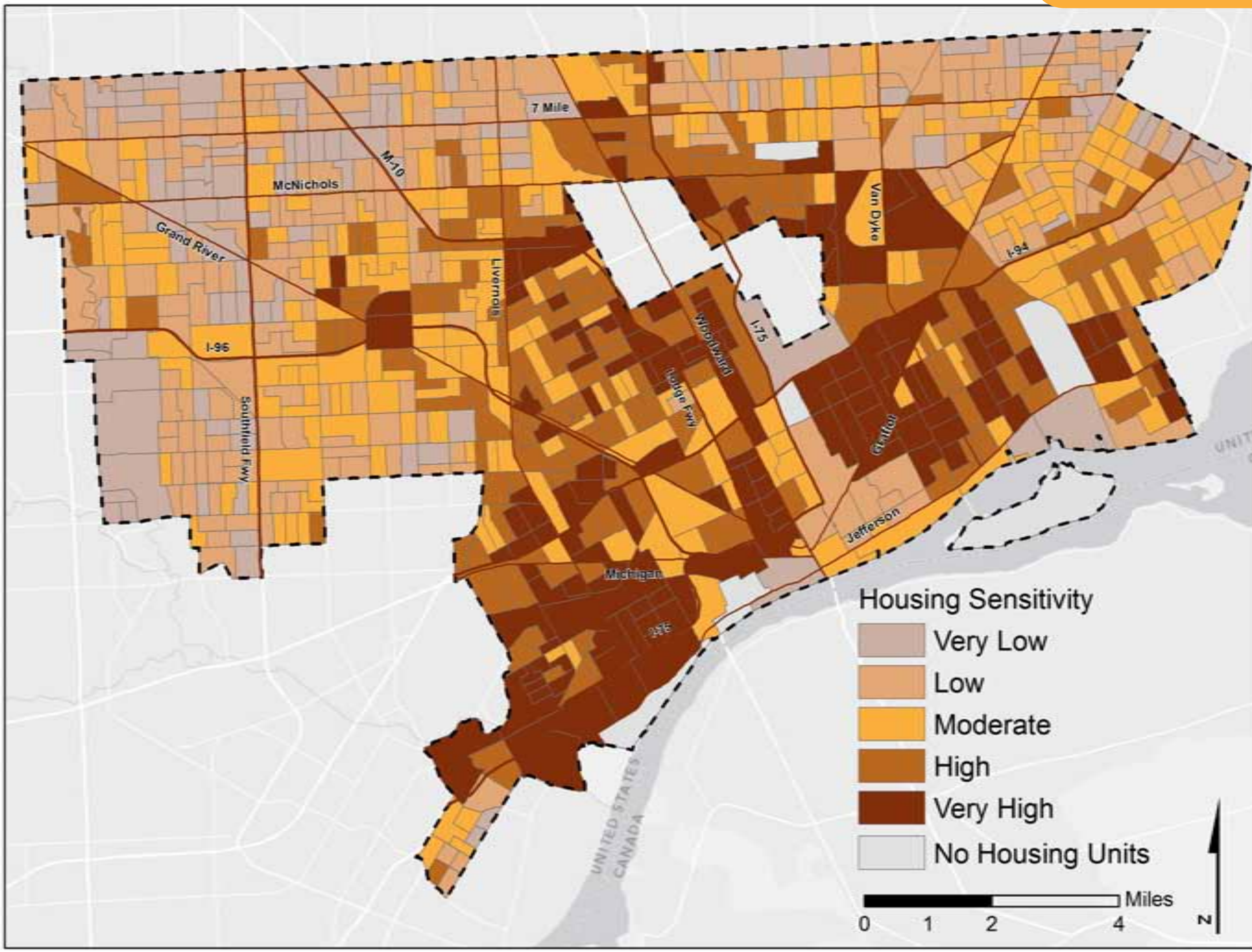
Source: GloVis Landsat 7 ETM+; US Census 2010; DWSD Wastewater Master Plan
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 16: Total Runoff Exposure by Block Group 2010



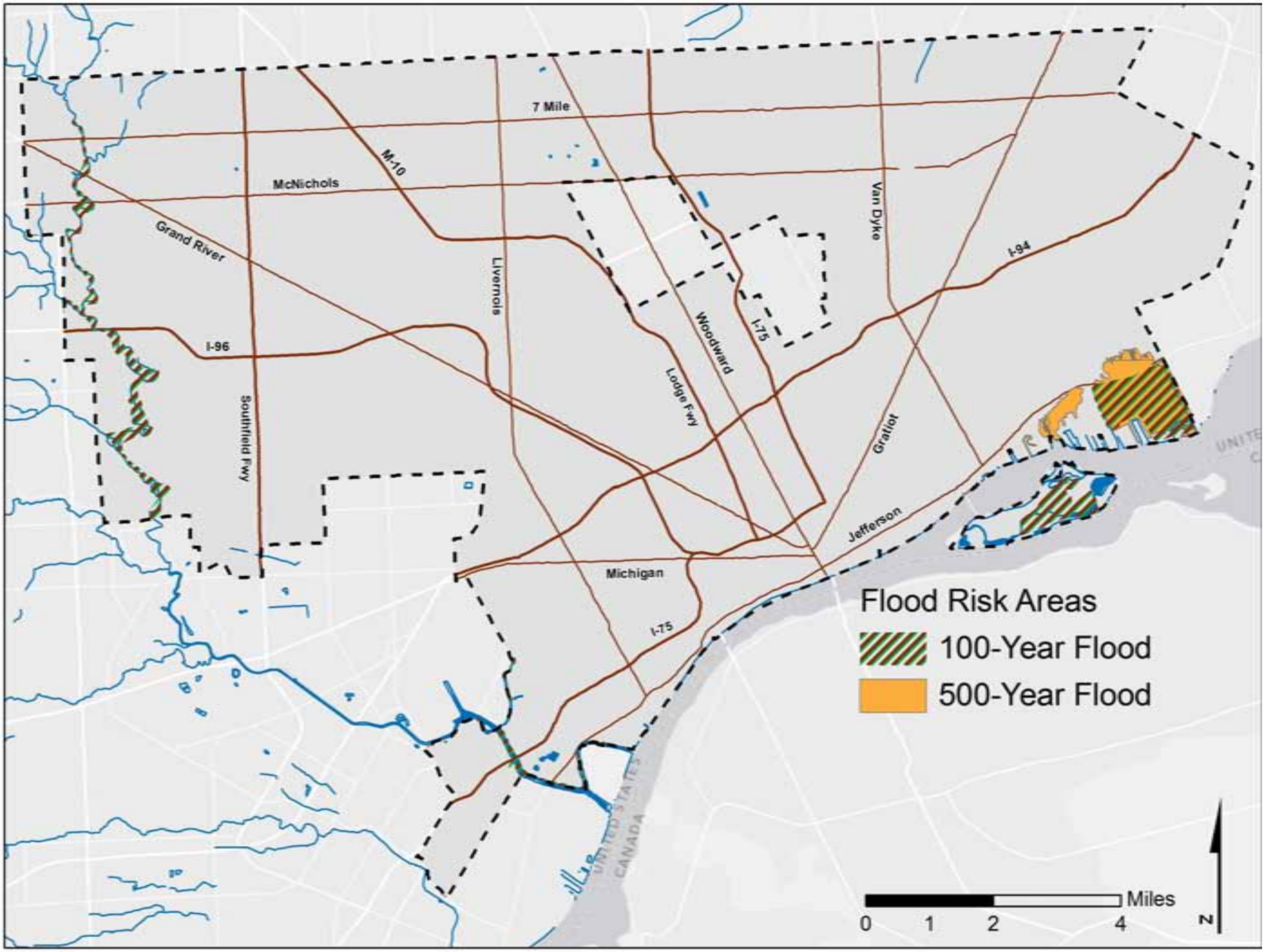
Source: Michigan Geographic Data Library; Michigan Digital Elevation Model; GloVis Landsat 7 ETM+; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 17: Housing Sensitivity Based on Income and Housing Age by Block Group 2010



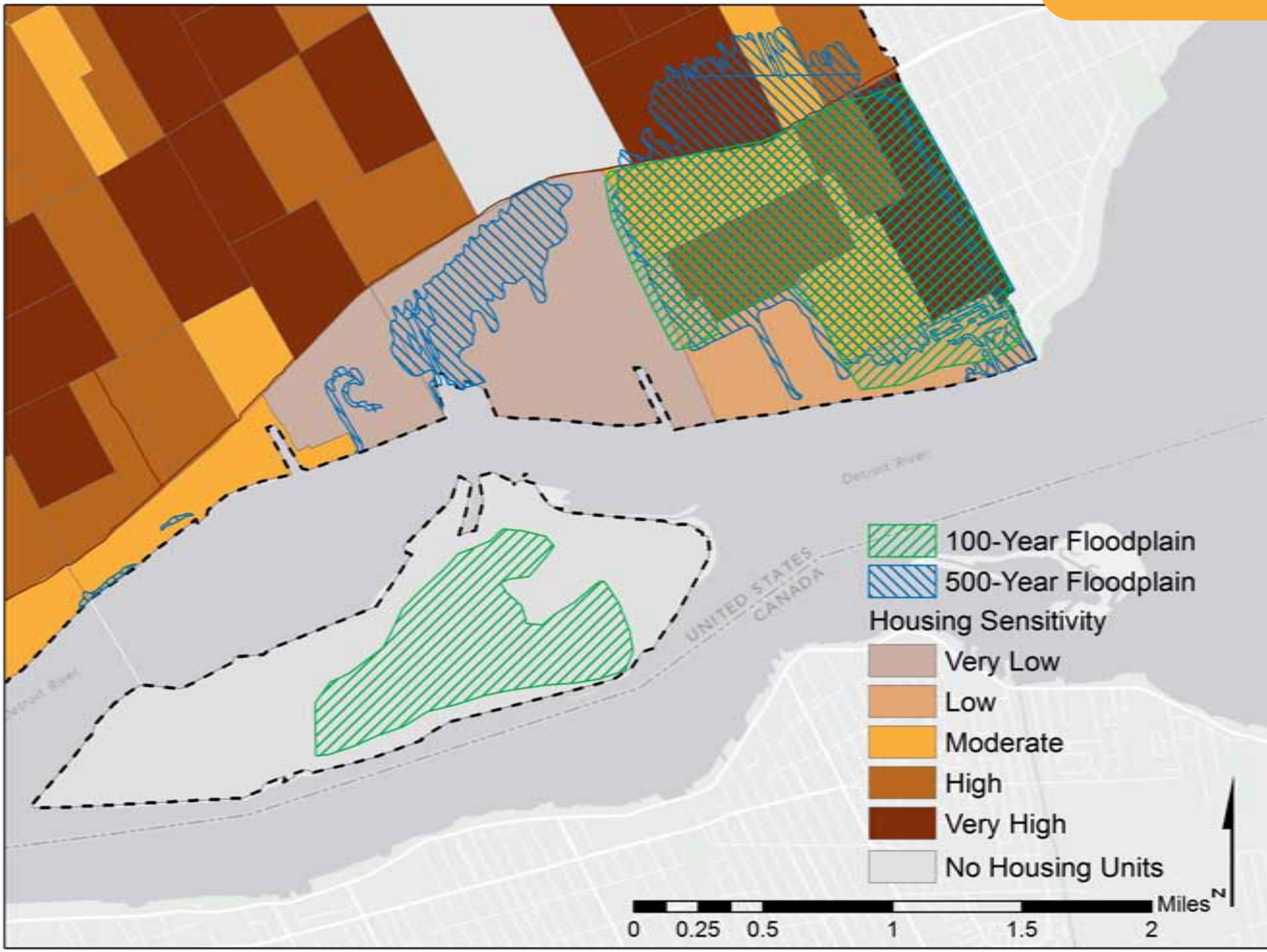
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 18: Flood Risk Hazard



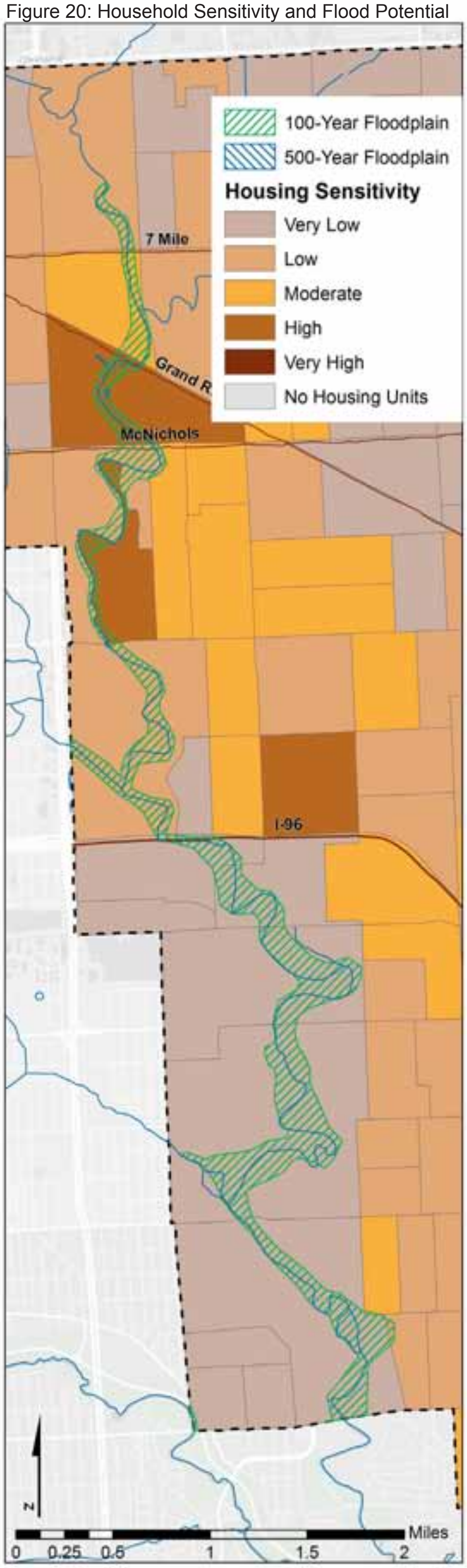
Source: Michigan Geographic Data Library, Hydrology; FEMA Flood Maps
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 18: Household Sensitivity and Flood Potential



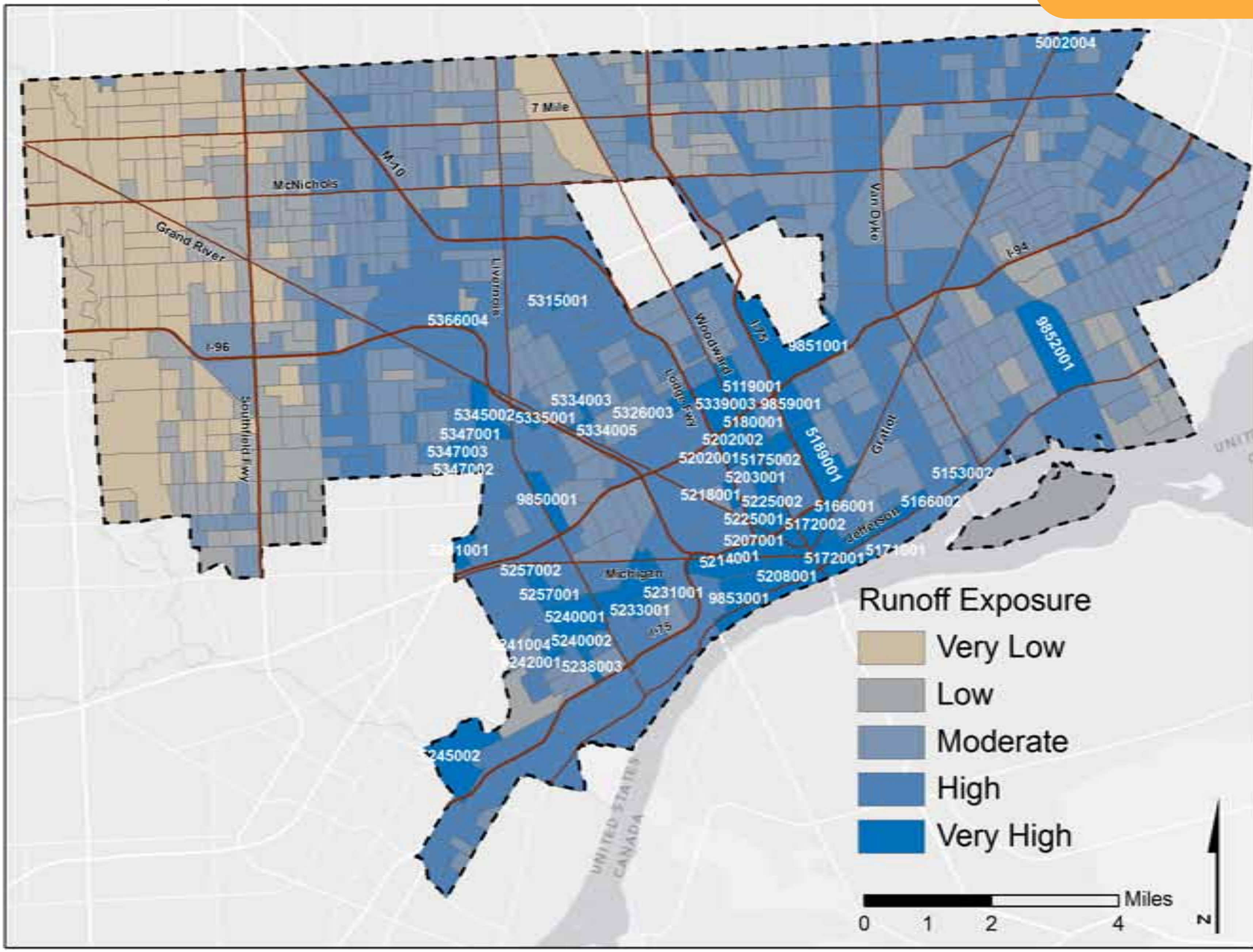
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Figure 20: Household Sensitivity and Flood Potential



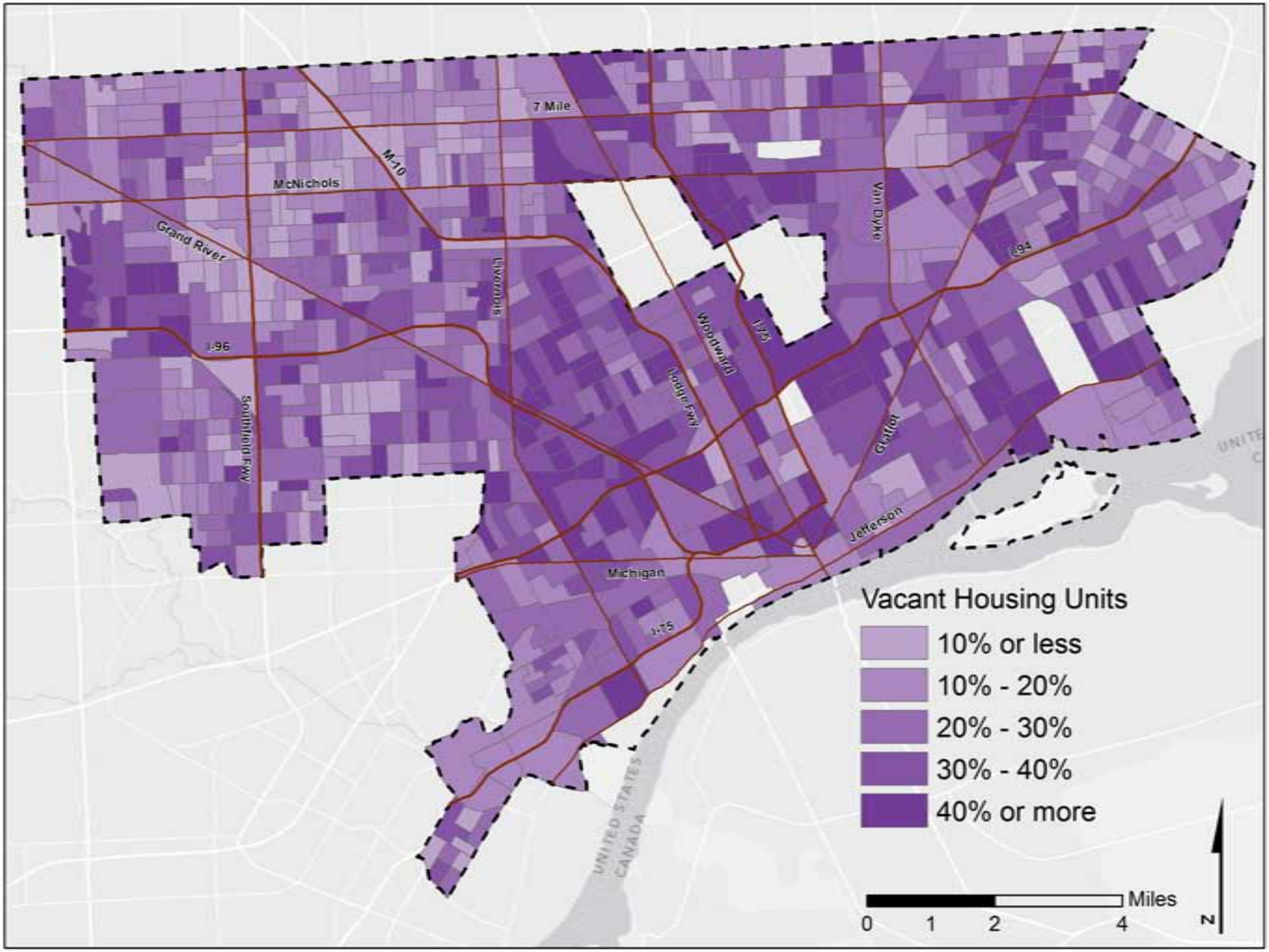
Source: American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Total Runoff Exposure by Block Group 2010



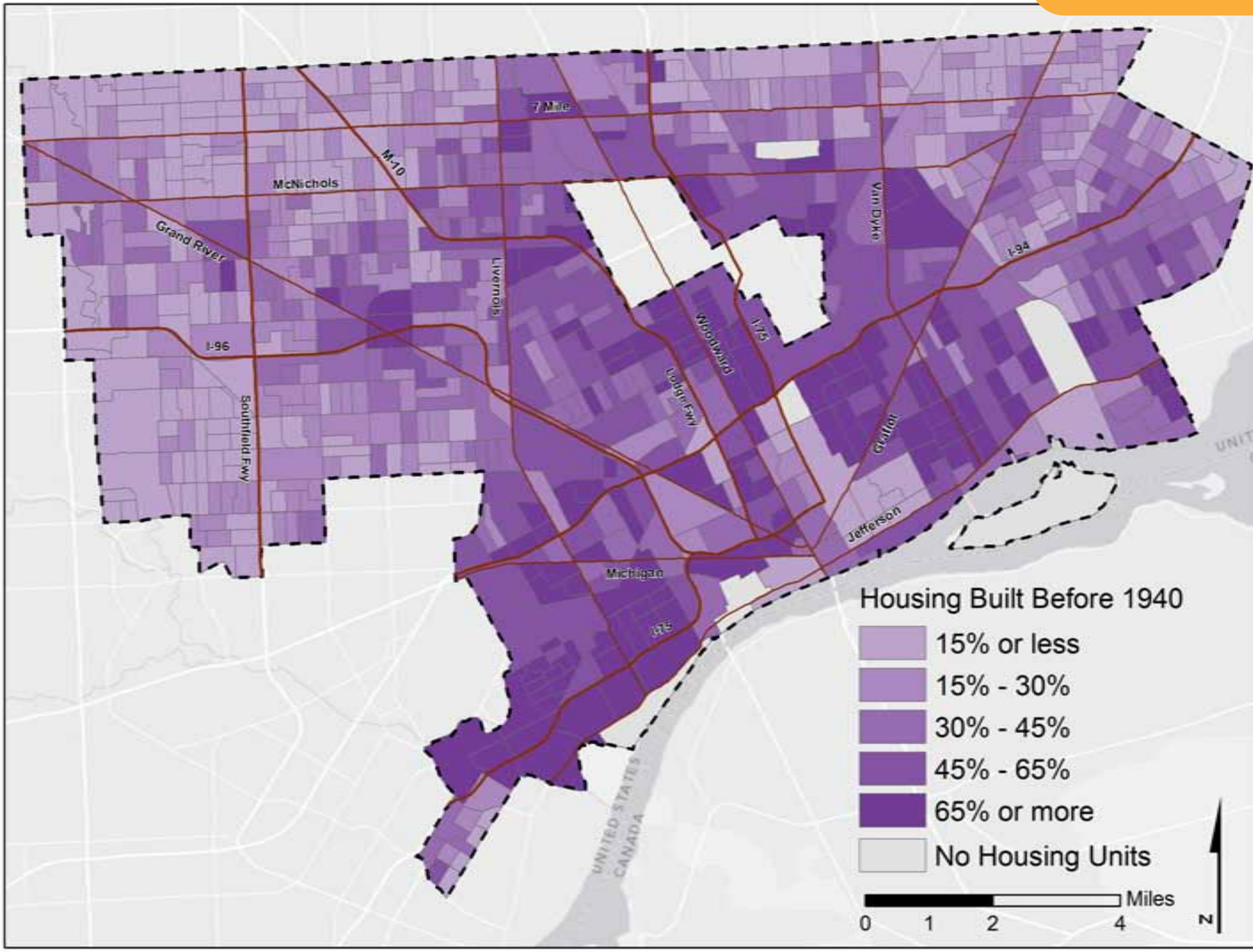
Source:Michigan Geographic Data Library, Michigan Digital Elevation Model, GloVis LandSat 7 ETM+; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Vacant Housing Units as Percentage of Total Units by Block Group 2010



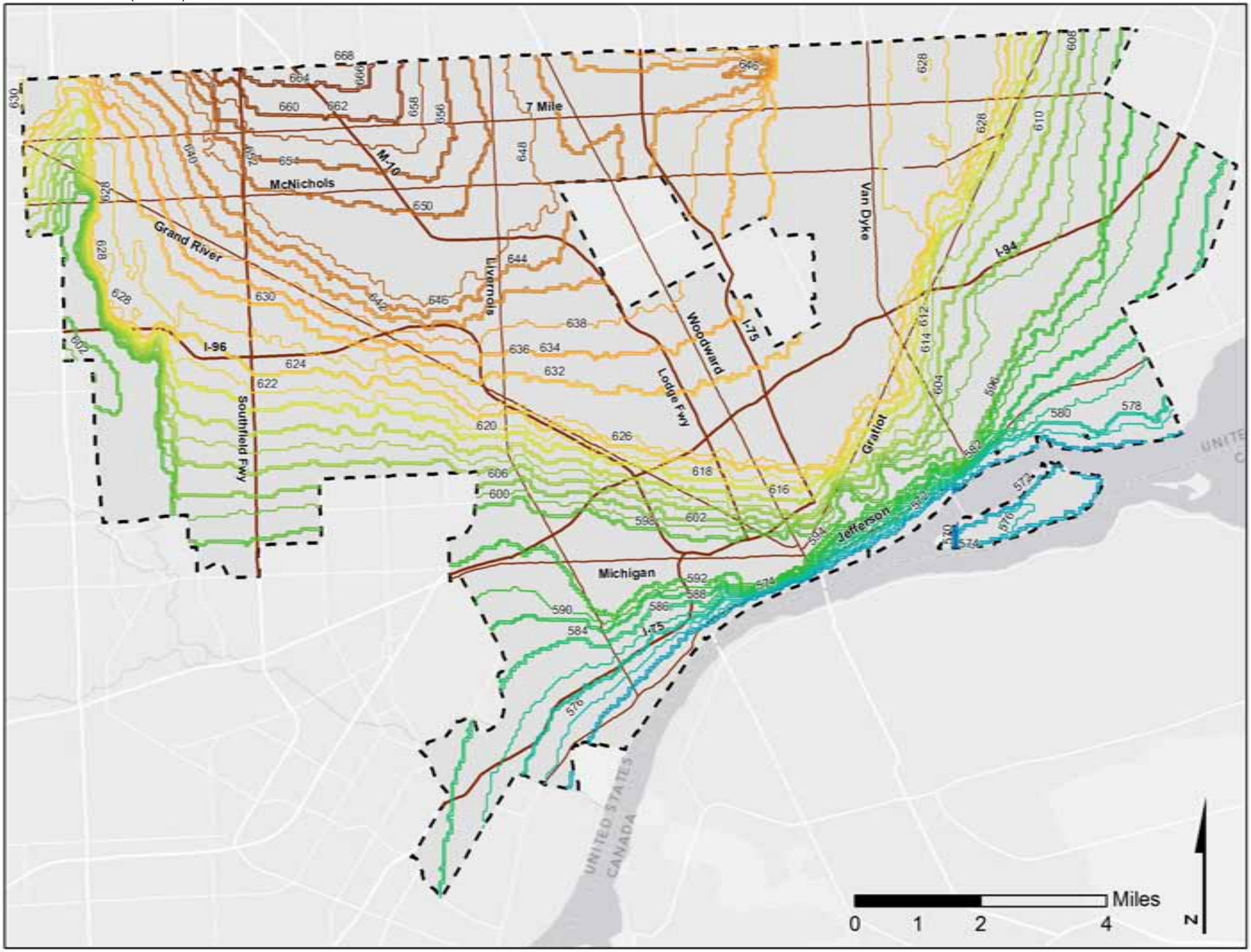
Source:American Community Survey 2006-2010; US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Percent of Housing Stock Building Before 1940 by Block Group 2010



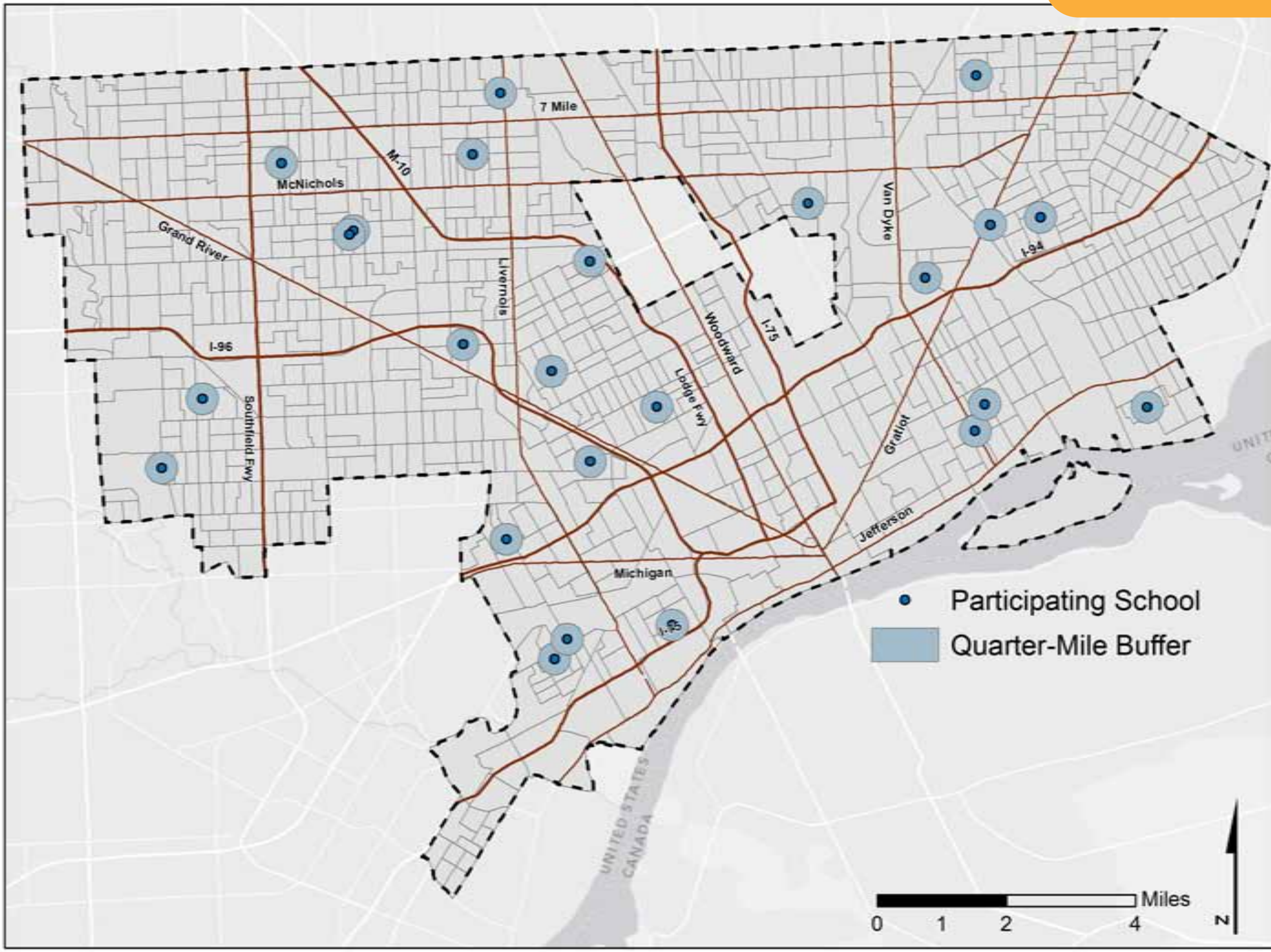
Source:American Community Survey 2006-2010, B25034, US Census 2010
Map Prepared By: University of Michigan Detroit Climate Capstone

Contour Elevation (in Feet)



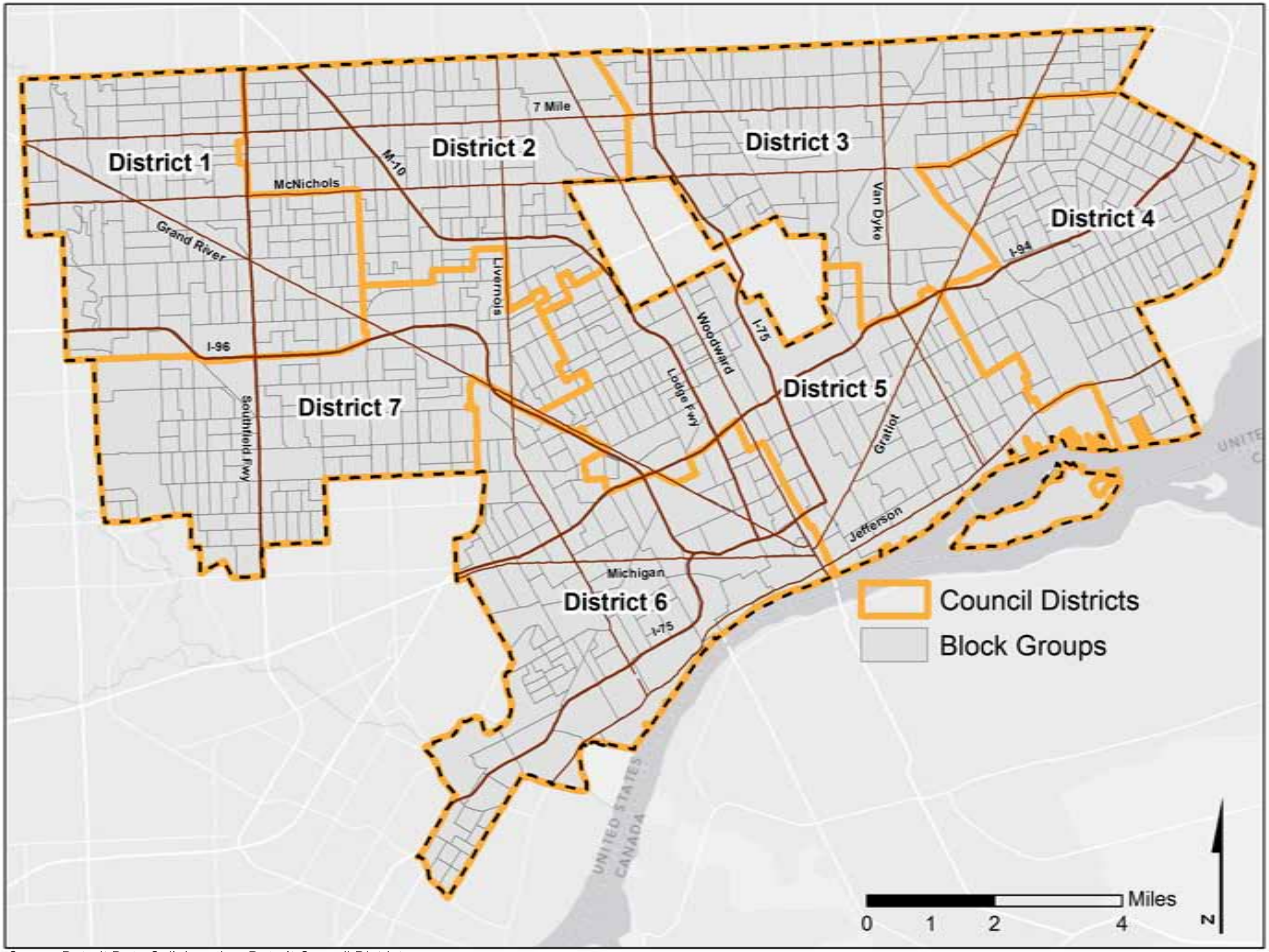
Source:Michigan Geographic Library; Michigan Digital Elevation Model
Map Prepared By: University of Michigan Detroit Climate Capstone

Participating Detroit “Safe Route to School” Programs



Source: Detroit Safe Routes Participating Schools <http://www.saferoutesinfo.org/>
Prepared By: Univiersity of Michigan Detroit Climate Capstone

Detroit Council Districts



Source:Detroit Data Collaborative. Detroit Council Districts
Map Prepared By: University of Michigan Detroit Climate Capstone

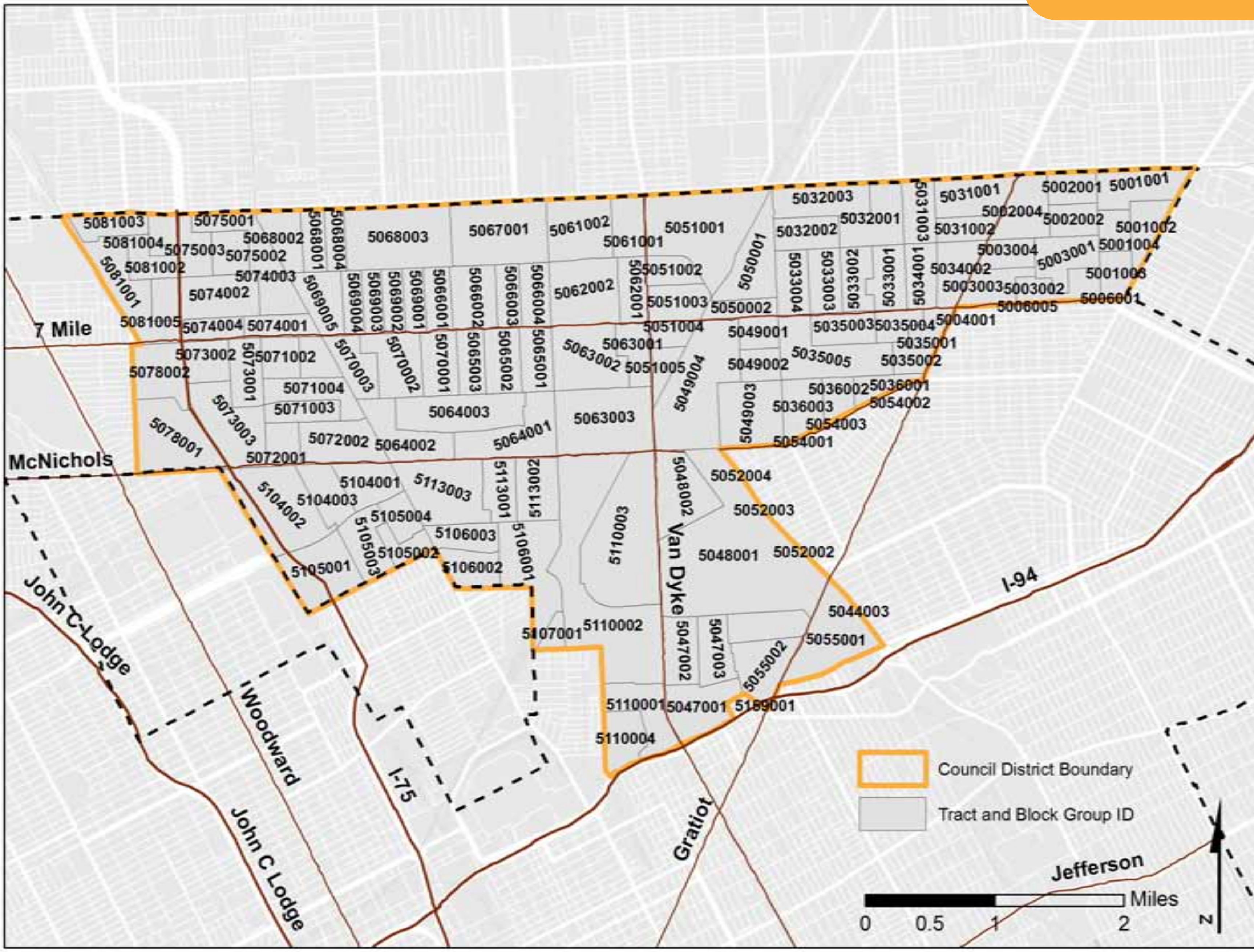
Detroit Council District 1 Block Groups

Source:Detroit Data Collaborative. Detroit Council Districts
Map Prepared By: University of Michigan Detroit Climate Capstone

Detroit Council District 2 Block Groups

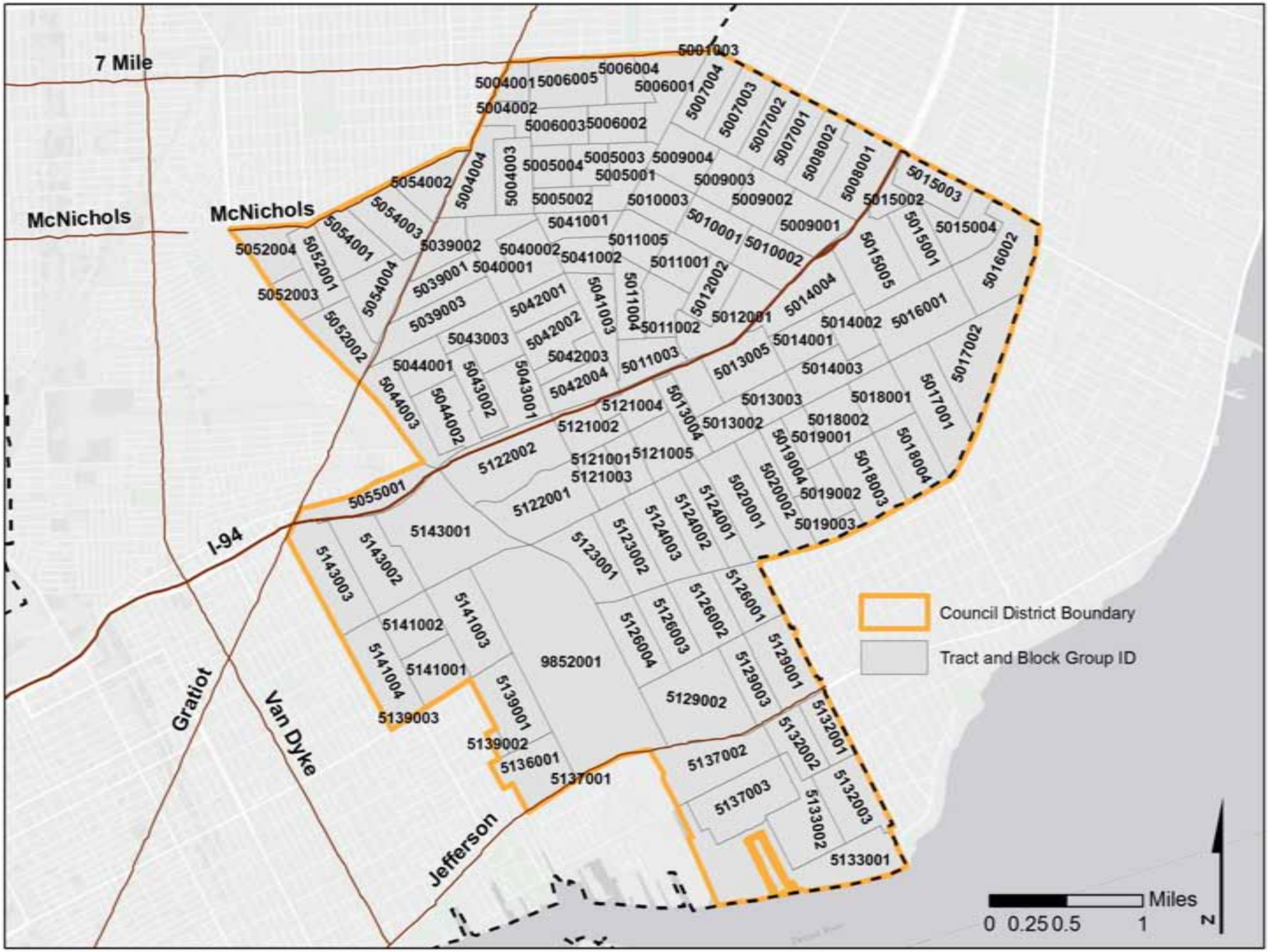
Source:Detroit Data Collaborative. Detroit Council Districts
Map Prepared By: University of Michigan Detroit Climate Capstone

Detroit Council District 3 Block Groups



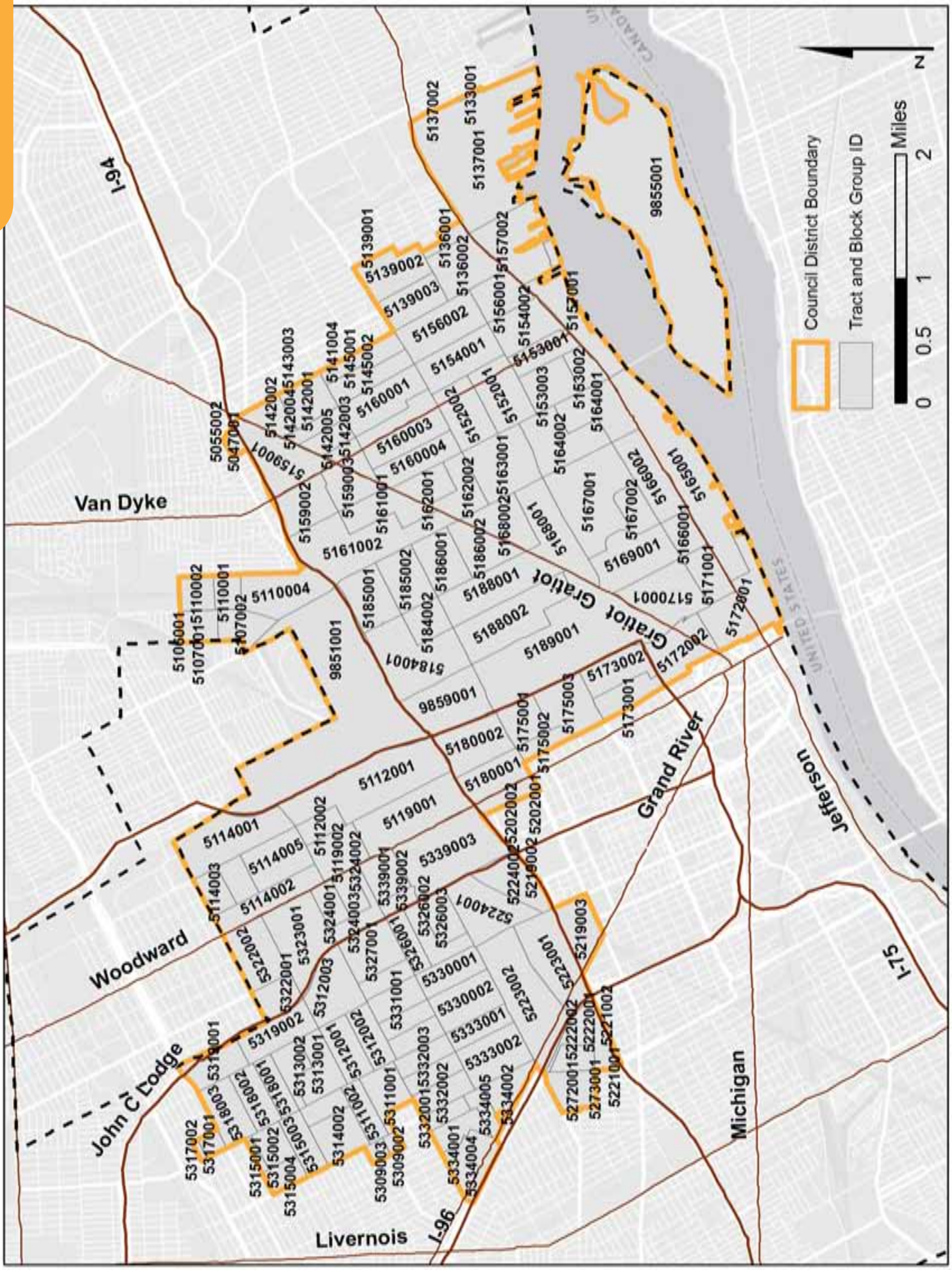
Source:Detroit Data Collaborative. Detroit Council Districts
Map Prepared By: University of Michigan Detroit Climate Capstone

Detroit Council District 4 Block Groups



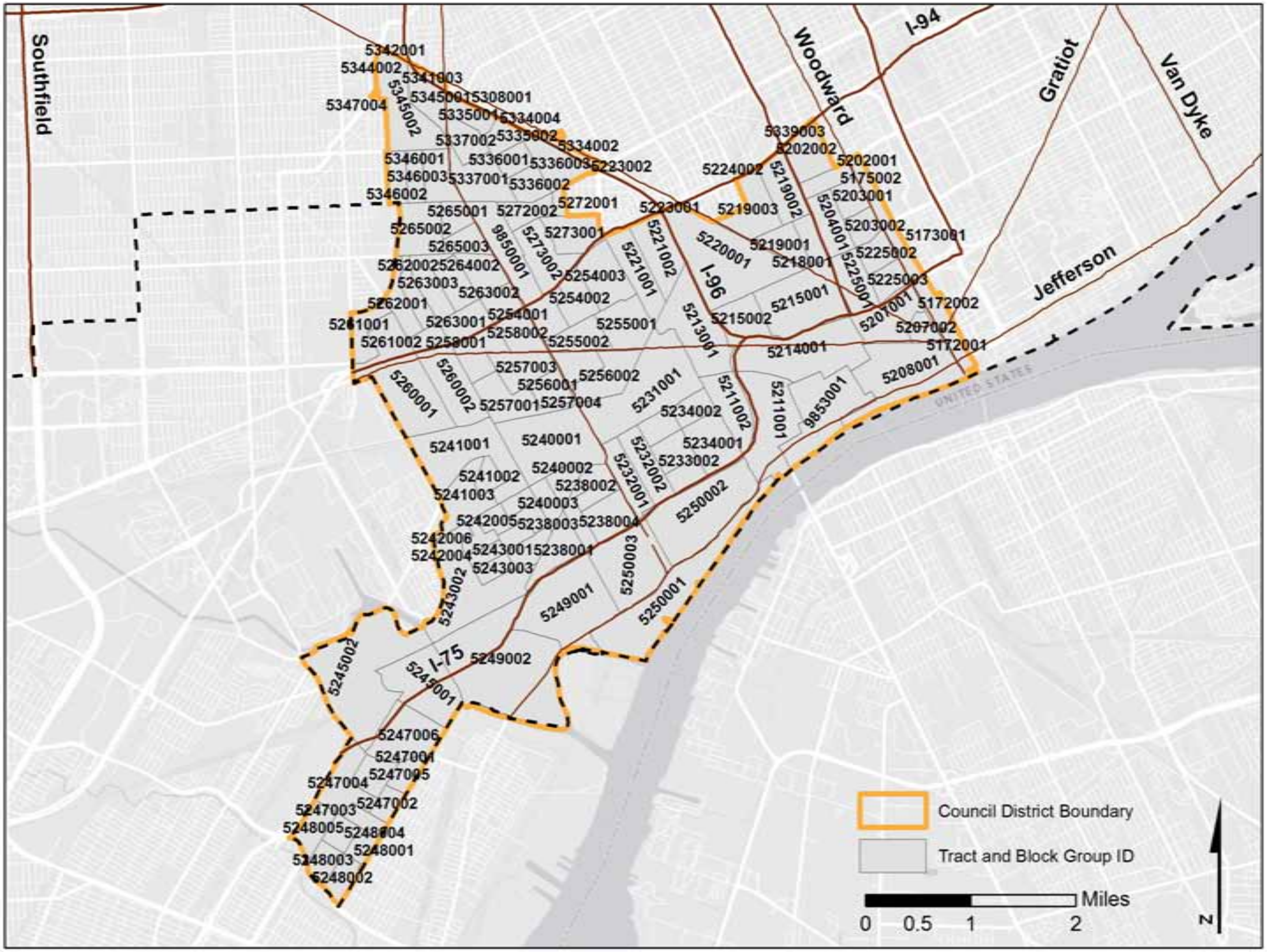
Source:Detroit Data Collaborative. Detroit Council Districts
Map Prepared By: University of Michigan Detroit Climate Capstone

Detroit Council District 5 Block Groups



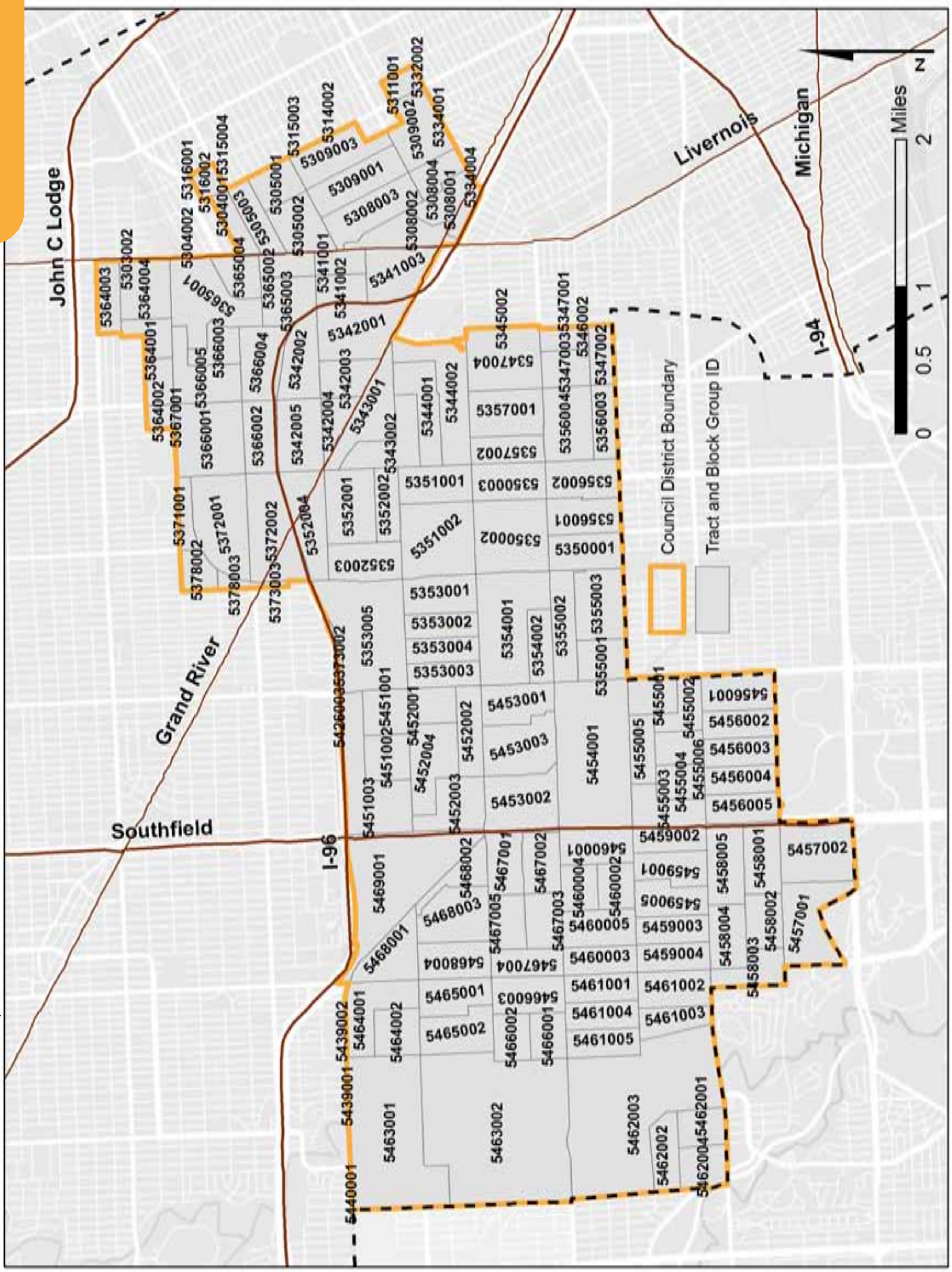
Source:Detroit Data Collaborative. Detroit Council Districts
Map Prepared By: University of Michigan Detroit Climate Capstone

Detroit Council District 6 Block Groups



Source:Detroit Data Collaborative. Detroit Council Districts
Map Prepared By: University of Michigan Detroit Climate Capstone

Detroit Council District 7 Block Groups



Source:Detroit Data Collaborative. Detroit Council Districts
Map Prepared By: University of Michigan Detroit Climate Capstone

University of Michigan Taubman College of Architecture & Urban Planning