LOWER GRAND RIVER WATERSHED RESILIENCE ACTION PLAN

Prepared by the Grand Valley Metropolitan Council and the Lower Grand River Organization of Watersheds

2024

ACKNOWLEDGEMENTS

About this Document

The key word in the title of this document is ACTION. The document is intended to assist municipal governments, communities, stakeholders, and citizen groups throughout the Lower Grand River Watershed become agents for positive change in the pursuit of higher water quality. Exponential changes in our climate, leading to increased precipitation, extreme temperatures, and frequent yet unpredictable weather events, have left many gaps in the "business-as-usual" method our region has traditionally employed when addressing issues of water quality. For example, increased precipitation puts a strain on existing infrastructure that is ill-equipped to deal with higher stormwater loads. The damages are costly to recoup and repercussions are ecologically extensive. Increased temperatures – especially extreme heat days (in excess of 90 degrees F) – may exceed energy sector resources while putting a disproportionate economic and physiological burden on low-income and disadvantaged communities (LIDAC). This document will layout steps that can be taken at every level to decrease the stress on our infrastructure and prepare our communities, especially LIDAC, to be adaptive and more resilient to our projected climate future. This document offers unique adaptation strategies while highlighting existing and/or potential areas of concern in each of the 32 sub-watersheds in the Lower Grand. Within our subwatersheds, each municipality and their surrounding communities have been examined to highlight the water positive actions taking place throughout our Lower Grand watershed.

A Watershed Perspective on Water Quality Issues

The fluid nature of water, especially stormwater, can make it difficult to point the blame at any one person or group when it comes to water quality issues. While the rain may fall in one location, the water runs downhill toward the nearest storm drain, picking up any contaminant in its path. By the time it reaches the surface waters of the Grand River, it is not feasible to attempt to track the culprit. This document explains that as water quality affects all of us, each of us holds a stake in maintaining that quality (from herein, "stakeholder" will refer to every person living, working, or playing within our watershed boundary). The authors and partners engaged in the creation of this document hold without any doubt or restriction that every drop of water that falls within the boundary of our watershed contributes to our overall water quality. Therefore, we believe in the power of efforts of all shapes and sizes to effect change. Increasing our watershed resiliency and adapting to the trends of climate change must happen at many scales across our region.

Grand Valley Metropolitan Council (GVMC) is a council of governments dedicated to enhancing the quality of life of the people of our metropolitan area through collaboration among regional partners. The mission of GVMC is to advance the current and future well-being of our metropolitan area by bringing together public and private sectors to cooperatively advocate, plan for, and coordinate the provision of services and investments which have environmental, economic, and social impact.

GVMC's Department of Environmental Programs addresses resource issues in the area we serve, and as we look toward the future, our efforts will continue expanding to coordinate with additional partners as we anticipate a changing climate and plan for sustainable support for resource management.

The Lower Grand River Organization of Watersheds (LGROW) is an agency of GVMC. LGROW brings together local municipalities and community stakeholders in a unique format to address issues facing the Lower Grand River and its watersheds. LGROW promotes community education and sustainable use of our river resources. LGROW works with communities to coordinate their NPDES stormwater permits, and the also works locally with grants. LGROW is committed to making the watershed an ongoing resource for all of us.

GVMC and LGROW offer this resilience plan for the subwatershed groups and communities of the Lower Grand River Watershed.

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EXECUTIVE SUMMARY
TOGETHER WE THRIVE

Increasing our watershed resiliency and adapting to the trends of climate change must happen at many scales across our region. LGROW takes a watershed perspective on issues facing individuals, communities, and governments within the Lower Grand River Watershed (LGRW) boundary while promoting sustainability of our river resource. The largest environmental issue of our time - and, perhaps, all times, as it impacts all other environmental issues - is climate change. A positive option is to adapt to a changing climate with the best preparations based on the best available data/science/projections. In this way we can educate ourselves as to what's coming by acknowledging the threats posed by a changing climate; prepare for a new environmental reality by learning our vulnerabilities to climate change; understand our strengths, seize on opportunities, make the necessary adaptations; and ***spring back*** from the adversities we may face. LGROW designates this process and outcome as ***resilience***.

In order to be resilient in the face of a changing climate, we first must understand the threats to individuals, communities, and governments within our watershed. The major threats include temperature, precipitation, flooding, drought, habitat fragmentation and suitability, invasive species, and impervious surfaces. Average annual temperatures have increased by 3 degrees over the last 50 years and are expected to increase another 3 degrees by 2050. For the LGRW, this means more average annual precipitation, which, in turn, leads to flooding; and longer, drier periods with an increased number of extreme heat days (those exceeded 90 degrees F). These conditions threaten native species, especially coldwater-adapted species, while favoring invasives.

The realization of these threats presents vulnerabilities at the individual, community, and government level. At the individual level, persons living within the LGRW are vulnerable to an increased incidence of extreme flooding, due to increased and excess precipitation. This can compromise homes and other structures by causing structural damage. Increased precipitation and flooding may also affect the livelihoods of individuals in particular sectors such as fishing, forestry, tourism, agriculture, and outdoor recreation. Air-quality issues, water-quality issues, and vector-borne disease patterns are all expected to worsen. Beyond these physical realities, a changing climate has further implications for human health as the ramifications of biologic and economic woes are felt psychologically. Communities and businesses, being the occupational and residential aggregations of individuals within each subwatershed of the LGRW, will experience these changes uniquely. Each community must be prepared to meet climate change on terms

appropriate to their socioeconomic situation. For example, low-income, disadvantaged communities (LIDAC), inhering in historically red-lined districts of intensive imperviousness, will likely bear a greater brunt than other communities. Agriculturalists, too, as their work is weather-dependent, will face great adversity, especially from an occupational standpoint. Other businesses, such as those involved in outdoor recreation, sport fishing, and tourism, may also see uneven losses from erratic seasonal shifts. Governance, in its turn, will have the unenviable task of maintaining the transportation, energy, and healthcare sectors that communities and, in turn, individuals, rely upon.

Fortunately for the LGRW, local governance, subwatershed groups, community groups, and individuals alike practice and promote strong watershed values as outlined in the Lower Grand River Watershed Management Plan (LGRWMP). These values include creating diverse, inclusive, and collaborative watershed activities; engaging in sustainable and high-quality watershed efforts; promoting a widely shared sense of legacy and heritage with watershed images and messaging; practicing methods, and delivering products, which are holistic and employ a systems approach; and evaluating progress and rewarding success through watershed organizations and programs. Furthermore, LGROW's position within GVMC gives access to, and credibility with, many local and state officials who have the power to institute changes needed at the governmental/agency/regulatory scale. The benefits of this organizational structure can be seen where GVMC's influence helped gather valuable information about the state of water infrastructure in our region. Policies, procedures, and channels for communication and action also already exist within the LGRW, creating a strong foundation for future resilience efforts. Finally, the LGRW's current and future resilience efforts are benefitted by a number of shared resources detailed in this document. Informed by these shared resources, communities and jurisdictions have begun developing plans focused on climate resilience, hazard mitigation, and specific aspects of climate change threats, such as groundwater depletion.

The current strengths of the LGRW point to opportunities that exist for ensuring the resilience of the watershed against the threats posed by climate change. We believe **the most effective strategies will be those that recognize the uncertainty of the future and work to increase the flexibility of the human and natural systems in response, relying on collaborative work across all levels of involvement.** Further, these strategies must incorporate individual, community, and government action, policy, infrastructure, natural spaces, and education to build on and expand the strengths of the LGRW. **Specific actions are outlined in this plan for each unique subwatershed, giving individuals, communities, and governments a place to start and/or continue their resiliency journey.** This plan is a necessary call to action as we work together, subwatershed by subwatershed, and united as the LGRW, to become resilient in the face of a changing climate.

INTRODUCTION

THE NEED FOR WATERSHED RESILIENCE

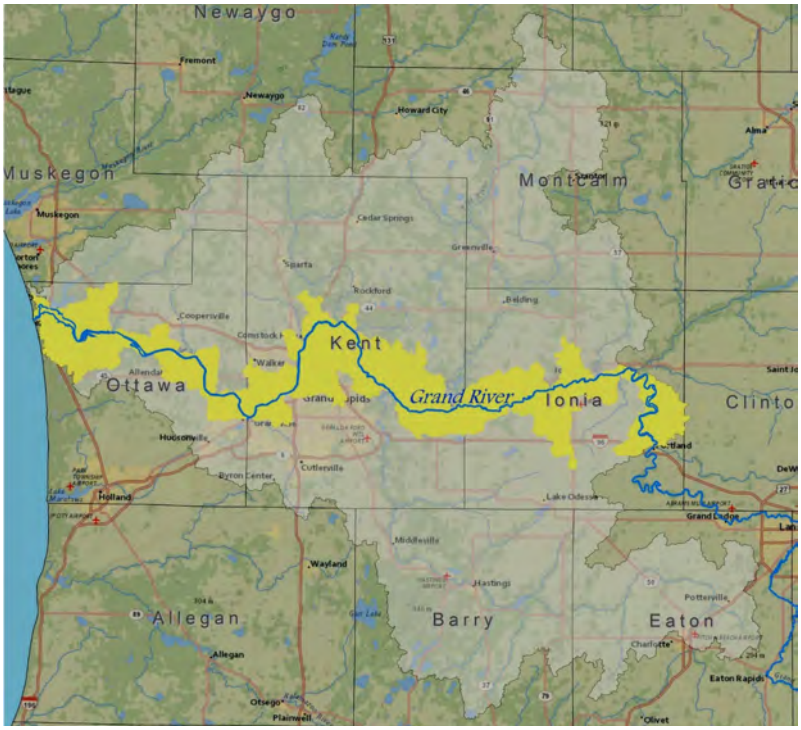
Climate ultimately governs weather; and weather, in turn, exerts control on water and ecosystems. Changes to either weather, water, or ecosystems will "feed back" to affect the others positively or negatively. Because of this, the fundamental changes currently occurring in weather patterns, due to climate change – specifically, patterns of increased temperature and precipitation – have cascading effects. These effects will have implications for the health and integrity of human, and other biological life, as well as their ecologies, across the world. Among the effects of an altered climate and water cycle are increased flooding, drought, extreme heat, further degradation of air and water quality, and habitat loss (EcoAnalysts, 2020). These effects compound problems arising from land use activities and pollution, and they contribute to further degradation of our natural surroundings (Jimenez Cisneros et al. 2014). We now live in a time of a changing climate, where the world we knew is in constant and unpredictable flux.

Global in nature, the effects of climate change are far-reaching and locally diffused. These effects are currently being felt at a local level within the Lower Grand River Watershed (LGRW). This results in shorter winters, warmer average annual temperatures, increased frequency of extreme precipitation and temperature events, and decreased duration of lake ice cover (UCS 2008; Cherkauer & Sinha 2010; GLISA 2019). These changes are likely to continue, and to be joined by others. Together, these changes are disrupting the rhythms and regular functions of both human and ecological communities within our watershed and will continue to do so, most likely at an exponential rate, as our populations grow, and our current model of everyday life continues.

It is crucial to recognize the current character of our watershed in order to understand the threats and vulnerabilities that it faces from a changing climate and the resources and strengths it possesses for building resilience. The Lower Grand River flows from the confluence of the Looking Glass River near the city of Portland, Michigan, westward into Lake Michigan. The main branch of the Lower Grand River extends over 92 miles, fed by 209 miles of major tributaries, and drains an area of 2,909 square miles (Figure 1). This area is comprised of 32 subwatersheds (Figure 2). Through the years of settlement and industrialization, the native vegetation has been altered and removed in many places. As of 2016, land cover within the watershed was 47% agricultural, 20% forested, 16% urban, 14% wetlands, 2% open water, and 1% open land (Figure 3)(NLCD 2016). Urban areas include commercial, residential, and industrial land uses. Land use has continued to trend towards developed and urbanized areas, largely through the transformation of

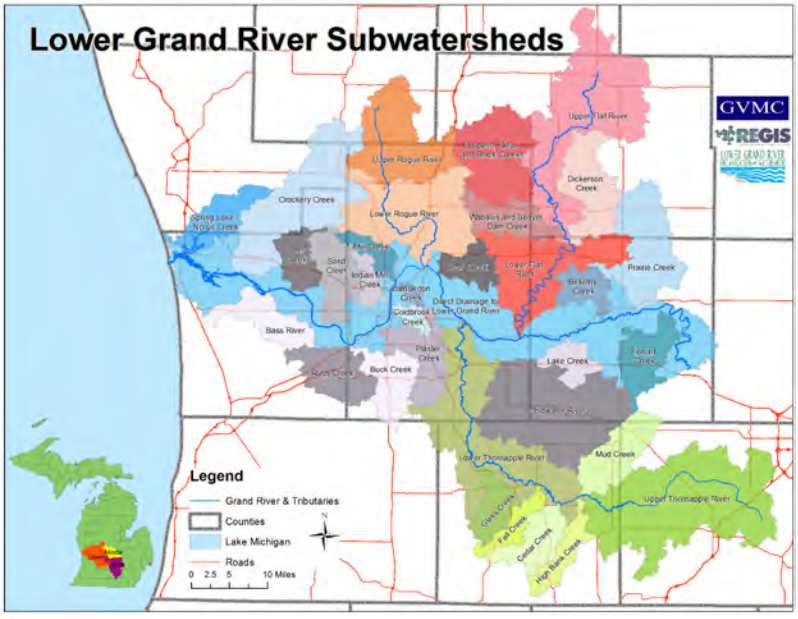
agricultural or open land to suburban or urban uses (Emili & Greene 2014). This change can be seen within the LGRW, with agricultural, open, and forested land cover having decreased while developed areas have increased since 2006 (NOAA C-CAP Land Cover 2006). Even so, nearly half of the watershed is still considered agricultural. Accordingly, a comprehensive view of our watershed must consider urban, suburban, rural, and agricultural interests and dynamics alike.

Figure 1



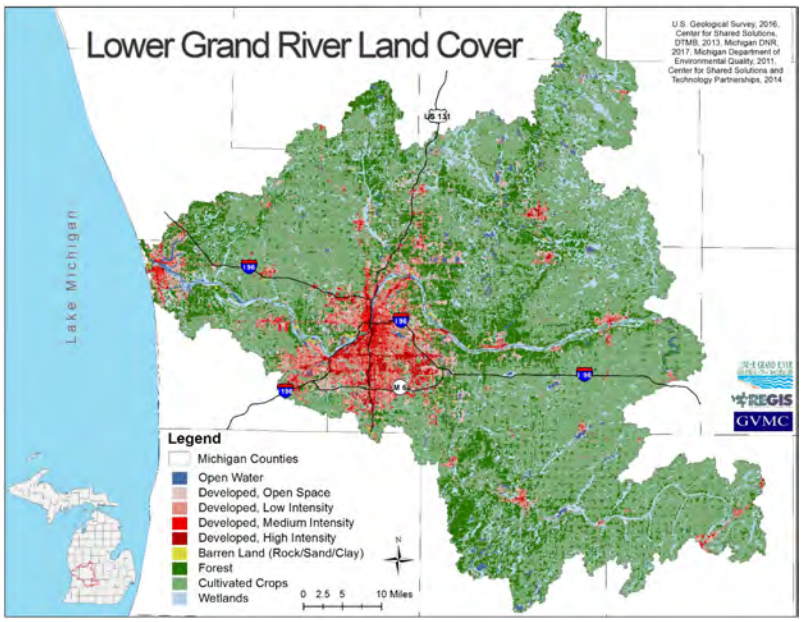
The direct drainage subwatershed of the Lower Grand River Watershed. The direct drainage subwatershed includes 92 miles of the Grand River mainstem (the Lower Grand River) and drains an area of 2,909 square miles. Copyright LGROW.

Figure 2



Subwatersheds of the Lower Grand River Watershed (LGRW). The LGRW contains 32 subwatersheds in total.

Figure 3



Land Cover in the Lower Grand River Watershed. As of 2016, Agricultural land cover, or "Cultivated Crops," was the dominant type at 47%.

While there is broad scientific consensus about the general direction and trends of change as the planet warms, the specific predictions are far from certain. Many unknowns remain about the precise magnitude and nature of these impacts. This uncertainty ultimately results in the loss of predictability, as history no longer serves as a reliable model for future actions and assumptions. Changes in temperature and precipitation are operating outside of the bounds of typical historical variation. So are the many processes and activities they influence, from stream flows to animal migration to human agriculture. This has implications for habitats, human communities, natural systems, built infrastructure, planning and development, and emergency preparedness. Such uncertainty requires readiness and flexibility in adapting and responding to the challenges and changes of the future. This capacity to adapt is known as resilience.

Resilience is inherent in natural systems, which can accommodate and adapt to a certain level of change without significant damage or harm. However, as exposure to stressors increases, or adaptive capacity decreases, resilience can become compromised. Due to the compounding issues of climate change and shifting land use, we are currently experiencing both. Building resilience must therefore focus on restoring and fostering the adaptive capacity of our human and natural systems. On a larger scale, this seems like an impossible feat; but the goal of resilience is more than attainable if we begin with individuals at the local level.

Local issues require local responses, on a scale and scope appropriate for their nature and extent. The impacts of climate change are complex, and this complexity does not fit neatly within traditional political boundaries. Floodwater will not stop at city limits.

County lines hold no jurisdiction over heatwaves. Climate change and its impacts can be most adequately addressed if the solutions, like the problems, consider multiple systems and processes and extend beyond the limits of traditional political boundaries. A watershed corresponds with an environmental reality, allowing for a more complete observation of, and response to, the threat of climate change. Moreover, the watershed scale is sufficiently limited in scope to allow for coordinated and cooperative action. Environmental changes caused by a changing climate will have profound human and societal impacts. It would be wise to align our efforts with the scale and scope at which they will be best positioned to provide meaningful adaptability.

Accordingly, this plan was written in response to the need for a holistic, watershed-based approach to developing resilience to climate change. Its purpose is to catalyze and build resilience within the LGRW to respond to the challenges and demands of a changing climate. The plan is intended to inform the subwatersheds within the LGRW of the likely impacts of climate change on our region, and to equip them with strategies, tools, and practices that will best position them to respond with resilience to the uncertainty of the future. It presents the most probable, local effects of global climate change, the current vulnerabilities and strengths of our watershed with regards to those threats, and opportunities that exist for building resilience. After considering these threats, vulnerabilities, strengths, and opportunities, it outlines a pathway towards action and resilience at the subwatershed scale. The appendix (Appendix 3) includes a resilience profile for each subwatershed of the LGRW, indicating key recommendations for increasing and maintaining resilience. It also includes a list of tools and resources (Appendix 2) to aid in these efforts. The implementation of these strategies is intended to protect and enhance the vibrant and productive human and ecological systems that comprise our watershed.

The plan is intended to **inform** the subwatersheds within the LGRW of the likely impacts of climate change on our region, and to **equip them with strategies, tools, and practices that will best position them to respond with resilience** to the uncertainty of the future

The scope of this plan is necessarily limited: while effective and sustainable resilience strategies must be accompanied by efforts to mitigate climate change itself, these latter practices are largely omitted from this plan. The scope of this plan is limited to effective and sustainable adaptation strategies. The sole purpose of this plan is to provide

actionable guidance for living in a time of accelerated climate change. Many of the recommendations of this plan will center around techniques for protecting, restoring, or mimicking natural systems as a strategy for building resilience. This approach recognizes that natural systems are best equipped for both reducing the incidence and magnitude of impacts of climate change, and for mitigating the damage done when these adverse impacts do occur. Through the protection, restoration, or mimicry of natural areas and associated processes, we can preserve and promote the resilience, productivity, and beauty of our watershed's habitats, ecosystem services, animal life, and human communities even in the face of an uncertain future.

Ultimately, in the face of a changing climate, inaction is the greatest threat. While it is clear that climate change has already begun and will continue to impact aspects of our day-to-day lives, we do not know the exact nature or extent of the changes that will result. Neither can we gauge, with precision, how drastic the interplays or feedback loops of weather, water, and ecosystems will become as the climate system grows more unpredictable. However, we are working with the most probable scenarios of climate change effects for our area based on recent data and research.

Efforts to build resilience must recognize and endeavor to operate within this uncertainty. In seeking to enhance our watershed's resilience, we do not claim to know the future, but rather position ourselves as a watershed and as a community to be prepared to recognize and respond, quickly and effectively, to the challenges and changes that will accompany our changing climate in the years to come. Increased precipitation, more frequent and intense storms, and an increase in extreme heat days are the most probable scenarios for which to prepare in our region. Resilience within our watershed will result from intentional, creative efforts to increase and restore the adaptive capacity of the natural and human systems on which we rely every day. It will equip individuals, communities, and governance with the awareness to notice threats, and the forethought, planning, and resources to adapt as necessary. Resilience recognizes both the gravity of the dynamic future with which we are confronted, and the hope present in the possibilities that exist for addressing it.

THREATS FROM CLIMATE CHANGE
IN THE LOWER GRAND RIVER WATERSHED

To define tangible steps towards resilience, it is important to know the specific threats and changes facing the watershed. Watershed level data and predictions are largely unavailable, but past and present conditions of each LGRW subwatershed coupled with future predictions for Grand Rapids and the Great Lakes Region as a whole, can provide insight into the general direction and magnitude of trends that may be experienced throughout the LGRW. These different scales help piece together a range of watershed-level changes: City-level data for climate impacts, available for Grand Rapids, offer high-resolution predictions that may not be uniformly applicable across the watershed, but offer a balance to the larger scale predictions for Michigan and the Great Lakes region. While the threats presented here center around the environmental and ecological impacts of climate change, these impacts do not occur in isolation. Rather, they are inseparable from the economic, social, and cultural factors that contribute to, and are affected by, their impact. Some of these effects are noted in the following consideration of threats, but there may be broader changes or impacts beyond what is noted here. In discussing watershed resilience, it is important to consider and address each of these factors and their interrelationships to protect the flourishing of human and ecological communities. In this section, the general threats posed by climate change are presented, along with some of their implications. The following section identifies how these intersect with vulnerabilities of the watershed at the individual, community, and government level.

THREATS FROM...

... TEMPERATURE

... PRECIPITATION

... FLOODING

... DROUGHT

... HABITAT FRAGMENTATION & SUITABILITY

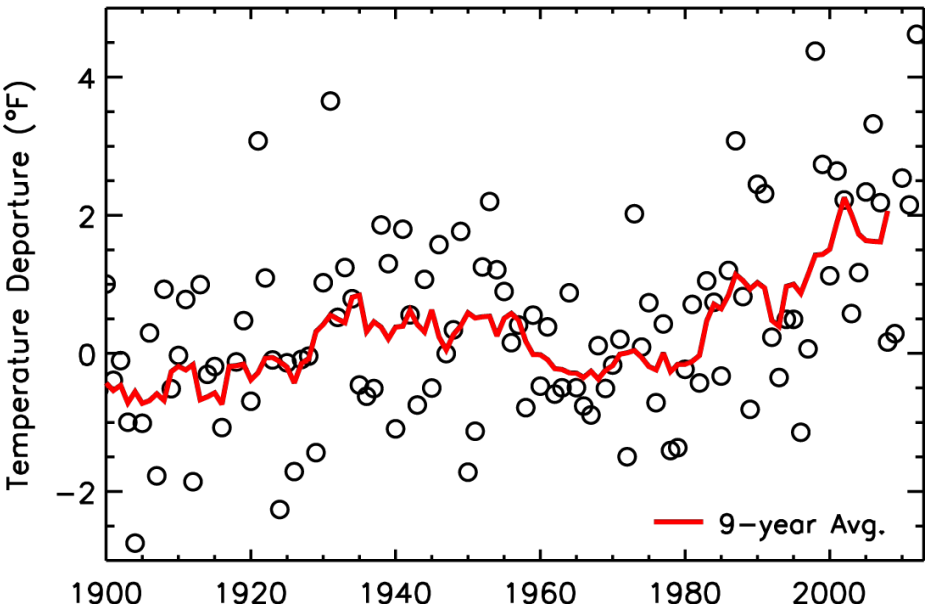
... INVASIVE SPECIES

... IMPERVIOUS SURFACES

THREATS FROM TEMPERATURE

The average annual temperature of the Great Lakes region has increased by 2.3°F since 1951 (GLISA 2019) (Figure 4).

Figure 4



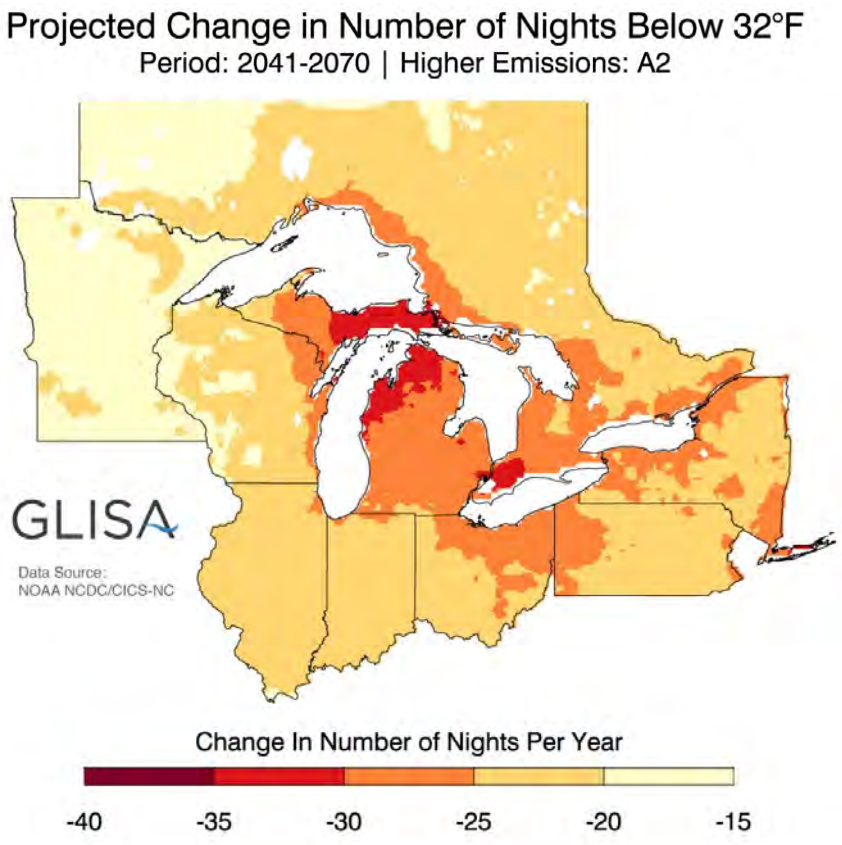
Observed annual temperature departures from the 1951-1980 average. Since 1951, annual average temperatures have increased by 2.3°F (1.3°C) across the 8 U.S. Great Lakes states (i.e., IL, IN, MI, MN, OH, NY, PA, and WI)." [from GLISA, n.d.,]

This warming has occurred across all four seasons, with the greatest increase in late spring and early winter (McDermid et al. 2015; GLISA 2019). Models suggest that this trend will continue for the Great Lakes region, with a predicted increase in average annual temperature of 3°F to 6°F by the turn of the century, with the lower estimate corresponding to a future scenario in which greenhouse gas (GHG) emissions are significantly reduced (NOAA 2019) (GLISA 2019). More locally to the LGRW, the GLISA Climate Summary for Grand Rapids predicts an increase in average annual temperature of 3°F to 5°F by mid-century (GLISA 2019). This warming corresponds to a predicted increase in heat wave occurrence and a decrease in the number of extreme cold events, as well as a decrease in the duration of snow and ice cover (ELPC 2019) (GLISA 2019). Urban heat islands and impervious surfaces compound in areas that were historically redlined and create greater temperatures in low-income communities. Specifically, in Grand Rapids, the number of days with temperatures in excess of 90°F are predicted to increase by as many as 30 per year by mid-century (High Emissions scenario), and 64 by the end of the century (High Emissions scenario); while the number of days falling below 32°F is predicted to decrease by as many as 129 by mid-century (High Emissions scenario) (GLISA 2019) (Figure 5). Urban heat islands and impervious surfaces compound in areas that were historically redlined and create greater temperatures in low-income communities; thus, low-income and disadvantaged communities (LIDAC), situated, primarily, in these areas, and with few means to change their circumstances/gain

resiliency, will bear a greater brunt of these climatic events than the rest of the populace.

Beyond human livelihoods, the rise in average annual air temperatures, and an increase in extreme heat days, will increase the average temperature of our water bodies, placing cold water and sensitive aquatic species at risk (Jiménez Cisneros et. al 2014; HRWC 2009).

Figure 5



Projected Change in Number of Nights Below 32 Degrees F for the period 2041-2070 under a Higher Emissions Scenario. This regional map was produced by the Great Lakes Integrated Sciences and Assessments (glisa.umich.edu) using data from the University of Wisconsin Nelson Institute Center for Climatic Research.

THREATS FROM PRECIPITATION

Along with changes in temperature, precipitation frequency, form, and intensity has changed and will continue to change. Within the Great Lakes region, average annual precipitation increased by 14% since 1951, with a greater volume of this precipitation coming in unusually large events (GLISA 2019; ELPC 2019). These events – "the heaviest 1% of storms" – have grown in frequency since 1951 and, on average, have produced 35% more precipitation (GLISA 2019). Looking forward, there remains uncertainty about the exact direction and nature of change in precipitation, though the Great Lakes region is

expected to see an increase in average annual precipitation (GLISA 2019). Grand Rapids, specifically, is projected to see an average annual increase of 3" of precipitation by mid-century and 7" by the end of the century (per GLISA 2019 High Emissions scenarios). More of this precipitation will also fall as rain, as winter precipitation is predicted to shift from snow towards rain as temperatures increase (EcoAnalysts 2020). Similar trends are likely across the LGRW. This change, however, is not uniformly distributed: the greatest percent increase is predicted to come in spring and winter, while summers are projected to become drier (WMEAC 2013).

THREATS FROM FLOODING

As noted previously, the frequency of extreme precipitation events, such as the heaviest 1% of storms, has increased and is likely to continue increasing as the climate changes (TetraTech 2015; WMEAC 2013; GLISA 2019). This greater risk of extreme precipitation is accompanied by a heightened risk of flooding, as large, rapid inputs of stormwater cause streams, rivers, and lakes to overflow their banks. Flooding itself is not inherently a problem: small floods can improve biological productivity, biodiversity, and ecosystem functioning (Talbot et. al 2018). However, extreme flooding can harm the ability of natural systems to provide ecosystem services such as water supply, disease regulation, and water filtration and quality (Talbot et. al 2018). Extreme flooding can also have economic impacts, causing damage to human property and infrastructure, or impairing the economic or aesthetic characteristics that may attract tourism. Another intersecting issue is incidence of flooding and increased precipitation. The particular impact on communities with aging or neglected infrastructure to handle these pressures, typically LIDAC that were historically redlined. Agricultural productivity will also be impacted, with heavy storms and inundation delaying planting, damaging crop productivity, and impairing soil fertility (ELPC 2019). The problem of flooding is exacerbated, especially in urban areas, by the prevalence of impervious surfaces, which prevent water from infiltrating. Aging stormwater infrastructure, with declining structural integrity and antiquated capacity, can add to the risk of flooding (More et al. 2016). For that reason, and general lack of means, LIDAC will likely suffer greater adversity than the general populace.

Increased precipitation will also lead to more stormwater runoff, or water that travels along the surface of the ground and flows into streams and waterways. Stormwater runoff transports various pollutants, such as chemicals, nutrients, and sediments, from roads, fields, and other surfaces as it flows across them (see LGROW.org/stormwaterintro). When these pollutants enter streams and rivers, they can impair the quality of the water,

at times making it unfit for human or animal uses. The high in-stream flow levels and rates that result from extreme precipitation can also cause increased erosion of stream banks and beds, altering the stream morphology and the habitat which it provides (Jiménez Cisneros et. al 2014). This occurs both in places where sediment is lost and where it is deposited.

THREATS FROM DROUGHT

Even as the frequency of extreme precipitation events increases in the Great Lakes region, droughts – considered, here, as "periods of 3 weeks with less than 0.5" of rainfall" - may also increase in frequency, as climate change exacerbates climatic extremes (Cherkauer & Sinha 2010, Jiménez Cisneros et. al 2014; GLISA 2019). As patterns of precipitation are altered by climate change, less total rain will fall in the summer with more time between these events (Jiménez Cisneros et. al 2014; GLISA 2019). This relative scarcity of rainfall will impact both human and natural processes and activities. Fields, lawns, and gardens will require management that takes this decreased rainfall into account. Agricultural producers will need to supplement this lost rainfall with irrigation or increase their water-use efficiency. The need for irrigation is heightened in cases where early season flooding led to late planting, leaving crops more susceptible to summertime drought (ELPC 2019). For natural systems, drought will result in lower water levels, which, when combined with the flow spikes caused by extreme precipitation, will create highly variable flows (Jiménez Cisneros et. al 2014). Drier summers are also predicted to decrease groundwater recharge (Leichenko & Solecki 2013). Combined with the increased irrigation likely to accompany decreased rainfall, this could contribute to aquifer depletion in the absence of careful management (UCS 2008).

THREATS FROM HABITAT FRAGMENTATION & SUITABILITY

These changes in precipitation and temperature will in turn alter the habitat suitability of water and land within the watershed. Although species differ in their tolerances to change and pollution in their surroundings, climate change will nonetheless result in broad declines in habitat quality and suitability. Aquatic mammals, fish, amphibians, invertebrates, and plants will each be impacted by these changes. In the water, fish life cycles will be altered as temperatures, flows, substrate composition, and water quality change (Lynch et. al 2016; EcoAnalysts, Inc 2020). Cold water fishes, such as trout and salmon, will be particularly at risk to habitat loss, migration disruption, and spawning interference (EcoAnalysts, Inc. 2020). Aquatic invertebrates, especially intolerant/sensitive

taxa such as stoneflies, caddisflies, and mayflies, which many fish species depend on for food, may be driven out or extirpated in certain stream reaches. On shores and banks, amphibians, migratory shorebirds, and waterfowl will lose nesting sites to erosion, high waters, and flooding (UCS 2008). On land, climate change will cause further habitat disruption. As temperatures rise, the entire composition of plant and animal communities may shift to follow. Specifically, this means that many species within North America have already begun to shift northwards to remain in the climate zone to which they are adapted (Lynch et. al 2016, UCS 2008). These shifts may occur at different times for different species, causing further disruption to ecosystem functioning by creating disjunctions in species interactions (Lynch et. al 2016; EcoAnalysts, Inc. 2020).

THREATS FROM INVASIVE SPECIES

As aquatic and land habitats become less suited for historical native species, the new conditions may favor invasive species (UCS 2008; McDermid et. al 2015; GLISA 2019). Climate change will further "modify the ecological impact of invasive species by enhancing their competitive and predatory effects on native species" (Rahel & Olden 2008). Currently, cold temperatures and winter oxygen depletion act as barriers to the establishment of many invasive species (Rahel & Olden 2008, UCS 2008). However, as temperatures rise, these barriers will decrease in occurrence and efficacy. Physical barriers to aquatic invasives also become less reliable as a changing climate alters flow patterns. Within the LGRW, high water levels could allow floodwaters to bypass the low head dams that currently prevent the spread of invasive sea lamprey upstream in the Grand River (EcoAnalysts, Inc. 2020). Pathogens and pests will also comparatively benefit under these new conditions, resulting in an increase in disease virulence, affecting both ecological and human communities, with the potential for pronounced effects in the agricultural sector (Rahel & Olden 2008). Ultimately, these changes have the potential to alter entire food webs, with ecological, agricultural, and economic effects. The shifting rates of production, consumption, and availability are a threat to humans and other creatures alike.

THREATS FROM IMPERVIOUS SURFACES

All these threats are exacerbated by the problems arising from widespread impervious surfaces, gray infrastructure, and disruptive land uses (NOAA 2019). Flooding, contamination, pollution, and habitat loss can all be mitigated, to an extent, by the unique functions of natural systems. They are inherently adaptable. Porous ground and planted land can absorb and slow the flow of water to provide regulation of air and water

temperatures, and to filter pollutants and nutrients from water before it reaches streams and rivers. Areas with impervious surface cover lack these functions of adaptability. Instead of infiltrating, water flows along the ground across impervious surfaces. As it does so, it accumulates volume and speed, contributing to flashiness and flooding of waterways (UCS 2008). It also picks up chemical or nutrient contaminants that it encounters as it flows into rivers, lakes, and streams. This compromises water quality. Additionally, impervious surfaces lead to warmer water temperatures, either by transferring heat to the water that runs across it or by allowing water to remain on the surface and be warmed by the sun. These increases in water flow volume, speed, contamination, and temperature all compound the impacts of a changing climate on water quality and habitat loss (UCS 2008). Not only do these developed and impervious surfaces lack the benefits provided by open land, but they also tend to replace and displace them, further reducing the resilience of the watershed. The conversion of wetlands, grasslands, and woodlands for agricultural, residential, or urban uses curtails their ability to effectively provide ecosystem services, with widespread impacts to natural and built landscapes alike (Benedict & McMahon 2006). In doing so, urban and developed areas "have a disproportionate influence on climate, hydrology, and water quality" even as they are among those most susceptible to the effects of a changing climate (ELPC 2019).

The threats of climate change will intersect with different vulnerabilities in different places and situations. LIDAC, for example, situated, historically, in areas of near total imperviousness, will suffer dramatic urban heat island effects. These extreme temperatures will interact synergistically with the urban heat island effect, a phenomenon in which developed areas become and remain warmer than their surrounding areas. This occurs because the buildings and surfaces used in traditional urban development absorb and retain more heat than would vegetative land cover (WMEAC 2013).

Therefore, while the changes in climatic conditions will be common to the entire LGRW, differences in land use, infrastructure, and preparedness at different levels and in different locations, will result in a unique experience of climate change for each subwatershed. Understanding these vulnerabilities to the threats of climate change is crucial for moving towards effective, actionable change.

VULNERABILITIES TO CLIMATE CHANGE
WITHIN THE LOWER GRAND RIVER WATERSHED

While the general impacts of climate change remain consistent across the watershed, the specific threats posed to subwatersheds will manifest differently at different levels. This is because individuals, communities, and governments within each subwatershed have unique vulnerabilities and weaknesses to the threats posed by a changing climate. Each of these levels deserves unique consideration. The distinct vulnerabilities at each level are presented next in to frame the discussion of appropriate and place-based opportunities to build resilience in the LGRW.

VULNERABILITIES...

...AT THE INDIVIDUAL LEVEL

...AT THE COMMUNITY & BUSINESS LEVEL

...AT THE GOVERNMENTAL LEVEL

VULNERABILITIES AT THE INDIVIDUAL LEVEL

Individuals and families living within the LGRW share a tacit concern for the wellbeing of the watershed as it supports their biological existence; in this way, they also share the same general vulnerability to the threats posed by climate change, though some, such as members of LIDAC, face a higher degree than other groups. Beyond the basic biological demands and varying but shared vulnerabilities, climate change presents risks to the mental, social, and economic wellbeing of individuals.

The increased incidence of extreme flooding, precipitation, and storms poses a threat to individuals' residences and property. Homes and other structures may become compromised, causing water and structural damage. Increased air temperatures correspond with increased electricity consumption for air conditioning and water consumption for irrigation by individuals and families, which, in turn, will lead to an increase in utility expenses. Increases in energy consumption may impact watershed residents by increasing the risk of power outages. Challenges to water infrastructure will also affect individual households, particularly those reliant on well water, as groundwater supplies are at greater risk for depletion. As demand increases at the individual level, residential water use may need to be restricted, or new wells may need to be drilled, limiting access and increasing utility costs.

The economic impacts of climate change will affect individuals in particular business sectors and communities more so than others. For example, those employed in such businesses as commercial fishing, forestry, agriculture, and outdoor recreation may be most directly impacted. While the impacts of climate change may create some opportunities for innovation and entrepreneurship, it will also have negative impacts for many individuals and businesses. Tourists, supply chain workers, and consumers of the products provided by the affected businesses will also experience economic disruption arising from climate change.

Individuals will also be affected by damage and losses of recreational resources under a changing climate. Recreational fishers will be impacted by impaired coldwater fisheries, partly due to warming temperatures/declining water quality, that will make our water bodies less productive. Declining water quality also limits the suitability of water resources for full or partial body contact, restricting suitability for swimming, paddling, and boating. Winter sporting opportunities will decrease as winters become warmer and precipitation increasingly falls as rain rather than snow. These losses impact the quality of life that is enjoyed by many within the watershed and may also correspond with harm to physical health (lack of healthful activity) and mental health (lack of direct environmental engagement).

A changing climate has further, more direct implications for human health. Increased heat, degraded air quality, and reduced water quality pose a direct threat to watershed residents. As the changing climate continues to raise average annual temperatures, extreme heat events are predicted to increase in frequency and duration, contributing to heat-related illnesses, such as heat exhaustion and heat stroke. Higher temperatures contribute to degraded ground-level air quality. Poor air quality can cause or exacerbate respiratory illnesses, such as asthma, and has the greatest impact on children, the elderly, and persons with underlying health conditions. These effects are often more pronounced for individuals of LIDAC who live in areas already experiencing greater pollution from

manufacturing or industrial operations (source).

The changes in temperature and precipitation that correspond to a changing climate also affect the quality of both surface and groundwater. Increased flooding and surface runoff will increase the sediment, nutrient, and contaminant loading of waterways, impairing the quality of water downstream and affecting its safety and usability for irrigation, fishing, swimming, and more. Increased flooding can also carry these contaminants into the places and spaces where people live, work, and recreate, with the potential to spread disease.

Vector-borne disease patterns will also be altered by changes in temperature and precipitation patterns. This includes increased transmission of mosquito-borne diseases such as malaria and yellow-fever, as milder winters and warmer, wetter springs will favor mosquitoes. Other changes in vector ecology could also alter the distribution and transmission of disease, leading to novel public health concerns and uncertainty (U.S. Climate Resilience Toolkit 2016).

Beyond these challenges, individuals will be presented with unprecedented levels of uncertainty and variability, as patterns of past climate and weather no longer serve as an accurate model for the future. Planning for a secure and flourishing future becomes more difficult under such conditions, with ramifications for the physical, mental, social, and economic wellbeing of individuals and families. The uncertainty and novelty that accompany a changing climate, and its negative impacts on individual wellbeing, can contribute to or worsen anxiety and emotional distress.

These negative changes will affect all individuals within the LGRW, but they will not do so equally. Rather, vulnerability is determined by an individual and their community's exposure to a threat, their individual or community's sensitivity to the threat's impacts, and the adaptive capacity of that individual or community to adjust or respond to potential consequences. In each of these areas, low-income, disabled, and elderly persons will most likely find themselves at a disadvantage, facing greater exposure, experiencing

heightened sensitivity, or lacking the resources necessary to adapt to the threats of climate change (Leichenko & Solecki 2013; WMEAC 2013). The same may be true for BIPOC populations or those with limited English language abilities. Resilience efforts must be cognizant of this inequality at an individual and family scale and factor in these heightened vulnerabilities when planning for holistic and just resilience projects and initiatives. Resilience efforts will not be successful unless they account for the most vulnerable persons of the watershed.

Due to their dependence on weather patterns, individuals within the agricultural sector face some of the greatest vulnerabilities to climate change. The erratic and unpredictable weather that accompanies a changing climate will require farmers to employ different products and practices. New measures for increasing soil fertility, ensuring sufficient water for crops, and choosing hardier or dry-climate adapted cultivars may all be necessary. Many farmers with small operations will be increasingly subject to economic risks as they work to balance the possibility of crop loss or failure against the cost of adaptation strategies or technologies (UCS 2008). Implementing creative, sustainable, and affordable resilience strategies will be crucial for future economic and ecological viability for these individuals.

VULNERABILITIES AT THE COMMUNITY & BUSINESS LEVEL

Urban, suburban, and rural communities within the watershed are all "home to diverse human populations, varied ecosystems, and complex infrastructure, all of which shape exposure, vulnerability, and adaptive capacity to climate stresses" (Leichenko & Solecki 2013, p. 95). These diverse areas and populations will also experience diverse impacts from climate change on their portion of the watershed. Increasingly, geographic communities of any size will be presented with new challenges arising from a changing climate. Cities, towns, neighborhoods, businesses, and other formal and informal associations of persons within the watershed will all be confronted with new challenges and stressors.

Extreme weather and the corresponding rise in extreme flooding and storms poses a risk to property, both public and private, owned or relied upon by communities. Buildings, parks, parking lots, roads, sidewalks, and more may become inundated more frequently. Beyond the immediate inconvenience of inaccessibility that this may cause, flooding or weather impacts can cause lasting damage that is costly to repair. Communities will likely need to dedicate more time and resources to monitoring, upkeep, and repairs of these spaces and structures as weather becomes more erratic.

Other elements of infrastructure crucial to the operation of communities and businesses are also vulnerable to climate change and its impacts. As energy generation and distribution structures are threatened by erratic weather, communities may experience increased energy shortages or outages. Water supplies may also become less reliable, as municipal plants are affected by greater weather extremes and groundwater supplies become depleted more rapidly. Roads, sidewalks, bridges, and railways will be adversely impacted by flooding and by increased freeze-thaw cycling, impairing the transportation infrastructure of communities. Business operations and supply chains will also be affected by these disruptions. Maintaining and improving the health, safety, and quality of life experienced by communities within the LGRW will require investment and innovation in response to these vulnerabilities of, and damages to, critical infrastructure and services.

The economic impacts of climate change on communities will extend beyond repair and replacement costs for damaged infrastructure. Direct losses or damages to sectors dependent on natural resources are among the most apparent economic repercussions. Changing temperatures and precipitation will contribute to depleted fish stocks (especially in coldwater fisheries), degraded natural areas (parks, forests, and dunes), with widespread impacts for industries reliant on fisheries, and forestry. Further costs may be incurred in an effort to prevent or mitigate the impact of these threats. The recreation industry may also suffer, as opportunities for activities such as fishing, paddling, or swimming are impaired by changes in water temperature, quality, and flow. Cold weather recreation, such as skiing and snowmobiling, will be challenged as winters become warmer and snow accumulation and retention decreases. This, in turn, affects tourism, extending the economic impacts of a changing climate far beyond those industries directly involved in procuring or providing access to natural resources. While new economic opportunities will also arise with these changes, they will not come without disruption to the current economic landscape of the communities of the LGRW.

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some of the greatest vulnerabilities to climate change. The erratic and unpredictable weather that accompanies a changing climate will require changes in the products and practices that farms employ. New measures for increasing soil fertility, ensuring sufficient water for crops, and choosing hardier or dry-climate adapted cultivars may all be necessary. However, the changes necessary for adapting to these threats may themselves pose a threat to other portions of the watershed, contributing greater nutrient and sediment pollution or decreasing surface or groundwater supplies in an attempt to maintain yields (Cherkaer & Sinha 2010). Many small farms will be increasingly subject to economic risks as they work to balance the possibility of crop loss or failure against the cost of adaptation strategies or technologies (UCS 2008). While most directly a threat to the livelihoods of the agricultural community, such threats will have a cumulative impact on the watershed, as half of the LGRW is considered agricultural.

Certain socioeconomic communities, given historic degradation and lingering inequalities, are especially vulnerable to the threats posed by a changing climate. Communities, for example, where populations have less education, lower income, less housing stability, or less access to capital will feel the effects of climate change on their physical, mental, and economic health more than others within the watershed. LIDAC and/or communities whose members speak English as a second language also tend to be more impacted by these changes and threats. This disparity poses another threat to communities, exacerbating inequalities and injustices that may already exist and leaving portions of the community far more vulnerable to the impacts of climate change on physical, mental, and economic well-being. Such injustices threaten social cohesion and are an affront to a just and thriving watershed community.

Indigenous communities/tribal nations are another group will be especially vulnerable to a changing climate. Traditional ways of life with cultural and spiritual significance are threatened by the changes that accompany a changing climate, posing a material, psychological, and existential threat to indigenous communities (Hatfield et. al 2018). As the land and its ecosystems alter in response to changes in patterns of temperature and precipitation, so also must the practices and traditions dependent on them. The impacts of climate change on diverse natural habitats, water quality, air quality, and habitat ranges for plants and animals all bear on the traditional ways of living that have been practiced within our watershed for centuries (BIA, n.d.). As the habitats for wild rice and other cultural foods shift or are lost, so also will be their role in traditional native culture and practices.

Culturally important forests, too, have been and will continue to be impacted by a changing climate, as the risk of pests, disease, and wildfire increases. Shifting seasonality can also impair the use of these tribal resources, as treaties may permit only designated periods of usage, which may no longer correspond with the actual timing of various

migrations and harvests (Hatfield et. al 2018, Whyte 2013). Beyond the direct loss of resources, there can also be a loss of a "sense of place and identity" that accompanies these impacts of a changing climate (Hatfield et. al 2018, p. 1). Traditional ecological knowledge (TEK) of native peoples, developed over centuries or millennia, is also threatened by unprecedented changes in climate, as historical patterns and observations are altered or lost and TEK is rendered "inconsistently reliable" (Hatfield et. al 2018, p. 7). TEK offers an understanding about "changes in the natural world that are not readily available through western science observations" (Hatfield et. al 2018). Both the exclusion of this knowledge from discourse on climate change adaptation and its disappearance would be a significant loss for indigenous communities and the watershed as a whole. Because of the close ties between native culture and the land, changes to the latter pose a substantial threat to the integrity and continuation of the former.

VULNERABILITIES AT THE GOVERNMENTAL LEVEL

The LGRW contains multiple different scales of governance: municipalities, counties, and the state of Michigan. All have a stake in the wellbeing of the watershed and face the same general threats posed by climate change. Across all scales of governance, climate change threatens infrastructure under the jurisdiction of governments. It also threatens residents' and constituents' wellbeing and property such that a governmental response or intervention may be required.

The broad and various impacts of a changing climate correspond to broad and various vulnerabilities in infrastructure. Critical systems will increasingly be put under stress by changing patterns of heat and precipitation, even as much of Michigan's infrastructure is already at risk or in need of attention (ASCE 2018). Climate change could impair or overload the capacity of critical services and infrastructure within the watershed. These critical services include infrastructure essential for providing a basic standard of health, safety, and shelter to both residents and businesses. As precipitation and temperature patterns become more extreme,

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transportation, energy, and healthcare sectors will face new stresses and threats to current physical and operational infrastructure. Extreme heat, flooding, and storms can negatively impact the functionality of hospitals, power plants, water treatment facilities, and more. These changes could also create situations that increase demand for their services which exhausts the capacity of the current infrastructure (GLSLCI 2016). Among the affected systems will be transportation, energy, stormwater, drinking water, groundwater, and public health infrastructure.

Transportation infrastructure is vulnerable to extreme precipitation and increased wintertime freeze thaw cycles. These factors will contribute to the more rapid degradation of roadways, requiring more frequent attention and repair. Flooding events will cause temporary interruptions to transportation, while also leading to roadway quality decline. These changes will make it more costly to build and repair roadways, and may compromise the capacity and safety of roads, tunnels, and bridges (EPA 2017). Road commissions at all levels of government will need to adapt to these altered conditions and increased stresses as the climate changes. "Extreme storms and temperatures can disrupt the delivery of health services and damage hospitals, clinics, wastewater treatment plants, and other facilities. Climate also impacts economic sectors that support health, such as energy, transportation, and agriculture" (U.S. Climate Resilience Toolkit 2016).

Energy infrastructure will also face new demands and threats. As temperatures warm, electricity use for air conditioning and cooling are likely to increase, while natural gas and oil usage for heating will likely decline (EPA 2017). Peak summertime demand for electricity will also increase, requiring capacity beyond what is currently available in most areas (EPA 2017). Providing energy in the quantities and forms that will be demanded under a warmer climate will require financial investment in new infrastructure. Due to the high volume of water used in cooling at power plants, summertime droughts could make it more difficult or costly to provide adequate energy in the future (EPA 2017). Furthermore, extreme storms and flooding can negatively affect the power grid, increasing the likelihood of power outages. This comes with a cost to repair and poses a potential threat to energy-dependent systems in food, transportation, healthcare, and industry.

Municipal stormwater systems are also vulnerable to threats from a changing climate. As extreme precipitation and flooding events increase in frequency, current stormwater systems are likely to become overwhelmed. Stormwater systems designed to accommodate historical precipitation patterns may be overwhelmed with the occurrence of extreme precipitation events. High volume and prolonged duration in excess of stormwater system capacity will lead to flooding. These issues of inadequate capacity will be worse in areas of the watershed where stormwater infrastructure is aging and will be more likely to give way under the increased stress of excess loading (ASCE 2018). Overwhelming or flooding these systems can lead to increased contamination of waterways from chemicals,

sediments, and nutrients carried off surfaces into waterways, causing problems for ecosystems, recreation, and human health (EPA 2017). Governments will be faced with the task of updating and maintaining stormwater systems to address this vulnerability or responding to the damage caused by their failure.

Surface water management will also need to adapt to a changing climate in order to avoid damage from unmanaged flooding. Where dams exist in the watershed, an increase in high-magnitude precipitation events can increase the risk of failure and flooding. In both areas with and without dams, a lack of thorough and effective emergency planning and preparedness, along with attentive monitoring, puts lives and property at risk from the threat of widespread flooding.

In addition to stormwater and surface waters, groundwater resources are also vulnerable to the threats of a changing climate. Increasing temperatures and shifting precipitation have impacts on both the quantity and the quality of available water in aquifers. These issues will be most pronounced in summer: decreased summer rainfall will decrease the rate of groundwater recharge, while increased temperatures will increase water use, especially for irrigation (EGLE 2020). When withdrawals outpace recharge, the groundwater levels will drop. These falling water levels could cause some wells to run dry, requiring new wells to be drilled. Aquifer depletion also heightens the risk of groundwater contamination by salts occurring naturally in the bedrock, which become concentrated as the water volume decreases. This contamination can impair water palatability, cause damage to drinking water systems, and harm crops. Without careful monitoring and management, municipal and private wells alike will increasingly be prone to these threats as the climate changes. Furthermore, groundwater supplies the base flow of most rivers and streams: declining groundwater can lead to lower water levels, reducing habitat quality or availability. Jurisdictions with municipal well water will need to be attentive to the condition of their wells and to the repercussions that a changing climate may have for their ability to provide reliable, safe, and clean well water.

Public health infrastructure, including hospitals, clinics, and other health facilities, could also experience damage, delay, or impairment from extreme temperatures or storms. The rate of groundwater recharge, while increased temperatures will increase water use, especially for irrigation (EGLE 2020). When withdrawals outpace recharge, the groundwater levels will drop. These falling water levels could cause some wells to run dry, requiring new wells to be drilled. Aquifer depletion also heightens the risk of groundwater contamination by salts occurring naturally in the bedrock, which become concentrated as the water volume decreases. This contamination can impair water palatability, cause damage to drinking water systems, and harm crops.

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Public health infrastructure, including hospitals, clinics, and other health facilities, could also experience damage, delay, or impairment from extreme temperatures or storms. The risks for public and human health infrastructure are also inseparable from damages to other systems on which this infrastructure relies, such as energy, transportation, and water, necessary both for ensuring human health and for maintaining functional healthcare systems.

These areas of vulnerability are further complicated by the uncertainty inherent in the threats of a changing climate: as climate change produces an increasingly uncertain future, past models for planning and management of infrastructure may no longer serve. Both routine and emergency preparedness will need to be adjusted, whether for snowfall predictions for planning road clearing and maintenance or for disaster modelling to appropriate adequate emergency funds (NOAA 2019). Past resources may no longer be appropriate or sufficient for addressing the challenges of the future, and historical assumptions may no longer apply. As the challenges, strains, and stresses placed on governmental organizations and resources shift, so will the planning, policies, and

practices appropriate to address them.

Beyond the material threats posed by climate change to the infrastructure and assets managed by governance at the federal, state, and local levels, governmental groups will also increasingly be tasked with responding to the challenges and damages of climate change on their constituents. Extreme weather conditions and storm events are likely to overwhelm the current capacities of individuals and communities, requiring emergency services to be dispatched. Such a response will require significant investments of resources and efforts beyond those currently required for regular operations. Particular attention to vulnerable communities, such as LIDAC, the elderly, and those with disabilities, will be needed, where current resources may already be inadequate, causing the impacts of climate change to rapidly become overwhelming. The threats and vulnerabilities facing government, then, are not isolated. Rather, they also include the following threats to communities, individuals, and their wellbeing.

The jurisdictional layers of counties, cities, and townships can create a patchwork of regulatory or managerial policy. Creating a holistic response to the threats of a changing climate in the LGRW will require coordination and cooperation across different levels of government and jurisdictions.

Individuals, communities, and governance all have unique vulnerabilities to climate change, which must be addressed. However, these different subwatershed scales also possess strengths in the face of this challenge, and these strengths can be developed further by leveraging existing opportunities. Individual and collaborative efforts are already underway to increase adaptive capacity, and there is abundant possibility for more. It is to these strengths and opportunities that we now turn.

STRENGTHS AND RESILIENCE
OF THE LOWER GRAND RIVER WATERSHED

WATERSHED VALUES

The EPA-approved, nine-element Watershed Management Plan (LGRWWMP) for the LGRW (2011) identifies the following values, which are central in the pursuit of resilience:

- Watershed activities are **diverse, inclusive, and collaborative**
- Watershed efforts are **sustainable** and of **high quality**
- Watershed images and messages create a **widely shared sense of legacy** and heritage
- Watershed methods and products are **holistic** and employ a **systems approach**
- Watershed organization and programs **evaluate progress and reward success**

Through the efforts of local governance, subwatershed groups, community groups, and individuals alike, these values are currently being practiced and promoted within the watershed. While the LGRWMP's focus is to reduce or eliminate non-point source pollution from entering the Grand River and its tributaries, it has laid a strong foundation for resilience in the face of an uncertain future. The strategies and projects that it recommends have had both direct and indirect benefits for increasing resilience. Directly, the practices aimed at reducing pollution of waterways help to offset some of the negative impacts of increased rainfall and stormwater runoff. Indirectly, the multiple and diverse benefits of the nature-based solutions which it recommends have resulted in the establishment of areas of resilient natural infrastructure. Many of the same practices that are beneficial for preventing pollution and stormwater runoff from damaging our waterways also address the threats posed by a changing climate. Urban and residential low impact development (LID), such as rain gardens, bioswales, and increased tree canopy, simultaneously filter out potential pollutants, manage the flow of rainwater, and can lessen flooding. Agricultural practices such as cover crop planting, nutrient management, and livestock management reduce the bacterial, chemical, and nutrient loads entering waterways. These same practices also give farms and orchards more

resilience to extreme weather, drought, and flooding. Preservation or restoration of natural areas, especially wetlands, provides benefits to water quality, and maintains habitat and resilient ecosystem functionality even as climate changes. The stormwater management plans implemented by some municipalities with stormwater permits within the watershed are another such example, offering guidelines for best practices in stormwater management with regards to infrastructure, development, and public education and involvement. These practices have already been promoted and implemented throughout the watershed and are just a few examples of the strengths possessed by the LGRW for establishing resilience.

STRENGTHS & RESILIENCE | **ORGANIZATIONAL STRUCTURE AND COMMUNITY PARTNERS**

LGROW's position within GVMC gives access to, and credibility with, a large number of local and state officials who have the power to institute changes needed at the governmental/agency/regulatory scale. This isn't always the case with other watershed groups, and the benefits can be seen where GVMC's influence helped gather valuable information about the state of water infrastructure in our region. Policies, procedures, and channels for communication and action also already exist within the LGRW, creating a strong foundation for future resilience efforts. Members and partners of LGROW have formed committees dedicated to advancing efforts in Sustainability, Subwatersheds, and Public Engagement within the LGRW. These committees bring together multiple stakeholders with a shared desire to address issues and concerns of the watershed. These committees also provide an avenue for the voices of watershed residents to be heard, and they build capacity and partnerships that will aid in the development and implementation of resilience efforts. The many subwatershed groups that exist within the LGRW are also a strong asset for future resilience efforts. These groups, comprised of citizen and municipal stakeholders, serve as advocates for awareness and address of watershed issues within their communities. They provide a pipeline for communication between the different communities and jurisdictions within the LGRW and individuals and their interests and needs. These champions of watershed issues are knowledgeable and engaged in their communities and offer one of the most crucial resources for watershed resilience as we look towards an uncertain future.

STRENGTHS & RESILIENCE | **SHARED RESOURCES**

The LGRW and its current and future resilience efforts are also benefited by the Data Repository maintained by LGROW (lgrow.org/data-repository) which compiles and

stores water quality data from across the watershed, allowing for ongoing, large-scale observation and monitoring that can inform decision making. Public education by these subwatershed groups and by LGROW have contributed to a base of knowledge about watershed issues among the public. Outreach activities have helped establish in-person and digital channels of communication that can continue to build awareness and capacity throughout the watershed as our collective attention turns to resilience efforts. Communities and jurisdictions have begun discussions or plans centered on questions of resilience, considering and developing capacities to respond to coming changes to the many aspects of life that are threatened by climate change. Already, plans focused on climate resilience, hazard mitigation, and specific aspects of climate change threats, such as depletion of groundwater, have been developed by communities within the LGRW.

Resilience efforts in the LGRW are also strengthened by strong commitment and awareness from watershed residents. Individuals and communities within the watershed value having clean, healthy, accessible freshwater. A survey conducted by Clean Water Action for the Wege Foundation in 2019 testified to this, reporting that the overwhelming majority of respondents consider the Grand River to be "a very valuable natural asset" to their communities (Brady-Enerson 2019). A 2019 poll conducted for GVMC and other watershed stakeholders by Public Sector Consultants found significant willingness among individuals to provide financial support for projects to protect and restore rivers, lakes, and streams (Public Sector Consultants 2019). This willingness and support from a wide variety of residents is a strong asset in creatively and effectively confronting the threats faced by the watershed from climate change.

OPPORTUNITIES TO BUILD RESILIENCE
WITHIN THE LOWER GRAND RIVER WATERSHED

The current strengths of the Lower Grand River Watershed point to further opportunities that exist for ensuring the resilience of the watershed against the threats posed by climate change. While these practices have had the beneficial secondary effect of building resilience, it is important to target the threats of a changing climate intentionally and directly. The most effective strategies will be those that recognize the uncertainty of the future and work to increase the flexibility of the human and natural systems in response, relying on collaborative work across all levels of involvement. This will maximize the adaptive capacity of human and ecological communities within the watershed. A threat to a given level may find its solution at a different level, or in strategies reliant on multiple levels. In this way, individual action may help build resilience against community threats, or government-level action may prove most effective in protecting individuals. A successful approach to building resilience will be diverse, multifaceted, and collaborative, and incorporate opportunities for each individual, community, and government. It will focus on a variety of strategies, incorporating individual and community action, policy, infrastructure, natural spaces, and education to build on and expand the strengths of the LGRW. The specific opportunities and recommendations that follow are elements that could be jointly implemented at the subwatershed and watershed scales as best fits the needs and capabilities of a community. Both policy and practice will play an important role in building resilience at the watershed scale. The call to action that follows these recommendations, and the list of tools and resources included in Appendix 2, elaborate on and concretize these opportunities in order to effect meaningful work in pursuit of resilience.

The policy and procedural recommendations focus on establishing systems that will promote resilience-building efforts and practices. These include managerial strategies and land use planning efforts that recognize and work to counteract the threats posed by climate

change. They also rely on efforts by subwatershed groups, neighborhoods, and individuals to organize and educate their communities about the threats and opportunities facing the LGRW and its residents. Opportunities to develop procedural strengths also include the development of consistent, robust, and accessible monitoring and data collection throughout the watershed by government, communities, and individuals. These measures are crucial for informing and involving stakeholders at all scales within the watershed in ensuring its enduring health and beauty. The measures proposed here seek to decrease the exposure and sensitivity of the persons, native biota, infrastructure, and ecosystems of the watershed to the threats posed by climate change even as they increase the adaptive capacity of these same groups.

These recommendations for procedure and policy are joined by recommended practices at the individual, community, and governmental levels. Principle among the practical strategies for building resilience and preparedness is the implementation of natural, or "green," infrastructure. Green infrastructure refers to an "interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife" (Benedict & McMahon 2006, p. 1). Green infrastructure works with the inherent resilience of natural systems and can be implemented on a variety of different scales, from a single yard or right-of-way to a city center to a county park. It takes advantage of the multiple benefits that can be provided by a single ecosystem or natural area, and values undeveloped areas for their cultural, ecological, and economic worth. In this way, the green infrastructure approach is distinct from the prevalent paradigm that views open spaces as lands that are simply not yet developed. Green infrastructure is distinguished from grey infrastructure, a term referring to human-engineered solutions for dealing with water, including stormwater sewers, pipes, and reservoirs. Green infrastructure provides a "more comprehensive suite of benefits than grey infrastructure alone" (More et. al, p. 13). It utilizes passive, low tech management tools, most of which focus on slowing, spreading, and sinking stormwater as it flows across the landscape (Hemenway 2015). Like grey infrastructure, however, green infrastructure requires active maintenance, protection, and, at times, restoration. The two approaches to stormwater management are not opposed: rather, they can be used in tandem to create a robust, cost-effective, and lower-impact system with benefits for both human and

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Green infrastructure can take a variety of different forms and approaches as it offers nature-based resilience. At an individual or local scale, green infrastructure includes wetlands, bioswales, rain gardens, green roofs, urban trees, permeable pavement, and rain barrels (Zuber 2015). At a larger regional scale, green infrastructure includes large urban forests, stream corridors, floodplain restoration, and wetland complexes (Zuber 2015). All these components are united by their common intent to prevent runoff by mimicking natural hydrological regimes. In doing so, they store water in the soil, reduce erosion, prevent nonpoint source pollution, minimize and mitigate flooding, and improve water quality (Hemenway 2015, Zuber 2015). Beyond its direct hydrologic benefits, green

infrastructure provides terrestrial and aquatic habitat, captures, and stores atmospheric carbon, and provides regulation of local climate (Emilsson & Sang 2017, Depilm & McPhearson 2017). The benefits are more than ecological and economical, however: the natural areas provided by green infrastructure are also beneficial to physical, mental, and social health. They provide places for recreation, improve air and water quality, alleviate stress, reduce exposure to excessive heat and noise, provide beauty, and stimulate social cohesion (Braubach et. al 2017).

In view of these many and varied benefits of green infrastructure at a variety of scales, the Watershed Management Plan for the Lower Grand includes a Natural Connections map for the LGRW (shown at the bottom of this page). This map shows a system of connected corridors and hubs that span the extent of the watershed, indicating priority areas for conservation and restoration. The maintenance or restoration of these areas is crucial for the ecological functioning of the LGRW. They were chosen based on their absolute or relative locations and their current or historic ecological importance for proper ecosystem function. Individual and coordinated efforts to preserve or maintain these areas will be especially effective and necessary for ensuring the resilience of the watershed in the face of an uncertain future. The recommendations that follow for strengthening the resilience of the watershed will draw heavily from the Natural Connections map, which is further reflected in the individual subwatershed resilience profiles included in Appendix 3.

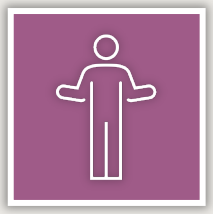
Developing resilience that offers comprehensive benefits to the watershed is **a matter of environmental, social, and economic justice**.

Developing resilience that offers comprehensive benefits to the watershed is a matter of environmental, social, and economic justice. This is crucial to efforts to maintain and build public health and quality of life within the LGRW. Prioritizing the retention and re-establishment of high-quality natural areas within the watershed will allow for the greatest adaptive capacity in the face of an uncertain climate future. In doing so, the human, animal, and plant communities of our watershed will benefit from a variety of effective ecosystem services, providing clean and safe habitat, and protection from flooding and extreme temperatures. This holistic approach to building resilience further adds to human quality of life by benefitting a variety of economic sectors and indices of human wellbeing, both directly and indirectly.

Nature-based solutions that protect, restore, or mimic natural ecosystem function will look different in different parts of the watershed and subwatersheds. Urban, residential,

agricultural, and natural areas are each best suited to a different suite of tools and strategies. Different levels of response, from individual to governmental, will be able to employ different resources and techniques at different scales to build resilience. A variety of distinct and creative strategies can be used to address and implement the priorities presented in the Natural Connections map and subsequent subwatershed resilience plans. Recommendations for building resilience in each such area are proposed below. Appendix 2 offers specific tools and resources targeted at addressing different priorities and practices. The subwatershed resilience plans in Appendix 3 help direct individuals, communities, and governance to the recommendations best suited to their context.

OPPORTUNITIES...



...AT THE INDIVIDUAL LEVEL

...AT THE COMMUNITY & BUSINESS LEVEL

...AT THE GOVERNMENTAL LEVEL

OPPORTUNITIES AT THE INDIVIDUAL LEVEL

Individuals, households, and families can make meaningful changes to strengthen not only their own resilience, but also that of their neighbors and of the entire watershed. Through practices that promote watershed resilience and participation in groups and processes that seek to identify and address the threats posed by climate change, individuals constitute an essential part of resilience efforts at the watershed scale. By the participation and efforts of informed, involved, observant, and active individuals, opportunities for increased resilience at every scale can flourish.

To consider ourselves as residents or citizens of a watershed may be a foreign concept. Political bounds, rather than ecological or hydrological divisions, are the typical geographic reference for most people living in the modern West. While it is typical to know and refer to the city, state, or country in which one resides, familiarity with watersheds is far less prevalent. These political bounds need not be wholly supplanted by a watershed-based understanding of place, but they ought to be complemented by it. Individuals who are informed about the location, characteristics, and dynamics of their watershed will be better poised to advocate for and develop its resilience (Figure 2). This place-based knowledge can be both propositional (from authoritative sources) and experiential (from personal experience). Many sources exist for both sorts of inquiry and knowledge: the latter can come from resources available through LGROW and many other partners, while the former may come from hiking, boating, paddling, or fishing in or along waterways throughout the watershed. Individuals will make a meaningful move towards resilience just by becoming familiar with the nature and characteristics of the LGRW and its subwatersheds. This opportunity can also be extended by informing and connecting others with resources to learn about the watershed.

Once informed, individual households and families can also act in ways that bolster the resilience of the LGRW. This will look different for different individuals: urban, rural, and agricultural property owners will vary in what practices are most effective and realistic for their situation. However, in each case, the underlying principle remains the same: when and wherever possible, ecosystems should be left intact so that they can continue to provide valuable ecosystem services, retaining habitat, hydrologic stability, and beauty for the benefit of individuals, communities, and wildlife. Where natural ecosystems have been lost to development or agriculture, portions of land should be restored to mimic their natural function. This can take many different forms: in an urban setting, a native garden, bioswale, or rain garden might be most appropriate. Tree plantings, permeable pavement and green roofs can also be space-efficient ways to decrease the negative environmental impact of urbanized areas. In an agricultural setting, a wetland could be restored to improve drainage and ecosystem function, with direct benefits for the landowner as well as for the watershed.

Rural landowners may also consider placing all or a portion of their land under a conservation or agricultural easement, a voluntary legal agreement that protects land from development in perpetuity, providing an enduring protection for the ecosystem services and corresponding resilience that the area of land provides. Land conservancies, such as the Land Conservancy of West Michigan, aid in developing and formalizing these protective agreements (see Appendix 2, "Land Conservancy of West Michigan – Conservation Agreements").

In addition to broad protection or creation of functional ecosystems, individuals can also implement practices that wisely steward water and land resources. These strategies both provide the individuals with resilience in the face of each flooding and drought and minimize the stress placed on ecological systems of the watershed, allowing for greater resilience in the face of changing patterns of temperature and precipitation. In addition to the above strategies for slowing, catching, and infiltrating stormwater, rain barrels can be used to capture stormwater run-off from roofs or other impervious surfaces. This water can be used for irrigation, further minimizing the water consumed from groundwater or municipal supplies. Other practices to reduce water consumption can also increase resilience as weather becomes more sporadic: using native and drought-tolerant species in gardens and lawns can reduce water inputs, as can reducing the frequency or intensity of mowing. In both agricultural and residential settings, adjusting the timing and manner of watering can significantly reduce the water needed, saving money and conserving water. This water conservation, in addition to human benefits, provides stability and quality of habitat for the many species in the watershed reliant on abundant, clean water to live and thrive. Soil and nutrient stewardship practices are also crucial for watershed health and resilience: preventing soil and nutrient runoff lessens the stress placed on aquatic species threatened by increasing water temperatures. Keeping soil and nutrients in place also benefits landowners, maintaining more natural fertility and reducing the need for external chemical inputs. Conservation districts throughout the LGRW offer valuable information and resources for practices such as cover cropping, vegetative buffering, and nutrient management. As flooding and drought both become more common, these practices for reducing soil loss, improving infiltration, and preventing nutrient runoff will benefit both farmers and ecosystems. Avoiding and removing pollutants from the local environment can also play a crucial role and can be achieved through decreased use of motorized vehicles, active avoidance of dumping and littering, and increased conscientiousness about use and proper disposal of household chemicals. Because of the interconnectedness of ecosystems and watersheds, riparian and non-riparian landowners alike will have an important part to play in protecting the resources of the LGRW. Attentive, active stewardship of land and water by individuals will play a key role in ensuring the resilience of the LGRW in the face of a changing climate and increasingly erratic weather patterns.

Individuals can also become involved in activities centered on planning, protecting, and understanding the LGRW and the changes and challenges it will face from a changing climate. Subwatershed organizations, LGROW committees, political involvement and more all allow individuals to understand and advocate for programs, practices, and policies that will create a flourishing watershed for all residents. Whether at the local, state, or federal scale, involvement of dedicated individuals in decision-making can prioritize measures that will protect and increase the resilience of the watershed and its residents in the face of a changing climate. Attentive observation and creative, collaborative, and inclusive discussions will equip decision makers at all scales with the tools to respond to and prepare for an uncertain future, and to build resilience that protects human and ecological communities and values.

OPPORTUNITIES AT THE COMMUNITY & BUSINESS LEVEL

Community practices and organizations, both formal and informal, are powerful and crucial tools for enacting change and ensuring resilience at the watershed level. Through coordinated local action, creative solutions can be implemented that best respond to the specific threats that a community faces while using the human, natural, and physical resources that it has available. Subwatersheds, neighborhoods, businesses, religious communities, and others are poised to bring together and leverage resources and abilities for the good of all residents of the LGRW, human and non-human alike.

At the subwatershed scale, watershed groups provide a valuable nucleus from which resilience efforts can originate and around which they can organize. Such groups bring together individuals living within a subwatershed to increase awareness and efforts to protect and improve their watershed. Watershed groups can be a crucial link for enacting not only the community-level opportunities and recommendations listed here, but also those at the governmental and individual levels. By acting as champions of watershed issues, they provide information, education, and resources that allow both government and individuals to become more informed, invested, and capable in protecting their watersheds. They coordinate efforts, involvement, and education of different stakeholders and supporting parties and bring the interests of each before the others. Their efforts allow for the efficient use and communication of resources and abilities at all scales to improve the wellbeing of the watershed and its residents. As the challenges from climate change confronting the LGRW and its subwatersheds continue and increase, this role will become all the more crucial. For subwatersheds that lack an organized watershed group, the formation of one is an important starting place for addressing the challenges and changes that a changing climate will bring. For subwatersheds that do have a watershed group, this ought to galvanize their efforts to be an effective institution addressing

individual, community, and governmental opportunities and roles in building a climate-resilient watershed. For more information on these subwatershed groups, visit the link included in Appendix 2 ("Subwatershed Groups of the LGRW").

Existent and new subwatershed groups can better monitor the impacts and changes occurring from a changing climate by collecting and documenting data about water quality, flow volumes, and more. These data can be input into the LGROW Data Repository (See link in Appendix 2) to help create a comprehensive view of the health of the LGRW across time and space. This monitoring will allow for targeted efforts that rapidly address threats arising from a changing climate, allowing for greater adaptability. It also allows for assessment of the efficacy of ongoing efforts, which will help identify the practices that are best suited to promote resilience in the waterways and communities of the LGRW.

In addition to monitoring, planning plays a crucial role in establishing long-term resilience in the face of an uncertain future. Informed, collaborative, inclusive, and responsive community plans for addressing the known and unknown threats of climate change allow for greater readiness and response. Such plans can address the specific threats faced by a community, as well as the unique opportunities and resources that exist for responding to them. This plan is one such example, intended to address the watershed scale threats proposed by climate change. However, subwatersheds, municipalities, neighborhoods, and businesses may want to develop their own plans, informed by this plan and their own resources and circumstances. A specific, localized consideration of the threats and opportunities that exist for a given community or organization can allow for changes to be made before any significant damages are incurred and can better prepare these groups to respond to more extreme circumstances. Stakeholder input should be sought in their development, ensuring that both the concerns and ideas for resolution of all vested parties are heard. This means soliciting a wide variety of data, information, and perspectives, and may be accompanied by citizen science efforts, compiling of Traditional Ecological Knowledge (TEK), and literary or art-based responses. Leveraging these various ways of knowing and of expressing knowledge

allows for a more holistic resilience, that both better understands the impacts of climate change and that equips more individuals and communities with the agency and resources to effect meaningful change (Hatfield et. al 2018, Whyte 2013). A community resilience or readiness plan may take a broad view of the threats confronting a community, as is included in the resilience plans for Grand Rapids and Grand Haven, or it may focus on a specific sector, resource, or critical infrastructure that is particularly at risk, as with Ottawa County's Groundwater Study. Such plans should be viewed as living documents, both informing and informed by community efforts to monitor impacts and build resilience.

Green infrastructure can also be implemented by communities and businesses in public and private spaces. The type of infrastructure will vary based on the size and location of the site, but there are practices that are appropriate at any scale which can help bolster the resilience of the community and of the watershed. Some businesses and community organizations make this their express purpose, as with the many nature preserves and nature centers within the LGRW, or the various champions of native plants that promote and facilitate the implementation of native, natural landscapes, bioswales, rain gardens, and more. However, even in the absence of an explicit focus on efforts to conserve intact ecosystems and their functionality, businesses and communities can have a significant impact. Implementing LID practices and ones that seek to manage stormwater on-site can reduce the risk of flooding and can provide benefits for water quality and hydrologic stability throughout the LGRW. Certifications, such as the Sustainable SITES certification for functional and regenerative landscaping or LEED green building certification, can help guide implementation efforts and can recognize and reward the efforts of businesses and organizations in increasing the sustainability and resilience of their communities and watersheds. Incorporating green spaces, using permeable pavement, capturing rooftop rainwater and more creates benefits for the community and the watershed as a whole, increasing the capacity to adapt to the changes that will accompany a changing climate. These practices also help lessen or ameliorate the threats to human health arising from climate change by reducing or providing relief from extreme heat, improving water and air quality, and benefiting mental health.

Developing robust and resilient systems of public transportation offers a further opportunity for reducing vulnerability to climate change impacts. Reliable, safe, and effective systems of public transit reduce the number of vehicles that need to be on the roads. This, in turn, can reduce the strain placed on transportation infrastructure, and can reduce the presence of automotive pollutants from roadways and the local environment. For example, on Clean Air Action Days, Grand Rapids transit system offers free bus rides. This incentive may help familiarize people with the system so that they feel more comfortable using it on a regular basis. Reducing pollutant stress can prove invaluable for maintaining the inherent resilience of natural systems as other stressors increase under a

changing climate.

Another means for communities to protect their own resources and resilience, as well as those of the watershed as a whole, is through wellhead protection. For municipalities, businesses, and individuals reliant on well water, wellhead protection guidelines protect the quality and safety of groundwater by preventing contamination. This is accomplished through voluntary, cooperative management focused on identifying threats and developing protections, and contingency plans (EGLE 2020). The team of stakeholders that comprise the wellhead protection team can provide a valuable community resource for gathering and communicating risks to groundwater, a critical part of building a resilient community. Explicitly identifying the threats of climate change for the supply and quality of groundwater in wellhead protection plans will allow for coordinated, cooperative action in protection of shared resources of the LGRW. Expanding wellhead protection and monitoring to evaluate rates of withdrawal and recharge of groundwater could provide a greater sensitivity, and corresponding ability to adapt, to effects of changing temperature and precipitation on groundwater supplies.

In all of these community-level opportunities, it remains important to be cognizant of the uneven distribution of climate change impacts on residents within the watershed. Variations in exposure and adaptive capacity rooted in income, race, age, and ability ought to be carefully considered as plans and practices to boost resilience are developed. Community-based resources aimed at educating all residents about the current and potential threats that they face and equipping them with the necessary resources to reduce the occurrence of impact of those threats, can help to address these discrepancies.

Initiatives to build resilience at the community level, in addition to direct protective benefits, can have wide-reaching positive effects. The green spaces, planning resources, and distinctive adaptive techniques used by communities and businesses help build a sense of place. Communities engaged in intentional planning and resilience efforts experience secondary benefits beyond protection from the threats of climate change: parks, preserves, and robust community organizations and institutions contribute to vibrant and attractive communities. These components of climate change preparedness, in addition to offsetting economic, physical, and social threats, can create positive benefits for these same areas.

GOVERNMENTAL LEVEL

Governmental policy and practices at the federal, state, and local levels can directly and indirectly support resilience efforts at the watershed scale. However, they can also directly

or indirectly hinder efforts to build resilience. While the LGRW spans many jurisdictions, an informed legislative landscape will offer the LGRW the most holistic and effective backdrop for increasing resilience. This, in turn, offers benefits to the various jurisdictions, providing safe places to live, work, and play, and supporting a robust economy and thriving civic life.

Due to the significant interplay between land use and climate change, watershed-focused land use planning plays a critical role in maintaining and increasing resilience and adaptive capacity. At the jurisdictional level, this can be accomplished by developing and enforcing zoning that intentionally and directly incorporates watershed considerations. A particular focus ought to be given to riparian areas, floodplains, and former or current wetlands for their importance in providing flood protection, increased water quality, and valuable habitat. Other areas of high-quality natural habitat ought to also be considered for restricted development because of the inherent resilience they provide. By limiting the type or extent of development that takes place in these areas, government can protect the valuable ecosystem services that they provide, which will only become more important as climatic impacts become more extreme.

In addition to zoning restrictions, governments can protect certain areas of land. Federal, state, and local governments alike can establish public lands to protect the natural and cultural resources that they contain, and to safeguard critical ecosystem services. Public parks, forests, and nature preserves maintain areas of natural land cover along with their hydrological and ecological benefits and provide beauty and opportunities for recreation to watershed residents and visitors alike. Establishing protected natural lands containing wetlands, forests, grasslands, and riparian areas all provide widespread benefits for human and ecological health in the face of a changing climate.

Protected natural areas are one component of green infrastructure. Other elements of green infrastructure can be implemented by state and local governments in order to bolster resilience. Practices in natural stormwater management can be used to

complement existing grey infrastructure, lessening the demands placed not only on stormwater systems but also on transportation, sanitation, and other critical infrastructure.

Different green infrastructure will be appropriate at different scales and in different situations: urban planning may favor linear parks, permeable pavement, street trees, and bioswales placed in road medians, while rural areas may prioritize larger recreational areas, rain gardens, and wetland restorations. Adding these multi-benefit strategies for stormwater management will give governments a broader, more flexible toolkit for addressing the challenges and changes that will increasingly arise as weather patterns continue to shift.

In addition to directly implementing green infrastructure in municipal planning and development, state and local governments can incentivize individuals, communities, and businesses to use these techniques. Financial incentives or creative pricing strategies for stormwater management can encourage the use of rain gardens, bioswales, and native plantings to manage water. As the individual and collective threat posed by climate change within the watershed increases, such strategies may prove valuable for increasing resilience.

Maintaining robust hazard mitigation plans that intentionally consider both the effects of climate change and the holistic nature of watersheds also provides an opportunity for government at the federal, state, and local level to increase adaptive capacity. Increasingly erratic weather, including heat spikes, cold shocks, and downpours, increases the likelihood of hazards such as floods and droughts at levels that exceed historical trends. Developing plans that acknowledge these realities and create robust response systems in case of their occurrence will provide protection for the individuals and communities of the LGRW.

Monitoring and data are also crucial for adapting to an uncertain climate future. As former patterns become unsuitable for future predictions, more information and data will be needed to guide future decision making and action. Gathering, analyzing, and establishing public access to data on changes in temperature, precipitation, and other factors impacting human and environmental systems will be necessary to ensure an enduring resilience.

Developing watershed-wide resilience requires watershed-wide collaboration. Traditional political and jurisdictional boundaries do not align with watershed boundaries. While this could pose a threat to the efficacy and efficiency of government-based approaches to building resilience, it also creates an opportunity for multiple stakeholder jurisdictions to bring together a variety of perspectives, interests, and resources to develop an expansive and inclusive framework for resilience that extends throughout the LGRW. Intentionally

developing such collaborations amongst public officials in the LGRW would strengthen and further the efforts of individual municipalities and communities and would more faithfully represent the scope and scale at which climatic changes will occur.

Crucial at every level is increased monitoring, both formal and informal, of watershed conditions. Formal monitoring will help to gauge the precise impacts that a changing climate is having on the LGRW, allowing for the creation of more accurate and useful predictive models. It will also allow for assessment of the efficacy of various resilience efforts, allowing energy and resources to be dedicated to those that are most effective in building resilience. Individuals and communities should take advantage of and participate in local community science activities to encourage and direct resilience-building efforts. Developing and promoting accessible platforms that allow for data and information from monitoring of climate change and resilience within the LGRW to be shared will allow for informed, inclusive, and diverse involvement.

As the landscape and climate in which we live continues to change, so too must our way of interacting with it.

CALL TO ACTION

RESPONDING AT THE SUBWATERSHED SCALE

The threat of climate change is not a distant concern: in both time and space, the changes taking place in patterns of temperature, precipitation, and storms are already affecting the LGRW. These threats intersect with different vulnerabilities at the individual, community, and governmental levels, and affect different land uses in unique ways. While there are practical and procedural strengths in the LGRW that bolster resilience and address some of these threats and vulnerabilities, further opportunities should be pursued in order to ensure resilience at all levels throughout the watershed. Subwatersheds and the communities they contain possess their own distinctive characteristics, vulnerabilities, strengths, and opportunities. The following framework offers steps and considerations to help subwatersheds move from awareness to action in response to the need for watershed resilience.

Identify or organize a dedicated team of watershed champions and stakeholders

In order to move from ideas to action, there must be a team or group with the explicit intention to protect and improve the health and flourishing of the subwatershed. Such a group ought to bring together diverse residents and stakeholders from the communities, businesses, and households of the subwatershed. This team can bring together the knowledge and perspectives of a variety of representatives from throughout the watershed, allowing for the vulnerabilities, strengths, and

opportunities of the subwatershed to be more holistically considered. This group can also serve as a nucleus for enacting change, partnering with government, businesses, organizations, and individuals throughout the subwatershed. With such a group in place, a subwatershed is poised to begin or continue the following steps towards resilience.

Assess the threats to and vulnerabilities of your subwatershed

Consider the threats posed by climate change: How are changes in temperature, precipitation, extreme storms, and flooding likely to play out in your subwatershed? What changes will these threats cause? Also consider the vulnerabilities of your subwatershed, across different levels (Government, Community, and Individual) and different land uses (Urban, Suburban, Rural, and Agricultural). What people, habitats, sectors, and infrastructure are vulnerable, and what specific weaknesses contribute to this vulnerability? Appendix 3 of this document provides tools to help with this assessment: for each subwatershed, there is a resilience profile examining the potential impact of climate change on the subwatershed as a consideration of land use and other characteristics. There is also a matrix that can be used to consider different threats and dynamics across different land uses and levels of implementation.

Consider the strengths and resources of your subwatershed

Investigate and evaluate current measures and tools in place to bolster resilience. Are there cities within the watershed that have developed resilience plans, or county-wide initiatives to reduce vulnerability? Is there strong interest among residents and businesses in green infrastructure? Consider also the financial, social, and natural capital and capacities of your subwatershed. Successful, place-based resilience will incorporate and leverage these existing resources and strengths.

Determine priority opportunities to address the threats facing your subwatershed

Opportunities abound within each subwatershed of the LGRW to maintain and increase resilience and adaptive capacity. There will be commonalities across all subwatersheds, but each one is also distinctive in the natural resources, governmental landscape, community values, and individual capacities. The subwatershed resilience profiles included in Appendix 3 identify some of these opportunities, but creative and collaborative efforts are likely to reveal more. Priority opportunities occur at the intersection of the greatest threats and strengths of a subwatershed. Consult the map of critical lands and the

recommendations for relevant and effective practices, policies, and procedures, and consider other locally specific concerns and responses. Then, identify which of these are congruent with existent strengths and resources. Identifying this intersection will help prioritize high-impact measures that are feasible within the constraints of individuals, communities, and governance within your subwatershed.

Identify tools and partners that can aid in subwatershed resilience efforts

Once priority opportunities and objectives are established, consider the tools and partners that can and should be used in their implementation. Appendix 2 of this plan presents tools and partners useful in accomplishing a variety of projects across strategies at all scales. Consider also local tools and partners that could be approached for collaboration. Are there organizations that are focused on climate change impacts and resilience within the communities of your subwatershed? Are there businesses or industries vulnerable to the impacts of a changing climate? Are there synergies between resilience efforts and other values, such as economic development, racial equity, or education that can be leveraged? An open and creative consideration of what partners and tools exist within a subwatershed will strengthen resilience efforts and will benefit holistic flourishing of the communities, businesses, and individuals of the LGRW.

Start somewhere

Your starting place need not be the grandest, most expansive, or most enterprising project. In fact, it may be better if it is not. Rather, begin with projects and initiatives that are realistic and feasible for the current capacity of the partners, tools, and resources you have. Every step towards resilience matters and choosing initial efforts that are realistic and attainable will help to build momentum and support to enable more endeavoring projects.

The many opportunities for building resilience within the LGRW and its subwatersheds can seem overwhelming: working to address the threats of a changing climate, to account for every vulnerability, and to leverage every opportunity can seem overwhelming. However, the breadth and variety of the recommendations included in this plan are not intended to prescribe that all must be implemented in every subwatershed, nor that the appropriate measures must all be undertaken simultaneously. Rather, these recommendations are given to help subwatersheds and communities consider the vulnerabilities that exist relative to the threats of climate change, and to identify specific, feasible, and actionable pathways towards a more resilient future.

CONCLUSION

PATHWAYS TOWARDS A RESILIENT WATERSHED

The concept of management at the watershed scale is not a new idea: As early as 1878, explorer and geographer John Wesley Powell proposed defining jurisdictional boundaries in the Western United States around watersheds so that disputes and the mechanism for their resolution would be appropriately aligned (Berkes 2003). While our political boundaries do not conform to those of our watersheds, the importance of holistic consideration and management of our watersheds remains important. As patterns of temperature and precipitation shift, both the impact and reliance of our ways of living on the world around us come into stark relief. These changes, being themselves environmental in nature, are best addressed from a perspective that takes environmental realities, such as watersheds, into account. This plan is intended to demonstrate the importance of such an approach and to identify the threats posed to the LGRW by a changing climate, as well as the strengths and opportunities that exist for countering them.

It is our hope that this plan, along with the existing efforts and commitment within the LGRW, will initiate a watershed-wide discussion of the impact of climate change on our region and of the steps that can be taken by government, communities, and individuals to increase resilience in spite of these changes. These steps towards resilience must be accompanied by efforts that address the root problem by mitigating anthropogenic climate change. Mitigation strategies provide a valuable and necessary complement to the measures proposed here, reducing the change and disruption that will be experienced. The omission of mitigation practices and measures from this plan does not negate or reject their importance. However, by limiting the scope to focus solely on resilience measures, it is hoped that those practices and considerations will come into more stark relief. Through such efforts, the LGRW can increasingly be characterized by opportunities for recreation and productive land uses that are safe, accessible, and enduring, and which contribute to healthy and flourishing human and ecological communities, capable of adapting to the circumstances with which they find themselves confronted. Through the intentional efforts of individuals, communities, and government, the infrastructure, neighborhoods, landscapes, and habitats of the LGRW can be given a future marked by resilience, collaboration, and widespread wellbeing, even when facing uncertainty.

The individuals, communities, and governments of each subwatershed of the LGRW are uniquely poised in their ability to effect meaningful and realistic changes that build watershed resilience. With a more limited geographic area, it is easier to recognize the specific changes and threats presented by a changing climate, and to identify and

gather the resources that exist within each area for building resilience in the face of these changes. For this reason, the subwatersheds are intended as the main audience of this plan. Serving as both a community resource and advocate, subwatershed groups can work with individuals, community partners, and governance to transmit the recommendations made in this plan in a manner appropriate to their watersheds. Through public education, collaborative initiatives, and ongoing dialogue, monitoring, and observation, subwatershed organizations have already proved to be invaluable champions of watershed health. This plan intends to offer accessible, understandable, and enabling support, guidance, and ideas that can encourage and direct the efforts of these groups and their communities going forward, and to connect them with valuable and effective resources.

Not all recommendations in this plan need to be pursued by each subwatershed. Each subwatershed is unique, with distinct communities, resources, land uses, and concerns. For that reason, Appendix 3 of this plan includes a Resilience Profile for each of the 32 subwatersheds of the LGRW. Each profile offers a concise overview of a specific subwatershed's characteristics and identifies priority recommendations and practices for building resilience therein. These recommendations are not a to-do list that must be accomplished by subwatersheds: not every recommendation must be accomplished in order for successful progress to be made. Neither are they exhaustive: there exist many other opportunities for creatively and effectively increasing resilience that have yet to be discussed. Rather, these recommendations provide a starting point for the initial steps. They are meant to serve as an inspiration for those seeking a way to get involved or to further their current initiatives, and to provide actionable ideas for individuals, communities, and governance within the subwatersheds of the LGRW seeking to build resilience.

In the resilience profiles in Appendix 3, a map is provided for each subwatershed. This map can be used to identify priority areas for restoration or preservation, which could indicate areas where efforts to appropriately integrate nature-based solutions with human presence and use will be most effective in increasing the resilience of our watershed and ought to be pursued. The priority areas are particularly important for the hydrological and ecological integrity of our watershed, impacting human and environmental health alike. Efforts in these locations will have the greatest relative impact for increasing In the resilience profiles in Appendix 3, a map is provided for each subwatershed. This map can be used to identify priority areas for restoration or preservation, which could indicate areas where efforts to appropriately integrate nature-based solutions with human presence and use will be most effective in increasing the resilience of our watershed and ought to be pursued. The priority areas are particularly important for the hydrological and ecological integrity of our watershed, impacting human and environmental health alike. Efforts in these locations will have the greatest relative impact for increasing our resilience. However, these efforts can take a

variety of different forms and approaches, drawing from and combining a variety of the different opportunities and strategies highlighted above and adapting them to suit the unique needs and resources of the individuals and communities involved. The scope and scale of resilience efforts may at times involve setting aside a large tract of land as a designated preserve, but, more often, it may include smaller-scale restoration efforts undertaken by an individual or community, or the planting of a rain garden, bioswale, or street trees. **The interconnectedness of our watershed means that a benefit to any location has the potential to benefit the entire system.** Street tree plantings and wetland reconstructions, though disparate in scope, both move our watershed toward a more stable, secure, and flourishing future.

The Natural Connections Map (linked in Appendix 2) includes large-scale restoration projects and priority areas as well as smaller scale components of green infrastructure. This map of each documented rain barrel, street tree, and infiltration basin throughout the LGRW serves as more than just a record of projects: rather, it celebrates the distinct and varied efforts of LGRW residents at every scale to protect and promote the health and safety of our environment and communities. The Resilience Profile also includes recommendations for policies, practices, and programs that may be particularly well suited to the unique context of each subwatershed. Other tools and resources are also identified in order to expand the toolkit at the disposal of subwatershed groups and residents: these are included in Appendix 2.

A watershed-based approach to climate resilience makes sense for many reasons. Ecosystems do not align with jurisdictional limits, and neither does much of the watershed's infrastructure. We need to change our response from a reactionary mode to being proactive in taking measures to build a more resilient watershed. The LGRW is fortunate to have cities and townships that care about their communities and residents, and to have people who care about the places they live. **Together, we will create resilience that allows all our watersheds to thrive. Through creative, intentional, and collaborative efforts, the LGRW can be a place of flourishing for human and ecological communities for many years to come.**

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LGROW GVMC

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APPENDIX I

GLOSSARY

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Adaptation	In the context of climate change, the process of adjusting to actual or expected climate and its effects
Anthropogenic climate change	Climatic changes caused by human activities
Bioswale	A channel designed to collect and convey stormwater runoff while removing debris and pollution. A type of green infrastructure
Critical infrastructure	Essential assets and systems for the functioning of a society and economy
Disaster Mitigation	
Ecosystem services	Benefits derived by humans, individually and societally, from healthy natural environments and ecosystems. These include supporting services (ex. Water cycle, soil formation), regulating services (ex. Climate regulation, water quality regulation), provisioning services (ex. Drinking water, food), and cultural services (ex. Opportunities for recreation, tourism)
GHG	Greenhouse gases. Greenhouse gases trap energy as heat within Earth's atmosphere and are necessary to maintain a livable temperature for life on Earth, but increasing atmospheric concentrations lead to warming and climate change.
Green infrastructure	Also referred to as natural infrastructure, green infrastructure is an approach to water management that protects, restores, or mimics the natural water cycle
Grey infrastructure	An approach to water management that relies on human-engineered structures such as drains, pipelines, and sewers
Impervious surfaces	Surfaces covered by water-resistant materials such as asphalt and concrete that prevent water from infiltrating
LGRW	Lower Grand River Watershed
LGROW	Lower Grand River Organization of Watersheds
Mitigation	In the context of climate change, efforts to reduce or prevent the emission of greenhouse gases
Rain garden	A depression planted with native vegetation, flowers, and shrubs that collects and infiltrates rainwater. A type of green infrastructure.
Riparian	Relating to, or situated along, the banks of a river or stream

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Watershed	The area of land that drains to a common body of water
WMEAC	West Michigan Environmental Action Council
Resilience	The adaptive capacity of human and natural systems. In the context of climate change, this involves the development and maintenance of societies, structures, and systems capable of withstanding the changes and challenges that a changing climate may bring
Subwatershed	A relative term referring to a distinct geographic region within a watershed that drains to a common body of water. Within the LGRW and this plan, this refers to the drainage basins of the tributary rivers, streams, and creeks of the Lower Grand.
Traditional Ecological Knowledge (TEK)	Knowledge acquired by indigenous and local peoples through hundreds or thousands of years of direct contact with the environment
Urban heat island	An urban area that experiences significantly warmer temperatures than surrounding suburbs and rural areas due to development and human activities.

APPENDIX II

TOOLS & RESOURCES

LGROW GVMC

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REPORTS & BACKGROUND ON CLIMATE CHANGE AND ITS IMPACTS:

Assessment of the Impact of Climate Change on the Great Lakes: This assessment from the Environmental Law & Policy Center (ELPC) offers a holistic view of the scope and nature of the impact of climate change on the Great Lakes region, with a unique emphasis on hydrological and ecological impacts of watersheds of the region. http://elpc.org/wp-content/uploads/2019/03/Great-Lakes-Climate-Change-Report.pdf

GLISA (Great Lakes Integrated Sciences and Assessments) Climate Divisions: Provides comparisons of current and historical annual data to assess trends in temperature, precipitation, and other climate factors throughout the Great Lakes region. http://glisa.umich.edu/resources/great-lakes-climate-divisions

National Climate Assessment: The fourth National Climate Assessment offers a broad and thorough consideration of the nature and impacts of climate change across the United States, with further threats and considerations offered by region and sector. It covers impacts on communities, economies, water, health, tourism, indigenous peoples, and more. https://nca2018.globalchange.gov/

State of Climate Change Science in the Great Lakes Basin: This 2015 report from the Toronto and Region Conservation Authority analyzes the impacts of climate change on the Great Lakes Basin, with a particular focus on climatological, hydrological, and ecological effects.
https://climateconnections.ca/app/uploads/2014/07/OCC_GreatLakes_Report_Full_Final.pdf

RESOURCE TOOLKITS & DATABASES:

US Climate Resilience Toolkit: The Climate Resilience Toolkit brings together information, resources, and tools for responding to and overcoming climate challenges. There are a vast array of tools and case studies, focused on a variety of different threats, vulnerabilities, and opportunities related to climate change. https://toolkit.climate.gov/ Specific resilience consideration and measures for the Great Lakes region, with suggestions and tools for both predicting future impacts and developing resiliency strategies, are located here:
https://toolkit.climate.gov/regions/great-lakes/building-resilience-great-lakes

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Adaptation Clearinghouse: An online database of resources for climate adaptation focuses on the built environment, with sections for such sectors as agriculture, business, ecosystems, small communities, public health, emergency preparedness, and more. https://www.adaptationclearinghouse.org/

Adaptation Resource Center (ARC-X): This service of the EPA is an "interactive resource to help local governments effectively deliver services to their communities even as the climate changes. Decision makers can create an integrated package of information tailored specifically to their needs. Once users select areas of interest, they will find information about the risks posed by climate change to the issues of concern; relevant adaptation strategies; case studies illustrating how other communities have successfully adapted to those risks and tools to replicate their successes; and EPA funding opportunities." https://www.epa.gov/arc-x

Agriculture Adaptation in a Changing Climate: This page from the USDA brings together various tools and resources for aiding agricultural producers in the Midwest in adapting to the increasingly erratic and extreme weather that accompanies a changing climate. https://www.climatehubs.usda.gov/agricultural-adaptation-changing-climate

EnviroAtlas: This resource from the US EPA "provides geospatial data, easy-to-use tools, and other resources related to ecosystem services, their stressors, and human health." Its interactive maps, downloadable data, and educational tools about ecosystem services and health make it well-suited for use at the governmental and community scales to understand the impact of policy and planning decisions on ecosystems. https://www.epa.gov/enviroatlas

GIWiz: The Green Infrastructure Wizard (GIWiz) tool from the US EPA is a "repository of EPA-sourced Green Infrastructure tools and resources designed to support and promote sustainable water management and community planning decisions." The tools and resources available allow users to learn about, research, design, and assess effective green infrastructure practices and measures for their specific situation. GIWiz can be used to "analyze problems, understand management options, calculate design parameters, analyze costs and benefits, evaluate tradeoffs, engage stakeholders, and/or develop education and outreach campaigns." https://www.epa.gov/sustainability/giwiz

Georgetown Climate Center: The Georgetown Climate Center, out of Georgetown Law, is a non-partisan center that compiles and distributes resources focused on the impacts of, and adaptation to, climate change, in state and local communities through effective policy. Resources and toolkits are provided for a variety of subtopics within adaptation, transportation, and clean energy. Green infrastructure and urban heat issues are also addressed.
https://www.georgetownclimate.org/about-us/index.html

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Great Lakes and St. Lawrence Cities - Best Practices Library: The Best Practices Library maintained by the Great Lakes and St. Lawrence Cities Initiative "is a dynamic, searchable database of Best Practices, Tools, and Information Documents that are specific to municipal issues in the Great Lakes – St. Lawrence Region." Municipalities can access tools used by peers on a variety of climate impacts, from water quality and availability to public health to habitat protection to public outreach and more. https://glslcities.org/resources/best-practices-library/

Healthy Watersheds Protection: This landing page from the US EPA brings together information, data, tools, and resources from the EPA for understanding, protecting, and improving watershed health. https://www.epa.gov/hwp

SmartGrowth: This tool from the US EPA provides information and resources for guiding development planning for communities of all sizes, based on creative strategies to develop in ways that preserve natural lands and critical environmental areas, protect water and air quality, and reuse already-developed land. https://www.epa.gov/smartgrowth/about-smart-growth

US EPA - Green Infrastructure: This page offers an explanation of green infrastructure, as well as descriptions and examples of different types of green infrastructure at a variety of different scales. It also offers explanations of barriers to green infrastructure, and concrete steps that can be taken to overcome those. https://www.epa.gov/green-infrastructure/what-green-infrastructure (The landing page for all US EPA green infrastructure resources can be found here: https://www.epa.gov/green-infrastructure)

TARGETED TOOLS & RESOURCES:

Assessing Health Vulnerability to Climate Change: A Guide for Health Departments: This guide from the CDC helps health departments assess local vulnerabilities to the health hazards associated with climate change. https://www.cdc.gov/climateandhealth/pubs/AssessingHealthVulnerabilitytoClimateChange.pdf

Cities Impacts & Adaptation Tool (CIAT): The Cities Impacts & Adaptation Tool from Great Lakes Adaptation Assessment for Cities "is a climate adaptation planning support tool for decision makers at the city level in the Great Lakes Region of North America. It provides usable data such as demographics, socioeconomic data, and both current and projected climate trends." It also

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provides a searchable database of adaptation tools and techniques to address specific threats or vulnerabilities affecting a city. http://graham-maps.miserver.it.umich.edu/ciat/home.xhtml

EGLE Office of Clean Energy (OCE): The OCE "supports state and local governments in mitigation and resiliency efforts to both achieve the state's carbon neutrality goal and help prepare communities for climate impacts. The Office also provides guidance in reducing greenhouse gas emissions, promotes renewable energy and energy efficiency, and advocates for the continued transition to a clean energy economy."
https://www.michigan.gov/egle/about/organization/climate-and-energy

EJScreen: The Environmental Justice Screening and Mapping Tool, or EJSCREEN, from the US EPA, brings together environmental concerns (such as wastewater, hazardous waste, and air quality) and demographic indicators (such as race, education, income, and ESL) on a single map. This allows communities to identify where vulnerable populations are concentrated and what other vulnerabilities they may be facing to holistically address questions of environmental justice while working towards watershed resilience. https://www.epa.gov/ejscreen

Evaluating Urban Resilience to Climate Change: A Multi-Sector Approach: This report from the US EPA "describes a comprehensive, transparent, and flexible tool that cities can use to identify the greatest risks, successes, and priorities for decreasing urban vulnerability and increasing resilience to climate change." It incorporates case studies and visualizations to help cities "target and prioritize adaptation planning." Its target audience is local and state planners, to aid in incorporating climate adaptation into planning.
https://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=322482

Great Lakes Climate and Demographic Atlas: This mapping tool from the Great Lakes Adaptation Assessment for Cities shows county-level statistics for the likely impacts of climate change on vulnerable populations, infrastructure, and the economy. These vulnerabilities can be used to direct efforts within subwatersheds.
http://graham.umich.edu/glaac/great-lakes-atlas

Great Lakes Integrated Sciences + Assessments (GLISA) Adaptation Monitoring and Evaluation Toolkit: "This page contains a number of resources to 1) introduce adaptation professionals to monitoring and evaluation and their potential benefits, 2) support the preparation for and execution of adaptation

evaluations, and 3) explain how to work with evaluation consultants. https://glisa.umich.edu/resources-tools/adaptation-monitoring-and-evaluation-toolkit/

How's My Waterway: This tool from the US EPA allows users to quickly and easily check the condition and existing data for their local streams and lakes, with information on pollutants and nutrient loading, as well as links to reports and groups that already exist for taking action.
https://mywaterway.epa.gov/

i-Tree Tools: This suite of tools allows jurisdictions and other stakeholders to assess the current tree canopy and corresponding benefits of their area, and to identify and assess the potential and value of further tree plantings in specific locations. It helps identify, prioritize, and design sites for future tree planting, with benefits for stormwater management, temperature regulation, and carbon sequestration. https://www.itreetools.org/

Land Conservancy of West Michigan - Conservation Agreements: Conservation agreements, in the form of conservation easements, provide protection for natural or agricultural land while still allowing landowners to live on, use, or sell their land. Conservation easements restrict future development, and are transferred with the deed to the land, providing lasting protection. They can also provide financial benefit to the landowner. The Land Conservancy of West Michigan helps landowners to develop these agreements and holds them in perpetuity.
https://naturenearby.org/land-protection/conservation-agreements/

LEED certification: Leadership in Energy and Environmental Design (LEED) is a green building certification, with measures for air quality, sustainability in building and construction materials and practices, energy efficiency, and more. Points are awarded based on performance measures and correspond to different levels of certification, with international recognition. Commercial and office buildings, homes, and schools are all eligible for certification, as are cities, communities, and neighborhoods. https://www.usgbc.org/leed

Living Shorelines Academy: This website provides information and resources about living shorelines, with the twin goals of retaining the shoreline stabilization effects of a hard structure while maintaining the important functions provided by natural shoreline ecosystems. Beneficial at an individual or community scale for property owners and managers to implement effective shoreline management that

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retains ecosystem function.
https://www.livingshorelinesacademy.org/index.php

Low Impact Development Manual for Michigan: This manual "provides communities, agencies, builders, developers, and the public with guidance on how to apply LID to new, existing, and redevelopment sites. [It] provides information on integrating LID from the community level down to the site level. It not only outlines technical details of best management practices, but also provides a larger scope of managing stormwater through policy decisions, including ordinances, master plans, and watershed plans."
https://semcog.org/desktopmodules/SEMCOG.Publications/GetFile.ashx?filename=LowImpactDevelopmentManualforMichiganSeptember2008.pdf

Michigan Wellhead Protection Program Guide: Produced by EGLE, this guidebook introduces wellhead protection, its working, and its role in safeguarding groundwater supplies. While it does not directly address the relationship between climate change and groundwater supplies, a holistic consideration of the potential sources of contamination and contingency planning that it contains could provide a starting place for effective management of well in a time of changing climate.
https://www.michigan.gov/documents/deq/deq-wb-dwehs-swpu-whpguidebook_256483_7.pdf

Midwest Glacial Lakes Conservation Planner: "MW Glacial Lakes Partnership's Lake Conservation Planner Tool gives information about climate impacts on lakes and their watersheds. It lets you filter lakes by county and major watershed and will also give some information on potential climate impacts from a fish perspective for the lakes."
http://ifrshiny.seas.umich.edu/mglp/?lat=43.62335&lng=-87.27759&fste=MI&fhuc=04050006

National Stormwater Calculator: A tool from the US EPA, the National Stormwater Calculator (SWC) "is a software application that estimates the annual amount of rainwater and frequency of runoff from a specific site. Estimates are based on local soil conditions, land cover, and historic rainfall records. Users supply information about the site's land cover and then select the LID controls they would like to use. The LID controls include seven green infrastructure practices. The SWC is designed to be used by anyone interested in reducing runoff from a property, including site developers, landscape architects, urban planners, and homeowners."
https://www.epa.gov/water-research/national-stormwater-calculator

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Populations at Risk: This geospatial tool from Headwaters Economics allows for the creation of detailed reports of at-risk or vulnerable populations by state, county, city, town, or various combinations thereof. These findings can be used to shape discussions of the vulnerable communities within a watershed and to pursue just proceedings and practices while pursuing climate resilience. https://headwaterseconomics.org/tools/populations-at-risk/

Rainwater Rewards green infrastructure benefits calculator: "The Rainwater Rewards green infrastructure benefits calculator was developed by West Michigan Environmental Action Council (WMEAC), Grand Valley State University (GVSU) and Michigan Tech Research Institute (MTRI) with funding from the USDA Forest Service Great Lake Restoration Initiative." https://rainwaterrewards.mtri.org/index.html.var

SITES certification: The sustainable SITES initiative is a landscape certification that recognizes practices and landscapes that "help reduce water demand, filter and reduce stormwater runoff, provide wildlife habitat, reduce energy consumption, improve air quality, improve human health and increase outdoor recreation opportunities." Points are awarded based on performance measures and correspond to different levels of certification, with international recognition. Building sites, parks, school grounds, home properties, and more are all eligible for SITES certification. http://www.sustainablesites.org/certification-guide

Tipping Point Planner: The Tipping Point Planner is an interactive tool for use by communities in the Great Lakes states to assess and plan for watershed health. Land uses, natural resources, and environmental concerns are identified and explored to determine potential threats and vulnerabilities. Tools for facilitated discussion help determine priorities and best strategies, and a watershed action plan is generated as a result. This tool can bring together many community stakeholders to discuss watershed threats and priorities and would be appropriate for use by a subwatershed group. http://tippingpointplanner.org/

Water Infrastructure and Resiliency Finance Center: Provided by the US EPA, "The Water Finance Center provides financing information to help local decision makers make informed decisions for drinking water, wastewater, and stormwater infrastructure to protect human health and the environment." It provides communities with technical and financial information and assistance in developing, implementing, and maintaining resilient water infrastructure. https://www.epa.gov/waterfinancecenter (The Water Finance Clearinghouse

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provides a searchable database of related resources and funds: https://ofmpub.epa.gov/apex/wfc/f?p=165:1:::::)

LGRW-SPECIFIC TOOLS & RESOURCES:

Adopt-a-Drain: LGROW's Adopt-a-Drain tool allows watershed residents to take action to directly protect our waterways by pledging to keep storm drains free and clear of debris. This maintains the functionality and efficacy of our stormwater systems and prevents pollution of waterways, which compounds the stresses of a changing climate. https://www.lgrow.org/adopt-a-drain

Find My Watershed: LGROW's Find My Watershed Tool allows residents of the LGRW to identify which subwatershed they live in by address. It also visualizes the location and extent of all the subwatersheds of the Lower Grand. This tool can help get individuals connected with the appropriate groups and resources for pursuing watershed resilience. https://www.lgrow.org/watershedmap

LGROW Committees: LGROW's committees provide a way for watershed stakeholders to participate and provide direct input on activities and issues throughout the watershed. This link offers descriptions about the focus and work of each committee. Committees are open to the public, and inquiries can be made by email.
https://www.lgrow.org/committees

LGROW Data Repository: The LGROW Data Repository collects, maintains, and shares standardized data on the biological and chemical conditions of the Lower Grand River and its tributaries. By compiling and analyzing data and trends from across the watershed throughout time, decision makers throughout the watershed are able to make informed and effective decisions about how to best protect and bolster resilience. https://www.lgrow.org/data-repository

LGROW Natural Connections Map: Available in both interactive and static formats, this map visualizes current and priority regions for green infrastructure in the LGRW and its subwatersheds. Current green infrastructure is classified by practice. This map can help recognize and celebrate the existent strengths and efforts within a subwatershed, as well as highlight regions for further resilience efforts. https://www.lgrow.org/green-infrastructure

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Subwatershed Groups of the LGRW: The Watershed Group directory can help residents find and connect with the dedicated group for their subwatershed within the LGRQ. As not all subwatersheds of the Lower Grand have an organized group, this can serve as a starting point for creating one, and other groups can provide mentoring and advice to those interested in beginning their own. https://www.lgrow.org/watershed-groups

APPENDIX III

SUBWATERSHED RESLIENCE PROFILES

LGROW GVMC

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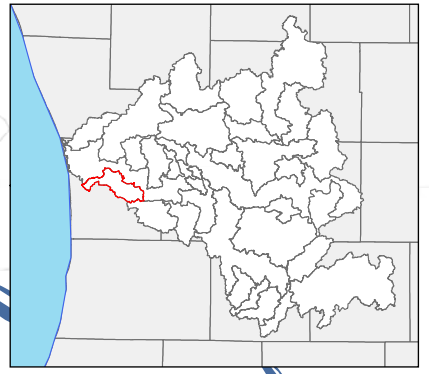
APPENDIX III: SUBWATERSHED RESILIENCE PROFILES

The following subwatershed profiles consist of a summary, table that outlines specific threats, vulnerabilities, and actions, and a map to be used for resilience planning. This Appendix is intended to be updated and used by individuals, communities, and government agencies to outline threats, vulnerabilities, and the actions and resources needed to address those threats and vulnerabilities. Some subwatersheds do not yet have a summary or table attached to the map, and will be filled out in the future.

Click here for Subwatershed Action Plan Template

Bass River Vision



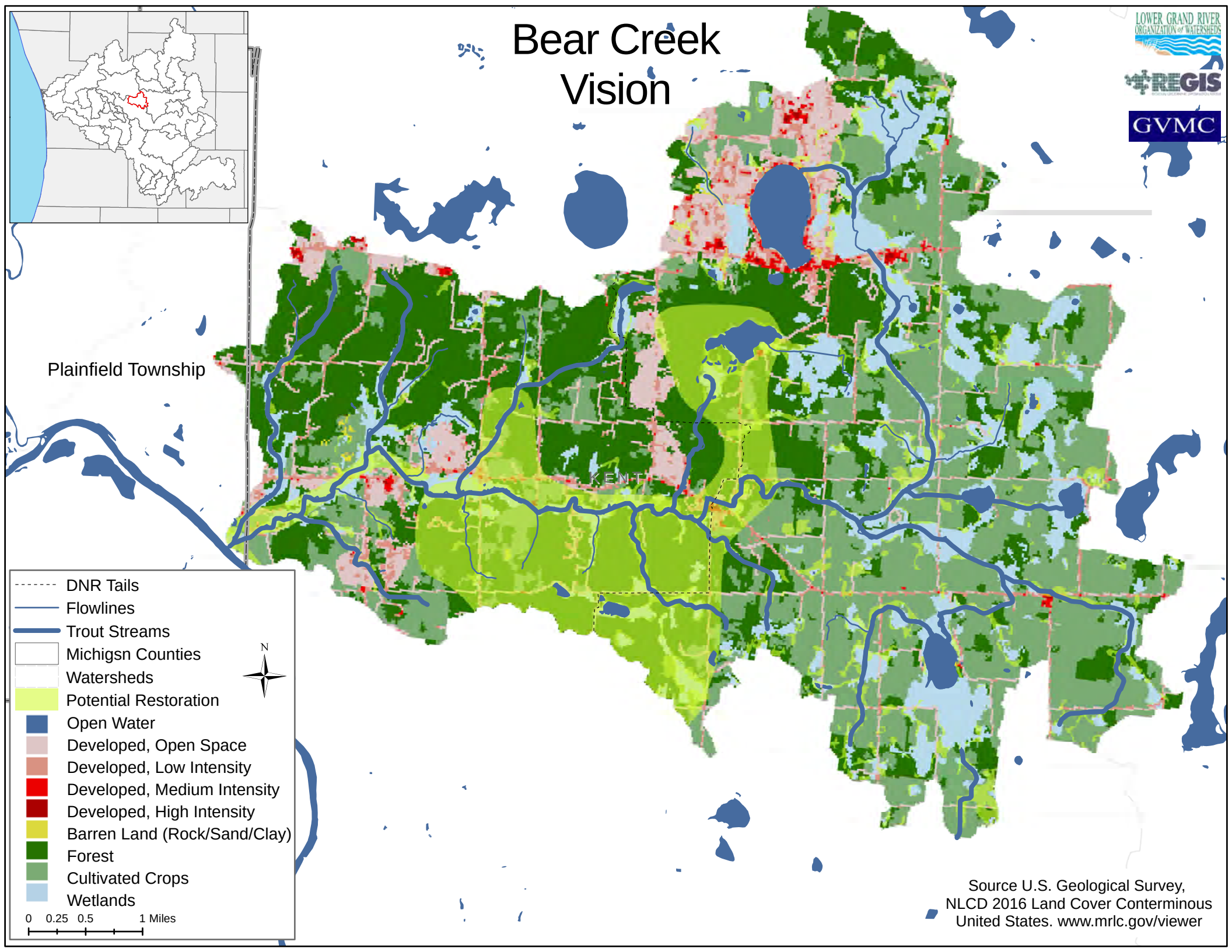
Flowlines
Trout Streams
Watersheds
Potential Restoration
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Forest
Cultivated Crops
Wetlands

N

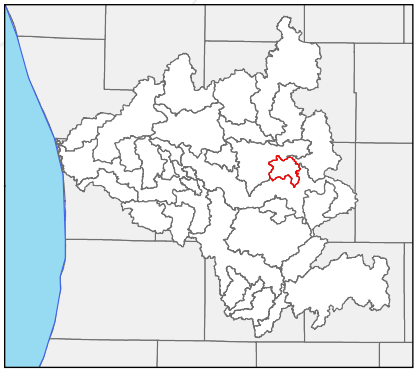
0 0.5 1 2 Miles

Georgetown Township

Source U.S. Geological Survey,
NLCD 2016 Land Cover Conterminous
United States. www.mrlc.gov/viewer


Bear Creek Vision
Plainfield Township
KENT
DNR Tails
Flowlines
Trout Streams
Michigsn Counties
Watersheds
Potential Restoration
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Forest
Cultivated Crops
Wetlands
N
0 0.25 0.5 1 Miles
Source U.S. Geological Survey, NLCD 2016 Land Cover Conterminous United States. www.mrlc.gov/viewer

Bellemy Creek Vision

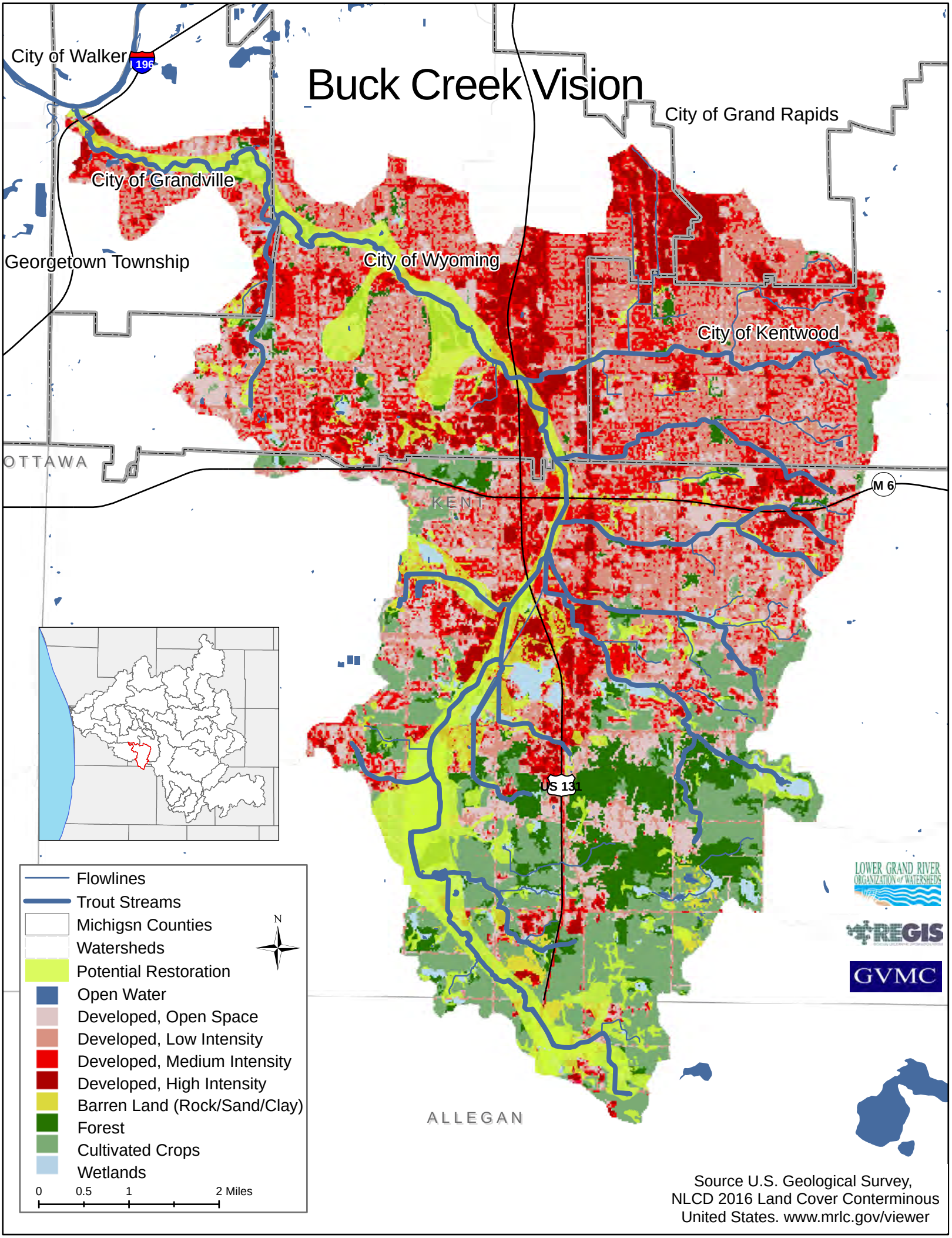


LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

REGIS

GVMC

Source U.S. Geological Survey,
NLCD 2016 Land Cover Conterminous
United States. www.mrlc.gov/viewer


Buck Creek Vision
City of Walker
196
City of Grandville
Georgetown Township
City of Wyoming
City of Grand Rapids
City of Kentwood
OTTAWA
KENT
M 6
US 131
ALLEGAN
Flowlines
Trout Streams
Michigsn Counties
Watersheds
Potential Restoration
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Forest
Cultivated Crops
Wetlands
N
0
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1
2 Miles
LOWER GRAND RIVER ORGANIZATION of WATERSHEDS
REGIS
GVMC
Source U.S. Geological Survey,
NLCD 2016 Land Cover Conterminous
United States. www.mrlc.gov/viewer

Buck Creek Subwatershed Climate Resiliency Report

Climate Resiliency and the Buck Creek Watershed

As we anticipate the effects of climate change on local ecosystems, building towards climate resilience is key to maintaining healthy watersheds. Changes in temperature, precipitation patterns, and species distribution will affect both terrestrial and aquatic ecosystems, along with increased pressures from human populations. Climate resilience is about recognizing these changes and building systems that can adapt and recover effectively.

The Buck Creek watershed is a subwatershed of the Grand River within Kent County and Allegan County. It includes parts of Kentwood, Wyoming, Byron Center, Grandville, Gaines Township, and a small part of Grand Rapids. The watershed is primarily urban (64%), with some agricultural (18%) and forest (11%) land.

Concerns

Buck Creek has high nitrogen and E. coli pollution levels already, and changes in the future could make it worse. More extreme weather events could lead to more runoff into the creek, adding more pollution. Increases in urbanization or industrialized agriculture would provide more possible pollution sources. Extreme weather events also contribute to flooding, an issue that will likely become worse for Buck Creek.

As a primarily urban watershed, future increases in temperature could have a negative impact on the creek. With minimal tree cover to cool the watershed, runoff from impervious surfaces such as roads and parking lots can contribute thermal pollution to the creek, along with other pollutants.

Recommendations

Green Stormwater Infrastructure (GSI) can help limit pollutants from urban runoff from entering the stream. Rain gardens and native plants, especially around parking lots, slow down flows and allow infiltration into the soil. Catching runoff will also limit thermal pollution. Reducing fertilizer use within the watershed is another way to reduce urban pollution.

Sustainable agricultural practices can also help the Buck Creek watershed. Keeping cattle out of riparian areas and planting buffer strips of native vegetation along the creek will reduce E. coli levels and other pathogens. Other practices like contour cropping and planting cover crops in the winter reduce agricultural runoff.

Buck Creek

Threats	Vulnerabilities	Actions		Applicable Resources
Flooding	Loss of property Flashy flows Financial constraints Mold in home	Individual	Install GSI	LGROW Storm Drain Kits LGROW Rainscaping AAD NFIP Rules EPA Flood Aware site
			Reduce turf grass	
			AAD	
		Neighborhood & Business	Install GSI	
			Plant and maintain trees	
			AAD	
		Local Government	Complete 'Are you Ready?' activity	
			Rezoning	
			Implment farmland preservation ordiniance	
Development	Loss of green space Neg. impacts to wildlife	Individual	Plant and maintain trees	Kent County Community Development Michigan LID Handbook LGROW Green Infrastructure Green Infrastructure Wizard EPA Green Infrastructure
			Plant Native Plants	
		Neighborhood & Business	Plant and maintain trees	
			Install GSI	
		Local Government	Follow stormwater standards to max. extent practicable	
			Reviewing and updating zoining ordinances	
			Communicate changes with residents	
Habitat Loss	Lack of native plants Poor landscaping practices Lack of education Wildlife desert	Individual	Plant Native Plants	LGROW Rainscaping Grandville Community Tree Project Wyoming Tree Amigos LCWM
			Participate in the Rainscaping Program	
			Plant and maintain trees	
		Neighborhood & Business	Participate in the Rainscaping Program	
			Plant and maintain trees	
		Local Government	Maintian Tree City USA status	
			Maintain existing protected areas	
Pollution	Air quality Trash Sediment Salt Fertilizers Lack of education Pet waste	Individual	Plant riparian buffers	Adopt a Drain Grand River West Michigan Clean Air Coalition Friends of Buck Creek EGLE Healthy Watersheds Protection LGROW Stream Clean Up Kit LGROW Community Science & Service Opportunities Teachers
			Participate in cleanup events	
			Pick up litter	
			AAD	
		Neighborhood & Business	Host cleanups	
			Outdoor cirriculum in schools	
			Envourage community service events	
		Local Government	Enforce Permits	
			Enforce environmental ordinances	
			Incentivize environmetnal cleanups	
			Adopt clean water policies	
Lack of Accessibility	Hard to get to green spaces Low income areas don't Lack of affordable housing	Individual	Volunteer with environmental orgs	Meels on Wheels Churches Local radio stations (ex: La Poderosa) Local TV stations The Rapid
			Support park millages	
		Neighborhood & Business	Share resources	
			Support volunteer transport/ridesharing	
			Schools to offer access to natural areas (field trips)	
		Local Government	Increase green space in underserved areas	
			Improve public transit opportunities to parks	
			Complete walkability surveys	
Heat & Drought	Lack of education Warm water temps Loss of biodiversity Threat to human health	Individual	Plant trees, native plants	Teachers LGROW Rainscaping Social Media Agriculture Adaptation Heat.gov
			Use rain barrels to store excess rainwater	
		Neighborhood & Business	Install rain gardens and GSI	
			Only plant native plants that need less care	
		Local Government	Adopt policies that eliminate pumping	
			Provide public cooling spaces	
			Provide incentives for GSI	
Indifference to Changing Climate	Less likely to take action Less support for local	Individual	Volunteer with environmental orgs	Local radio stations (ex: La Poderosa) Local TV stations Social Media Community events focused on children (ex: Story Telling Time) Educators
			Talk with friends and family about the threats of climate	
		Neighborhood & Business	Provide storyteling spaces for kids	
			Create a force of volunteers	
			Seek dtudent volunteers for environmenatl events	
		Local Government	Provide education and access to green spaces	
			Promote outdoor opportunities	
			Patner with schools for community service opportunities	

Coldbrook Creek Vision

Legend

- Flowlines
- Michigsn Counties
- Watersheds
- Potential Restoration
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Forest
- Cultivated Crops
- Wetlands

N

0 0.25 0.5 1 Miles

U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013,Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Coldbrook Creek Subwatershed Climate Resiliency Report

Climate Resiliency and the Coldbrook Creek Watershed

As we anticipate the effects of climate change on local ecosystems, building towards climate resilience is key to maintaining healthy watersheds. Changes in temperature, precipitation patterns, and species distribution will affect both terrestrial and aquatic ecosystems, along with increased pressures from human populations. Climate resilience is about recognizing these changes and building systems that can adapt and recover effectively.

Coldbrook Creek is a primarily urban watershed within Kent County. It includes parts of Grand Rapids, East Grand Rapids, and Grand Rapids Township. The watershed drains Reeds Lake and Fisk Lake, as well as the campuses of Aquinas College and Cornerstone University.

Concerns

Much of Coldbrook Creek has been channelized underground into pipes and culverts, which limits options for increasing watershed resiliency. With few natural riparian ecosystems, Coldbrook Creek does not have a significant buffer system to keep out urban pollutants. Not having aboveground creek access also makes education about the watershed more difficult. If residents can't see the creek, it becomes harder for them to care about it.

As an urban watershed, an excess of impervious surfaces contributes to increased runoff. Water flowing off of roads and parking lots heats up before entering the creek and can cause thermal pollution. Urban runoff can also contain pollutants like fertilizer, salt, and E. coli that can make the water dangerous for wildlife and people.

Recommendations

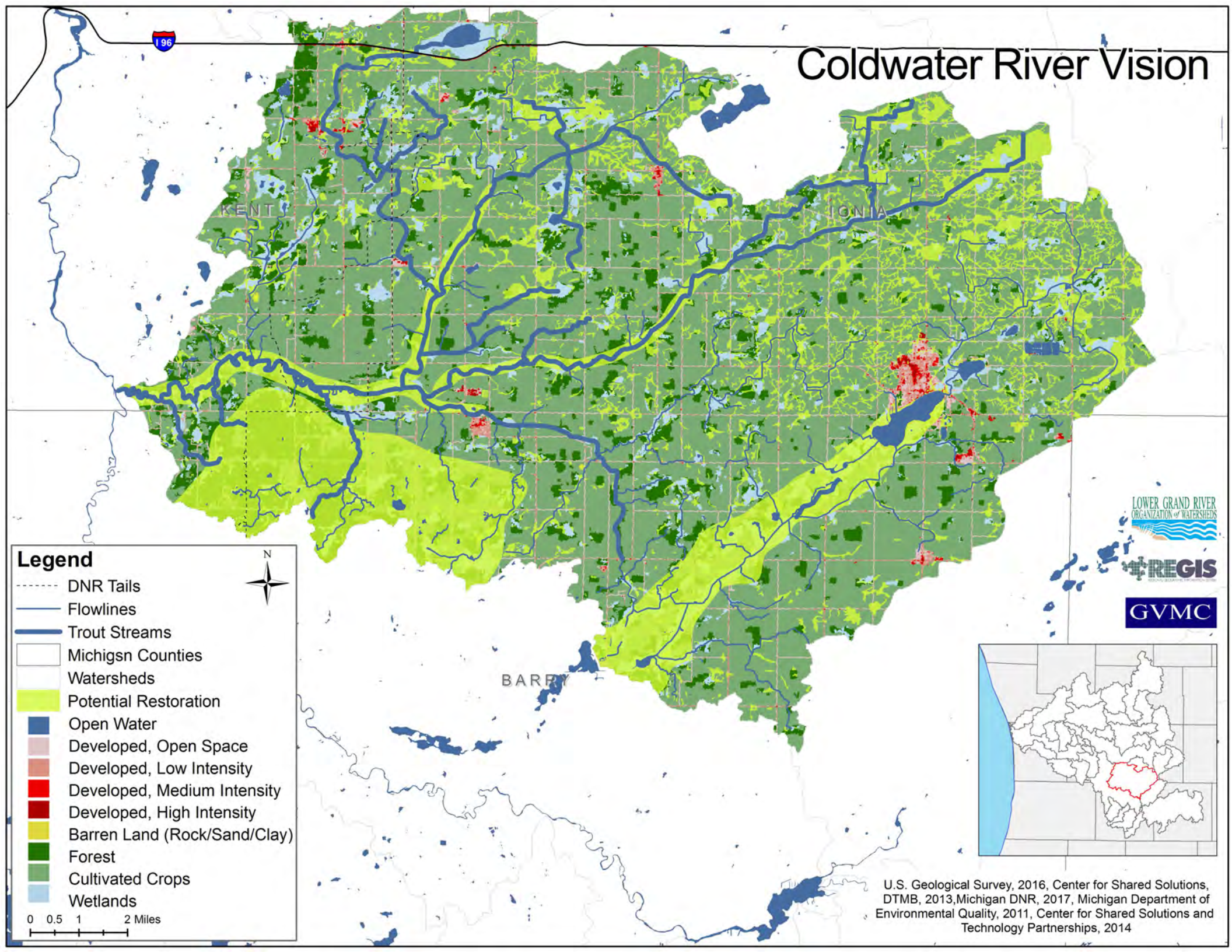
Daylighting is one of the most important things that can be done for Coldbrook Creek. Restoring riparian habitat introduces a buffer to slow down runoff and allow pollutants to be deposited before reaching the creek. Daylighting can also provide opportunities for restoring native habitats. Incorporating native plant species would not only help to reduce runoff, but would also provide habitat for native species.

Using the best examples of aboveground Coldbrook Creek for educational opportunities should be a priority. Partnering with Aquinas College to host educational events about the watershed would help local residents care about the creek. The Creek is also aboveground in Highland Park, which has served as an outdoor classroom for neighborhood schools, which could also host homeowner education events.

Coldbrook Creek

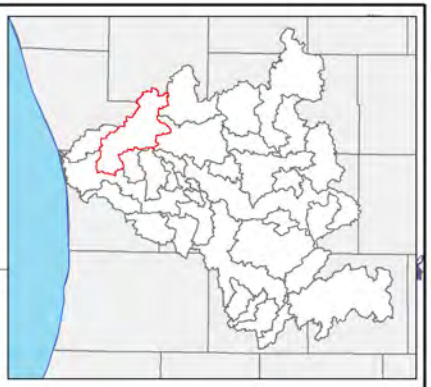
Threats	Vulnerabilities	Actions		Applicable Resources
Pollution	Thermal pollution Urban runoff Pathogens Excess road salt Decrease in water quality	Individual	Practice better waste management	Adopt a Drain Grand River
			Reduce fertilizer use on lawns	WMCAC
			Plant native species	EGLE Healthy Watersheds Protection
			Lobby for new sustainable development	LGROW Stream Clean Up Kit
		Neighborhood & Business	Install GSI	LGROW Community Science & Service Opportunities
			Host and support volunteer cleanup activities	Kent County Health Department
			Have septic systems checked	LGROW Rainscaping
		Local Government	Provide incentives for GSI	Agriculture Adaptation
			Regulate salt and fertilizer use	
			Install native buffer strips along the creek	
Development	Increase in impervious surfaces Loss of tree coverage Increase in pollution sources Channelization	Individual	lobby for sustainable development ordinances	Urban Waters
			Plant native trees	Michigan LID Handbook
			Donate time and money to local conservation	MSU Extension
		Neighborhood & Business	Partner with local conservation organizations	Kent County Health Department
			Install GSI with new construction	Municipal Consultants
				EPA
		Local Government	Require native tree plantings with new	Green Infrastructure Wizard
			Sustainable development ordinances	EPA Green Infrastructure
			Prioritize daylighting within the watershed	
Flooding	Damaged infrastructure Erosion Habitat loss	Individual	Rain barrels and rain gardens	EPA flood aware site
			Plant native trees	NFIP Rules
				EPA flood aware site
		Neighborhood & Business	GSI	LGROW Rainscaping
			Adopt a wetland programs	
			Green development, limit impervious surfaces	
		Local Government	Local wetland protection	
			Plant and keep tree coverage	
			Educate the public	
			Maintain local protected areas	

Coldwater River Vision



U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013,Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Crockery Creek Vision



NEWAYGO

MUSKEGON

KENT

OTTAWA

Legend

- DNR Tails
- Flowlines
- Trout Streams
- Michigsn Counties
- Watersheds
- Potential Restoration
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Forest
- Cultivated Crops
- Wetlands

N

0 1 2 4 Miles

LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

REGIS

GVMC

U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013,Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Deer Creek Vision

MUSKEGON

I 96

OTTAWA

Legend

- DNR Tails
- Flowlines
- Michigsn Counties
- Watersheds
- Potential Restoration
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Forest
- Cultivated Crops
- Wetlands

N

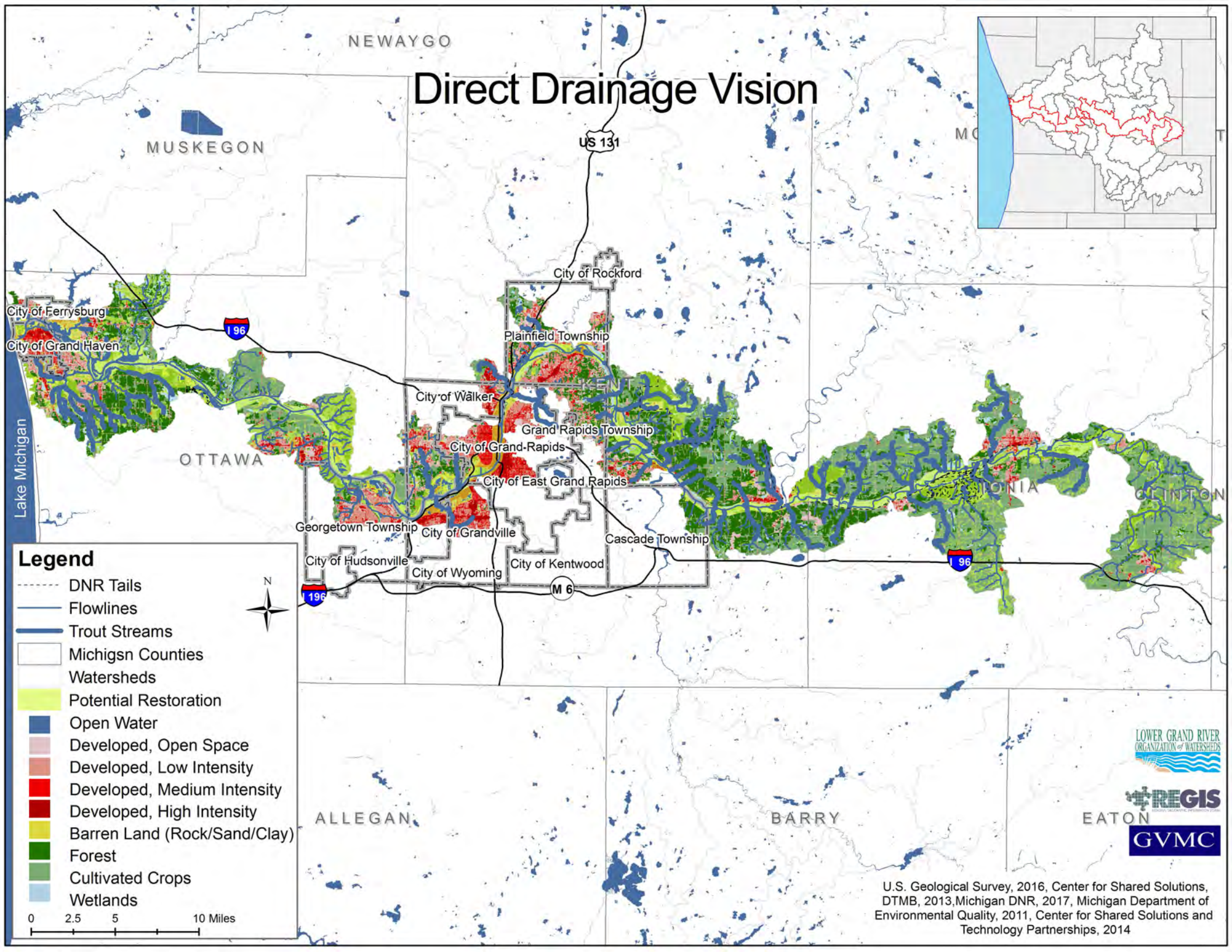
0 0.25 0.5 1 Miles

LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

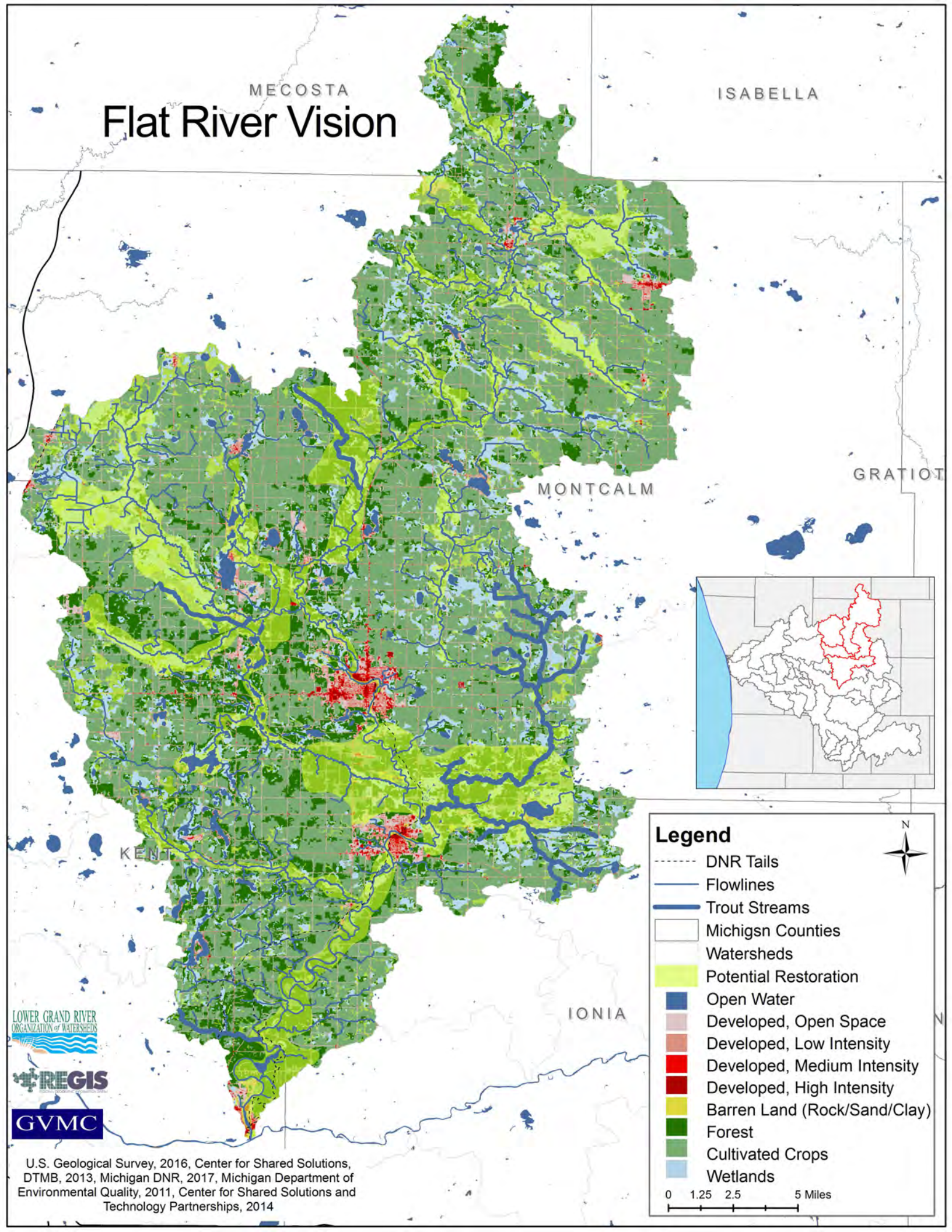
REGIS

GVMC

U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013, Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014


Direct Drainage Vision
NEWAYGO
MUSKEGON
US 131
City of Rockford
City of Ferrysburg
City of Grand Haven
I 96
Plainfield Township
City of Walker
Grand Rapids Township
City of Grand Rapids
OTTAWA
Lake Michigan
City of East Grand Rapids
IONIA
CLINTON
Georgetown Township
City of Grandville
Cascade Township
City of Hudsonville
City of Wyoming
City of Kentwood
I 196
M 6
I 96
ALLEGAN
BARRY
EATON
Legend
DNR Tails
Flowlines
Trout Streams
Michigsn Counties
Watersheds
Potential Restoration
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Forest
Cultivated Crops
Wetlands
N
0 2.5 5 10 Miles
LOWER GRAND RIVER ORGANIZATION of WATERSHEDS
REGIS
GVMC
U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013,Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Flat River Vision



LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

REGIS

GVMC

U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013, Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Indian Mill Creek Vision

Legend

- DNR Tails
- Flowlines
- Trout Streams
- Michigsn Counties
- Watersheds
- Potential Restoration
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Forest
- Cultivated Crops
- Wetlands

0 0.275 0.55 1.1 Miles

N

KENT

City of Walker

I 96

US 131

City of Grand Rapids

LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

REGIS

GVMC

U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013,Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Indian Mill Creek Subwatershed Climate Resiliency Report

Climate Resiliency and The Indian Mill Creek Watershed

As we anticipate the effects of climate change on local ecosystems, building towards climate resilience is key to maintaining healthy watersheds. Changes in temperature, precipitation patterns, and species distribution will affect both terrestrial and aquatic ecosystems, along with increased pressures from human populations. Climate resilience is about recognizing these changes and building systems that can adapt and recover effectively.

Indian Mill Creek drains a watershed of 10,979 acres within Kent County. The watershed contains an even mix of urban (43%) and agricultural (39%) land, including parts of Alpine Township,Walker, and Grand Rapids.

Concerns

As both an agricultural and an urban watershed, Indian Mill Creek faces a variety of threats. Nitrogen and phosphorus pollution is a major issue for Indian Mill Creek, and if agricultural practices do not become more sustainable, this issue will likely become worse.

Flooding has the possibility of destroying crops as well as urban infrastructure. An increase in extreme weather events will likely result in an increase in flood events. As a watershed on the edge of an urban area, increased development and urban growth could be a problem in the future as well. Any Alpine township or Walker growth would likely expand outward from the Grand Rapids area into more of the Indian Mill Creek watershed. Increased development would mean an increase in impervious surfaces and runoff that lowers water quality.

Recommendations

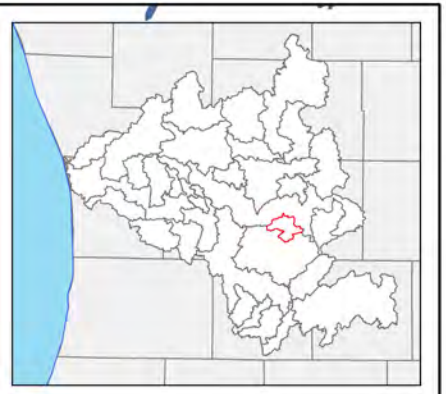
A focus on environmentally friendly agricultural practices will help to keep the Indian Mill Creek watershed resistant. Indian Mill Creek carries high sediment loads, and practices like no-till agriculture, cover crops, and contour farming could help hold soil in places. Reductions in commercial fertilizer and pesticide use would limit nonpoint source nutrient pollution.

Green development requirements should be put in place by Alpine Township and the city of Walker, such as stream buffers and GSI. Within the urban areas of the watershed, individual actions by residents can help make a difference. Replacing lawn with native plants reduces water demand and runoff, while also providing for native species. Proper waste management keeps trash and pollutants out of the water.

Indian Mill Creek

Threats	Vulnerabilities	Actions		Applicable Resources
Heat	Increased energy Drought Violence Stress to plants Negative health impacts	Individual	Plant trees and native drought resistant plants	LGROW Rainscaping LEED Certification Kent County Health Department EGLE Renewable Energy EnviroAtlas Heat.gov
			Lobby for green development and green spaces	
			Utilize natural heating and cooling systems and make your house more energy	
		Neighborhood & Business	Create LEED certified buildings	
			Advocate for local greenspaces and tree coverage, especially in underserved	
			Minimize paved surfaces	
		Local Government	Open cooling centers	
			Support urban tree cover	
			Prepare for increased demand for water	
			Solar panel incentives for increased energy demand	
			Educate the public on the risks of heat exhaustion and heat stroke	
Lack of Access to Necessities	Food shortages Housing shortages Increased prices for food Lack of vaccines Income disparity Crop failures Crime Unhealthy habits	Individual	Support local food banks	Kent County Health Department Food Pantries The Rapid Walker Community Resources Agriculture Adaptation
			Participate in local watershed cleanups	
			Plant gardens	
		Neighborhood & Business	Organize community gardens	
			Host food drives	
			Donate time to local charities	
		Local Government	Free public access to outdoor recreation	
			Provide cheap housing options	
			Educate the public on healthy living practices	
			Pop-up health centers	
Flooding	Loss of property Flashy flows Financial constraints Decreased transporation Displaced persons	Individual	Rain barrels and rain gardens	NFIP Rules EPA Flooding LGROW Storm Drain Kits Adopt a Drain Grand River
			Plant native species	
			Adopt a drain	
		Neighborhood & Business	Green development, limit impervious surfaces	
			GSI - curb cut rain gardens	
			Adopt a wetland programs	
		Local Government	Local wetland protect	
			Incentives for GSI	
			Plant and maintain tree cover	
			Educate the public on flooding threats and prevention	
Pollution	Failing septic systems Trash E. coli Fertilizers/Pesticides Contaminated well water	Individual	Plant riparian buffers	Adopt a Drain Grand River WMCAC Friends of Indian Mill Creek EGLE Healthy Watersheds Protection LGROW Stream Clean Up Kit LGROW Community Science & Service Opportunities EPA Septic Smart
			Participate in cleanup events and AAD	
			Pick up litter	
			Inspect and mainatin septic systems	
		Neighborhood & Business	Host cleanups	
			Septic awareness	
			Pursue incentives for organic farming	
		Local Government	Promote conservation practices (farms)	
			Enforce environmental ordinances	
			Incentivize environmetnal cleanups	
			Adopt clean water policies	
Extreme Storms	Wind storm damage Damage to homes Extreme winter cold Power outages Loss of property Lost work time (outages) Loss of resources (trees)	Individual	Plan ahead for extreme weather	Consumers Energy Outage Map
			Help your neighbors with snow	
			Adopt a drain	
		Neighborhood & Business	GSI - curb cut rain gardens	
			Stormwater credits	
		Local Government	Provide public areas with heat, wifi, etc	
			Keep emergency services well supplied and funded	
			Bury power lines to avoid power outages	

Lake Creek Vision



IONIA

I 96

- DNR Tails
- Flowlines
- Trout Streams
- Michigsn Counties
- Watersheds
- Potential Restoration
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Forest
- Cultivated Crops
- Wetlands

N

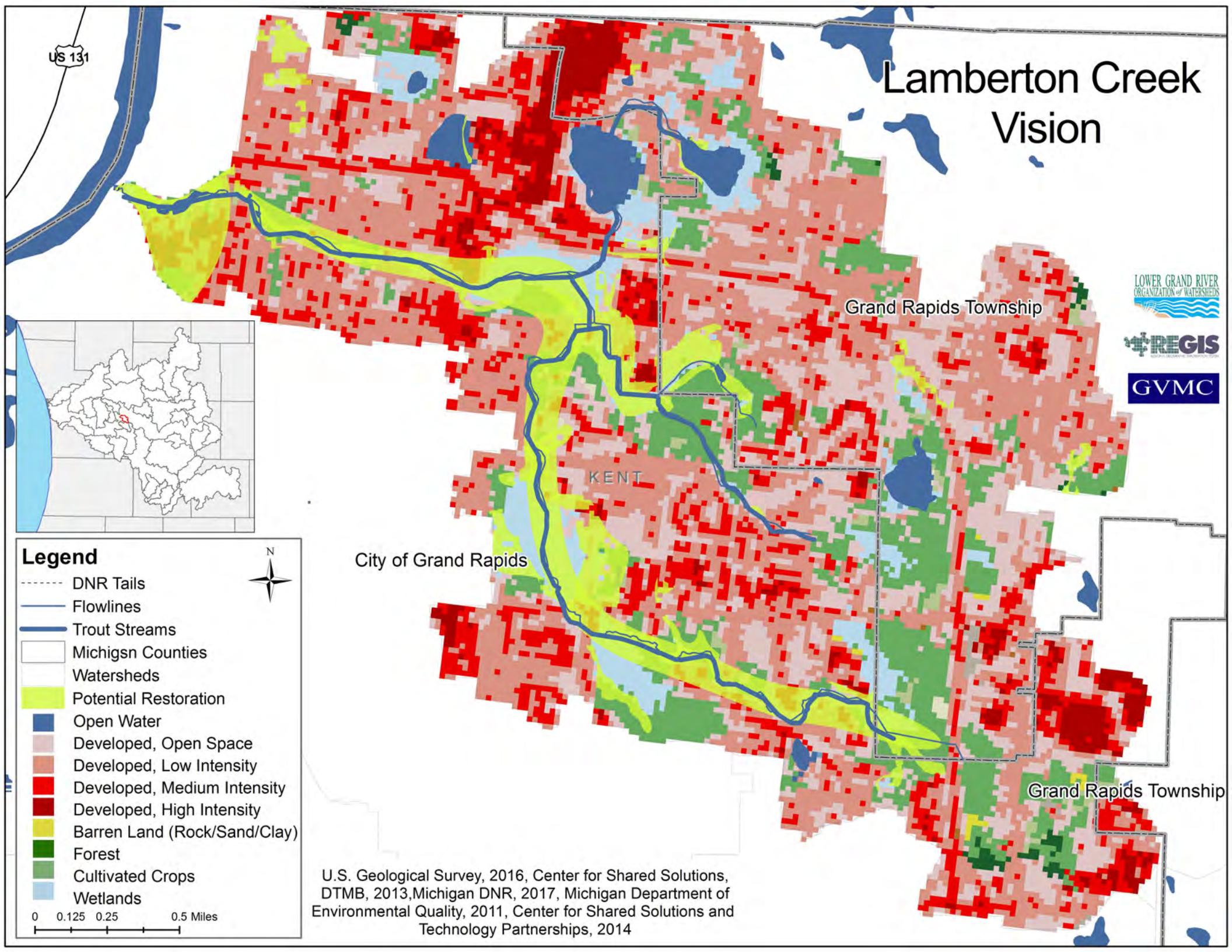
0 0.25 0.5 1 Miles

LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

REGIS

GVMC

Source U.S. Geological Survey,
NLCD 2016 Land Cover Conterminous
United States. www.mrlc.gov/viewer


Lamberton Creek Vision
US 131
Grand Rapids Township
KENT
City of Grand Rapids
Grand Rapids Township
LOWER GRAND RIVER ORGANIZATION of WATERSHEDS
REGIS
GVMC
Legend
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DNR Tails
Flowlines
Trout Streams
Michigsn Counties
Watersheds
Potential Restoration
Open Water
Developed, Open Space
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Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Forest
Cultivated Crops
Wetlands
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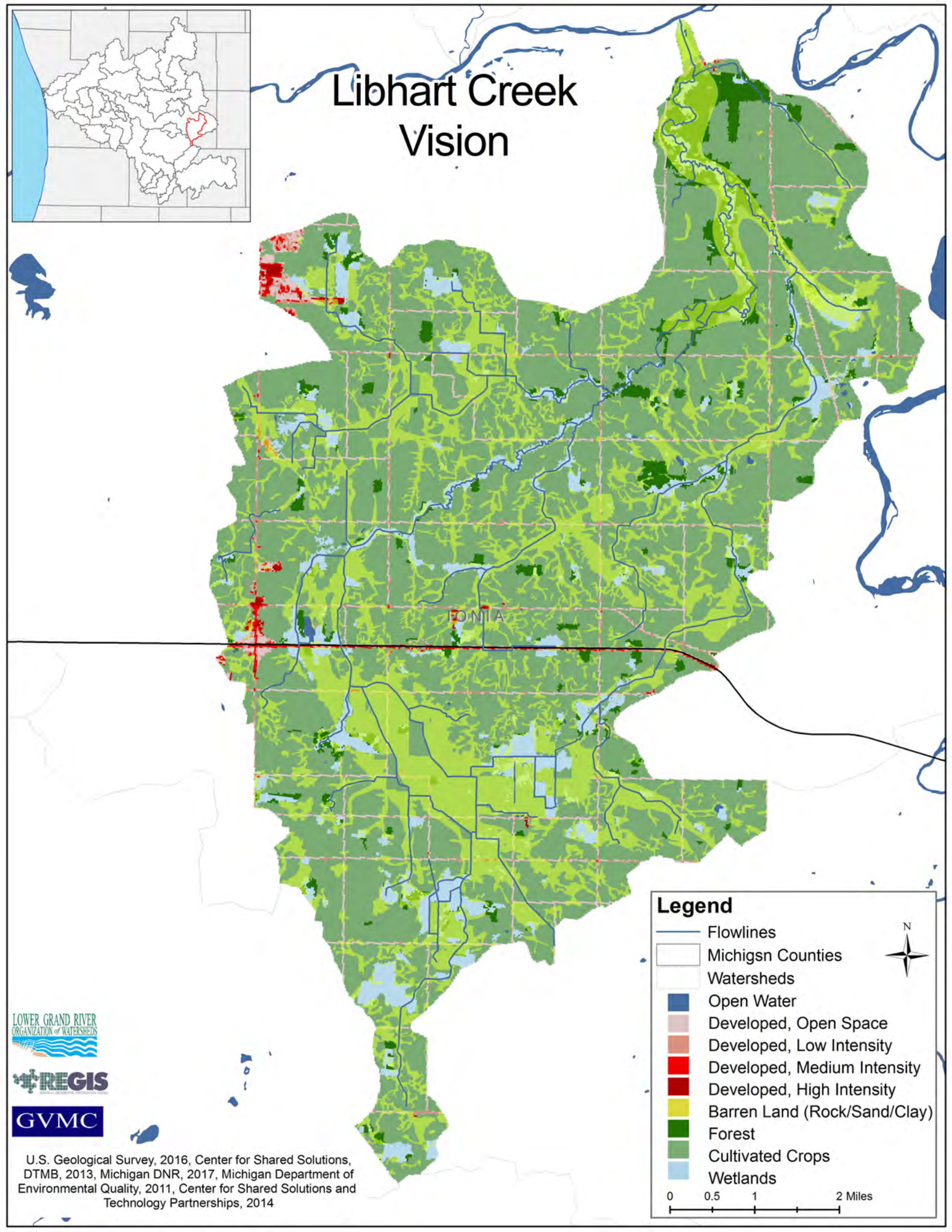
U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013,Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014


Libhart Creek
Vision
MONTCALM
Legend
Flowlines
Michigsn Counties
Watersheds
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Forest
Cultivated Crops
Wetlands
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2 Miles
LOWER GRAND RIVER ORGANIZATION of WATERSHEDS
REGIS
GVMC
U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013, Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Mill Creek Vision

OTTAWA

KENT

Plainfield Township

US 131

City of Walker

Legend

- DNR Tails
- Flowlines
- Trout Streams
- Michigsn Counties
- Watersheds
- Potential Restoration
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Forest
- Cultivated Crops
- Wetlands

N

0 0.25 0.5 1 Miles

LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

REGIS

GVMC

U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013, Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Mill Creek Subwatershed Climate Resiliency Report

Climate Resiliency and the Mill Creek Watershed

As we anticipate the effects of climate change on local ecosystems, building towards climate resilience is key to maintaining healthy watersheds. Changes in temperature, precipitation patterns, and species distribution will affect both terrestrial and aquatic ecosystems, along with increased pressures from human populations. Climate resilience is about recognizing these changes and building systems that can adapt and recover effectively.

The Mill Creek watershed is a subwatershed of the lower Grand River primarily within Kent County. The majority of the 12,955 acres that Mill Creek drains are agricultural, accounting for 65% of the watershed, while urban areas only make up 17%. The majority of the Mill Creek watershed is within Alpine Township, with sections in Chester, Wright, Sparta, and Plainfield Townships as well.

Concerns

With changing climate in the future, the Mill Creek watershed will likely face similar problems as it does today. Mill Creek already sees high loads of nitrogen and phosphorus pollution due to agricultural and urban runoff, and this will likely increase as agriculture intensifies and development grows. As a primarily agricultural watershed, Mill Creek could face an increased water demand, and paired with the possibility of more intense droughts and heat, stream flow could be heavily affected.

The Mill Creek watershed does not currently have a high percentage of natural areas in the watershed, and the degradation of current natural areas could lower its resiliency as a system. Only 3% of the watershed is comprised of wetlands. If the remaining natural areas are not protected, Mill Creek could lose its natural resiliency.

Recommendations

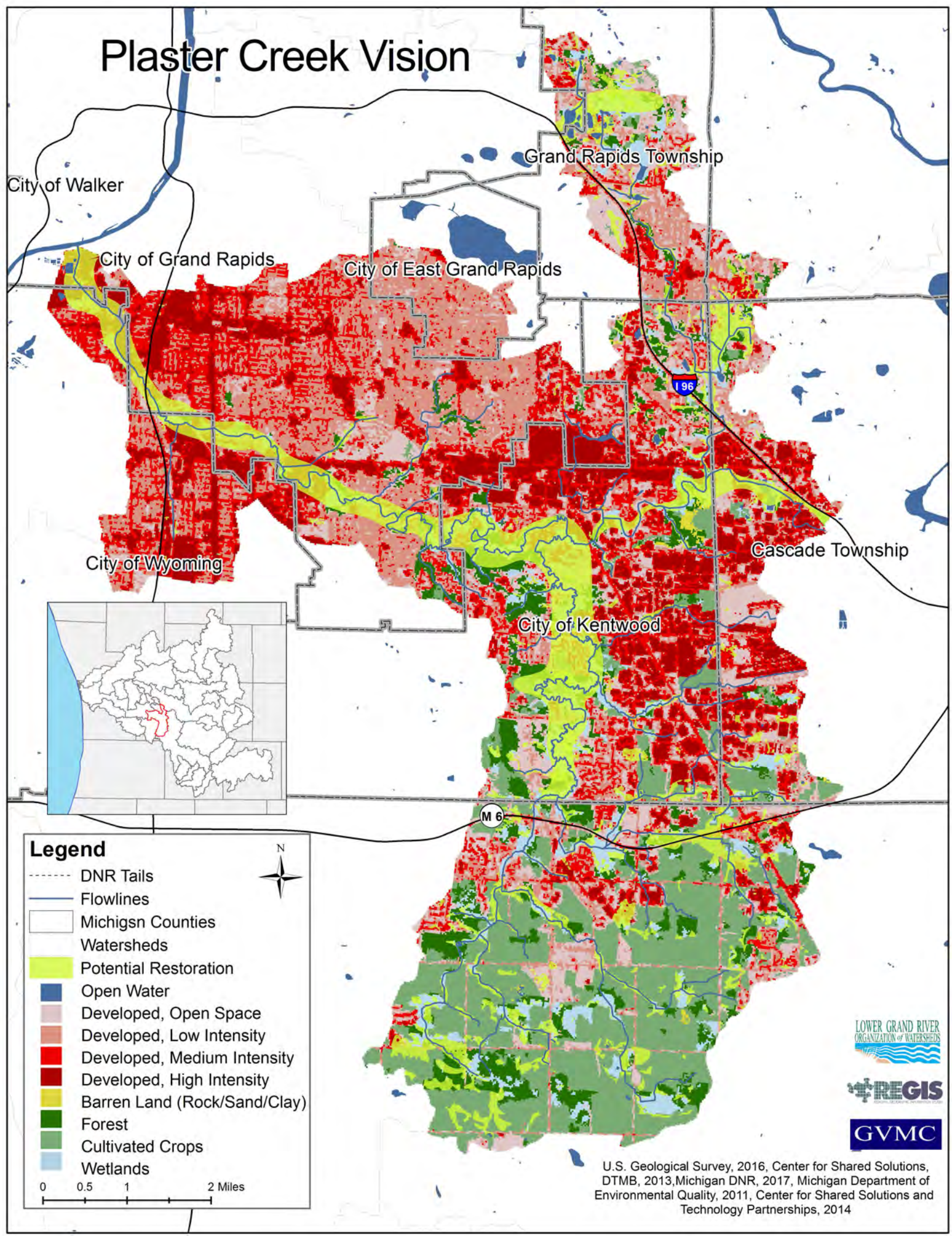
Environmentally friendly agricultural practices will be key to a resilient Mill Creek watershed. Practices like no-till farming, buffer strips, and cover crops can help prevent excess runoff and sedimentation. Reducing pesticide and fertilizer use can decrease pollution loads for Mill Creek.

Protection of the remaining wetlands and forests should be a priority, either through local government or conservation easements on private property. Habitat restoration efforts can help provide more buffer areas to improve water and ecosystem quality.

Perhaps the most important step towards climate resiliency would be the creation of a Mill Creek Watershed organization. A group that could provide education and support for people living within the watershed would be a crucial first step in increasing environmental stewardship in the area.

Mill Creek

Threats	Vulnerabilities	Actions		Applicable Resources
Pollution	Algal blooms Pesticides on ag. land Agricultural runoff Sediment loads Old septic systems	Individual	Native plantings	Adopt a Drain Grand River WMCAC LGROW Rainscaping EGLE Healthy Watersheds Protection LGROW Stream Clean Up Kit LGROW Community Science & Service Opportunities EPA Septic Smart
			Proper waste management	
			No fertilizer on lawns	
		Neighborhood & Business	Sustainable agricultural practices	
			GSI and sustainable development	
			Minimal pesticide and fertilizer use	
			Cover crops and no-till practices	
		Local Government	GSI incentives	
			Protect existing wetlands and forests	
			Enforce permits and adopt Clean Water laws	
			Educate the public on pollution sources	
Community Health	Migrant workers Extreme heat (summer) Extreme cold (winter) Water quality Property damage	Individual	Support local charities	Kent County Health Department Ottawa County Health Department MiEJ Agriculture Adaptation EnviroAtlas Heat.gov
			Donate clothing and other necessities	
		Neighborhood & Business	Support local charity organizations	
			Host food drives	
		Local Government	Protect green space	
			Provide public amenities	
			Provide public health screenings	
Habitat loss	No native stream buffers Loss of species Loss of natural resilience More flood prone	Individual	Plant native plants	LCWM Native Plant Guild MDNR
			Conservation easements on native areas	
			Support local conservation groups	
		Neighborhood & Business	Native plantings in developments	
			Adopt a wetland programs	
		Local Government	Protect remaining natural areas	
			Support and provide restoration efforts	
			Ordinances that require native plantings	
			Educate public on the need for native habitats	
			Provide incentives for native plantings and GSI	


Plaster Creek Vision
Grand Rapids Township
City of Walker
City of Grand Rapids
City of East Grand Rapids
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Cascade Township
City of Wyoming
City of Kentwood
M 6
Legend
DNR Tails
Flowlines
Michigsn Counties
Watersheds
Potential Restoration
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Forest
Cultivated Crops
Wetlands
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LOWER GRAND RIVER ORGANIZATION of WATERSHEDS
REGIS
GVMC
U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013,Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Plaster Creek Subwatershed Climate Resiliency Report

Climate Resiliency and The Plaster Creek Watershed

As we anticipate the effects of climate change on local ecosystems, building towards climate resilience is key to maintaining healthy watersheds. Changes in temperature, precipitation patterns, and species distribution will affect both terrestrial and aquatic ecosystems, along with increased pressures from human populations. Climate resilience is about recognizing these changes and building systems that can adapt and recover effectively.

The Plaster Creek watershed is a subwatershed of the Lower Grand River located within Kent County. The creek drains an area of 38,600 acres, with 65% of it urban, and only 17% of it being agricultural land. Most of the watershed lies within Grand Rapids and Kentwood, with parts in Cascade, Ada, Caledonia, Grand Rapids, and Gaines Townships, as well as the cities of East Grand Rapids and Wyoming.

Concerns

Many of the issues Plaster Creek already struggles with will likely increase with climate change. Plaster Creek already struggles with high loads of sediment transport, as well as nitrogen and phosphorus pollution. Heavy rainfall events will create more flooding in an area already prone to flood events. In a primarily urban watershed, flooding can damage infrastructure and harm human health. More flooding events also contribute to increased sedimentation loads and runoff that lowers water quality.

Increases in temperature could lead to increases in thermal pollution, especially for a predominantly urban watershed with lots of impervious surfaces. Plaster Creek faces pollution threats from industrial, suburban, and agricultural sources, all of which could be exacerbated in the future. Increased urbanization could lead to more industry and increased volumes of common urban pollution sources. If agricultural yields decrease due to climate change, agricultural land could see more intensification, including the use of more pesticides and herbicides that pollute waterways.

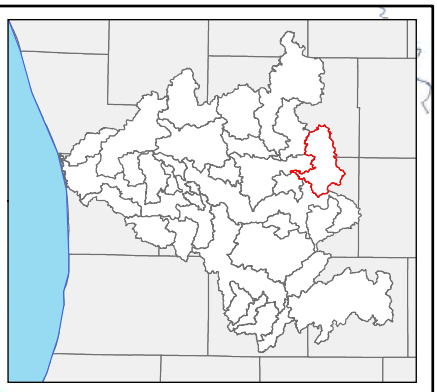
Recommendations

A resilient Plaster Creek watershed will involve action from all groups involved. Simple actions like proper pet waste disposal and minimizing the use of fertilizers for lawns can decrease urban pollution sources. Local government and conservation groups should encourage and subsidize GSI in order to minimize runoff. Maintaining existing green spaces within the watershed and restoring degraded areas can help create a buffer between urbanized areas and Plaster Creek, as well as work to minimize thermal pollution by providing shade and cool places.

Plaster Creek

Threats	Vulnerabilities/Impacts	Actions		Applicable Resources
Flooding	Transportation barriers Street flooding Flashy flows Mold in home Loss of property Financial constraints/rebound Safety	Individual	Install GSI	LGROW Storm Drain Kits
			Reduce turf grass	PCS GSI
			Wet proof basements	LGROW Rainscaping
			AAD	AAD
		Neighborhood & Business	Install GSI	NFIP Rules
			Daylighting	EPA Flood Aware site
			Plant and maintain trees	City of Grand Rapids Stormwater Vulnerability Assessment
			AAD	
		Local Government	Complete 'Are you Ready?' activity	
			Rezoning	
			Implment farmland preservation ordiniance	
Lack of Resources/Education/Information	Misinformation/Lack of trust Lack of educators Access to technology Language barrier Rental rights Food deserts Safe spaces Funding gaps Representation Stigmas	Individual	Get to know your neighbors	Hispanic Center
			Learn about community resources	Asian Center
			Share information	Neighborhood Associations
			Advocate for change	Business Associations
		Neighborhood & Business	Install and maintain community gardens	Food Pantries
			Offer information in multiple languages	
			Host local food trucks with local produce	
			Share and assist with grant applications/funding	
			Promote local food pantries	
		Local Government	Instill a culture of care	
			Build trust with community	
			Perform targeted outreach	
			Enforce rent control	
Community Health	Lead in homes and water Mental health Cancer Mold Power outages Gentrification/displacement Epidemic/pandemic response Crime Racism Stigmas	Individual	Get home tested for lead	Hispanic Center
			Health screenings	Asian Center
			Advocate for neighborhood outdoor recreation	Neighborhood Associations
				Business Associations
		Neighborhood & Business	Participate in and provide equitable development	Food Pantries
			Provide equipment for outdoor activities	Kent County Health Department
		Local Government	Provide access to green spaces	Agriculture Adaptation
			Promote outdoor opportunities	EnviroAtlas
			Adopt and mplement DEI actions	Heat.gov
Pollution	Air quality Trash E. coli Industrial discharges Drinking water Groundwater contamination PFAS	Individual	Adopt a drain	Adopt a Drain Grand River
			Pick up litter	WMCAC
			Participate in a stream clean up	EGLE Healthy Watersheds Protection
			Observe Clean Air Action Days	LGROW Stream Clean Up Kit
			Test drinking water	LGROW Community Science & Service Opportunities
			Follow agricultural conservation pracitces	Kent County Health Department
			Participate in community science water quality monotiring	
		Neighborhood & Business	Host clean ups	
			Host adopt a drain block parties	
			Maintain permit compliance	
			Install air quality monitors	
		Local Government	Enforce permits	
			Protect source water areas	
			Offer health testing	
			Adopt clean water policies	

Prairie Creek Vision



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Flowlines
Trout Streams
Michigsn Counties
Watersheds
Potential Restoration
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Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Forest
Cultivated Crops
Wetlands

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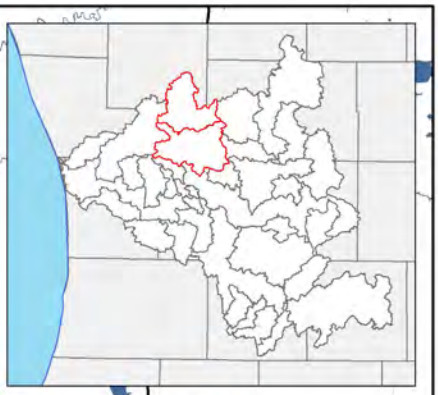
LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

REGIS

GVMC

Source U.S. Geological Survey, NLCD 2016 Land Cover Conterminous United States. www.mrlc.gov/viewer

Rogue River Vision



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City of Rockford

Plainfield Township

City-of-Walker

Grand Rapids Township

City of Grand Rapids

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- Flowlines
- Trout Streams
- Michigsn Counties
- Watersheds
- Potential Restoration
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Forest
- Cultivated Crops
- Wetlands

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LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

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GVMC

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Rogue River Subwatershed Climate Resiliency Report

Climate Resiliency and Rogue River Watershed

As we anticipate the effects of climate change on local ecosystems, building towards climate resilience is key to maintaining healthy watersheds. Changes in temperature, precipitation patterns, and species distribution will affect both terrestrial and aquatic ecosystems, along with increased pressures from human populations. Climate resilience is about recognizing these changes and building systems that can adapt and recover effectively.

The Rogue River is a subwatershed of the Grand River, and it drains an area of 139,522 acres. The watershed is primarily within Kent and Newaygo counties, with small parts of Ottawa, Muskegon, and Montcalm counties as well. It encompasses the cities of Casnovia, Kent City, Sparta, Rockford, Cedar Springs, and Sand Lake. Around 44% of the watershed is agricultural land, with forested land (27%) and wetlands (12%) the next two highest types of land cover.

Concerns

Pathogens are the primary pollutant of concern in the Rogue River watershed. Most of this concern centers around agricultural practices, and with a changing climate, these conditions could get worse. Extreme weather events can lead to more runoff, and as human population demands grow, intensification of agriculture could lead to an increased volume of possible pollutants being used on farms.

The spread of invasive species threatens the watershed as well. The Rogue River area has a significant amount of forests and wetlands, and the health of these ecosystems is important for the watersheds climate resilience. With the changing climate and increased pressure from human development with a growing population, invasive species are likely to become more of an issue. Invasive species have the potential to drastically alter ecosystems and harm water quality.

Recommendations

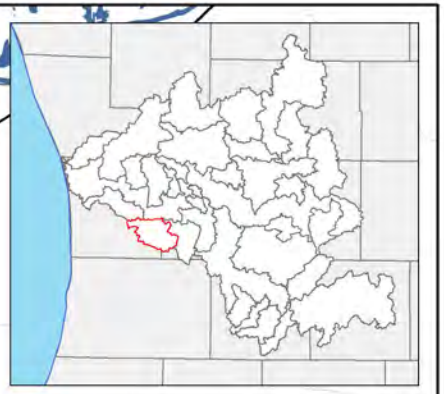
Sustainable agricultural practices can help keep the Rogue River resilient. Keeping livestock out of the river and planting buffer strips along riparian areas will help reduce pathogens and nutrient pollution. Polycultural practices can help increase yields without increasing pesticide and fertilizer use. Soil stabilization practices like contour farming and cover crops could minimize sediment loads.

Since the Rogue River watershed still has a significant amount of remaining natural habitat, keeping that habitat healthy should be a priority. Protecting remaining ecosystems as well as effective management will help keep existing natural resiliency. Removing invasive species, especially in wetland ecosystems, is one of the best ways to keep ecosystems and natural cycles healthy.

Rogue River

Threats	Vulnerabilities	Actions		Applicable Resources
Pollution	agricultural runoff failing septic systems sedimentation pathogens	Individual	Practice sustainable agriculture	Rogue River Watershed Partners
			Plant buffer strips near water	WMCAC
			Check for failing septic systems	EGLE
			Plant native trees	LGROW Rainscaping
		Neighborhood & Business	Install Green Stormwater Infrastructure	Agriculture Adaptation
			lobby for clean water policy	EGLE Healthy Watersheds Protection
		Local Government	Provide incentives for GSI	
			Maintain existing wetlands and protected land	
			Enforce clean water regulations	
Invasive Species	degredation of native ecosystems loss of native species compromised natural systems threats to agriculture	Individual	Volunteer your time to remove invasives	Invasive Species Field Guide
			Donate to local conservation organizations	Kent Conservation District
			Plant only native plants	Invasive Species Disposal Guide
		Neighborhood & Business	Host and support volunteer cleanup events	Michigan Invasive Species Program
			Plant only native plants	
			Partner with local conservation groups	
		Local Government	Provide educational materials about invasive species	
			Monitor public lands for invasive species threats	
			Protect as much native habitat as possible	
Flooding	Habitat destruction Loss of property Damaged infrastructure Erosion	Individual	Rain barrels and rain gardens	EPA flood aware site
			Plant native trees	LGROW Rainscaping
				NFIP Rules
		Neighborhood & Business	GSI	
			Adopt a wetland programs	
			Green development, limit impervious surfaces	
		Local Government	Local wetland protection	
			Plant and keep tree coverage	
			Educate the public	
			Maintain local protected areas	

Rush Creek Vision



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Legend

- DNR Tails
- Flowlines
- Michigsn Counties
- Watersheds
- Potential Restoration
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Forest
- Cultivated Crops
- Wetlands

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LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

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GVMC

U.S. Geological Survey, 2016, Center for Shared Solutions, DTMB, 2013,Michigan DNR, 2017, Michigan Department of Environmental Quality, 2011, Center for Shared Solutions and Technology Partnerships, 2014

Rush Creek Subwatershed Climate Resiliency Report

Climate Resiliency and the Rush Creek Watershed

As we anticipate the effects of climate change on local ecosystems, building towards climate resilience is key to maintaining healthy watersheds. Changes in temperature, precipitation patterns, and species distribution will affect both terrestrial and aquatic ecosystems, along with increased pressures from human populations. Climate resilience is about recognizing these changes and building systems that can adapt and recover effectively.

The Rush Creek watershed is a subwatershed of the Lower Grand River, draining parts of both Kent County and Ottawa County. The creek drains an area of 38,401 acres, comprising mostly of urban (46%) and agricultural (38%) land. The watershed includes parts of Hudsonville, Grandville, Byron Township, Wyoming, Blendon Township, Georgetown Township, and Jamestown Township.

Concerns

Flooding will likely be an issue in most watersheds as heavy precipitation events are predicted to increase, but it could become problematic for Rush Creek as continual development increases impervious surfaces. The Rush Creek watershed is primarily urban, and it will likely become even more urbanized as Georgetown Township and Ottawa County as a whole continue to grow. Increased development has the potential to decrease available wetlands and natural areas that are crucial for healthy watershed hydrology.

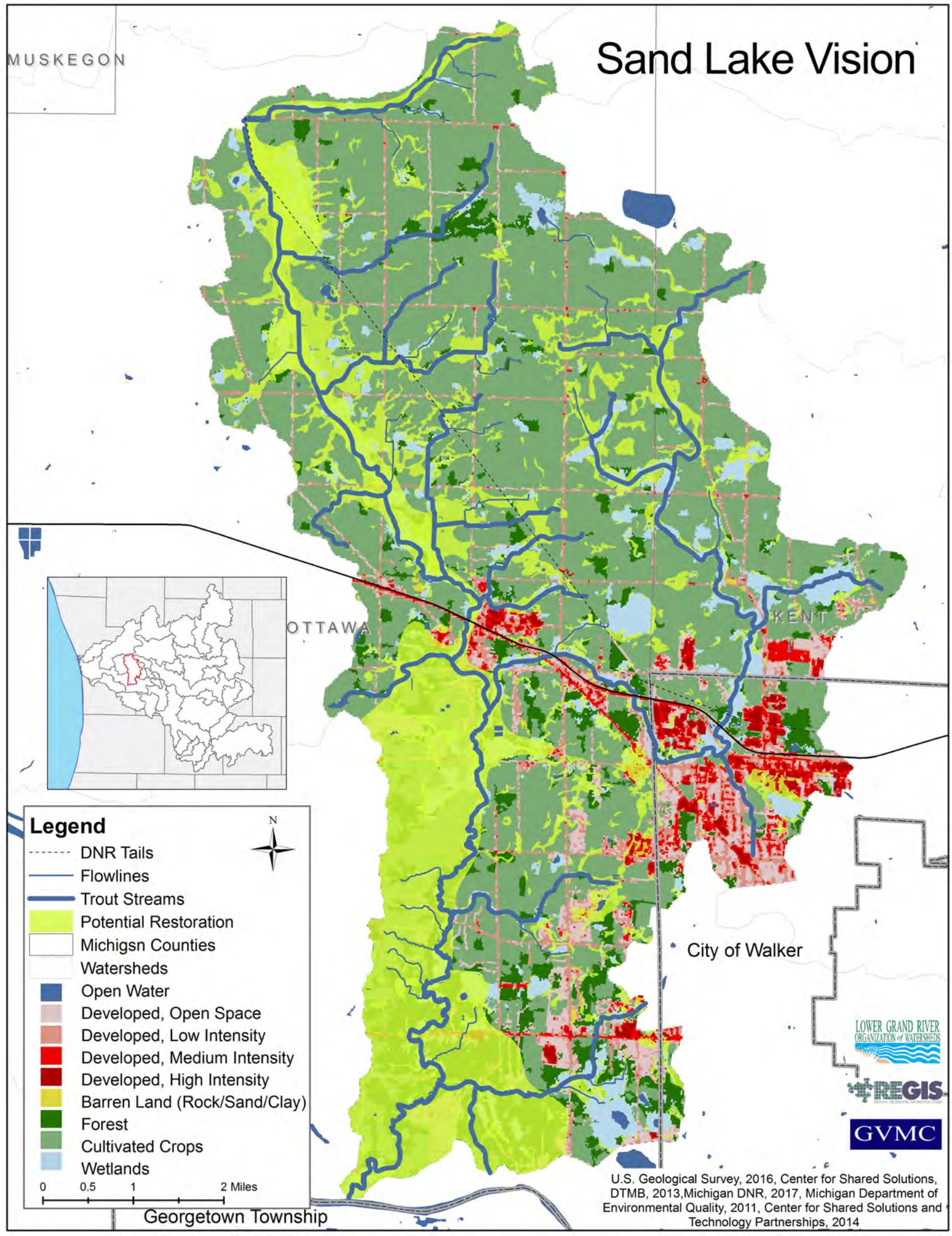
Significant increases in population within the watershed could increase flooding as impervious surfaces increase runoff. Excess runoff also contributes to thermal and nonpoint source pollution, lowering the water quality of Rush Creek. Thermal pollution is already a concern for Rush Creek, and increasing temperatures associated with climate change will likely exacerbate the problem.

Recommendations

A resilient Rush Creek watershed will involve effective protection of the remaining natural areas and management of excess stormwater. As population growth and development continue, the implementation of Low Impact Development and green infrastructure should be prioritized. Stormwater management can be applied to both existing infrastructure by adding rain gardens and rain barrels, and future development by creating government programs and incentives for green infrastructure.

Rush Creek

Threats	Vulnerabilities	Actions		Applicable Resources
Flooding	Damaged infrastructure Damaged crops Human health Poor water quality Erosion Traffic safety Flooded basements	Individual	Rain barrels and rain gardens	LGROW Rainscaping
			Tree coverage	LGROW storm drain kits
			Native plants	Native Plant Guild
		Neighborhood & Business	GSI - curbcut rain gardens	AAD
			Green development, limit impervious surfaces	NFIP rules
			Adopt a wetland programs	EPA flood aware site
		Local Government	Financial incentives and programs for GSI	MiEJ Screen
			Local wetland protection	
			Stormwater credit trainings	
			Plant and keep tree coverage	
			Educate the public	
Pollution	Poor water quality Damaged ecosystems Human sickness High E. coli levels Wildlife health Groundwater contamination Loss of aquatic wildlife Failing septic systems Salt runoff Degraded road conditions	Individual	Proper pet waste management	Adopt a drain Grand River
			Septic system testing	LGROW stream cleanup kit
			Recycling	LGROW Community Science and Service Opportunities
			Two-stage ditches	Native Plant Guild
			Proper manure application	EGLE Healthy Watersheds Protection
		Neighborhood & Business	Support local conservation organizations	WMCAC
			Vegetative buffer strips	ODC
			Salt application education	Local municipal tours (water plants, etc.)
			GSI implementation and support	Health Departments (Ottawa County and Kent County)
		Local Government	Local wetland protection	Agriculture Adaptation
			Educate the public	
			Adopt clean water policies	
			Adopt septic ordinances	
			Incentivize pervious disconnect	
			Enforce permits	
Increased development	Increased possible pollution sources Destruction of habitat Loss of wetlands Increase in impervious surfaces Increased runoff Increased demand on water Changes to hydrology Lack of preserved spaces	Individual	Support local conservation efforts	Specialized lanscapers?
			Plant native plants	Urban Waters
			Conservation easements	Michigan LID Handbook
			lobby for sustainable development ordinances	MSU Extension
		Neighborhood & Business	Support restoration efforts and watershed cleanups	OCD (and native plant sales)
			Green growth, solar panels, rain gardens, etc	Municipal Consultants
				EPA
		Local Government	Protect remaining wetlands and natural areas	Green Infrastructure Wizard
			Monitor water quality and water use	EPA Green Infrastructure
			Change parking lot ordinances	
			Support green development and GSI	
			Succession Planning	
			Restoration of degraded areas	
Loss of ecology	Loss of natural systems Lack of examples of healthy watershed Lack of recreation opportunities Destruction of habitat Invasive species and species migration	Individual	Support local park systems	Native Plant Guild
			Conservation easements on private natural areas	Ottawa Conservation Disctrict
			Lobby for increased protection of natural areas and water	Ottawa County Parks
		Neighborhood & Business	Promote a local park or conservation organization	Land Conservancy of West Michigan
			Maintain existing natural areas on property	State representatives and local governments
			Plant native species	Watershed management Plan
		Local Government	Protect remaining wetlands and natural areas	MDNR
			Create urban tree canopies	
			Organize restoration efforts	
			Educate about native plants and ecology	


Sand Lake Vision
MUSKEGON
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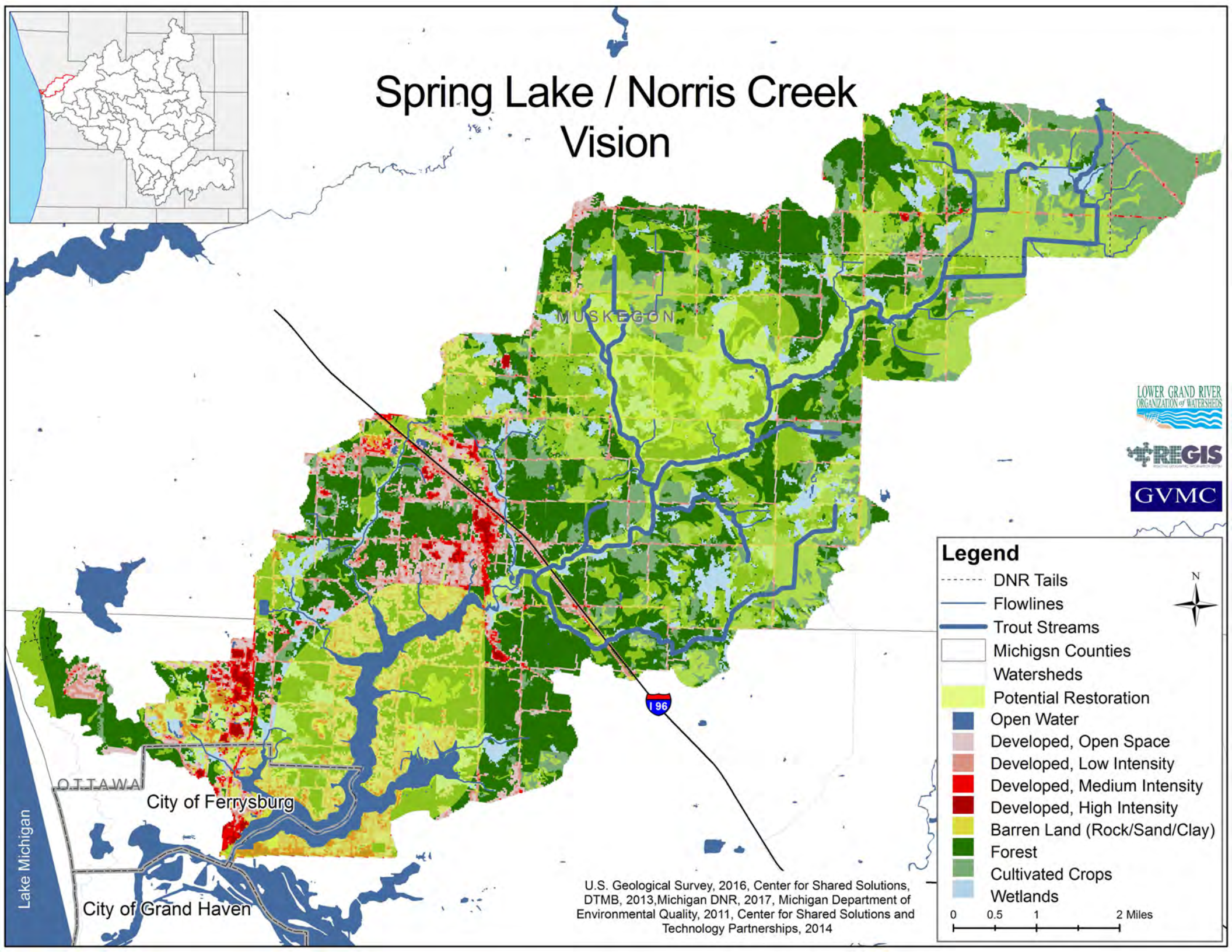
Spring Lake / Norris Creek Vision
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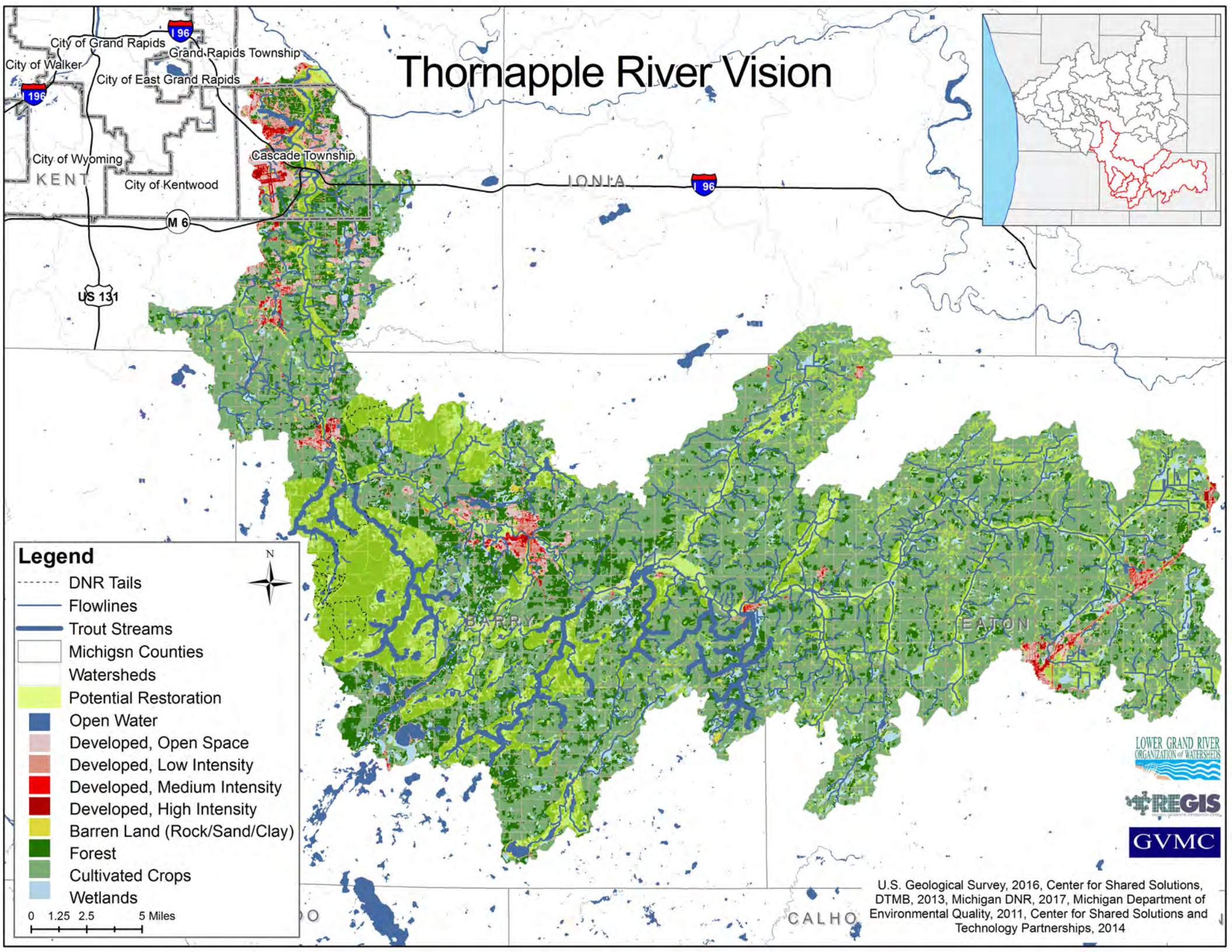
Thornapple River Vision
City of Grand Rapids
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