Charlevoix County

Natural Hazards Mitigation Plan

2024

FEMA Letter of Approval

ACKNOWLEDGEMENTS

The 2024 Charlevoix County Hazard Mitigation Plan is prepared for Charlevoix County, Michigan and the jurisdictions in the county that have participated in the development of the plan update, per the table below. The plan is the culmination of an interdisciplinary and interagency planning effort that required the technical assistance and contributions from representatives of the organizations and jurisdictions listed below. Refer to Appendix G for a table of how and when the representatives of each participating entity contributed to the development of the plan. Each jurisdiction is invited to be a participant in future regular review and updates of the plan.

PARTICIPATING AGENCY/ JURISDICTION	REPRESENTATIVE	TITLE
Charlevoix County Board of Commissioners	Robert Jess	District 1 Commissioner
	Chris Christensen	District 2 Commissioner
		District 3 Commissioner
		District 4 Commissioner
	Scott Hankins	District 5 Commissioner; BOC Chairman
		District 6 Commissioner
Charlevoix County	Sienna Wenz	Emergency Management Coordinator
	Kevin Shepard	County Administrator / Human Resources Director
	Julia Drost	Clerk
	Becki King	Finance Director
	Emily Selph	Equalization
	Kiersten Stark	Planning Director
	Pam Grassmick	Planning Commissioner
	Larry Levengood	Planning Commissioner/ Lake Charlevoix Association member
	Chuck Vondra	County Sheriff
	William Church	Lieutenant, County Sherriff's Office
City of Boyne City	Michael Cain	City Manager
	Kevin Spate	Police Chief
	Mary Shaffer	Resident
City of Charlevoix	Jill McDonnell	Chief of Police (current)
	Gerard Doan	Deputy Chief of Police (former)
	Rob Sholey	Deputy Chief of Police
	Jonathan Scheel	Zoning Administrator/Code Enforcement Official
	Mary Millington	Planning Commissioner
	Perry Irish Hodgson	Shade, Tree & Parks Commission Chair
City of East Jordan	Tom Cannon	Administrator
	Mark Penzien	Mayor
Bay Township	Xavier Gaudard	Supervisor
Boyne Valley Township	Sue Hobbs	Supervisor
Chandler Township		

PARTICIPATING AGENCY/ JURISDICTION	REPRESENTATIVE	TITLE
Charlevoix Township	J. B. Hoyt	Trustee
	Sandra Witherspoon	Clerk
Eveline Township	Sandi Whiteford	Clerk
Evangeline Township	James Howell	Supervisor
	Jennifer Neal	Zoning Administrator
Hayes Township	Ron VanZee	Supervisor
	Roy Griffitts	Planning Commission Chair
Marion Township		
Melrose Township	Vern Goodwin	Supervisor
	Robin Hissong Berry	Clerk
Norwood Township	Leslie Meyers	Zoning Administrator
Peaine Township	Doug Tilly	Supervisor
South Arm Township		
St. James Township	Bobbi Welke	Supervisor
	Shelby Harris	Planning/Administrative Assistant
	Beth Croswhite	Planning Commissioner
	Lori Taylor-Blitz	Planning Commission Chair
Wilson Township	Norman Vogt	Planning Commission Chair
Village of Boyne Falls		
Grand Traverse Band of Ottawa and Chippewa Indians	Jolanda Murphy	Public Safety/Emergency Manager
	Becky Oien	Tribal Manager
	Sgt. Russ Cavanaugh	Tribal Police
	Garrett Fairchild	Fire Chief
	Lori Savaso	Risk Manager
	Courtney Hessel	Natural Resources
	Sammie McLellan-Dyal	Tribal Historic Preservation Officer
Little Traverse Bay Bands of Odawa Indians		
Charlevoix County Road Commission	Patrick Weeks	Manager
	James Vanek	Staff Engineer
Grandvue Medical Care Facility	Andrea Seese	Corporate Compliance Officer

PARTICIPATING AGENCY/ JURISDICTION	REPRESENTATIVE	TITLE
Charlevoix-Cheboygan-Emmet (CCE) 911 Central Dispatch	Chris Heckman	Deputy Director
	Pamela Woodbury	Executive Director
Jordan Valley EMS Authority	Meghan Meyer	Director
Munson Charlevoix Hospital	John McDonald	General Manager
Health Department of Northwest Michigan	Chloe Capaldi	Emergency Preparedness Coordinator
American Red Cross	Matthew Glenn	
Charlevoix Conservation District	Chris Anderson	Michigan Agriculture Environmental Assurance Program Technician
Charlevoix, Antrim, Kalkaska, and Emmet (CAKE) – Cooperative Invasive Species Management Area (CISMA)		
Tip of the Mitt Watershed Council	Jennifer McKay	Policy Director
Great Lakes Islands Alliance	Robert Anderson	Beaver Island rep.; Interim Chair of GLIA Steering Committee
Forestview Senior Housing (in St. James Twp.)	Alana Anderson	
Holtec Decommissioning International, Big Rock Point	Tim Horan	Contractor
	Tom LaCroix	Site Manager
East Jordan Plastics (in South Arm Township)	Marc Lercel	Employee

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I. INTRODUCTION

Hazard mitigation is defined as any action taken before, during, or after a disaster or emergency to permanently eliminate or reduce the long-term risk to human life and property from natural, technological and human-related hazards. Mitigation is an essential element of emergency management, along with preparedness, response and recovery.

Mitigation allows repairs and reconstruction to be completed after an incident occurs in such a way that does not just restore the damaged property as quickly as possible to pre-disaster conditions. It also ensures that such cycles are broken, that post-disaster repairs and reconstruction take place after damages are analyzed, and that sounder, less vulnerable conditions are produced. Through a combination of regulatory, administrative, and engineering approaches, losses can be limited by reducing susceptibility to damage. When successful, hazard mitigation will lessen the impact of a disaster on people, property, the environment and economy, and continuity of services through the coordination of available resources, programs, initiatives, and authorities.

A *hazard*, in the context of this plan, is an event or physical condition that has potential to cause fatalities; injuries; damage to personal property, infrastructure, or the environment; agricultural product loss; or interruption of business or civic life. The Charlevoix County Natural Hazard Mitigation Plan focuses primarily on *natural* hazards such as extreme temperatures, drought, wildfires, flooding, shoreline hazards (such as dangerous currents, flooding, erosion, waterspouts and seiche), thunderstorms, high winds, hail, tornadoes, extreme winter weather, dense fog, space weather, and invasive species. The plan will also consider these technological and human-related hazards: dam failure, public illness outbreak, and human-induced electromagnetic pulses.

The following natural hazards were not included in the analysis for this Hazard Mitigation Plan: earthquakes, subsidence, and meteorites and other impacting objects. Based upon review of the Michigan State Police's 2019 *Michigan Hazard Analysis*, most of Michigan is not located in an area subject to major earthquake activity. Additionally, there are no mines in the county, and sinkhole risks in the county range from "absent or likely absent" in generally the west half of the county to "infrequent or likely infrequent" in the east half of the county. Damaging meteorite events were not evaluated due to the lack of historical impact in northern Michigan and their low probability of occurrence.

The main objective of the Charlevoix County Natural Hazard Mitigation Plan is to permanently eliminate or reduce long-term risks to people and property from natural hazards so that assets such as transportation, infrastructure, commerce, and tourism can be sustained and strengthened. This can be accomplished through collaborative efforts/activities amongst agencies within the county to protect the health, safety, and economic interests of the residents and businesses through planning, awareness, and implementation.

Through this Plan, a broad perspective was taken in examining multiple natural hazard mitigation activities and opportunities in Charlevoix County. Each natural hazard was analyzed from a historical perspective, evaluated for potential risk, and considered for possible mitigation.

Since the 2016 Plan's adoption period, the following notable projects have been completed that aid in the county's hazard mitigation efforts:

- Local governments along the Lake MI coastline, and many adjoining the inland lakes of Lake Charlevoix and Walloon Lake, adopted their new or revised FEMA Flood Insurance Rate Maps (FIRMs) in 2019 and/or 2022. Local units of governments interested in revising their local ordinances to include shoreline protection/property protection measures can utilize the FIRMs as a resource. The new FIRMs are also referenced in the County's building permit application process.

- In October 30, 2023 through May 2024, the Michigan Department of Transportation (MDOT) invested $6.3 million to replace 20,000 pounds of structural steel on the US-31 bascule bridge in Charlevoix, including the bridge's tread and track components, which facilitate the structure's operation. The project also included work on the bridge railings, electrical components, joints, curbs, and gutters. This work extends the bridge's service life and maintain reliability of regular bridge operations.

Appendix D provides a list of mitigation strategies included in the Charlevoix County 2016 Natural Hazards Mitigation Plan, along with their current status and how they may have been integrated into other local planning mechanisms.

Section VII of this plan, "Mitigation Strategies and Priorities", provides a current list of hazard mitigation strategies for each natural hazard identified. Mitigation strategies were developed based on discussions with local officials and a review of FEMA/MSP best practices for hazard mitigation. (Refer to Appendix E for a list of Alternative Strategies that were

considered.) Strategies are grouped according to their purpose: Awareness and Preparation; Shelters; Buildings & Infrastructure; Utilities & Technology; and Environment & Natural Resources. The strategies table also includes: a description of each strategy; what hazards it addresses; where the strategy applies; who is responsible for implementing the strategy; how the strategy will be implemented (what resources are available to apply the strategy); the estimated timeframe for completion; the level of priority; and what type of strategy it is. Most strategies are intended to be action items completed during the 5-year timeframe in which the plan is active. Some long-term strategies may extend beyond the 5-year timeframe due to feasibility or level of difficulty.

Recognizing the importance of reducing community vulnerability to natural hazards, Charlevoix County is actively addressing the issue through the development and implementation of this plan. This process will help ensure that Charlevoix County remains a vibrant, safe, enjoyable place in which to live, raise a family, continue to conduct business, and maintain a tourist base. The Plan serves as the foundation for natural hazard mitigation activities and actions within Charlevoix County, and will be a resource for building coordination and cooperation within the community for local control of future mitigation and community preparedness around the following goals:

Goal 1: Increase local awareness and participation in natural hazards mitigation strategies
Goal 2: Integrate hazard mitigation considerations into the community's comprehensive planning process
Goal 3: Utilize available resources and apply for additional funding for hazard mitigation projects
Goal 4: Develop and complete natural hazards mitigation projects in a timely manner

II. PLANNING PROCESS

The Stafford Act, as amended by the Disaster Mitigation Act of 2000, shifted the Federal Emergency Management Agency's (FEMA) scope of work to promoting and supporting prevention, or what is referred to as hazard mitigation planning. FEMA requires government entities to have a natural hazards mitigation plan in place and updated on a 5-year cycle as a condition for applying for grant funding related to natural hazard mitigation and remediation. The last Natural Hazard Mitigation Plan was completed for Charlevoix County in 2016 by the former Tri-County Office of Emergency Management. The 2016 Plan also included hazard mitigation plans for Cheboygan and Emmet counties. Following the dissolution of the three-county Office of Emergency Management (OEM) in July 2020, Charlevoix County started its own OEM. The adoption of the 2024 Plan will reaffirm the eligibility of the county, as well as those local municipalities who participated in the planning process and adopted the county's plan, for federal pre-disaster mitigation funding.

Plan Development

The update of the County's plan was led by the Natural Hazards Task Force ("Task Force") composed of the County's Local Emergency Planning Committee (LEPC), organized by the Charlevoix County Emergency Management Coordinator. LEPC members consist of first responders and local, regional, and state public entities that ensure the preparedness of the County through efforts such as coordination and cooperation amongst members; recommending equipment purchases; and conducting training, exercises, and public education. Networks Northwest staff assisted with development of the updated plan by providing meeting and public input facilitation, conducting an online survey, and writing the plan. Task Force/LEPC meetings were held both virtually and at the County Emergency Operations Center, and were open to the public. Notifications of all meetings involving work sessions/public input sessions were posted on the Charlevoix County's OEM webpage.

Representatives of all of the following types of stakeholders were invited to participate in the planning process by various methods: email invitation, phone calls, meeting attendance/presentation, or mailed letters. Stakeholders included local and regional agencies involved in hazard mitigation activities; agencies that have the authority to regulate development; neighboring communities; representatives of businesses and other private organizations; and representatives of nonprofit organizations, including community-based organizations that work directly with and/or provide support to underserved communities and socially vulnerable populations (such as the Health Department of Northwest Michigan and the Grand Traverse Band of Ottawa and Chippewa Indians). Please refer to the Acknowledgements section in the beginning of this plan for a list of participants; Appendix G for a detailed table showing how and when representatives participated in the planning process; and Appendix H for meeting and public input documentation. Refer to Table _ in this plan for information on jurisdictional participation in the 2016 Hazard Mitigation Plan.[1] All Charlevoix County jurisdictions - except for ____- have participated in the development of this 2024 Hazard Mitigation Plan.

The following is a list of events that contributed to the development of the 2024 Natural Hazard Mitigation Plan:

- An online survey was available from August 24, 2022 to January 11, 2023. The survey questions were crafted to obtain input from Charlevoix County stakeholders on their experiences with past hazard events; perceived level of concern regarding impacts from future natural hazard events; and past and future mitigation projects.

- Task Force meetings where Networks Northwest staff provided new information pertaining to the plan:
  - August 15, 2022
  - November 21, 2022
  - January 23, 2023
  - April 17, 2023
  - August 21, 2023
  - November 20, 2023
  - January 22, 2024
  - February 26, 2024

- On January 3, 2023, the Charlevoix County Emergency Manager and Networks Northwest staff met with Pat Weeks (CCRC Manager) and James Vanek (CCRC Staff Engineer) of the Charlevoix County Road Commission to discuss road infrastructure issues as well as recently completed and future planned road improvements.

[1]The 2016 Hazard Mitigation Plan for Charlevoix County did not specifically state which communities participated in the development of the plan; information on local government participation in the 2016 plan process was inferred from meeting documentation appended to the plan.

- Public Input Sessions held to obtain feedback on hazards of concern and potential mitigation strategies:
  - January 23, 2023 – in person at Charlevoix County's Whiting Park in Eveline Township
  - October 9, 2023, 5:30-7:30 pm, via Zoom to discuss issues/concerns with Beaver Island communities
  - October 11, 2023, 5:30-7:30 pm, in person at the East Jordan EMS building
  - October 18, 2023, 5:30-7:30 pm, in person at the Charlevoix County Offices, Shirley Roloff Center
  - October 25, 2023, 5:30-7:30 pm, in person at the Boyne City Government Offices

- On November 29, 2023, Networks Northwest staff presented at the Charlevoix County Planner's Forum, held at the Charlevoix City Library, to summarize the purpose and content of the drafted Hazard Mitigation Plan and invite local governments to provide input and become participants in the plan's development.

Appendix C provides a summary of feedback received from meetings held with stakeholders and the public during the planning process.

During development of the plan, all local/tribal government entities in Charlevoix County were provided the opportunity to participate in the online community survey, participate in scheduled meetings, and comment on draft plan materials. Additionally, representatives from county and regional agencies that encompass or share borders with Charlevoix County (listed below) were invited to participate in the planning meetings, and were able to view the draft plan materials on the hazard mitigation project page of Network Northwest's website.

- Jolanda Murphy, Public Safety/Emergency Manager, Grand Traverse Band of Ottawa & Chippewa Indians
- Little Traverse Bay Bands of Odawa Indians
- Matthew Adamek, Emergency Operation Director, Antrim County Emergency Services
- Matthew Blythe, Emergency Management Coordinator, Emmet County Office of Emergency Management
- Lieutenant Jeremy Runstrom, Director, Cheboygan County Office of Emergency Management
- Victor F.C. Jones, Emergency Services Coordinator, Otsego County Office of Emergency Services
- Robert Carson, Regional Director of Community Development, Networks Northwest

Community Survey Results

The community survey was available in an online format from August 2022 to January 2023 from the Charlevoix County OEM's webpage and Networks Northwest's project webpage. The Charlevoix County Emergency Management Coordinator also emailed Task Force members, local government officials and other community stakeholders with an invitation (and follow up reminders) to take the survey. The survey asked sixteen questions related to hazard mitigation and received 54 responses. The majority of responses were from elected or appointed officials, emergency personnel, and property owners/residents (Table 1). Complete survey results are included as Appendix B.

Table 1: Survey Responses by Local Municipality

Local Unit	# of Reps*	Title/Role (If Indicated)
Charlevoix County	15	Local government employees; elected or appointed officials; County Planning Commissioners; District 5 County Commissioner; City Manager; Long-term care facility employee – Emergency Preparedness; County EMC
City of Boyne City	4	City residents/property owners; City Clerk
City of Charlevoix	13	City residents; Planning Commissioner; Shade Tree and Parks Commission; Hospital employee/Emergency Management; EMS Director
City of East Jordan	3	City residents; local government employee; City Administrator
Village of Boyne Falls	1	Resident
Bay Township	3	Elected officials
Boyne Valley Township	3	Residents/property owners; Township Supervisor; elected official
Chandler Township	1	Residents/property owners
Charlevoix Township	2	Township Clerk; EMS Director
Evangeline Township	1	Resident
Eveline Township	3	Township Clerk; EMS Director
Hayes Township	1	EMS Director
Hudson Township	0	
Marion Township	2	Resident; EMS Director
Melrose Township	1	Township Supervisor
Norwood Township	2	EMS Director; Zoning Administrator
Peaine Township	1	Residents/property owners; Beaver Island Historical Society Director
South Arm Township	3	Residents/property owners
St. James Township	7	Residents/property owners; Township Supervisor; Township Admin. Assistant; Planning Commissioner; Historical Society Director
Wilson Township	2	Residents/property owners; Township Clerk

Other	5	Cheboygan County Emergency Management; Otsego County; Tip of the Mitt Watershed Council; GTB Tribal Historic Preservation Officer; Antrim County Employee

Note: *When asked to identify which jurisdiction a survey participant represented, they could select multiple communities that applied to them.

Responses to Question 3-5 asked about participants' knowledge of local planning efforts including the current hazard mitigation plan (60% indicated they were unfamiliar with the plan), local master plans (77% said yes they have an adopted Master Plan), and a local Capital Improvements Plan (CIP) (33% indicated that they have a CIP).

Questions 6 and 7 asked participants if there had been significant natural hazard event within their community in the past 10 years and, if so, to describe the nature of the event. 32% said they had experienced a significant natural hazard in the last 10 years, with descriptions provided as follows:

No Specific Location
- COVID-19
- Heavy snowfall
- Strong winds; high wind storms in December 2021
- Power outage
- Ice storm
- High water levels (Lake Michigan) 2018-2019
- Flooding
- Erosion

City of Boyne City
- Tornado

City of Charlevoix
- Blizzard
- Extreme winter weather

City of East Jordan
- Flooding of public areas, parks and infrastructure. Over capacity of wastewater system with stormwater

Bay Twp.
- Wind storm

Charlevoix Twp.
- Flooding

Peaine Twp.
- High water, erosion
- Some houses threatened by high water, storm driven events

St. James Twp.
- High water, erosion
- High Lake Michigan levels and high winds combined for shore erosion and damage to homes/property

Antrim County
- Tornado
- Straight-line winds

Responses to question #8 indicated that 59% of participants were "somewhat concerned", 31% were "very concerned", and 10% were "not concerned" about future natural hazard events impacting their community.

Question 9 asked what types of natural hazard events were likely to have the largest impact on the survey participant's community (Table 2).

Table 2. Survey Question #9 Results Summary

What type of natural hazard events are likely to have the largest **impact on your community (i.e., flood, winter storm, thunderstorm/wind, drought, illness outbreak)?**			
Ranking	**Hazard**	**Times Mentioned in Survey Responses**	**Locations of Concern**
#1	Severe Winter Weather	33	Countywide
#2	High Wind, Thunderstorm/Wind	32	Countywide
#3	Flooding	17	Countywide; City of Boyne City, City of East Jordan, Townships of Bay, Boyne Valley, Chandler, Charlevoix, Eveline, Peaine, South Arm, St. James, Wilson
#4	Illness Outbreak	13	Countywide
#5	Shoreline Erosion	11	Lake MI Communities: City of Charlevoix; Townships of Peaine, St. James, Bay, Hayes, Charlevoix, and Norwood
#6	Drought	7	Countywide
#7	Tornado	3	Countywide
#8	Fire	2	Countywide; St. James and Peaine Townships
#9	Lightning Strike (radiation leak at former Big Rock Nuclear Plant caused by lightning strike)	1	Hayes Township
	Dam failure	1	Boyne Valley Township
	Hail	1	Countywide
	Increased storms	1	Countywide

Questions 10 asked about community concerns regarding infrastructure withstanding a natural hazard event in the future. Areas with specific infrastructure concerns mentioned include:

- Countywide
  - Electrical outages due to storms
  - “Shoreline infrastructure damage from soil erosion due to high lake levels”
  - “High water levels in the net 15-20 yrs could be worse than what the area had in the past couple years”
- Boyne Valley Township
  - Potential dam failure (Boyne USA-owned dam; Boyne Falls Village-owned dam on M-75)
- City of East Jordan water and sewer services
- City of Charlevoix
  - Aging drawbridge on US-31 – a major connector for the City and region - is in need of replacement
  - General utilities
  - “Water infrastructure can be challenging in extreme cold”
- Wilson and Boyne Valley Townships
  - “Dam situation on Deer Lake”
  - “Power outages due to high winds/storms”
- St. James Township
  - “Utilities are above ground wires that are open to damage by wind, trees downed, etc.”
  - ”Lack of generator operations during cold periods.”
  - “Fragile road beds and cultural assets”
- Peaine and St. James Townships
  - “Phone/internet service on Beaver Island”
  - Concerns for repair times for island utility outages
  - “Concern for our water/sewer infrastructure in the event of heavy precipitation or freezing [temperatures]”
- Eveline Township
  - “Utility issues would most affect our residents”
- Norwood Township
  - “A local road tax doesn’t address the road and culvert needs throughout the Township”
- The Mackinaw Bridge (in Cheboygan/Emmet counties)

Questions 11 and 12 asked if a community had considered mitigation strategies for potential or current hazards, and if so, what strategies they would like to explore in the future. 38% of respondents indicated "yes", with the following potential mitigation strategies they would like to explore:

- Countywide
  - Updates to the power grid
  - Backup power sources
  - Utilize climate mitigation strategies for coastal communities as encouraged by the Tip of the Mitt Watershed Council
  - Culvert improvements and utilization of the new [Antrim] County Hydrology Model
  - Conducting annual emergency scenario planning drills regarding US-31 bridge outage and Big Rock [former nuclear power plant site in Hayes Township].
- Eveline Township
  - Shoreline erosion
- St. James Township/Peaine Township
  - Update Beaver Island Emergency Operations Plan with a focus on planning for power outages, backup power sources and shelters; evacuation plans; CIP
  - Strengthen building codes in high risk erosion areas
- City of East Jordan
  - "Collaborative efforts between jurisdictions, shared services, emergency response with private utility companies"
- City of Charlevoix
  - Revising infrastructure as possible

Question 13 asked if a community had requested assistance for past mitigation projects. Only 4 out of 45 respondents said "yes". A representative from Charlevoix Township indicated they received assistance from FEMA regarding Floodplain Management Provisions.

Question 15 asked if there was any additional information to consider in the Plan update:

- Beaver Island
  - Place power lines underground
  - Keep island logistics in mind
  - Power outages for an island community is a serious issue; loss of power means loss of a winter's food supply kept in refrigerators/freezers
  - "Island needs local team to aid in emergencies, especially when off-island emergency personnel are not available and/or power, internet and phone services are disrupted."
- Problems with maintaining staffing levels of local Fire, Police and EMS
- South Arm Township
  - Flooding in Six Mile Lake

The final survey question asked survey-takers to respond with their contact information if they wish to be involved in the plan development process. Several responded with their email address.

Draft Plan Review and Comment

Upon approval by the Natural Hazards Task Force, the draft plan was released for review and comment on ___. Figures 1 and 2 illustrate the posting of draft plan materials and public hearing notification on Networks Northwest's project webpage and the County OEM's webpage. The public was also notified through a published notice in the ___ on __ of the County's draft Hazard Mitigation Plan and the opportunity to provide feedback at the public hearing held on ____ (Figure 3). The following comments were received during the public review period or at the public hearing:

Figure 1: Networks Northwest Project Webpage

Source: Accessed ____

Figure 2. Charlevoix County's OEM Webpage

Source: Accessed ____

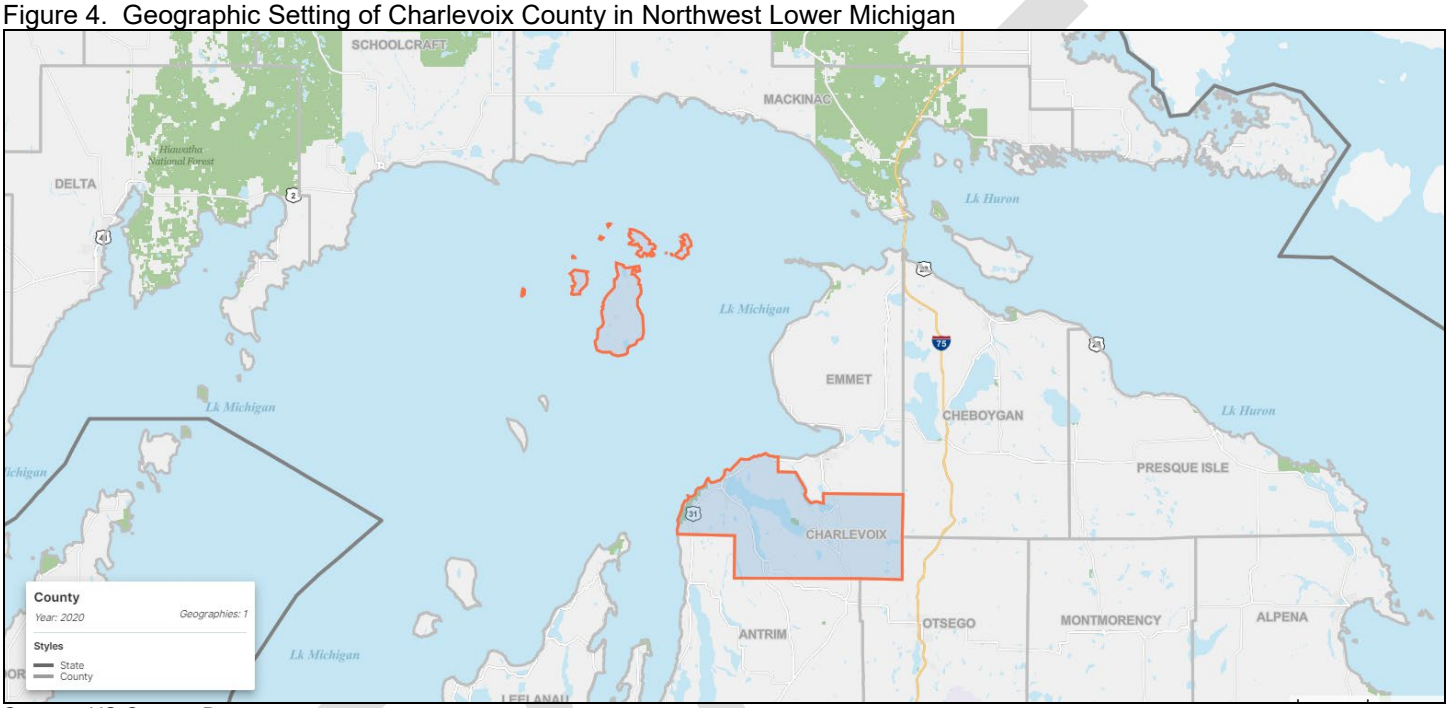
Figure 3. Public Notice in the ___ Newspaper, DATE

COMMUNITY PROFILE

Location
Charlevoix County is located in Northwest Lower Michigan (Figure 4). The mainland portion of the county is bordered by Lake Michigan, Emmet County, Cheboygan County, Otsego County and Antrim County. There are 11 outer islands in the Beaver Island Archipelago: Garden, High, Gull, Hog, Pismire, Whiskey, Trout, Shoe, Hat, Horseshoe and Squaw/Ojibwe islands. Only Trout and Squaw/Ojibwe Islands contain private residences.

Refer to Appendix A for maps illustrating Charlevoix County's main roads, water bodies and jurisdictions.

Figure 4. Geographic Setting of Charlevoix County in Northwest Lower Michigan



Source: US Census Bureau

Land Use/Land Cover
Charlevoix County contains approximately 416 square miles of land and 974 square miles of water (including Lake Michigan). It is one of the smallest counties in the state and contains a larger amount of surface water both within and adjacent to its boundaries than most other counties in Michigan. There are 38 named inland lakes in the County, ranging in size from 0.65 acre to 17,200 acres, and equal to about 40 square miles. Including the Beaver Island Archipelago, there are 138 miles of Great Lakes shoreline in the County. Wetlands occupy 18 percent of the County's land area. Many wetlands are small, occupying less than 5 acres. Most of the County's wetlands are wooded cedar swamps, which are important for wildlife and water quality, and are a source of cedar wood products.

Critical Dune Areas are located in small parts of the City of Charlevoix as well as in the Townships of Charlevoix, Norwood, Peaine, and St. James. The State legislature identifies these coastal dunes as unique, irreplaceable, and fragile resources that provide significant recreational, economic, scientific, geological, scenic, botanical, educational, agricultural, and ecological benefits.

Natural resources and features of local and regional significance include the following:

- Lake Michigan Shoreline – Approximately 23 miles long on the mainland, this ecologically unique area is home to many threatened species and species of special concern.
- Beaver Island Archipelago – Islands in this group include 77 square miles of land area and well over 100 miles of Great Lakes shoreline. It is also home to many threatened and special concern plant and animal species.
- Lake Charlevoix – With a surface area of 17,200 acres and 56 miles of shoreline, Lake Charlevoix is the third largest and one of the highest quality inland lakes in Michigan. This lake is critical for waterfowl and fisheries. Its largest tributary is the Jordan River. The Lake Charlevoix Watershed covers approximately 332 square miles - much of the County.
- Boyne River – This river is approximately 22 miles long, with a 40,320-acre watershed. The river is a state designated blue ribbon trout stream.

- Jordan River – One of Michigan's designated Natural Rivers. Highly valued for its fishery, beautiful river valley and recreation. Most of the watershed is in Antrim County, although significant portions extend into the City of East Jordan and South Arm, Wilson and Boyne Valley Townships.
- Walloon Lake – The southern shore of this lake lies within Charlevoix County. It is the source of the Bear River.
- Bear River Wetland Complex – One of the largest wetland complexes in the County, and continues into Emmet County.

There are 48 threatened, endangered or special concern species in the County, seven of which are federally listed (Table 3). Many of these species occur in Great Lakes shoreline areas and in the Beaver Island Archipelago.

Table 3: Federally Listed Endangered and Threatened Species

Scientific Name	Common Name	Federal Status
Charadrius melodus	Piping plover	Endangered
Cirsium pitcheri	Pitcher's thistle	Threatened
Iris lacustris	Dwarf lake iris	Threatened
Mimulus michiganensis	Michigan monkey flower	Endangered
Myotis septentrionalis	Northern long-eared bat	Threatened
Solidago houghtonii	Houghton's goldenrod	Threatened
Somatochlora hineana	Hine's emerald dragonfly	Endangered

Sources: U.S. Fish & Wildlife Service and Michigan Natural Features Inventory (MNFI), as cited in the *Charlevoix County Future Land Use Plan (2018)*
Note: MNFI provides County specific data as a reference; it is not a definitive list, and it is subject to change.

Park and recreation areas are abundant throughout the county (Table 4). One of the largest recreation areas in the county is Boyne Mountain in Boyne Valley Township. The four-season resort hosts many special events and provides recreation opportunities such as skiing, golf, fly fishing, sports fields, trails, a timber suspension bridge, an indoor waterpark, and a zip line.

Table 4. Parks and Recreation Acreage by Unit of Government

Unit of Government	Acreage
Chandler Township	16,810
Peaine Township	12,791
Melrose Township	8,678
Boyne Valley Township	4,947
Hudson Township	3,441
Norwood Township	2,282
Wilson Township	1,304
Bay Township	1,189
Evangeline Township	1,018
Hayes Township	907
South Arm Township	833
Charlevoix Township	660
City of Boyne City	649
County of Charlevoix	520
Marion Township	424
Eveline Township	401
City of Charlevoix	123
City of East Jordan	110
St. James Township	93
TOTAL	**57,179**

Source: Charlevoix County Parks and Recreation Plan, 2020-2024

The predominant land cover type in Charlevoix County is ___ at __%

The second most prevalent land cover type is __ at __%, followed by ___ at _% (____acres) (Table 5). Wetlands contribute significantly to water quality by acting as filters of storm water in addition to sustaining forest growth and providing habitat for wildlife. These areas generally are not suitable for development, but provide open space and recreational value as well as vital habitat for culturally significant animal and plant species.

Agriculture is the ___ largest type of land cover in the county. According to the 2017 USDA Census of Agriculture, there were 29,940 acres of farmland (271 total farms) in Charlevoix County, with the average farm size being 110 acres. Compared to the 2012 Agricultural Census, this represents a 20% loss of total farmland, a 9% loss in the number of farms, and a 13% decline in the average size of a farm in the County. The market value of agricultural products sold in 2017 was $8,415,000. Crops (particularly fruits, tree nuts, berries, grains, oilseeds, dry beans, dry peas, other crops and hay) represented 59% of those sales, while livestock, poultry and products represented 41%. Charlevoix County ranks 61 out of 83 counties in the State of Michigan for the amount in sales of agricultural crops, and 61 out 82 counties in the State for the amount in sales of livestock, poultry, and agricultural products sold. The top crops produced by acreage were:

- Forage (hay/haylage), all (5,524 acres)
- Corn for grain (2,417 acres)
- Corn for silage or greenchop (501 acres)
- Cherries, tart (data withheld to avoid disclosing data for individual operations)
- Apples (293 acres)

Developed land cover is found predominantly in and around the cities of Boyne City, Charlevoix and East Jordan; the Village of Boyne Falls; and major roads such as M-66, M-75, M-32, US-31 and US-131.

Table 5: Land Cover by Type, Charlevoix County

Classification	Acres	Percent
Developed (High Intensity)		
Developed (Med. Intensity)		
Developed (Low Intensity)		
Developed (Open Space)		
Agriculture (Cultivated Crops and Hay/Pasture)		
Forested (Deciduous, Evergreen and Mixed)		
Wetlands		
Shrub/Scrub, Herbaceous		
Barren Land		
Open Water		
TOTAL		100.00%

Source: Networks Northwest

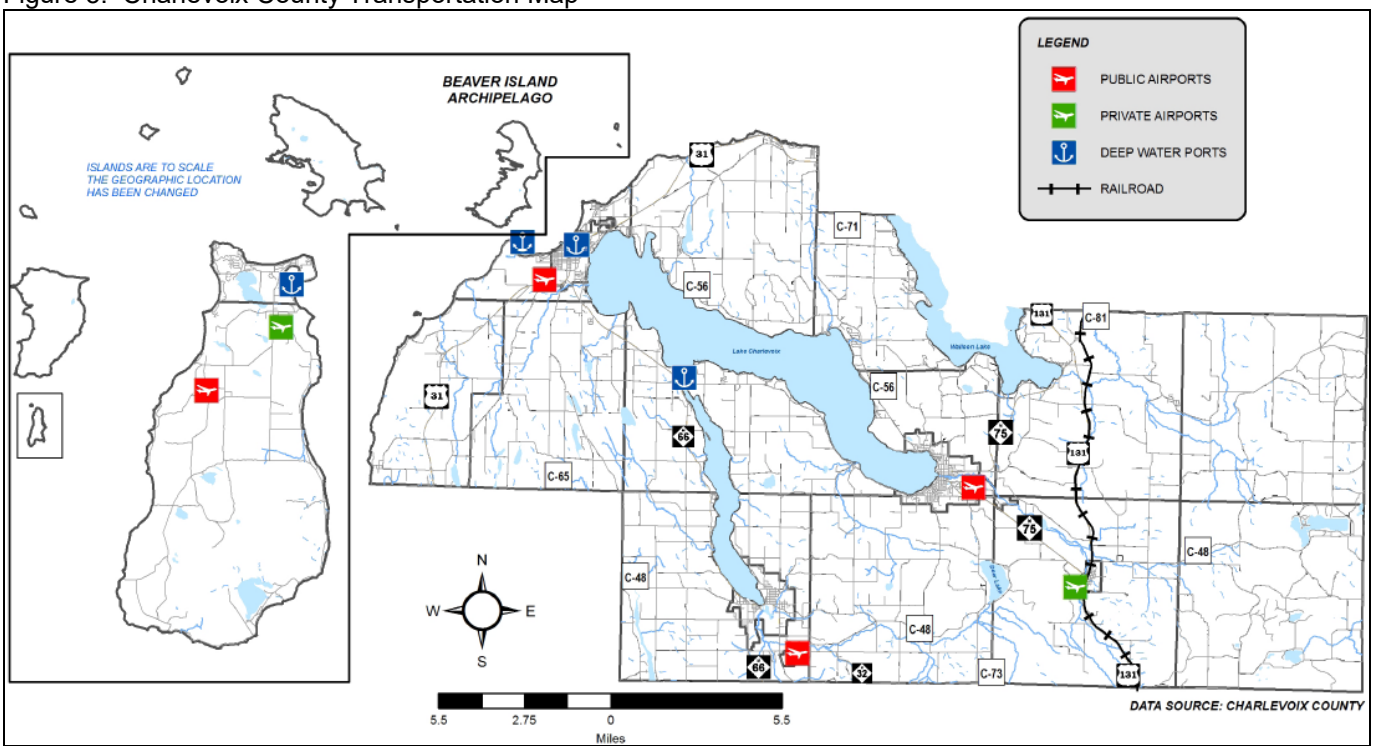
The 2016 Charlevoix County Hazard Mitigation Plan indicated that 172,200 acres, or 64.5% of the county's total land area were forested lands, and 67,349 acres, or 25.2% were wetlands. When comparing this data to current data, the amount of forested areas and wetlands have _____.

While development in the county has remained fairly steady in the past decade, it has been noted that the type of new development is changing. Office and industrial development has largely stopped, commercial development has slowed, but residential development is occurring as quickly as plans can be approved. Housing of all types and prices is in demand, but many communities desire smaller units and multiple family units. This type of housing is especially important for the senior population and local workforce, and will likely be in demand for many years. The Environmental Features Map in Appendix A shows the intensity of development in the county as well as natural features.

Transportation
The information in this section was primarily sourced from the Charlevoix County Future Land Use Plan (2018).

Charlevoix County's transportation network consists of approximately 968 miles of public roads, 4 public airports, 2 private airports, one rail line, 2 ferries and 4 deep water ports (Figure 5).

Figure 5. Charlevoix County Transportation Map



Source: Charlevoix County Future Land Use Plan (2018)

State highways include: M-75 connecting Boyne City, Walloon Lake and the Village of Boyne Falls; M-32 connecting East Jordan to the City of Gaylord (in Otsego County); and M-66 connecting East Jordan to Charlevoix. Federal highways include US-31 along the Lake Michigan coastal communities of Hayes, Charlevoix Township, City of Charlevoix and Norwood; and US-131 throughout Boyne Valley Township, the Village of Boyne Falls, and Melrose Township. The one rail line generally runs parallel to US-131 and experiences limited use, with typical freight traffic being one round trip per week from southern Michigan to Petoskey. Road names are indicated on the maps in Appendix A.

Two passenger ferries provide service in Charlevoix County. The Ironton Ferry, which is owned and overseen by the Charlevoix County Transportation Authority, transports passenger vehicles, as well as pedestrians and bicyclists, across the South Arm of Lake Charlevoix between the mainland and the peninsula in Eveline Township. It operates from mid-April through mid-November. The Beaver Island Transportation Authority of St. James Township is responsible for the operation of the ferry service between Charlevoix and Beaver Island. The "Emerald Isle" ferry is owned by the State of Michigan and the Authority contracts with the Beaver Island Boat Company to operate the vessel. The "Beaver Islander" ferry is owned by the Beaver Island Boat Company and serves as a back-up to the Emerald Isle and for operation during the peak tourist season. Funding for half of the fuel for the Beaver Islander is provided by the Transportation Authority. The ferry service is available from mid-April through mid-December.

The publicly-owned Beaver Island Airport is overseen by the Beaver Island Airport Commission. In 2014, a new terminal building was constructed. Fresh Air Aviation, based in Charlevoix, is the main operator at the airport. Fresh Air Aviation provides year-round passenger flight service between Charlevoix and Beaver Island in addition to charter flights, lighthouse air tours, and shipping services.

The Beaver Island Airport runways are planned for reconstruction in the next few years, which will require the temporary closure of this airport and the temporary installation of an asphalt paving plant. Taking advantage of the asphalt plant's resources, both Townships are collaborating with the Charlevoix County Road Commission to prepare for needed road projects on the Island, including plans for St. James Township to initiate Phase II of the Donegal Bay Bike Path, and

Peaine Township currently working to obtain a primary road status for East Side Drive to potentially allow future road improvements during this period an asphalt plant is on Island.[2]

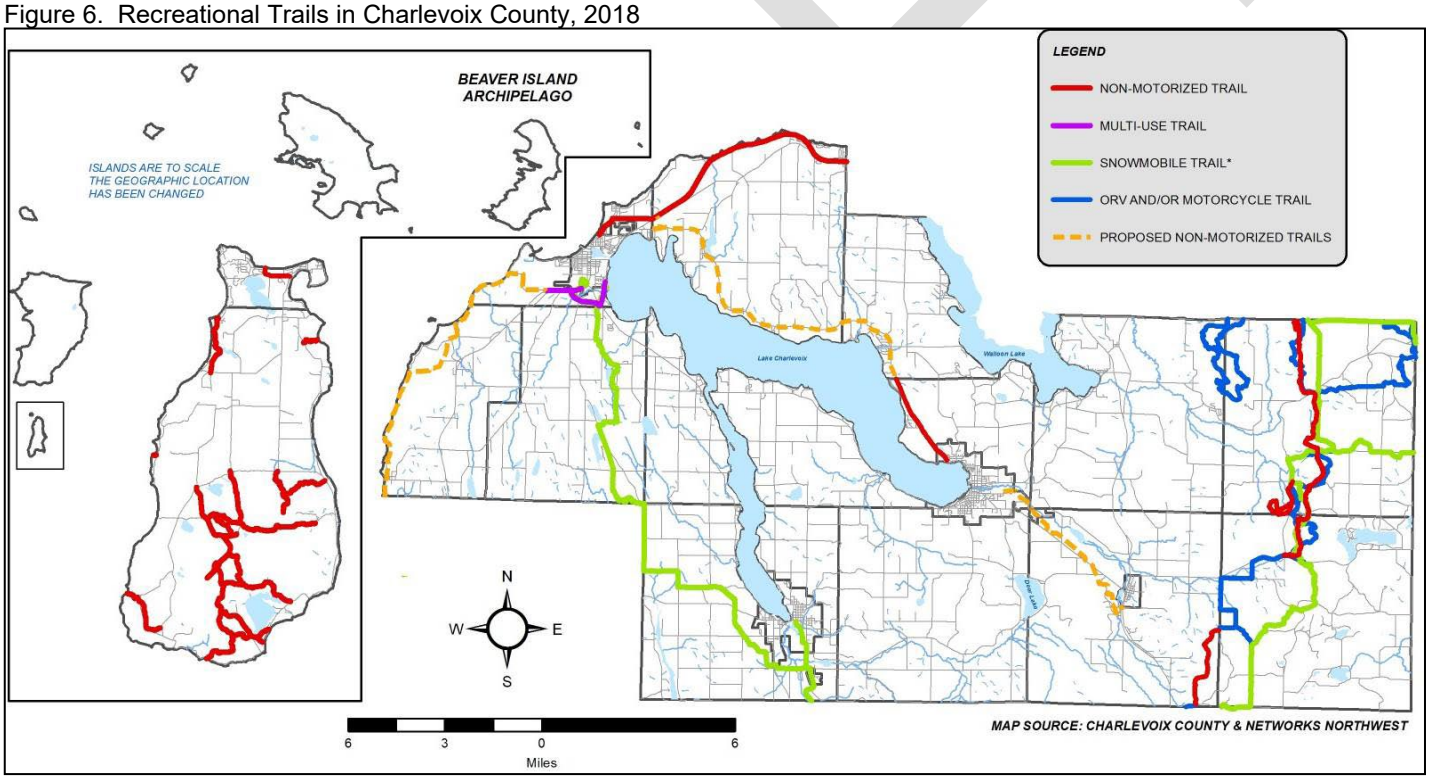
Welke Airport is the privately-owned airport on Beaver Island and is owned and operated by Island Airways. Island Airways provides passenger and freight service between Beaver Island and Charlevoix, in addition to perishables, U.S. Postal Service mail, and shipping services including prescription medication. Island Airways, the U.S. Coast Guard, Northflight and Guardian also provide emergency medical flights from Welke Airport to Charlevoix Airport.

The County's four deep water ports – Ironton (on the South Arm of Lake Charlevoix in Eveline Township), Round Lake (in the City of Charlevoix), St. Marys Cement Co. (on Lake Michigan in Charlevoix Township) and St. James Harbor (in St. James Township, Beaver Island) - serve as a means of transporting both goods and passengers to and from various locations around the Great Lakes as well as international destinations. While not highly developed for general shipping purposes, improvements can be made over time to accommodate appropriate shipping needs.

Charlevoix County's rural character and scattered development patterns leave most residents dependent on the use of private vehicles. The only public transportation option is Charlevoix County Transit's demand-response (dial-a-ride) bus for Charlevoix County residents. County veterans and residents over age 60 receive free rides to medical appointments as a benefit of a partnership between the Charlevoix County Commission on Aging and the Charlevoix County Department of Veteran Affairs. The transit service also offers delivery of online grocery orders.

There are also many miles of recreational trails throughout the county (Figure 6).

Figure 6. Recreational Trails in Charlevoix County, 2018



Source: Charlevoix County Future Land Use Plan (2018)

[2] Source: Beaver Island Master Plan, 2023

Climate

Northwest Lower Michigan has a four season climate with mild summers and cold, snowy winters. The presence of Lake Michigan generally keeps coastal areas warmer in the winter and cooler in the summer, with less precipitation than at locations further inland. Table 6 provides historical climate information from the years 2000 to 2023 for the county.

Table 6. NOAA Online Weather Data for Charlevoix County, 2000-2023

NOAA Weather Station	Beaver Island	City of Charlevoix	Village of Boyne Falls	City of East Jordan	"East Jordan 2NW" (2 mi. N. of City of East Jordan in South Arm Twp.)
Greatest Monthly Mean Precip. (Oct.)	4.44"	4.57"	4.71"	4.14"	5.64"
Mean Annual Precipitation	32.82"	34.32"	37.04"	31.73"	39.38"
Mean Annual Avg. Temp. (F.)	44.3	46	47.2	46.5	44.8
Warmest Month	July				
Coldest Month	February		January	February	
Maximum Record Temperature	92 degrees in July 2005	97 degrees in Aug 2006	102 degrees in June and July 2018	99 degrees in Aug 2006	95 degrees in July 2018
Minimum Record Temperature	-23 degrees in Feb. 2015	-18 degrees in Feb. 2015	-28 degrees in Feb. 2015	-30 degrees in Feb. 2015	-27 degrees in Feb. 2015
Mean Annual Avg. Snowfall	75.1"	88.6"	109.1"	124.2"	117.9"
Maximum Record Snowfall	137.9" in 2008-09	158.9" in 2008-09	172.5" in 2013-14	183.4" in 2008-09	161.3" in 2017-18
Minimum Record Snowfall	35.6" in 2009-2010	44.6" in 2020-21	60.0" in 2020-21	56.3" in 2020-21	74.2" in 2020-21

Source: National Weather Service's Climate Information, NOAA Online Weather (NOW) data https://www.weather.gov/wrh/Climate?wfo=apx
Note: Some NOAA Weather Stations are missing monthly data records

On any given day, coastal areas of Charlevoix County are highly susceptible to quick, sudden changes in the weather. Depending on the time of the year, the Great Lakes have a significant impact on temperatures, precipitation, and the strength of storms. In the spring when the lake water is colder than the air over them, they extract heat from the atmosphere. During the fall, the Great Lakes give off heat and moisture. In both cases, storms arrive on land stronger and more persistent than they might otherwise be. Thunderstorms, extreme winter weather events, and excessive rainfall are common natural hazards with the potential to cause loss of life and significant property damage. This plan identifies potential hazards and mitigation strategies to reduce the impact of those hazard events.

Population

Charlevoix County is the 4th most populated county in the ten county region of Northwest Lower Michigan with a population of 26,054 persons (Table 7).

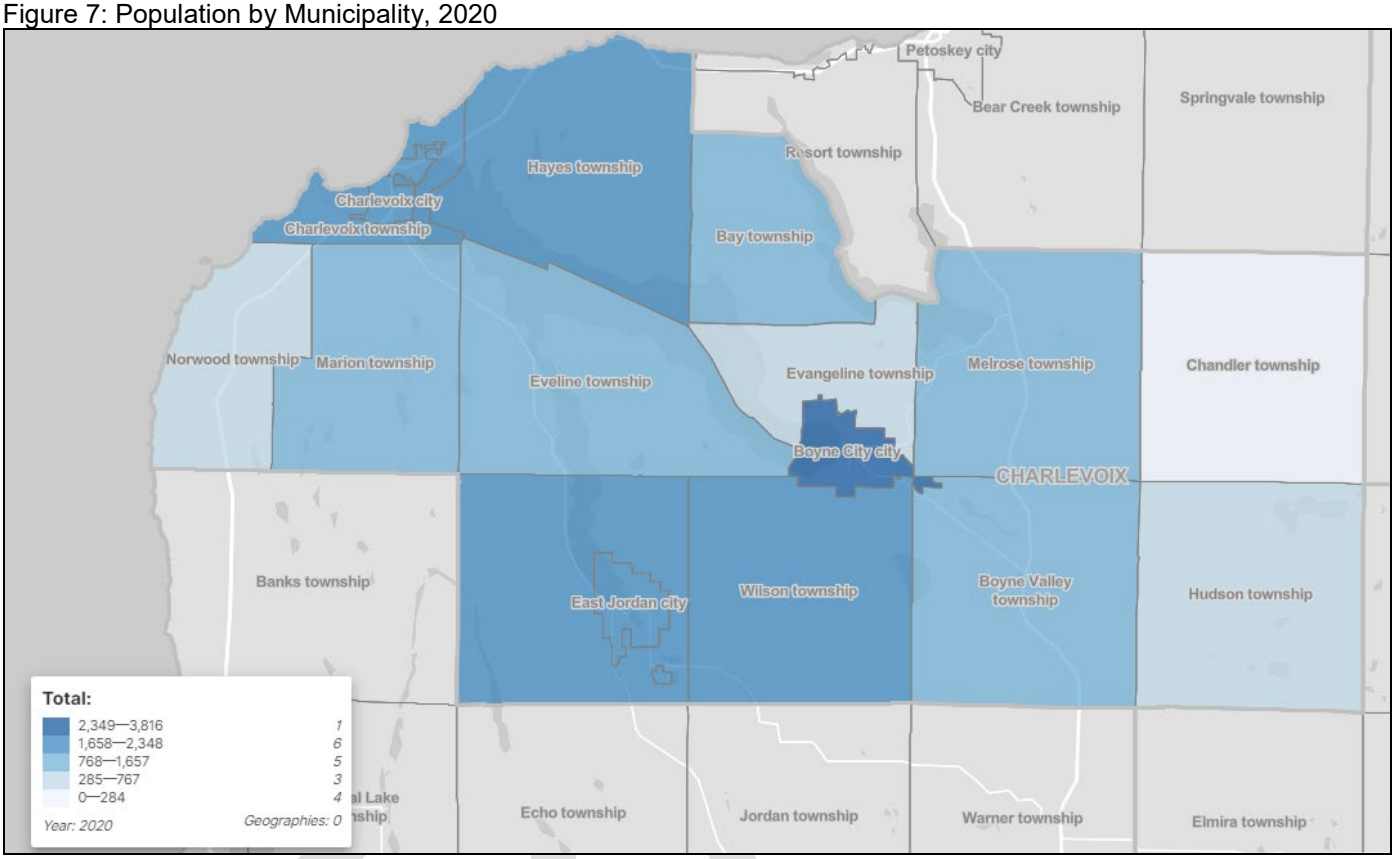
Table 7: Population by County, State, 2020

Jurisdiction	Population
Missaukee County	15,052
Kalkaska County	17,939
Benzie County	17,970
Leelanau County	22,301
Antrim County	23,431
Manistee County	25,032
Charlevoix County	**26,054**
Emmet County	33,673
Wexford County	34,112
Grand Traverse County	95,238
State of Michigan	10,077,331

Source: US Census Bureau, 2020 Decennial Census, File DP1

Charlevoix County contains 15 townships, 3 cities, and the Village of Boyne Falls. In addition, there are indigenous tribal lands within the county under the ownership of the Grand Traverse Band Tribe of Ottawa and Chippewa Indians (GTB) and the Little Traverse Bay Bands of Odawa Indians (LTBB). These include, but are not limited to, the LTBB Satellite Offices in Hayes Township and the GTB Tribal Satellite Office and housing units in Eveline Township.

Figure 7: Population by Municipality, 2020



Source: US Census Bureau, 2020 Decennial Census, 2020 DEC Redistricting Data (PL 94-171)

Source: US Census Bureau, 2020 Decennial Census, 2020 DEC Redistricting Data (PL 94-171)

A comparison of the 2010 and 2020 decennial census data indicates there was slight increase in county population from between 2010 and 2020 of 105 persons (0.4%) (Table 8). The communities with the greatest number of new residents include Boyne Valley Township (230), followed by Charlevoix Township (118) and Hayes Township and the City of Boyne City (81 each). The City of Charlevoix lost the most residents (165), followed by the City of East Jordan (112), Wilson Township and St. James Township (106 each), and Marion Township (57). It is also important to note that Peaine Township, which adjoins St. James Township on Beaver Island, also lost 26 residents. St. James Township had the greatest percentage of population loss, while the Village of Boyne Falls had the greatest percentage of population gain.

Table 8: Population by Municipality and County, 2010 and 2020

Jurisdiction	2010 Total Population	2020 Total Population	Numeric Change	Percent Change	Participant[3] in the 2016 Hazard Mitigation Plan?
Charlevoix County	25,949	26,054	105	0.40%	Yes
City of Boyne City	3,735	3,816	81	2.17%	Yes
City of Charlevoix	2,513	2,348	-165	-6.57%	No
City of East Jordan	2,351	2,239	-112	-4.76%	No
Hayes Township	1,919	2,000	81	4.22%	Yes
South Arm Township	1,873	1,939	66	3.52%	Yes
Wilson Township	1,964	1,858	-106	-5.40%	Yes
Charlevoix Township	1,645	1,763	118	7.17%	No
Marion Township	1,714	1,657	-57	-3.33%	No
Eveline Township	1,484	1,515	31	2.09%	Yes
Boyne Valley Township	1,195	1,425	230	19.25%	Yes
Melrose Township	1,403	1,405	2	0.14%	Yes
Bay Township	1,122	1,142	20	1.78%	Yes
Evangeline Township	712	767	55	7.72%	No
Norwood Township	723	700	-23	-3.18%	Yes
Hudson Township	691	671	-20	-2.89%	No
Village of Boyne Falls*	294	358	64	21.77%	No
Chandler Township	248	284	36	14.52%	No
Peaine Township	292	266	-26	-8.90%	No
St. James Township	365	259	-106	-29.04%	No

Source: US Census Bureau, 2010 and 2020 Decennial Census, DEC Redistricting Data (PL- 94-171). Note: *The population counts for the Village of Boyne Falls are included in the population counts for Boyne Falls Township

Like many northwest Michigan communities, Charlevoix County experiences an influx of seasonal residents and tourists during the summer months. However, the decennial Census and the American Community Survey only consistently and comprehensively track the permanent population. The 2022 *Seasonal Population Study for Northwest Lower Michigan* analyzed the 2020 seasonal population for these ten counties: Antrim, Benzie, Charlevoix, Emmet, Grand Traverse, Kalkaska, Leelanau, Manistee, Missaukee, and Wexford. The study collected data for permanent and part-time residents and overnight visitors in accommodations and short-term rentals by County. Northwest Lower Michigan's permanent base population is 310,802 and expands to its largest seasonal population of 676,052 in July, a 118% increase.

Charlevoix County's combined population (full-time residents, part-time residents and overnight visitors) increases by as much as 72% (24,930 persons) from the minimum monthly population of 34,603 in April to the greatest monthly population of 59,533 in July. In July, the county experiences 33,479 part-time and overnight visitors - a 128% increase from the base population of 26,054. On average, the county's population grows by 61%, or 15,791 people, throughout the year (Table 9).

[3] The 2016 Hazard Mitigation Plan for Charlevoix County did not specifically state which communities participated in the development of the plan; information on local government participation in the 2016 plan process was inferred from meeting documentation appended to the plan.

Table 9: Charlevoix County Seasonal Population by Month

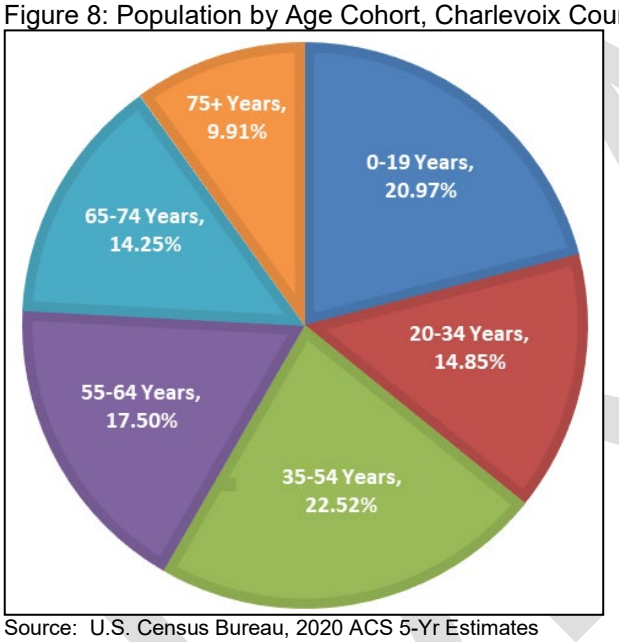
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Permanent Population	26,054	26,054	26,054	26,054	26,054	26,054	26,054	26,054	26,054	26,054	26,054	26,054	26,054
Combined Population	34,781	34,949	34,780	34,603	40,504	53,131	59,533	55,564	42,809	40,635	34,694	36,153	41,845
Difference	8,727	8,895	8,726	8,549	14,450	27,077	33,479	29,510	16,755	14,581	8,640	10,099	15,791
% Change	33%	34%	33%	33%	55%	104%	128%	113%	64%	56%	33%	39%	61%

Source: 2022 Seasonal Population Study for Northwest Lower Michigan

Age, Race & Disability

Understanding the age distribution and median age of Charlevoix County can help identify social, economic, and public service needs in the community. The county's total estimated 2020 population is broken into age cohorts (analyzing which proportions of a municipality's population are in which stages of life). This gives a nuanced view of the makeup of a community. Figure 8 indicates the cohort group with the largest population is the 35 to 54 year old group, followed by those in 0 to 19 year old group. This indicates a fairly young population, and a population likely to grow in the future due to a large number of persons within the family-forming age group (mid-20s to mid-40s). As shown in Figure 9, in 2020 the median age (the midpoint where half the population is younger and half the population is older) of Charlevoix County is older (49.1 years) than the State (39.8 years). The county, like the State, is aging, but at a faster rate. The youngest community in the county is Chandler Township with a median age of 36.3 years; the oldest community in the county is Peaine Township with a median age of 68.2 years (Figure 10).

Figure 8: Population by Age Cohort, Charlevoix County, 2020



Source: U.S. Census Bureau, 2020 ACS 5-Yr Estimates

Figure 9: Median Age Trends, 2000, 2010, and 2020

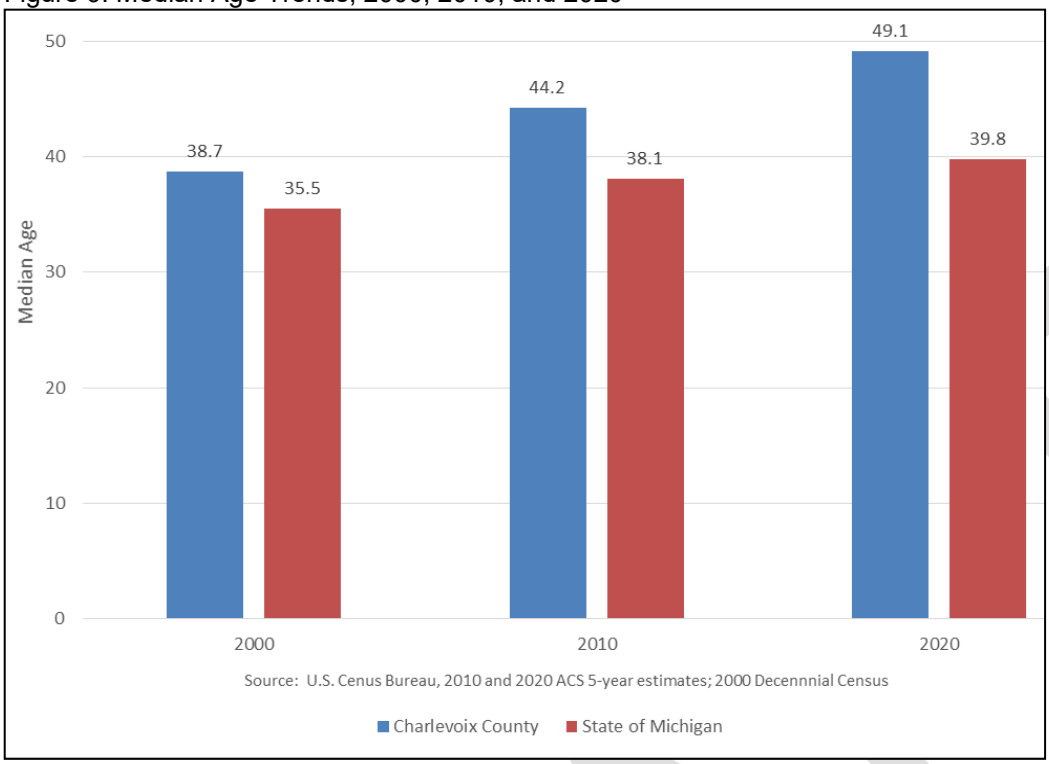
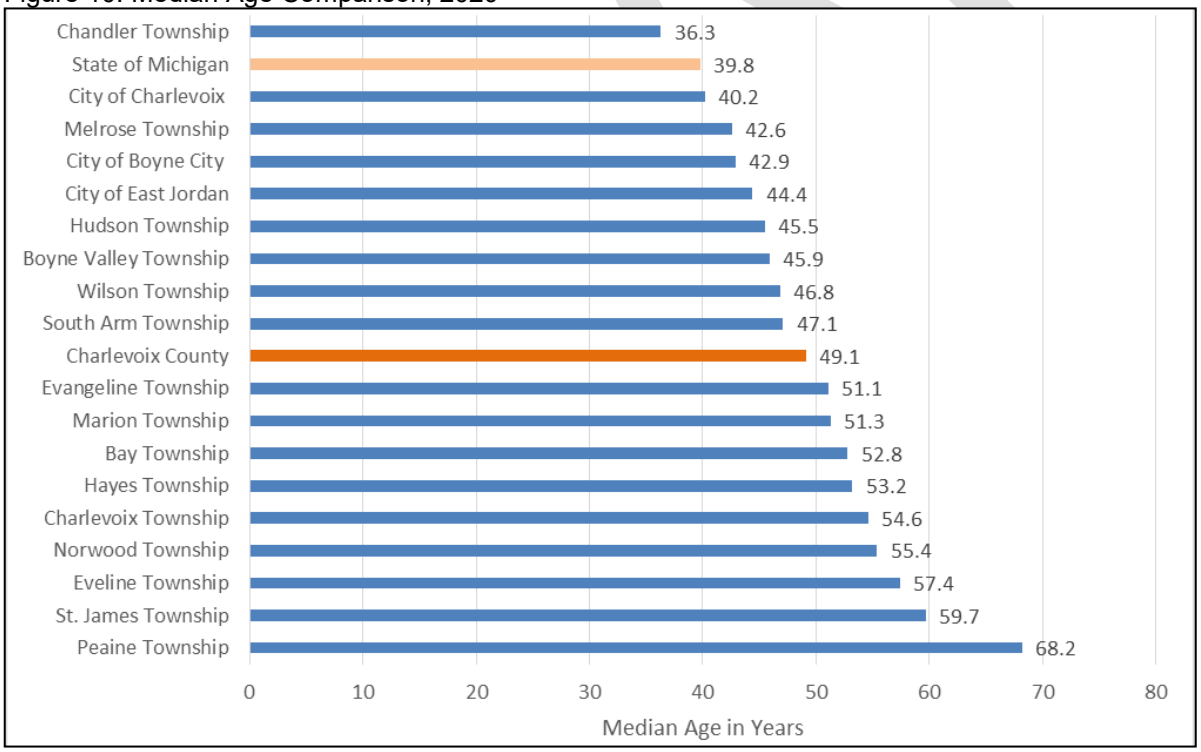


Figure 10: Median Age Comparison, 2020



Source: U.S. Census Bureau, 2020 ACS 5-Yr Estimates

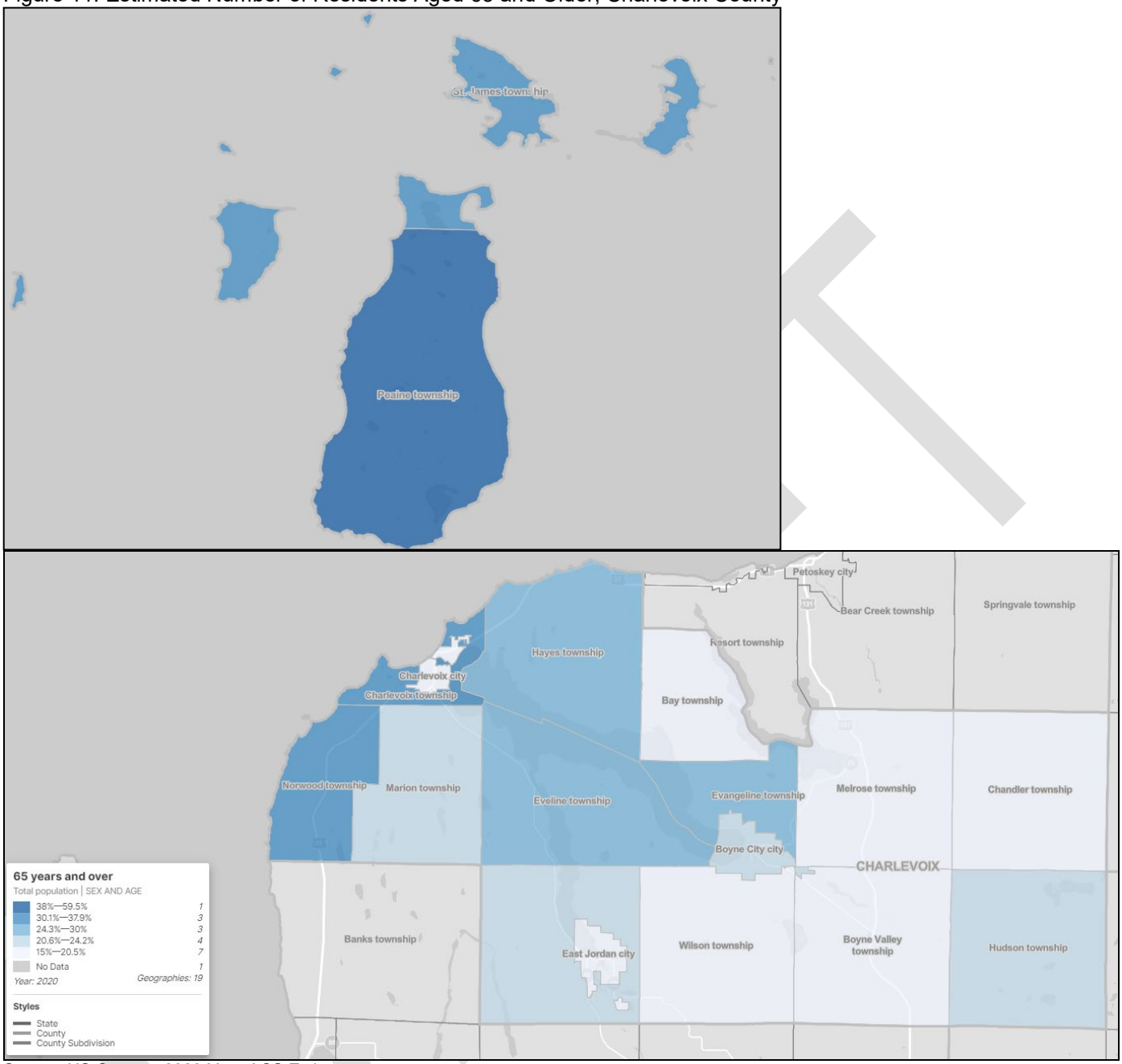
Persons over the age of 65 can be more vulnerable to the effects of natural hazard events, such as power outages, extreme temperatures, and illness outbreaks. An estimated 31% of county residents aged 65 years or older has one or more type of disability (Table 12). Figure 11 and Table 10 indicate that the greatest numbers of this cohort are located in the City of Boyne City, Charlevoix Township, the City of Charlevoix, and Hayes Township. Communities with the greatest percentage of their population who are aged 65 and older are St. James and Peaine Townships.

Table 10. Estimated Population Over Age 65 by Jurisdiction

Jurisdiction	Est Age 65+	Total Pop Est	% Age 65+
Charlevoix County	6,328	26,197	24.16%
City of Boyne City	885	3,721	23.78%
Charlevoix Township	615	1,780	34.55%
City of Charlevoix	506	2,467	20.51%
Hayes Township	505	1,784	28.31%
South Arm Township	473	2,014	23.49%
Eveline Township	459	1,560	29.42%
Marion Township	429	1,774	24.18%
City of East Jordan	410	2,133	19.22%
Wilson Township	385	2,091	18.41%
Boyne Valley Township	268	1,356	19.76%
Norwood Township	246	737	33.38%
Evangeline Township	233	776	30.03%
Bay Township	212	1,036	20.46%
Melrose Township	211	1,405	15.02%
Hudson Township	166	730	22.74%
Peaine Township	154	259	59.46%
St. James Township	121	319	37.93%
Chandler Township	50	255	19.61%

Source: U.S. Census Bureau, 2020 ACS 5-Yr Estimates

Figure 11. Estimated Number of Residents Aged 65 and Older, Charlevoix County



Source: US Census, 2020-Year ACS Estimates

As indicated in Table 11, an estimated 15.3% of Charlevoix County residents have one or more type of disability, and an estimated 31% of persons with one or more type of disability are aged 65 years or older. The City of Boyne City has the highest estimated number of persons in their community with a disability (490 persons), followed by Charlevoix Township and the City of East Jordan (Table 12). Hudson Township has the highest estimated percentage of their community population with a disability (29.9%).

Table 11: Persons with a Disability in Charlevoix County, 2020 Estimates

Total Civilian Noninstitutionalized Population	Estimated Persons
With one or more disability	3,966 (15.3%)
Age 0-17 with a disability	272 (5.5% of that age group)
18 to 64 years with a disability	1,814 (12.2% of that age group)
65 years and over with a disability	1,880 (31% of that age group)

Source: US Census, 2020 ACS 5-yr Estimates

Table 12. Persons with a Disability in Charlevoix County Communities, 2020 Estimates

Community	Est. total civilian non-institutionalized population	Est. # with a disability	Est. % with a disability
City of Boyne City	3,721	490	13.20%
Charlevoix Township	2,395	434	18.10%
City of East Jordan	2,133	353	16.50%
Marion Township	1,774	295	16.60%
Hayes Township	1,784	268	15.00%
Wilson Township	2,091	268	12.80%
South Arm Township	1,903	262	13.80%
Boyne Valley Township	1,356	243	17.90%
City of Charlevoix	1,716	240	14.00%
Eveline Township	1,560	237	15.20%
Hudson Township	730	218	29.90%
Melrose Township	1,405	214	15.20%
Norwood Township	737	111	15.10%
Evangeline Township	776	98	12.60%
Bay Township	1,036	92	8.90%
Village of Boyne Falls	343	73	21.30%
St. James Township	319	67	21.00%
Peaine Township	259	41	15.80%
Chandler Township	255	35	13.70%

Source: US Census Bureau, 2020 ACS 5-Year Estimates; Table S1810

The racial makeup of Charlevoix County is predominantly white (92.3%). 1.6% of the population identifies as Hispanic or Latino (and can identify as any race or a combination of races). 4.8% of the population is of two or more races; 1.5% of the population is American Indian and Alaska Native; 0.6% is of some other race; 0.5% is Asian; 0.3% is Black or African American; and 0.0% is Native Hawaiian or Other Pacific Islander.

The racial composition estimates of each jurisdiction in the County, as well as those identifying as being of Hispanic and Latino Origin, are shown in Table 13. Highlighted entries in the table indicate concentrations of persons non-white race or those of Hispanic or Latino origin by geography. The largest estimates of those groups in certain communities are listed below. These communities represent areas that contain small concentrations of minority populations, which are also considered socially vulnerable populations in a natural hazard event scenario. There may be an increased need for public assistance in these communities as these population groups may have limited social and financial resources to withstand or recover from a hazard event.

- Black or African American race alone: City of Charlevoix and Charlevoix Township (11 persons each); City of Boyne City (12 persons)
- American Indian/Alaskan Native alone: City of East Jordan (53 persons); Charlevoix Township (52 persons); Hayes Township (46 persons); Wilson Township (35 persons); South Arm and Eveline Township (31 persons each); City of Boyne City (28 persons); City of Charlevoix (20 persons)
- Asian alone: City of Boyne City (30 persons); Charlevoix Township (20 persons)
- Of two or more races: City of Boyne City (218 persons); City of East Jordan (141 persons); Hayes Township (110 persons); City of Charlevoix (104 persons); South Arm Township (95 persons); Charlevoix Township and Marion Township (71 persons each)
- Of Hispanic or Latino Origin (these survey respondents can identify as any type of race): City of Boyne City (68 persons); City of East Jordan (49 persons); Charlevoix Township (48 persons); South Arm Township (36 persons); Marion Township (35 persons); Eveline Township (31 persons)

Additionally, the 2020 ACS 5-Year Estimates Tables for Charlevoix County estimate that 0.2% of all households (26 households with a margin of error of + or – 19) are limited English-speaking households. This poses a possible communication challenge in providing these households with public notices/warnings prior to or during a hazard event, or during rescue and recovery efforts after a disaster.

Table 13: Race and Hispanic/Latino Origin, Charlevoix County Communities

	Total population	White	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian & Other Pacific Islander	Some Other Race	Two or More Races	Hispanic or Latino (of any race)
Charlevoix County	26,054	24,052	78	384	124	10	164	1,242	425
	100.00%	92.30%	0.30%	1.50%	0.50%	0.00%	0.60%	4.80%	1.60%
Bay Township	1,142	1,073	0	11	6	0	12	40	9
	100.00%	94.00%	0.00%	1.00%	0.50%	0.00%	1.10%	3.50%	0.80%
Boyne Valley Township	1,425	1,334	3	13	4	0	10	61	24
	100.00%	93.60%	0.20%	0.90%	0.30%	0.00%	0.70%	4.30%	1.70%
Chandler Township	284	270	2	3	2	0	1	6	5
	100.00%	95.10%	0.70%	1.10%	0.70%	0.00%	0.40%	2.10%	1.80%
Charlevoix Township	1,763	1,596	11	52	20	1	12	71	48
	100.00%	90.50%	0.60%	2.90%	1.10%	0.10%	0.70%	4.00%	2.70%
City of Boyne City	3,816	3,500	12	28	30	0	28	218	68
	100.00%	91.70%	0.30%	0.70%	0.80%	0.00%	0.70%	5.70%	1.80%
City of Charlevoix	2,348	2,187	11	20	11	1	14	104	26
	100.00%	93.10%	0.50%	0.90%	0.50%	0.00%	0.60%	4.40%	1.10%
City of East Jordan	2,239	2,024	7	53	0	2	12	141	49
	100.00%	90.40%	0.30%	2.40%	0.00%	0.10%	0.50%	6.30%	2.20%
Evangeline Township	767	699	3	2	5	2	12	44	14
	100.00%	91.10%	0.40%	0.30%	0.70%	0.30%	1.60%	5.70%	1.80%
Eveline Township	1,515	1,396	1	31	7	0	13	67	31
	100.00%	92.10%	0.10%	2.00%	0.50%	0.00%	0.90%	4.40%	2.00%
Hayes Township	2,000	1,815	6	46	9	0	14	110	18
	100.00%	90.80%	0.30%	2.30%	0.50%	0.00%	0.70%	5.50%	0.90%
Hudson Township	671	626	0	8	1	0	2	34	7
	100.00%	93.30%	0.00%	1.20%	0.10%	0.00%	0.30%	5.10%	1.00%
Marion Township	1,657	1,545	8	19	5	0	9	71	35
	100.00%	93.20%	0.50%	1.10%	0.30%	0.00%	0.50%	4.30%	2.10%
Melrose Township	1,405	1,313	0	16	8	1	9	58	15
	100.00%	93.50%	0.00%	1.10%	0.60%	0.10%	0.60%	4.10%	1.10%
Norwood Township	700	660	4	10	0	1	2	23	5
	100.00%	94.30%	0.60%	1.40%	0.00%	0.10%	0.30%	3.30%	0.70%
Peaine Township	266	251	0	1	1	0	0	13	5
	100.00%	94.40%	0.00%	0.40%	0.40%	0.00%	0.00%	4.90%	1.90%
St. James Township	259	238	0	5	0	0	3	13	2
	100.00%	91.90%	0.00%	1.90%	0.00%	0.00%	1.20%	5.00%	0.80%
South Arm Township	1,939	1,797	7	31	3	2	4	95	36
	100.00%	92.70%	0.40%	1.60%	0.20%	0.10%	0.20%	4.90%	1.90%
Village of Boyne Falls	358	330	1	0	0	0	0	27	11
	100.00%	92.20%	0.30%	0.00%	0.00%	0.00%	0.00%	7.50%	3.10%
Wilson Township	1,858	1,728	3	35	12	0	7	73	28
	100.00%	93.00%	0.20%	1.90%	0.60%	0.00%	0.40%	3.90%	1.50%

Source: US Census Bureau, 2020 Decennial Census, DEC Demographic Profile, Table DP1

Housing

The average household size for Charlevoix County residents is 2.21 persons, which is slightly lower than the State's average of 2.45 persons. Locally and at a state-wide level, the average household size has continued to get smaller over the decades of census reporting.

The county had 17,451 housing units in 2020 (Table 14). Of those, there are an estimated 11,765 households, or "occupied housing units". The Census defines a household as all the people who occupy a single housing unit, regardless of their relationship to one another.

Between 2010 and 2020, the county experienced a slight increase in the number of housing units (1.17%, or 202 units). The City of Boyne City has the largest percentage of housing units of all municipalities in the county (13.17%), followed by the City of Charlevoix, Eveline Township and Boyne Valley Township. The community that experienced the greatest growth in housing units between 2010 and 2020 was Boyne Valley Township, gaining 345 housing units. Some communities that experienced a loss in housing units also experienced population loss between 2010 and 2020, as previously presented; those that experienced a population increase, but a decrease in housing units include Marion, Chandler, South Arm and Melrose Townships.

Much of the County's housing stock is over 40 years old, with an estimated 55.6% of the county's residential units built before 1980 (Table 15). An estimated 80.6% of the county's household units are 1-unit, detached structures, which are commonly referred to as single-family homes, and 7% are mobile homes. Table 16 indicates the estimated number of mobile home units by community. The City of Boyne City has the most units (222), followed by Charlevoix Township (207), Hayes Township (175), and Wilson Township (105). The locations of concentrated mobile/manufactured homes in the county are indicated on the Hazard Area Maps in Appendix A.

Table 14. Housing Units by Municipality

Community	2010 Housing Units	2020 Housing Units	% Change	% of 2020 Total Housing Units
Charlevoix County	17,249	17,451	**1.17%**	
City of Boyne City	2,292	2,298	**0.26%**	13.17%
City of Charlevoix	2,201	2,148	**-2.41%**	12.31%
Eveline Township	1,381	1,388	**0.51%**	7.95%
Boyne Valley Township	833	1,178	**41.42%**	6.75%
Hayes Township	1,134	1,162	**2.47%**	6.66%
City of East Jordan	1,189	1,138	**-4.29%**	6.52%
Charlevoix Township	1,067	1,137	**6.56%**	6.52%
South Arm Township	1,078	1,046	**-2.97%**	5.99%
Melrose Township	935	906	**-3.10%**	5.19%
Wilson Township	876	867	**-1.03%**	4.97%
Bay Township	847	859	**1.42%**	4.92%
Marion Township	777	784	**0.90%**	4.49%
Peaine Township	564	529	**-6.21%**	3.03%
Evangeline Township	504	524	**3.97%**	3.00%
Hudson Township	549	516	**-6.01%**	2.96%
St. James Township	452	415	**-8.19%**	2.38%
Norwood Township	412	408	**-0.97%**	2.34%
Village of Boyne Falls*	178	196	**10.11%**	1.12%
Chandler Township	158	148	**-6.33%**	0.85%

Source: US Census Bureau, Decennial Census - 2010 and 2020 DEC Redistricting Data (PL 94-171)

Note: *Village of Boyne Falls' housing unit data is incorporated in the housing unit counts for Boyne Valley Township.

Table 15. Year Built, Charlevoix County Housing Units

Year Structure Built	Estimated Units	% of Total	
Built 2014 or later	302	1.70%	
Built 2010 to 2013	241	1.36%	
Built 2000 to 2009	1,951	10.99%	
Built 1990 to 1999	2,764	15.57%	
Built 1980 to 1989	2,620	14.76%	44.38%
Built 1970 to 1979	2,973	16.75%	55.62%
Built 1960 to 1969	2,095	11.80%	
Built 1950 to 1959	1,311	7.38%	
Built 1940 to 1949	1,383	7.79%	
Built 1939 or earlier	2,113	11.90%	
Total	17,753		

Source: US Census, 2020 ACS 5-yr Estimates, DP04 Selected Housing Characteristics

Table 16. Estimated Mobile Home Units, Charlevoix County

Community	Mobile homes	% of Housing Units
Charlevoix County	1,247	7.00%
City of Boyne City	222	9.70%
Charlevoix Township	207	17.90%
Hayes Township	175	15.20%
Wilson Township	105	10.00%
Hudson Township	83	13.70%
City of East Jordan	76	6.40%
Boyne Valley Township	72	8.20%
South Arm Township	59	5.50%
Melrose Township	58	6.40%
Marion Township	38	4.20%
Evangeline Township	35	7.40%
City of Charlevoix	34	1.60%
Peaine Township	22	4.00%
Village of Boyne Falls	21	9.70%
Bay Township	17	1.90%
Eveline Township	17	1.20%
Norwood Township	14	2.90%
Chandler Township	10	6.00%
St. James Township	3	0.60%

Source: US Census, 2020 ACS 5-yr Estimates, DP04 Selected Housing Characteristics

Housing Tenure, Table 17, summarizes the status of housing units, whether occupied or vacant, as well as the median housing value of owner-occupied units ($171,000) and the median gross rent ($782). Of the 17,753 total estimated housing units, (66%) are occupied (indicating physically occupied, principal residence housing units), and 34% are categorized as vacant (this includes seasonally-occupied homes). As described previously, Charlevoix County's combined population (full-time residents, part-time residents and overnight visitors) increases by as much as 72% from the minimum monthly population of in April to the greatest monthly population in July.

Table 17: Housing Tenure Estimates, 2020

Charlevoix County Housing Units	17,753	%
Occupied housing units	11,725	66%
Owner-occupied	9,579	82%
Median Housing Value	$171,000	
Renter-occupied	2,146	18%
Median Gross Monthly Rent	$782	
Vacant* housing units	6,028	34%

Source: US Census, 2020 ACS 5-year Estimates, Table DP04 Selected Housing Characteristics
Note: * "Vacant" indicates a non-occupied residence at the time of the survey

Areas of New Development in Charlevoix County
Since the completion of the 2016 Charlevoix County Hazard Mitigation Plan, there have been some areas in the county that have experienced new development or have plans for future new development:

City of East Jordan – sites for redevelopment, per the city's 2020 Master Plan:
- The 64.4 acres of land where the East Jordan Ironworks foundry was located is planned for a multi-use development that would include small, medium and large lot residential development, including workforce housing
- The 1.27 acre former public boat launch site – desired future mixed use development with residential units

City of Boyne City
- Fox Run Manufactured Home Community (49 homes completed; planned for up to 140 home sites); construction began in 2021 and is ongoing.

City of Charlevoix – per the city's 2022 Master Plan:
- Promote infill development to "provide a variety of housing options for a range of incomes, ages, family sizes, and needs" (p. 119)

Boyne Valley Township
- As discussed previously in this plan, between 2010 and 2020 the township grew by 230 persons (a 19.25% increase), which is the most of any jurisdiction in Charlevoix County. Note that this number includes an increase of 64 persons within the Village of Boyne Falls. The number of housing units in the Township also increased between 2010 and 2020, with an addition of 345 housing units (a 41.42% increase). Future housing development is expected within Boyne Mountain Resort property.

Lake Michigan and Inland Lakefront Properties
- In general, infill development of vacant lots or replacement of older houses with larger, new houses has occurred near FEMA-designated flood zones along Lake Michigan, Lake Charlevoix or Walloon Lake.

Economic Profile
The *2021 Comprehensive Economic Development Strategy (CEDS)* prepared by Networks Northwest is the product of a locally-based, regionally-driven economic development planning process to identify strategies for economic prosperity. The plan was prepared for the ten county region of northwest Lower Michigan. Table 18 provides a comparison of annual average wage for each county in the CEDS planning area for 2018. Kalkaska County has the highest average annual wage at $50,971, followed by Grand Traverse County at $44,562. Charlevoix County has the third highest average annual wage at $44,558.

Table 18: Average Annual Wage by County, 2018

County	Average Annual Wage
Antrim	$33,081
Manistee	$33,821
Benzie	$33,908
Missaukee	$35,917
Leelanau	$36,833
Emmet	$40,258
Wexford	$40,586
Charlevoix	**$44,558**
Grand Traverse	$44,562
Kalkaska	$50,971

Source: 2021 Comprehensive Economic Development Strategy (CEDS) prepared by Networks Northwest

The economic profile of Charlevoix County is further described in Table 19. The county's industry makeup is divided into 20 different North American Industry Classification Sectors (NAICS) with associated industry job numbers and annual average wages. The average annual wage in 2018 was $44,558. The industry with the largest number of jobs in 2018 was "manufacturing" with 23.3% of jobs, followed by "accommodation and food services" with 17.3% of jobs, and "health care and social assistance" with 16% of jobs. The industry with the highest annual average wage was "utilities" at $107,000, followed by "manufacturing" at $60,866 and "wholesale trade" at $53,155.

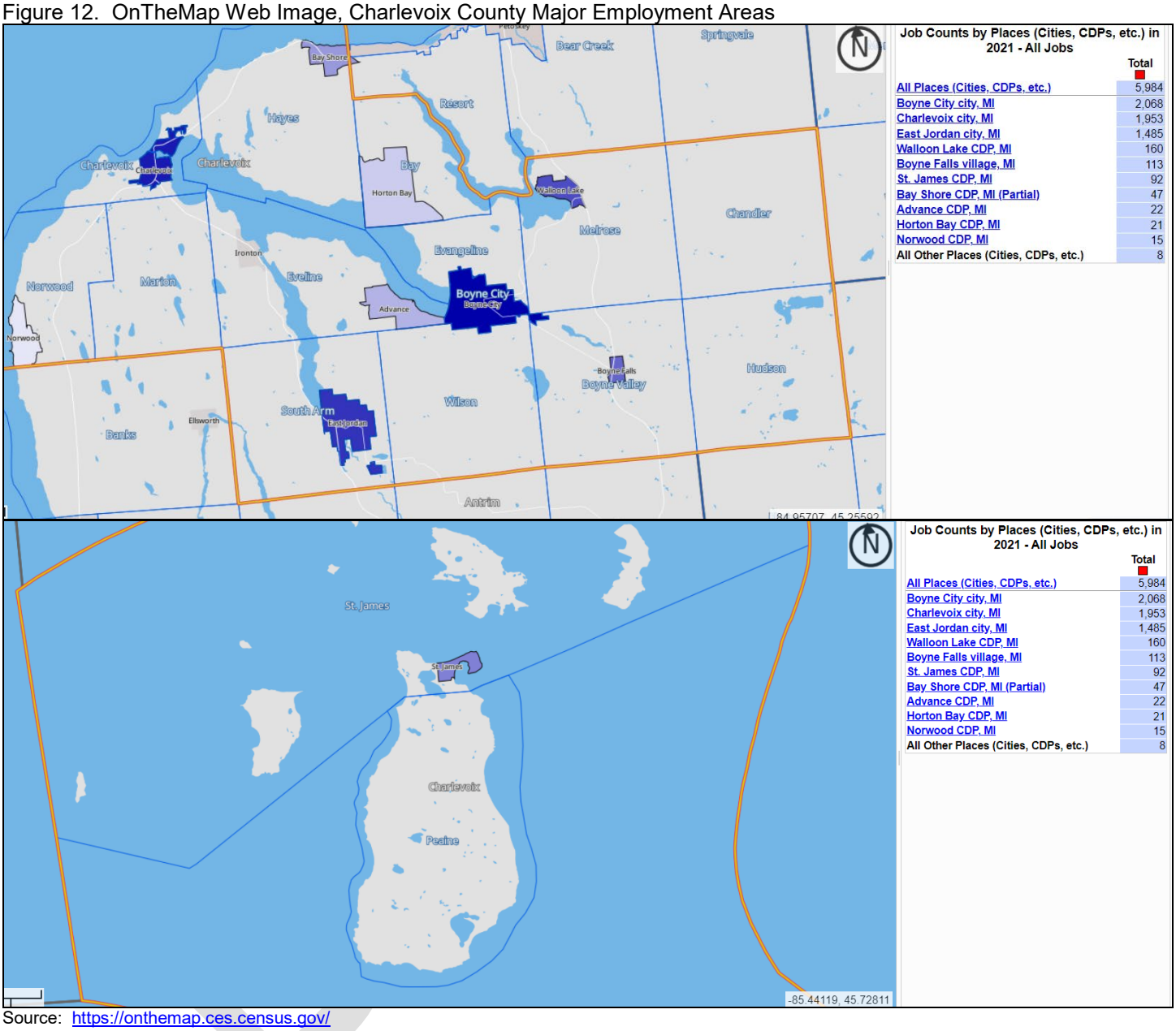
Table 19: Charlevoix County Economic Distribution by Industry, 2018

Industry (NAICS)	Establishments	Jobs	% Distribution of Jobs	Annual Average Wage
Total Covered Employment	782	10,527	100.00%	$44,558
Agri., forestry, hunting	5	D	D	D
Mining	1	D	D	D
Construction	120	646	6.10%	$43,806
Manufacturing	45	2,451	23.30%	$60,866
Wholesale trade	16	53	0.50%	$53,155
Retail trade	114	876	8.30%	$29,009
Transportation, warehousing	17	129	1.20%	$42,443
Utilities	4	147	1.40%	$107,000
Information	13	72	0.70%	$27,706
Finance and Insurance	29	160	1.50%	$47,784
Real Estate, rental, leasing	29	184	1.70%	$27,435
Professional, technical services	44	D	D	D
Administrative, waste services	53	253	2.40%	$33,625
Educational services	11	648	6.20%	$51,753
Health care, social assistance	59	1,687	16.00%	$46,962
Arts, entertainment, recreation	37	266	2.50%	$31,888
Accommodation and food services	79	1,826	17.30%	$27,051
Other services, exc. public admin.	76	305	2.90%	$44,314
Public administration	22	618	5.90%	$41,886
Other (includes private, management of business, and unallocated)	8	206	2.10%	N/A

Source: 2021 Comprehensive Economic Development Strategy, Networks Northwest
**D means limited industries of a sector that would disclose confidential information*

Additionally, OnTheMap, an online interactive tool available from the US Census Bureau, allows for viewing the estimated job density within the county. This website may be useful for emergency preparedness planning as related to response and potential impact to local economic activity areas. It appears the greatest density of jobs are located in the City of Boyne City, City of Charlevoix, City of East Jordan, and the Walloon Lake census-designated place (CDP). The figures below screenshots of the interactive map when completing an area profile analysis for all workers in all jobs in the county in 2021.

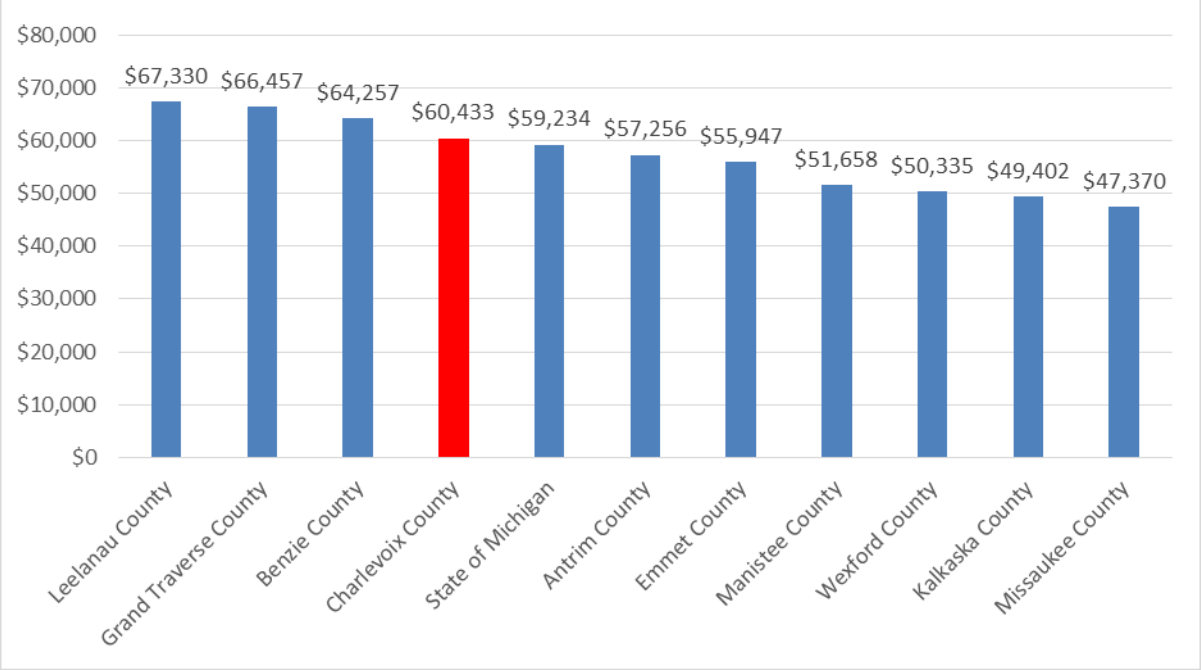
Figure 12. OnTheMap Web Image, Charlevoix County Major Employment Areas



Source: https://onthemap.ces.census.gov/

Figures 13 and Table 20 present a comparison of the median household income (MHI) across the ten county region, the State of Michigan, and local jurisdictions. Charlevoix County has a median household income of $60,433, ranking the fourth highest in the region. Leelanau County has the highest median household income at $67,330. Within Charlevoix County, Eveline Township has the highest MHI at $76,513, and the City of Charlevoix has the lowest MHI at $36,341.

Figure 13. Estimated Median Household Income by County, State, 2020



Source: US Census, 2020 ACS 5-yr Estimates, Table S1901

Table 20. Median Household Income (MHI), Charlevoix County, 2020

Jurisdiction	Median Household Income
City of Charlevoix	$36,341
City of East Jordan	$46,458
Peaine Township	$52,813
Boyne Valley Township	$53,438
City of Boyne City	$55,357
Hudson Township	$56,250
Chandler Township	$58,750
CHARLEVOIX COUNTY	**$60,433**
Charlevoix Township	$62,500
Norwood Township	$63,906
Melrose Township	$64,643
Evangeline Township	$68,500
St. James Township	$68,500
Marion Township	$68,854
South Arm Township	$68,919
Hayes Township	$72,250
Bay Township	$73,869
Wilson Township	$76,000
Eveline Township	$76,513

Source: US Census, 2020 ACS 5-year estimates, Table S2503

The following tables describe the population with the lowest incomes. It is estimated that in 2020, 9.7% of people in the county lived at or below the poverty level (Table 21). The City of Charlevoix had the highest estimated number of persons living below the poverty level in the county at 607 persons, followed by the City of East Jordan, South Arm Township, and the City of Boyne City (Table 22). The highest estimated percentage of a community's population estimated to be living in poverty occurs in the City of Charlevoix at 25.4%, followed by the City of East Jordan and the Village of Boyne Falls. The Census describes poverty thresholds differently based on the size of the family and the number of related children living together, as illustrated in Table 23.

Table 21. Poverty Estimates, Charlevoix County and State of Michigan, 2020

Poverty	Charlevoix County	State of Michigan
Families living below the poverty level	491 (6.4%)	232,432 (9.2%)
Families with related children under age 18, in poverty	343 (12.9%)	172,916 (15.6%)
Persons living below the poverty level	2,493 (9.7%)	1,337,256 (13.7%)

Source: US Census, 2020 ACS 5-yr Estimates, Tables S1701 and S1702

Table 22. Poverty Estimates, Charlevoix County Communities, 2020

Community	Est. Total Population for whom poverty status is determined	Est. # below poverty level	Est. % below poverty level
City of Charlevoix	2,389	607	25.40%
City of East Jordan	2,127	445	20.90%
South Arm Township	1,901	202	10.60%
City of Boyne City	3,686	201	5.50%
Marion Township	1,754	158	9.00%
Eveline Township	1,560	122	7.80%
Melrose Township	1,392	115	8.30%
Hudson Township	730	112	15.30%
Charlevoix Township	1,713	107	6.20%
Boyne Valley Township	1,345	101	7.50%
Hayes Township	1,773	88	5.00%
Bay Township	1,027	63	6.10%
Village of Boyne Falls	335	55	16.40%
Evangeline Township	776	55	7.10%
Chandler Township	255	32	12.50%
Wilson Township	2,089	32	1.50%
Peaine Township	259	29	11.20%
St. James Township	319	13	4.10%
Norwood Township	733	11	1.50%

Source: US Census, 2020 ACS 5-yr Estimates, Table S1701

Table 23. US Census Poverty Thresholds for 2020

Poverty Thresholds for 2020 by Size of Family and Number of Related Children Under 18 Years (in dollars)										
Size of family unit	Weighted average thresholds	Related children under 18 years								
		None	One	Two	Three	Four	Five	Six	Seven	Eight or more
One person (unrelated individual):	13,171									
Under 65 years.....	13,465	13,465								
65 years and over.....	12,413	12,413								
Two people:	16,733									
Householder under 65 years.....	17,413	17,331	17,839							
Householder 65 years and over.....	15,659	15,644	17,771							
Three people.....	20,591	20,244	20,832	20,852						
Four people.....	26,496	26,695	27,131	26,246	26,338					
Five people.....	31,417	32,193	32,661	31,661	30,887	30,414				
Six people.....	35,499	37,027	37,174	36,408	35,674	34,582	33,935			
Seven people.....	40,406	42,605	42,871	41,954	41,314	40,124	38,734	37,210		
Eight people.....	44,755	47,650	48,071	47,205	46,447	45,371	44,006	42,585	42,224	
Nine people or more.....	53,905	57,319	57,597	56,831	56,188	55,132	53,679	52,366	52,040	50,035
Source: U.S. Census Bureau, 2021. Note: The source of the weighted average thresholds is the 2021 Current Population Survey Annual Social and Economic Supplement (CPS ASEC).										

Financial hardship is further described in the United Ways of Michigan report entitled *ALICE in Michigan: A Financial Hardship Study*. ALICE, which is an acronym for "Asset Limited, Income Constrained, Employed", are those households with income above the Federal Poverty Level, but below the basic cost of modern living, such as housing, child care, food, health care, technology and transportation. The ALICE threshold is described as, "*the average income that a household needs to afford the basic necessities… for each county in Michigan. Households earning below the ALICE Threshold include both ALICE and poverty-level households*" (ALICE, 2021). An estimated 27% of all households in the County are considered ALICE, and 9% of households are estimated to live below the poverty level (Table 24). These households likely would not have reserve savings to cover an emergency, such as impacts to their personal property from a hazard event.

Table 24. ALICE and Poverty Households in Charlevoix County

Location	Total Households	Households Below ALICE Threshold	Households in Poverty
St. James Township	148	40 (27%)	Census data not available for households
Peaine Township	153	61 (40%)	
Evangeline Township	294	94 (32%)	
Norwood Township	365	99 (27%)	
Bay Township	479	115 (24%)	
Hudson Township	293	117 (40%)	
Eveline Township	682	184 (27%)	
South Arm Township	773	209 (27%)	
Melrose Township	656	210 (32%)	
Wilson Township	840	227 (27%)	
Boyne Valley Township	591	230 (39%)	
Hayes Township	752	233 (31%)	
Charlevoix Township	797	239 (30%)	
Marion Township	749	255 (34%)	
City of East Jordan	997	479 (48%)	
City of Boyne City	1,827	713 (39%)	
City of Charlevoix	1,277	753 (59%)	
CHARLEVOIX COUNTY	**11,769**	**27% (state average 26%)**	**9% (state average 13%)**

Data Sources: https://www.unitedforalice.org/county-reports/michigan; US Census Bureau 2021 ACS 5-Year Estimates, Table S1701
Note: There is no ALICE data available for Chandler Township

The county's economic profile can be further described by considering the cost of housing, transportation, and other goods and services. The budgeting rule of thumb has been that a household should spend no more than 30 percent of its income on housing costs. According to the 2023 Housing Needs Assessment (produced by Housing North), the greatest rental housing gaps in the county are for the two lowest housing affordability segments (rents below $1,669 that are affordable to households earning up to 80% of AMHI). The study also found that the greatest for-sale housing gap in the county is for product priced between $222,401 and $333,600, which is affordable to households earning between $66,721 and $100,080. Additionally, many renter households are already cost burdened – paying more than 30% of their income toward housing costs (Table 25).

Table 25. Cost Burdened Households in Charlevoix County

Cost Burdened Households – Paying more than 30% of income toward housing costs		Severe Cost Burdened Households – Paying more than 50% of income toward housing costs	
Renter	**Owner**	**Renter**	**Owner**
43.5%	18.6%	17.3%	5.8%

Source: Housing North *2023 Housing Needs Assessment: Charlevoix County Data Summary*

III. Hazard Identification and Assessments

Vulnerability Assessment

Natural hazard impacts on the community can be understood by evaluating vulnerabilities for commonly agreed upon assets. A community's assets are defined broadly to include anything that is important to the character and function of a community and can be described very generally in the following categories:

- People
- Economy
- Built environment
- Natural environment

Vulnerable populations include the economically disadvantaged, elderly, homeless, persons with a disability, and those of a minority race. Those that live unsheltered or in homeless encampments, assisted living facilities, mobile home parks, or isolated subdivisions are more susceptible to natural hazard events. Locations of mobile/manufactured homes and campgrounds/RV parks are represented on the *Vulnerable Populations and Hazard Areas Map* in Appendix A. (There may be other existing locations of vulnerable populations that are not indicated on the map.) The State Equalized Value (SEV) of the approximate area of these properties, based on the US Census Bureau's 2020 ACS 5-year estimates and Charlevoix County Equalization data, is as follows:

- Campgrounds: $_____
- Mobile/Manufactured Homes: $_____

The natural environment is the primary influencing factor for residents choosing to live and vacation in northwest Michigan. Charlevoix County is home to abundant forest lands, inland lakes and streams, unique sand dune areas, Lake Michigan shoreline and all of the wildlife within that are integral to the identity of the community. While natural resources are abundant, they are vulnerable to all types of hazards. Northwest Lower Michigan is also home to many sensitive wildlife populations that require specific climates and habitats to survive. Damaged, destroyed, or changing natural environments may decrease the chances for certain species' survival.

As stated previously, Northwest Michigan receives an influx of seasonal residents in the summer months. According to the 2022 report by Networks Northwest, *Seasonal Population Study for Northwest Lower Michigan*, Charlevoix County's combined population (full-time residents, part-time residents and overnight visitors) increases by as much as 72% (an addition of 24,930 persons) from the minimum monthly population of 34,603 in April to the greatest monthly population of 59,533 in July. In July, the county experiences 33,479 part-time and overnight visitors - a 128% increase from the base population of 26,054. On average, the county's population grows by 61%, or 15,791 people, throughout the year. While the seasonal population changes are integral to the seasonal tourist economy, they also create an increased demand for limited public services and can put pressure on existing infrastructure capabilities.

Broadband, or high-speed internet service, has been limited in rural parts of the county, particularly on Beaver Island. In 2023, Peninsula Fiber Network, a telecommunications carrier, was awarded a $61 million grant to support their "Critical Crossings Project". The plan includes three internet connectivity projects, one of which will be an underwater fiber optic connection between Charlevoix and Beaver Island and into the Upper Peninsula. There are also overland fiber routes to connect Charlevoix to Bellaire and Mancelona (in adjoining Antrim County), Gaylord (in adjoining Otsego County), and continue across the state. The project is expected to be completed before 2028. Currently the only internet connection linking the upper and lower peninsulas of Michigan is located on the Mackinac Bridge, so this new connection will improve local resiliency to ensure reliable communications capabilities.

Infrastructure points (stream crossings, bridge conditions, and dams) and their available condition ratings are shown on the Infrastructure Map in Appendix A. Additionally, locations of critical infrastructure facilities are represented on the Critical Infrastructure Map in Appendix A. Table 26 provides a summary of critical infrastructure facilities in Charlevoix County.

Table 26. Charlevoix County Critical Facilities and Infrastructure

No. of Facilities (TOTAL)	FACILITY TYPE
14	**Agricultural** (farms; food processing, packaging, and production facilities)
23	**Communications** (towers and related structures)
14	**Dams**
31	**Emergency Services** (County Sheriff, County Road Commission, Police, EMS, Fire, Public Works, USCG Station in Charlevoix)
33	**Energy** (Primarily electric and natural gas utility infrastructure)
29	**Government Facilities** (Local Government halls; DPW buildings; County Commission on Aging Service Buildings in East Jordan, Boyne City, Charlevoix Twp. and Beaver I.)
20	**Healthcare** (Medical care service centers and assisted living facilities)
21	**Industry**

30	**Transportation**
	• 6 Airports
	  ○ Beaver Island Airport (scheduled to be rehabilitated in spring of 2026; provides nighttime emergency air transport)
	  ○ Welke Airport (Beaver Island)
	  ○ City of Charlevoix Municipal Airport
	  ○ City of Boyne City Municipal Airport
	  ○ Boyne Mountain Airport
	  ○ East Jordan Municipal Airport
	• 12 Marinas
	  ○ Beaver Island Municipal Marina (St. James Township)
	  ○ City of Charlevoix Marina
	  ○ Northwest Marine Yacht Club (City of Charlevoix)
	  ○ Charlevoix Yacht Club (City of Charlevoix)
	  ○ Harborage Marina (Boyne City)
	  ○ F. Grant Moore Municipal Marina (Boyne City)
	  ○ Somerset Pointe Yacht Club & Marina (Eveline Township)
	  ○ Tommy's (formerly Bay) Marina (Eveline Township)
	  ○ Ironton Cove & Marina (Eveline Township)
	  ○ Bear Cove Marina (Bay Township)
	  ○ City of East Jordan Municipal Marina
	  ○ S. Arm Marina and Gas Docks (South Arm Township)
	• US-31 bascule bridge in the City of Charlevoix
	• Road Commission buildings, Beaver Island Boat Co. ferry service docks, Charlevoix pier lighthouse, Ironton Ferry and stone dock, County Transit service and Indian Trails bus service.

45	**Water and Sewer Infrastructure** (municipal water wells, lift stations, water treatment plants, and wastewater treatment plants)

Source: Charlevoix County Emergency Management

Historical Analysis

The Historical Analysis of hazards in Charlevoix County uses information on impacts and losses from previous hazard events to predict potential impacts and losses during a similar event. Because of the frequency of these events, communities are more likely to have experience with and data on impacts and losses. There have been seven incidents involving a federal or state declaration of an emergency or disaster affecting Charlevoix County (Table 27; red, bold text). These events are also included in the hazard analysis for individual event types.

Table 27. Presidential and Governor Declared Disasters or Emergencies for Charlevoix County

Date of Incident	Type of Incident	Affected Area	(P)residential Declaration* / Federal ID Number** or State of Emergency (G)overnor's Declaration***
3/13/2020, 3/27/2020 Ended 5/11/2023	Pandemic	**Statewide**; Nationwide	(P) Emergency (3455) (P) Major Disaster (4494) (G) Emergency
1/29/2019	Extreme Cold	**Statewide**	(G) Emergency
2/13/2014	Deep Frost	**Charlevoix**, Cheboygan, Chippewa, Delta, Emmet, Gogebic, Luce, Mackinac, and Marquette Co.	(G) Emergency
9/7/2005	Hurricane evacuation	**Statewide**	(P) Emergency (3225)
9/4/2005			(G) Disaster
12/1993 to 05/1994	Underground Freeze	10 counties: **Charlevoix**, Cheboygan, Chippewa, Delta, Gogebic, Houghton, Mackinac, Marquette, Ontonagon, and Schoolcraft Co.	(P) Major Disaster (1028)
3/10/94 3/4/94 2/23/94, 2/25/94		**Charlevoix**, Cheboygan, Chippewa, Delta, Gogebic, Houghton, Mackinac, Marquette, Ontonagon, and Schoolcraft Co.	(G) Emergency
1/26-27/1978	Blizzard, snowstorm	**Statewide**	(P) Emergency (3057); (G) Disaster
3/2/1977	Drought	44 counties: Alcona, Alger, Alpena, Antrim, Arenac, Baraga, Benzie, **Charlevoix**, Cheboygan, Chippewa, Clare, Crawford, Delta, Dickinson, Emmet, Gladwin, Gogebic, Grand Traverse, Houghton, Iosco, Iron, Isabella, Kalkaska, Lake, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Mecosta, Menominee, Missaukee, Montmorency, Oceana, Ogemaw, Ontonagon, Osceola, Oscoda, Otsego, Presque Isle, Roscommon, Schoolcraft, and Wexford Co.	(P) Emergency (3035)

Notes

***Does not include separate Secretary of Agriculture or Small Business Administration (SBA) disaster declarations, which are issued under other authorities. Declarations after 1974 were issued under PL 93-288 (Disaster Relief Act), as amended by the Robert T. Stafford Disaster Relief and Emergency Assistance Act (1988) and the Disaster Mitigation Act (2000).**

****Indicates federal declaration number assigned by FEMA or its predecessor agencies**

*****Declarations since 1977 were issued under 1976 PA 390, as amended (Michigan Emergency Management Act).**

Sources: Sources: FEMA https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties and Michigan State Police 2019 Michigan Hazard Analysis (MHA) pub. 103

Hazard Descriptions

Charlevoix County is vulnerable to a wide range of natural hazards. Hazard events have the potential to impact community residents and visitors, economic drivers in the community, critical infrastructure, the built environment, and the natural environment. Charlevoix County Emergency Management is challenged with managing these threats to protect life and property. This plan includes a profile for each hazard event the County is likely to face. Each profile includes the location, extent, previous occurrences, probability of future events, and a vulnerability assessment.

- **Location** is the geographic areas within the planning area that are affected by the hazard, such as a floodplain. The entire planning area may be uniformly affected by some hazards, such as drought or winter storm. Location may be described in narrative and or through map illustrations.
- **Extent** is the strength or magnitude of the hazard. Extent can be described in a combination of ways depending on the hazard.
- **Previous occurrences** describe the history of previous hazard events within the county. This information helps to estimate the likelihood of future events and predict potential impacts. The extent of historic events may be included when the data is available. Data is primarily collected from the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) Storm Events Database.
- **Probability of future events** is the likelihood of the hazard occurring in the future based on previous event occurrences and any trends that may appear. Probability may be defined using historical frequencies or statistical probabilities.
- **Vulnerability assessment** accounts for the type, amount, and value of assets such as: existing and future buildings, infrastructure, critical facilities, populations, recreation areas and environmental features that may be impacted by a hazard, along with existing community assets to mitigate or respond to the hazard.

Data for hazard events in Charlevoix County was compiled from several different sources. Weather event data was collected primarily from the National Centers for Environmental Information through the National Oceanic and Atmospheric Administration's (NOAA) website. All data sources include:

- **FEMA's webpage on Disaster Declarations for States and Counties** was referenced for the most up-to-date data on Presidential- and Governor-Declared emergencies and disasters (Table __)

- **Climate** https://www.weather.gov/wrh/Climate?wfo=apx – Historical local observed weather data; Climate prediction and variability; local high impact event summaries

- **Past Severe Weather Events - NOAA Storm Event Database** https://www.ncdc.noaa.gov/stormevents/ Data available to search beginning in 1950 to within 3 months from present day; however, information for various events is limited and non-contiguous. The database provides local storm reports, damage reports, and recorded event descriptions. The event types researched for Charlevoix County include the following (the event types in italics are as these types of events are listed in the Storm Events Database):
    - Dangerous Currents (i.e., *Rip Current*)
    - Dense Fog (*Dense Fog*)
    - Drought (*Drought*)
    - Extreme Temperatures (*Cold/Wind Chill, Extreme Cold/Wind Chill, Heat, Excessive Heat)*
    - Extreme Winter Weather (*Blizzard, Freezing Fog, Frost/Freeze, Heavy Snow, Ice Storm, Lake-Effect Snow, Sleet, Winter Storm, Winter Weather*)
    - Flooding *(Flash Flood, Flood*)
    - Hail (*Hail*)
    - Seiche (Seiche)
    - Shoreline Flood (*Lakeshore Flood*)
    - Thunderstorm and High Wind (*Heavy Rain, Lightning, High Wind, Strong Wind, Thunderstorm Wind*)
    - Tornado (*Tornado, Funnel Cloud, Waterspout*)
    - Wildfire (*Wildfire*)

- **Wildfires -** The *Michigan Hazard Analysis*, completed by the Michigan State Police in 2019, was referenced to collect data on wildfires that occurred on State-owned land between 1981 and 2018 (as reported by the MDNR).

- **Dams** - The websites for the National Inventory of Dams and MI-EGLE's Michigan Dam Inventory were used to collect information on dams in the county.

- **Dangerous Currents** - The National Weather Service's Great Lakes Beach Hazards Incident Statistics indicates current-related fatalities and rescues on the Great Lakes from 2002 to 2020.
- **Drought** - Historical local observed drought data was obtained from the US Drought Monitor.
- **Space Weather/Electromagnetic Pulses** - MSP *2019 Michigan Hazard Analysis*
- **Public Health Emergency** – Michigan Department of Health and Human Services; MSP *2019 Michigan Hazard Analysis*

The NOAA NCEI Storm Events Database is updated on a rolling basis, and thus is always being added to. Thus, additional events will be added in future updates of this Natural Hazards Mitigation Plan. The database indicates that 248 events were reported between 01/01/1950 and 8/31/2023 (26,906 days). There were a total of 225 days with an event, 32 days with an event and property damage, and 1 day with an event and crop damage. No injuries or deaths were recorded with these events. Those events as well as the emergency/disaster declaration events are included in the hazard analysis. It is important to note when viewing the data that most of the events were recorded after the mid-1990's, even though the available search range dates back to 1950. Those events, as well as emergency declaration events, are included in the hazard analysis. The hazard analysis groups the events into categories as shown in Table 28.

Table 28: Charlevoix County Hazard Events by Type, Location, and Year

Type of Event	# of Events	Event Location	Years Event Recorded
Wildfire	173	MDNR Lands	1981-2018
Extreme Winter Weather (i.e. Ice storm, Heavy Snow, Blizzard)	149	Countywide	*1978, 1996-2019, 2021-2023
Thunderstorm/Wind and High Wind	51	Countywide	1962, 1971, 1982, 1985, 1988, 1991, 1996, 1998-2007, 2009-2011, 2013, 2015-2018, 2020-2021
Hail	34	Countywide	1962, 1963, 1985, 1996-1998, 2000, 2002-2004, 2007, 2008, 2011-2014, 2016, 2017
Extreme Temperatures (Heat / Cold)	2 / 5	Countywide	2001, 2018 / 1994*, 2007, 2014*, 2015, *2019
Tornado	4	Boyne Valley Township, Wilson Township, City of Boyne City	1955, 1977, 1989, 2002
Lakeshore Flood	3	Lake MI Coastal Communities; along the shores of Lake Charlevoix	10/21/2019, 4/13/2020, 11/15/2020
Drought	3	Countywide	*1977, 2007 (2)
Riverine and Urban Flooding (Flash Flood)	1	City of Charlevoix	6/18/2012
Lightning	1	Countywide	2000
Public Health Emergency	1	Statewide/Nationwide	*2020
Dense Fog	0	Countywide	
Lake MI Shoreline Hazards (Waterspout, Seiche, Dangerous Current)	0	Norwood, Charlevoix, Hayes, Bay, St. James and Peaine Townships; City of Charlevoix	
Space Weather/EMPs	0	County / Region	
Invasive Species	-	Countywide	Ongoing

Sources: NOAA National Centers for Environmental Information Storm Events Database; MDNR; USFS/USDA; Michigan State Police-Dept. of Homeland Security; FEMA; NWS Great Lakes Beach Hazards Incident Statistics. Note: * indicates a state or federal declaration of an emergency or disaster

Economic Impact Analysis

Table 29 presents the *reported* deaths, injuries/rescues/illnesses, property damages, and crop damages from hazard events in Charlevoix County from 1950-2023. There have been 76 deaths and 6,091 illnesses, which were related to the COVID-19 pandemic. The economic impact of NOAA-recorded hazard events for Charlevoix County is $903,000 in property damages and $7,500,000 in crop damages. It should be noted that many events likely cause numerous small amounts of property damage, but these often go unreported.

Table 29. Extent of Damage by Event Type, Charlevoix County

Event	Deaths	Rescue, Injury/ or Illness	Property Damages	Crop Damages
Extreme Winter Weather	0	0	$295,000	$7,500,000
Thunderstorm and High Wind	0	0	$323,000	$0
Lakeshore Flooding and Erosion	0	0	$235,000	$0
Hail	0	0	$45,000	$0
Tornado	0	0	$3,000	$0
Riverine and Urban Flooding	0	0	$2,000	$0
Extreme Temperatures (Heat or Cold)	0	0	$0	$0
Lightning	0	0	$0	$0
Drought	0	0	$0	$0
Wildfire	0	0	$0	$0
Waterspout, Seiche, or Dangerous Currents	0	0	$0	$0
Dense Fog	0	0	$0	$0
Public Health Emergency (COVID-19 Pandemic)	*76	*6,091	N/A	N/A
Space Weather	0	0	$0	$0
Invasive Species	N/A	N/A	N/A	N/A
TOTAL	**76**	**6,091**	**$903,000**	**$7,500,000**

Sources: NOAA's National Centers for Environmental Information; NWS Great Lakes Beach Hazards Incident Statistics; *State of Michigan https://www.michigan.gov/coronavirus/stats reported confirmed and probable cases and deaths and cases attributed to COVID-19 as of 11/14/2023.

Table 30 provides an overview of each potential hazard's estimated impact on the State Equalized Values (SEV) for real and personal property (residential and commercial). SEV is equal to half the true value of the property. Population data is collected from the US Census, 2019 ACS data. According to the 2022 report, *Seasonal Population Study for Northwest Lower Michigan*, assume a 119% increase to account for the highest estimated annual average seasonal population within the county (which occurs in August).

Table 30. Hazard Impacts by Location (referencing Hazard Areas and Vulnerable Population Map in Appendix A)

Hazard Event	Location	Population Totals	State Equalized Value
Extreme Winter Weather, Thunderstorm, Hail, Lightning, Tornado, Extreme Temperatures, Dense Fog, Invasive Species, Space Weather, Pandemic, Drought	Countywide		
Inland Flooding	Jordan River communities (City of East Jordan, South arm Township); Six Mile Lake area (South Arm Township); Boyne River communities (Boyne Valley Township, Boyne Falls Village City of Boyne City); urbanized areas (City of Boyne City, City of Charlevoix, City of East Jordan); various areas throughout the county where road/water crossings need infrastructure upgrades		
Shoreline Flooding and Erosion	Communities adjoining Lake Michigan, Lake Charlevoix, and Walloon Lake (all communities except Chandler, Hudson, Wilson, and Boyne Valley Townships and Boyne Falls Village)		
Waterspout, Seiche or Dangerous Currents	Hayes, Charlevoix, Norwood, St. James and Peaine Townships; City of Charlevoix		
Wildfire	Wildfire concern areas: orchards in Norwood, Marion and Eveline Townships; various parts of Peaine Township on Beaver Island		
	Pine forest areas (White, Red and Jack Pine) – scattered in various areas throughout every community except City of Charlevoix.		
Tornado, High Wind, Thunderstorm/Wind, Hail, Lightning, Extreme Temps, Wildfire, Flooding	Campgrounds: City of East Jordan; the Townships of Boyne Valley Township, Marion, Evangeline, Eveline, Norwood, Charlevoix, Chandler, South Arm, St. James, and Peaine.		
Tornado, High Wind, Thunderstorm/Wind, Hail, Heavy Snow	Mobile/Manufactured Home Communities: Charlevoix Township, Hayes Township, City of Boyne City, Village of Boyne Falls, City of East Jordan		

Sources: 2020 ACS 5-year Estimates; Charlevoix County Equalization

Extreme Winter Weather

The National Weather Service defines a winter weather event as: *a winter weather phenomenon (such as snow, sleet, ice, wind chill) that impacts public safety, transportation, and/or commerce. It typically occurs during the climatological winter season between October 15 and April 15.* The Extreme Winter Weather category in this Plan's hazard analysis includes the following subcategories: winter weather, winter storm, ice storm, heavy snow, blizzard, frost/freeze, and lake effect snow. Blizzards are the most perilous snowstorms and are characterized by low temperatures, strong winds, and enormous amounts of fine, powdery snow. Snowstorms have the potential to reduce visibility, cause property damage, and loss of life.

According to the 2019 Michigan Hazard Analysis, the 29 counties of the Northern Lower Peninsula of Michigan have an annual average of 79 snowstorm events, with 0 average annual deaths or injuries, $6.53 million in average annual property damage and $20 million in crop damage. Michigan experiences large differences in snowfall over short distances due to the Great Lakes. The average annual snowfall accumulation ranges from 30 to 200 inches with the highest accumulations in the northern and western parts of the Upper Peninsula. In Lower Michigan, the highest snowfall accumulations occur near Lake Michigan and in the higher elevations of northern Lower Michigan. For example, the average snowfall ranges from 141 inches in the Gaylord area to 101 inches in Traverse City.

Ice and sleet storms generate sufficient quantities of ice or sleet that result in hazardous conditions and/or property damage. Ice storms occur when cold rain freezes on contact with the surface and coats the ground, trees, buildings, and overhead wires with ice. Ice storms are often accompanied by snowfall, which can cause property damage, treacherous conditions, and power loss. When electric lines are down, households are inconvenienced, and communities experience economic loss and the disruption of essential services. Conversely, sleet storms are small ice pellets that bounce when hitting the ground or other objects. The ice pellets do not stick to objects, but can cause hazardous driving conditions.

According to the 2019 Michigan Hazard Mitigation Plan, Michigan has 16 average annual ice and sleet storm events with 0.2 average annual deaths, 0.5 average annual injuries, and $11.4 million in average annual property and crop damage.

Location
Extreme winter weather events are regional events that are not confined to geographic boundaries and can affect several areas at one time with varying severity depending on factors such as elevation and wind patterns. All of Charlevoix County is at risk to the occurrence and impacts from extreme winter weather. The coastal communities are more susceptible to lake-effect snow due to proximity to Lake Michigan.

Extent
Snowstorms can be measured based on snowfall accumulations or damages. The average annual snowfall in Charlevoix County varies depending on location according to NOAA's Online Weather data: Beaver Island, 75.1"; City of Charlevoix 88.6"; Village of Boyne Falls, 109.1"; South Arm Township (2 miles north of the City of East Jordan), 117.9"; City of East Jordan, 124.2". Extreme winter weather events in total caused $295,000 in property damages and $7,500,000 in crop damages between 1996 and 2023 (Table 31). Extreme winter weather events have the highest amount of monetary damages on record compared to any other hazard event in Charlevoix County.

Table 31. Extreme Winter Weather Events and Impacts, Charlevoix County

Event Type	Number of Events	Property Damage	Crop Damage	Event Year(s)
Winter Weather	1	$ -	$ -	2006
Frost/Freeze	1	$ -	$ 7,500,000	4/27/2012
Ice Storm	3	$ -	$ -	2001, 2005, 2008
Blizzard	7	$ -	$ -	1978, 1997-1999, 2002, 2019, 2022
Lake-Effect Snow	22	$ -	$ -	2006-2014, 2016
Heavy Snow	50	$ 250,000 (3/2/2012)	$ -	1996-2009, 2012, 2014, 2016, 2018
Winter Storm	65	$ 45,000 (11/27/2007)	$ -	1996-1998, 2000-2010, 2012-2019, 2021-2023
TOTAL	**149**	**$ 295,000**	**$ 7,500,000**	

Source: NOAA: National Centers for Environmental Information; Michigan State Police 2019 *Michigan Hazard Analysis*

Previous Occurrences
Since 1996, there have been 148 extreme winter weather events reported for Charlevoix County, which include heavy snow, ice storms, frost/freeze, blizzard, lake-effect snow winter storm and winter weather events (Table 31). Additionally, in 1978, Charlevoix County, along with the rest of the state of Michigan, received a Presidential Emergency Declaration for a snowstorm and blizzard. In recent years, the more common events are winter storms with moderate snowfall of 5-10 inches. Heavy snow, blizzards, and lake-effect snows have been less common. Nonetheless, extreme winter weather events are the most frequently recorded extreme weather event with the potential to impact the entire county and cause widespread damage.

One of the highest-impact snowstorms in recent memory pounded Northern Michigan on the night of March 2, 2012. Low pressure tracked from Missouri, to southern Lower Michigan, and on to eastern Canada, while rapidly strengthening. Precipitation surged northward into the region on the evening of the 2nd. This was primarily snow, except in parts of east central Lower Michigan (especially near Lake Huron), where temperatures were mild enough for rain. Snow wound down on the morning of the 3rd, and though somewhat blustery winds occurred behind the system on the 3rd, blowing snow was limited because the snowfall was so wet. Snow totals ranged from 6 to 14 inches across most of Northern Michigan. Higher amounts fell near and west of Grand Traverse Bay, with a maximum amount of 20 inches near Lake Ann. With relatively warm temperatures, the snow was very wet; Traverse City saw around a foot of snow during the night, with a low temperature of 33 degrees. The snow stuck to everything, with the weight of the snow downing many, many trees and power lines. Power outages were widespread, with an outright majority of Northern Michigan residents losing power at some time during or after the storm. In Benzie County, 95 percent of residents lost power. Outages lasted up to a week in some spots. Great Lakes Energy described it as the worst snowstorm (in regards to power outages) in 30 years. A number of counties and communities opened shelters to aid those without power or heat. Also included in the tree damage was substantial damage to fruit trees in the Grand Traverse Bay region, particularly cherry trees. This event accounts for $250,000 in reported damages in Charlevoix County.

The frost/freeze event on listed in Table 31 took place on April 27, 2012 across Northwest Lower Michigan. A killing freeze caused extreme damage to agriculture, particularly in the fruit belt of Northwest Lower Michigan. Traverse City saw low temperatures of 25 degrees on the 27th, 31 degrees on the 28th, and 26 degrees on the 29th. These values were not exceptionally colder than normal lows, which are in the middle 30s. Ultimately, the main culprit was a stretch of unprecedented warmth in mid-March, which included five consecutive 80-degree days (17th-21st). This caused fruit trees to bud out far, far ahead of schedule, and left them vulnerable to even relatively normal weather as the spring progressed. The tart cherry crop was a total loss, while other orchard fruits such as sweet cherries, apples, pears, and peaches saw losses in excess of 90% of the expected crop. This event accounts for $1.7 million in crop damage in Charlevoix County.

The winter storm event on November 17, 2007 was the result of a clipper low pressure system that rapidly intensified in northwest Lower Michigan. Lake effect snow and very strong winds developed after a cold front passed on the morning of the 27th. Charlevoix and Pellston both measured wind gusts around 60 mph by midday. Some trees and power lines were downed as a result. One building in Boyne City was significantly damaged by a falling tree. Snowfall in the snowbelts was generally two inches or less. However, a narrow band of about four inches fell from Norwood to Grayling. The snow and gusty winds combined to produce near blizzard conditions at times. This event accounts for $45,000 in property damages in Charlevoix County.

Probability of Future Events and Vulnerability Assessment
Between 1996 and 2023, Charlevoix County has had 148 extreme winter weather events. This averages to about 5.3 events every year. Therefore the probability of an event occurring in future years is 100 percent. Severe winter weather events have the potential of shutting down electric service and transportation routes in towns and businesses for a significant period of time. Air travel (the primary transportation method on and off the island in the winter) to Beaver Island is also limited or impossible during extreme winter weather events. Blowing and drifting snow with blizzard conditions cause driving hazards. Ice damage may occur when high winds push lake water and ice past the shoreline, causing damage to public infrastructure and residential property. The agriculture industry in the county is vulnerable to unseasonable temperature fluctuations and ice storms.

Beaver Island's electric infrastructure is capable of operating entirely on generated power. In other words, in the case of emergencies, the Island's backup generators will power the Island. Great Lakes Energy (GLE) conducts assessments of its infrastructure every three years to determine where equipment may need to be upgraded. GLE may be making upgrades to the generator plant on the Island in the next five years to ensure that backup generated power is as reliable as possible. This would be a positive improvement for the Island, especially as the number of extreme storms are expected to increase in northern Michigan, increasing the risk for power outages.

The electric service providers in Charlevoix County (Great Lakes Energy, Consumers Energy, and the City of Charlevoix) maintain the vegetation near their power lines by performing regular trimming of vegetation and yearly inspections for dead trees and other hazards. Additionally, GLE has a full-time employee on Beaver Island to provide immediate service. While the west side of the Island has buried electric service lines, the east side of the Island has overhead lines that remain sensitive to disruptions due to high wind and heavy snow/ice storms. Property owners and the townships of Peaine and St. James should work with GLE to bury lines.

During the winter months, the population is largely made up of the base permanent residents. However, there is increasing demand from seasonal residents to purchase property and retire or work remotely from highly desirable northern and coastal communities like those in Charlevoix County. New residents, especially those locating in remote areas, increase the chance of risk to life and property. Winter-related events cause difficult driving conditions and in the event of an emergency, can make travel increasingly difficult for emergency personnel who may be more frequently dispatched to rural areas. During severe winter weather events, persons most vulnerable in Charlevoix County include elderly persons; persons living at or below the poverty level; members who live in remote rural areas; those with limited access to technology including cellular phone service and broadband internet; and those without access to an emergency power source.

Thunderstorms and Severe Winds

The National Weather Service defines a severe thunderstorm as: *a thunderstorm that produces a tornado, winds of at least 58 mph (50 knots or ~93 km/h), and/or hail at least 1" in diameter.* These storms can also produce lightning or heavy rain (that could cause flash flooding). Severe thunderstorms can occur at any time in Michigan, although they are most frequent during the warm spring and summer months from May through September.

High wind events are also included in this hazard category. Long-lived wind events associated with fast-moving severe thunderstorms are known as a *derecho* (pronounced similar to "deh-REY-cho"). According to the National Weather Service, a derecho is a widespread, long-lived wind storm that is associated with a band of rapidly moving showers or thunderstorms. Although a derecho can produce destruction similar to the strength of tornadoes, the damage typically is directed in one direction along a relatively straight swath. As a result, the term "*straight-line wind damage*" sometimes is used to describe derecho damage. By definition, if the wind damage swath extends more than 240 miles (about 400 kilometers) and includes wind gusts of at least 58 mph (93 km/h) or greater along most of its length, then the event may be classified as a derecho. A derecho often occurs during the spring or summer; however, it can occur any time of the year.

Location
Thunderstorms and severe wind are regional events that are not confined to geographic boundaries and can affect several areas at one time with varying severity depending on factors such as elevation and wind patterns. All of Charlevoix County is at risk to the occurrence and impacts from thunderstorms and severe winds.

Extent
Thunderstorms can be measured based on wind speed or damages. The average wind speed for thunderstorm/wind and high wind events in Charlevoix County is 50 knots. There is $323,000 in property damages and no crop damages associated with these events on record with NOAA for Charlevoix County.

Previous Occurrences
Between the years 1962 and 2023, there have been 51 thunderstorm/wind or high wind events reported in Charlevoix County (Table 32). This is the second-most frequently occurring type of severe weather event in the county.

The event narratives on record with NOAA indicate that many of the storm and wind events uprooted trees, caused power outages from damaged power lines, and caused some structural or vehicle damages.

Table 32. Thunderstorm and Wind Events Previous Occurrences, Charlevoix County

Event Type	Number of Events	Deaths	Property Damage	Crop Damage	Event Year(s)
Thunderstorm/ Wind	40	0	$224,000	$ -	1962, 1971, 1982, 1985, 1988, 1991, 1996, 1998-99, 2001-07, 2011, 2013, 2016-18, 2020-21
High Wind	11	0	$99,000	$ -	1998, 2000, 2001, 2003, 2005, 2009, 2010, 2015, 2021
TOTAL	**51**	**0**	**$323,000**	**$ 0**	

Source: NOAA: National Centers for Environmental Information

In addition, while not a NOAA recorded storm event, the St. James Township Supervisor indicated that during a wind storm in November 2022, the overhead electric lines were downed between the Beaver Island GLE electrical distribution station and the landward point of entry of the lines at Lake Michigan. This resulted in a two day power outage of the buried electrical system on the island, and three days outage for the damaged aerial system.

Probability of Future Events and Vulnerability Assessment
Between the years 1982 and 2023[4], there have been 49 thunderstorm/wind or high wind events reported in Charlevoix County. This averages to 1.2 events per year; therefore the probability of an event occurring in a future year is 100 percent. Damage from straight line winds usually affects multiple counties with the loss of electricity from trees/tree limbs downing power lines; widespread property damage; and potentially exposing people to severe injury or fatality due to flying debris. The magnitude of the impact of thunderstorm/wind and high wind events depends on the seasonal population, seasonal activities, and the spread of development.

[4] The events for the years 1962 and 1971 were excluded from the probability analysis due to the large temporal gap between the remaining events on record.

Beaver Island's electric infrastructure is capable of operating entirely on generated power. In other words, in the case of emergencies, the Island's backup generators will power the Island. Great Lakes Energy (GLE) conducts assessments of its infrastructure every three years to determine where equipment may need to be upgraded. GLE may be making upgrades to the generator plant on the Island in the next five years to ensure that backup generated power is as reliable as possible. This would be a positive improvement for the Island, especially as the number of extreme storms are expected to increase in northern Michigan, increasing the risk for power outages.

The electric service providers in Charlevoix County (Great Lakes Energy, Consumers Energy, and the City of Charlevoix) maintain the vegetation near their power lines by performing regular trimming of vegetation and yearly inspections for dead trees and other hazards. Additionally, GLE has a full-time employee on Beaver Island to provide immediate service. While the west side of the Island has buried electric service lines, the east side of the Island has overhead lines that remain sensitive to disruptions due to high wind and ice storms. Property owners and the townships of Peaine and St. James should work with GLE to bury lines.

During the warm or summer months, the area's population expands to include both the permanent population and visitors. Residents and visitors are attracted to both rural, sparsely populated rural areas and urbanized areas (particularly for annual special events; see Table 34. Mobile home communities, and campgrounds, and numerous annual special events that draw a large number of tourists to outdoor recreation areas were identified as specific areas of vulnerability (see Tables 33).

Thunderstorms can appear quickly and cause significant damage. Aside from the cities of Boyne City, Charlevoix and East Jordan, the county's population is geographically spread out and notifying them of tornado warnings or watches can be difficult. Severe thunderstorm/high wind alerts are provided to the public via the BeAlert notification system, television and radio announcements. The efficacy of the BeAlert system is limited due to the sign up process, as citizens must request to be added to the alert system.

Table 33. Campgrounds and Mobile/Manufactured Home Communities in Charlevoix County

Community	Campground	Mobile/ Manufactured Home Areas
Boyne Valley Township	Boyne Country RV Park and Campground	
	Lost Woods Farm & Forest Eco-Resort	
Chandler Township	Chandler Hill Campground	
Charlevoix Township	Fisherman's Island State Park (north campground – 45 sites)	Charlevoix Estates Lake Terrace
City of Boyne City		Lakeview Village Fox Run
City of East Jordan	Tourist Park	4 areas throughout the city
Evangeline Township	Young State Park	
Eveline Township	Whiting Park	
Hayes Township		Lake Michigan Heights
Marion Township	Church of God Family Camp	
Norwood Township	Fisherman's Island State Park (south campground – 45 sites)	
Peaine Township	Beaver Island Hideaway Campground Beaver Island Retreat Bill Wagner Memorial Campground	
St. James Township	St. James Twp. Campground Port St. James Stable Campground (in Port of St. James Association)	
South Arm Township	Six Mile Lake Campground Chain of Lakes Camp	
Village of Boyne Falls		One area in the village

Table 34. Annual Major Special Events in Charlevoix County

Location	Event	Typical Dates of Event
Beaver Island	Bike Festival	Last weekend in June
	Independence Day Parade; Independence weekend fireworks and Boat Parade	4th of July holiday
	Irish Festival	The Friday/Saturday after Labor Day in September
City of Boyne City	Mushroom Festival	Mid-May
	4th of July Festival/Fireworks	4th of July Holiday
	Boyne Thunder Powerboat Poker Run	Second Friday/Saturday in July
Village of Boyne Falls/Boyne Valley Township	Polish Festival	1st weekend in August
	Boyne USA Events	Year-round
City of Charlevoix, Charlevoix Twp., and Hayes Twp.	Charlevoix Marathon (running race on Little Traverse Wheelway and local roads)	3rd Saturday in June
City of Boyne City, Wilson Twp., South Arm Twp., City of East Jordan	Michigan Mountain Mayhem (Bicycle Road Race)	3rd Saturday in June
City of Charlevoix	Boyne Thunder Powerboat Poker Run	Second Friday/Saturday in July
	Venetian Festival	A week in mid-late July
	Art Fair	2nd Saturday in August
	Apple Fest	2nd weekend in October
City of East Jordan	Freedom Festival	5 days in mid- to late- June
Melrose Township	Walloon Lake 4th of July Celebration and Fireworks	Around the 4th of July
	Northern Michigan Antique Flywheelers Show	4 days- the last weekend in July

Hail

Hailstorms occur when a severe thunderstorm produces hail that falls to the ground. Hail is formed when the updrafts of the storm carries water droplets above the freezing level, where they form into rounded or irregular lumps of ice that range from the size of a pea to the size of a grapefruit. When the weight of the hail is no longer supported by the air, it falls to the ground and has the potential to batter crops, dent automobiles, and injure people and wildlife. Sometimes, large hail appears before a tornado since it is formed in the area of a thunderstorm that tornadoes are most likely to form.

According to the 2019 Michigan Hazard Mitigation Plan, Michigan has on average 191 hail storms, an expected annual statewide loss of about $16.6 million, no deaths, and approximately 1 injury per year. Despite damaging hail occurring in every part of Michigan, the areas of the state most prone to severe thunderstorms (e.g. the Southern half of the Lower Peninsula) are also most prone to large and damaging hail. The majority of the hailstorms occur during the growing season from May through August when crops have the greatest potential to be damaged by hail.

According to the 2012 Michigan Hazard Analysis, the National Weather Service began recording hail activity in Michigan in 1967. The National Weather Service issues forecasts for severe thunderstorms with sufficient warning time to allow residents to take appropriate action to reduce the effects of hail damage to vehicles and some property. However, little can be done to prevent damage to crops. For example, during September 26-27, 1998, a line of severe thunderstorms moved across northern Lower Michigan producing hail up to 2” in diameter, destroying an estimated 30,000-35,000 bushels of apples at area farms, and damaging several homes and vehicles.

Location
Hailstorms are regional events that frequently accompany thunderstorms, and are not confined to geographic boundaries. The severity of hailstorms may range across the affected areas. All of Charlevoix County is at risk to the occurrence and impacts from hailstorms. According to the National Weather Service, Charlevoix County is in an area of the United States that has on average two days of hailstorm events per year.

Extent
The description of hail is based on its approximate size, as described as follows in Table 35. If a thunderstorm produces hail that is 1 inch in diameter (quarter size) or larger, it is considered to be a severe thunderstorm.

Table 35. NOAA Hail Size Description

Appearance	Approximate Size in Inches
Pea	0.25-0.5 inch
Penny	0.75 inch
Nickel	0.88 inch
Quarter	1.00 inch
Walnut/Ping Pong	1.50 inch
Golf Ball	1.75 inch
Hen Egg	2.00 inch
Tennis Ball	2.50 inch
Baseball	2.75 inch
Tea Cup	3.00 inch
Grapefruit	4.00 inch
Softball	4.50 inch

Hail can damage aircraft, homes and cars, and can be deadly to livestock and people. Hailstorms have caused no deaths or injuries, no recorded crop damages, and $45,000 in property damages in Charlevoix County. The greatest extent hail reported in Charlevoix County was 3 inches on July 8, 2016 in East Jordan, causing $45,000 in property damage (to vehicles).

Previous Occurrences
Between 1962 and 2023, Charlevoix County had 34 hail events reported to NOAA (Table 36). The episode and event narratives for the hailstorm on July 8, 2016 is as follows:

Powerful thunderstorms developed over Lake Michigan late in morning of the 8th, ahead of an incoming cold front. These storms produced very large hail, and some damaging winds, as they swept across northern Michigan. Approximately 60 percent of the cherry crop in northwest Lower Michigan was damaged by the severe thunderstorms. Some vehicles were damaged by very large hail.

Table 36. Hail Events, Charlevoix County

Place	Date	Magnitude (inches)
	6/30/1962	1.75
	5/8/1963	1.5
	9/7/1985	1.5
EAST JORDAN	7/8/1996	0.75
BOYNE CITY	9/11/1996	1
CHARLEVOIX	7/2/1997	0.75
CHARLEVOIX	6/24/1998	0.75
CHARLEVOIX	6/24/1998	1
IRONTON	5/12/2000	1
EAST JORDAN	8/8/2000	0.75
IRONTON	4/18/2002	1
EAST JORDAN	8/12/2002	0.75
EAST JORDAN	7/31/2003	0.88
BOYNE FALLS	8/9/2004	0.75
EAST JORDAN	3/26/2007	0.75
CHARLEVOIX	10/18/2007	0.75
BOYNE CITY MUNI ARPT	4/25/2008	0.75
CLARION	4/25/2008	0.75
BOYNE FALLS	5/30/2008	1
EAST JORDAN	6/27/2008	0.75
CLARION	5/22/2011	1
EAST JORDAN	6/8/2011	0.75
BIRCH HILLS	6/8/2011	0.75
EAST JORDAN	6/8/2011	0.75
EAST JORDAN	6/8/2011	1
EAST JORDAN	6/8/2011	1.75
BIRCH HILLS	6/8/2011	0.75
BOYNE CITY MUNI ARPT	5/27/2012	0.75
EAST JORDAN ARPT	5/20/2013	1.5
ST JAMES WELKE ARPT	7/22/2014	0.75
EAST JORDAN	7/8/2016	3
EAST JORDAN	10/17/2016	1.5
BOYNE MTN ARPT	10/17/2016	0.88
EAST JORDAN	9/4/2017	0.88

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

There have been 31 hail events reported between 1996 and 2023[5] in Charlevoix County, which equates to an average of 1.1 hail events per year. Therefore, there is a 100% annual chance of a hail storm occurring in the county. All buildings, exposed infrastructure, and populations are at risk from hailstorms since hail causes damage to roofs, brick walls, glass, landscaping, crops, and cars. Mobile homes and campground populations located throughout the county and are more susceptible to impacts from hail. Hail can also damage roads, sidewalks, bridges, and above ground utilities. Hail has the potential to cause injury and death, and populations are advised to take shelter when an event occurs.

[5] The events for the years 1962, 1963, and 1985 were excluded from the probability analysis due to the large temporal gap between the remaining events on record.

Riverine and Urban Flooding

Fluvial, or Riverine flooding occurs when rivers, streams, and lakes overflow into adjacent floodplains due to prolonged, intense rainfall, rapid snowmelt or ice jams. Flooding can damage or destroy property, disable utilities, destroy crops and agricultural lands, make roads and bridges impassable, and cause public health and safety concerns. Floods occur in the early spring, but also occur in the winter due to ice jams, and during the summer or fall from severe thunderstorms. Flooding caused by severe thunderstorms has a greater impact on watercourses with smaller drainage areas.

Pluvial, or *Urban, flooding* occurs when water flows into low-lying areas because it does not have a place to go, due to impervious surface coverage. This flooding occurs from a combination of excessive rainfall, snowmelt, saturated ground, and inadequate drainage, and is becoming more common in Michigan. Since development is occurring in floodplains, the natural landscape is unable to properly disperse the water. Urban flooding also has the potential to overflow onto docks or other structures with electricity running to them, which increases the risk for an electric shock drowning. Additionally, storm and sanitary sewers are unable to handle the water flows associated with storm events, which can result in sewer overflows and affect the water quality of nearby lakes and rivers, as well as structures with basements or shallow groundwater tables.

Dam failure is also a potential source of flooding. Infrastructure in the state is aging and costly to maintain. FEMA has created guidelines that describe the approach and terminology used to classify dams, as explained in their *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams (April 2004)*. The dam hazard potential classification system, as shown in the table below, was developed by the Interagency Committee on Dam Safety (ICODS) as part of the National Dam Safety Program. The system provides groups who manage dams a common way to understand and talk about the possible negative impacts to people and property downstream in the case a dam fails or is mis-operated. Although the system does not speak to the condition of the dam, it does reflect probable loss of human life and impacts on economic, environmental, and lifeline interests.

Figure 14. Dam Hazard Potential Classification System

DAM HAZARD POTENTIAL CLASSIFICATION	LOW HAZARD POTENTIAL	SIGNIFICANT HAZARD POTENTIAL	HIGH HAZARD POTENTIAL
LOSS OF HUMAN LIFE	None Expected	None Expected	Probable
ECONOMIC LOSSES	Low and generally limited to owner	Yes	Yes *(but not necessary for this classification)*
ENVIRONMENTAL DAMAGES	Low and generally limited to owner	Yes	Yes *(but not necessary for this classification)*
LIFELINE INTERESTS IMPACTED	No	Yes	Yes *(but not necessary for this classification)*

Source: National Inventory of Dams

According to the 2019 Michigan Hazard Analysis, the most damaging hazard in Michigan, based upon estimated physical damages and known response/recovery costs, appears to be floods. The MSP reports that flooding events have a statewide expected annual loss estimated at more than $100 million ($25.69 million had previously been estimated in the 2014 Michigan Hazard Mitigation Plan, but Federal Disaster 4195 confirmed a higher magnitude more in line with earlier EGLE estimates, as that Metro Detroit flood event was quite similar to Federal Disaster 1346 during the previous decade).

The MSP's 2019 Michigan Hazard Analysis indicates that the Northern Lower Peninsula averages 0.3 annual flooding events, with average annual property and crop damages of $2,591,244 due to flooding.

Location
Areas of urban development (City of Boyne City, City of Charlevoix and City of East Jordan) are more vulnerable to flash flooding than other rural areas of the county due to high amount of impervious surfaces.

Also, seasonally high water tables, often occurring in late winter and the spring, can compromise aging or inadequate septic systems, leading to contamination of local lakes and streams. Seasonal flooding in the spring also affects many road/stream crossings, particularly near wetlands, throughout the county.

Members of the Natural Hazards Task Force identified the Boyne River corridor and Jordan River corridor as areas of riverine flood hazard concern, particularly due to the risk of potential dam failure along those rivers. Additionally, flooding occurred on land around Font Lake in St. James Township and Peaine Township during times of high groundwater tables/Lake Michigan water levels in 2019-2020.

The National Inventory of Dams maintains information for these four dams in the county: The Boyne Falls Dam (State-regulated), East Jordan Dam (State-regulated), Boyne River Dam (Federally regulated), and Walloon Lake CC Dam #14 (not regulated). Refer to Figure _ and Table __ for details.

The Boyne Falls Dam in Boyne Valley Township is an earth embankment dam on the Boyne River with two concrete culvert spillways. The dam embankment has a length of approximately 400 feet and a structural height of approximately 23 feet. The dam creates a head of approximately 18 feet and an impoundment with a surface area of approximately 17 acres. The original construction date of the dam is unknown. The upstream and downstream slopes of the earth embankment are approximately 2 horizontal to 1 vertical. The top width of the embankment crest is approximately 40 feet. The crest of the dam serves as the roadway for Michigan Highway M-75. The roadway has an asphalt pavement and guardrail on both sides.

The East Jordan Dam in South Arm Township was constructed primarily of earth in 1900 on Deer Creek, and was originally owned and operated by Consumers Energy to produce electricity. The powerhouse was removed in 1950. The dam has a height of approximately 23 feet and a head of 13 feet. The earth embankment is approximately 315 feet long with an average width of 15 feet at the top. The spillway is made of concrete and is a gravity overflow type with no water level control device for Patricia Lake. The dam was bought by East Jordan Plastics in 1978 and is currently being used as a reservoir for their fire protection system. The size of impoundment is approximately 65 acres with a head of 13 feet.

In addition, the Michigan Dam Inventory indicates there are 13 dams in the county (not counting the federally-regulated Boyne River Dam, owned by Boyne USA, Inc.). Many of these dams are small, privately owned dams that are not regularly inspected by the State of Michigan. Refer to Figure 15 and Tables 37 and 38 for details. These dams are also labeled on the Infrastructure Map in Appendix A.

Figure 15. Locations of Dams in Charlevoix County, per the National Inventory of Dams

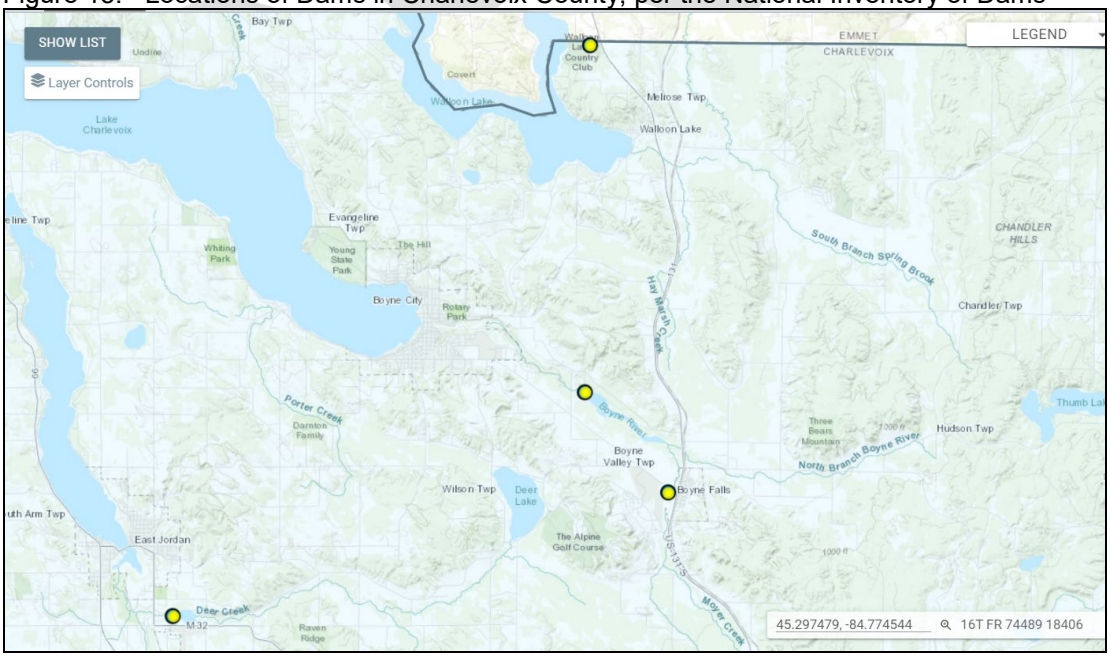


Table 37. Details on Dams in Charlevoix County, per the National Inventory of Dams

Name	Boyne Falls Dam	East Jordan Dam or "Lake Patricia Dam"	Boyne River Dam	Walloon Lake CC Dam #14
Downstream Hazard Potential	Significant	Significant	Low	Significant
Location	Boyne Valley Township at M-75 bridge over the Boyne River, west of US-131	South Arm Township	Boyne Valley Township	Melrose Township
Height (Ft)	23	23	37	16
Storage (Acre Ft)	88	865	1,390	8
Water Body	Boyne River	Jordan River	Boyne River	Tributary to Walloon Lake
Owner	Village of Boyne Falls	East Jordan Plastics	Boyne USA, Inc.	Walloon Lake Country Club
Year Completed	Unknown	1900	1904	1989
Purpose	Recreation; Retired Hydro	Recreation; Retired Hydro	Hydroelectric /Recreation	Recreation /Irrigation
Regulatory Agency	MI EGLE	MI EGLE	FERC	None
Condition Assessment/Date	"Satisfactory" 10/19/2021	"Fair" 5/31/2018	"Poor" 9/9/2022; as of 4/11/2023, the dam's operational status is "under remediation"	6/14/1990
Inspection Frequency	Every 4 years	Every 4 Years	Every 3 years	-
Emergency Action Plan Last Revised	12/28/2021	12/31/2006	1/31/22	N/A

Sources: National Inventory of Dams; EGLE Michigan Dam Inventory

Figure 16. Locations of Dams in Charlevoix County per EGLE's Michigan Dam Inventory

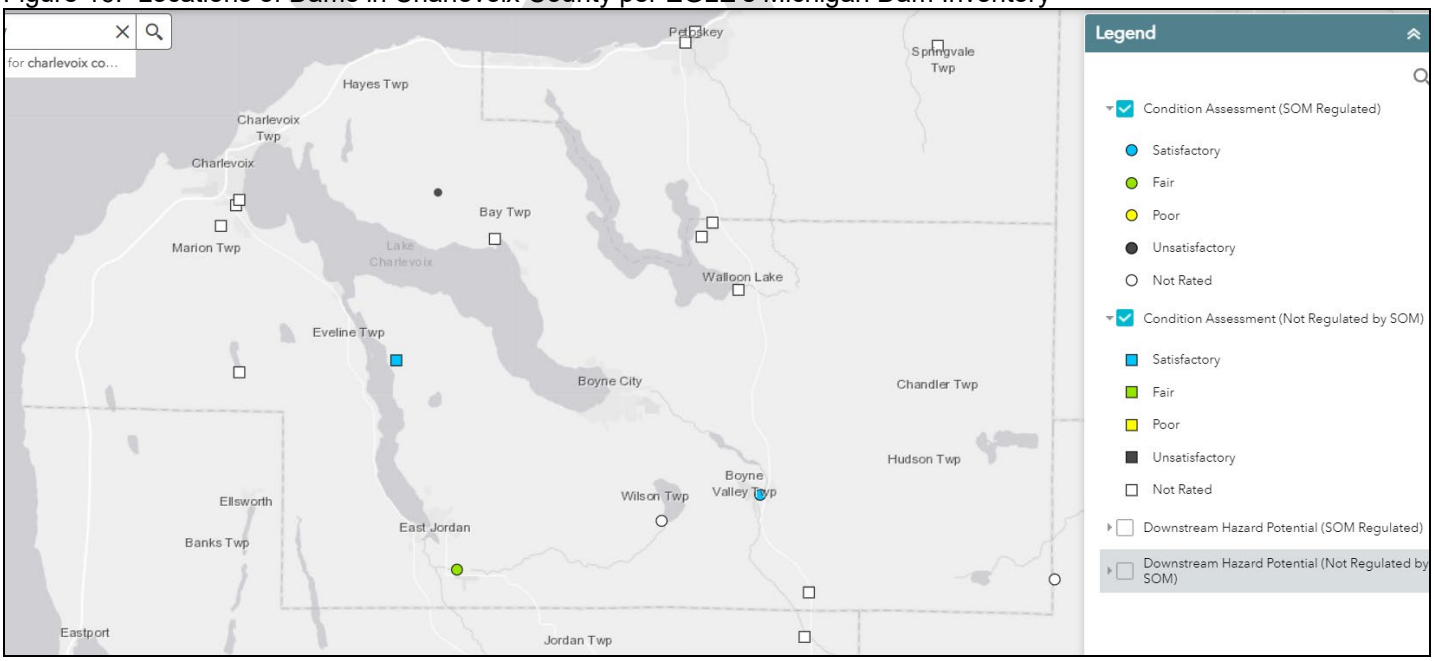


Table 38. Details on Dams in Charlevoix County per EGLE's Michigan Dam Inventory

Dam Name	Boyne Falls Dam	East Jordan Dam	Walloon Lake CC Dam #14	Walloon Lake CC Dam #3	Walloon Lake Dam (Weir)	Lawton Walleye Pond Dam	Charlevoix KMart Retention Basin Dam	Deer Lake Level Control Structure	Belvedere Golf Club Dam	Marion Hills Dam	Stover Creek Dam	Horton Creek Dam	Massey Dam
Other Dam Names		Lake Patricia Dam	#14 Pond Dam	#3 Pond Dam		DNR Walleye Rearing Pond							Moyer Creek Trout Ponds
Location	Boyne Valley Twp.	South Arm Twp.	Melrose Twp.	Melrose Twp.	Melrose Twp.	Eveline Twp.	Charlevoix Twp.	Wilson Twp.	Marion Twp.	Marion Twp.	Charlevoix Twp.	Bay Twp.	Boyne Valley Twp.
Downstream Hazard Potential	Significant	Significant	Significant	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Emergency Action Plan	Yes	Yes	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
EAP Updated	2/2/2021	12/31/2006											
Owner Type	Local Government	Private	Private	Private	Private	Private	Private	Private	Private	Private	Private	Private	Private
Owner Name	Village of Boyne Falls	East Jordan Plastics	Walloon Lake Country Club	Walloon Lake Country Club	Walloon Lake Cottage Owners	Unknown	Agree Development Company	Deer Lake Property Owners Assoc.	Belvedere Golf Club	David L. Campbell	Irish Boat Shop Inc.	Horton Bay Club	Marion Massey
Inspector	Dan DeVaun	Paul Repasky, P.E.	MDNR	MDNR	None	MDEQ Pawloski	MDNR	Lucas C. Porath, P.E.	None	None	None	MDNR	
Regulatory Authority	Part 315	Part 315	Inventory	Inventory	Inventory	Inventory	Inventory	Part 307	Inventory	Inventory	Inventory	Inventory	Inventory
Inspection Date	10/19/2021	6/1/2018	6/14/1990	6/14/1990	1/1/1901	5/23/2001	6/14/1990	12/12/2018	1/1/1901	2/8/1991	1/1/1901	6/15/1989	1/1/1901
Inspection Frequency	4 Years												
Next Inspection	12/31/2025	12/31/2022				12/31/2006		12/31/2021					
Year Completed		1900	1989	1989	1911	1987	1990	1973			1948		
Dam Type	Earth	Earth Gravity	Earth	Earth	Gravity	Earth	Earth	Other	Rockfill	Earth Gravity		Earth	
Purposes	Retired Hydro	Retired Hydro	Recreation Irrigation	Recreation Irrigation	Other	Other	Flood & Stormwater	Recreation	Other	Recreation	Recreation	Recreation	
River	Boyne River	Deer Creek	Tributary to Walloon Lake	Tributary to Walloon Lake	Bear River	Tributary to Lake Charlevoix	Tributary to Lake Charlevoix	Deer Creek	Stover Creek	Marion Creek	Stoner Creek	Horton Creek	Moyer Creek
Trout Stream			No	No		No	No					Yes	
Fish Passage	No	No	No	No	No	No	No	No	No	No	No	No	No
Lamprey Barrier			No	No		No	No					Yes	
Delegated Authority								Charlevoix County Drain Commissioner					
Report Received		12/20/2018						12/13/2018					
Condition Assessment	Satisfactory	Fair	Not Rated	Not Rated	Not Rated	Satisfactory	Not Rated	Not Rated	Not Rated	Not Rated	Not Rated	Not Rated	Not Rated
Condition Assessment Detail	Meets applicable tolerable risk criteria		Not under state jurisdiction	Not under state jurisdiction	Not under state jurisdiction	Meets applicable tolerable risk criteria	Not under state jurisdiction	Other	Not under state jurisdiction	Not under state jurisdiction	Not under state jurisdiction	Not under state jurisdiction	Not under state jurisdiction

Extent

The extent of an inland flooding event can be measured by the amount of property damage and accumulation of rainfall. There has been one flash flood event on record with NOAA for Charlevoix County, in the City of Charlevoix, which caused $2,000 in property damages (Table 39). No crop damages were reported and there have been no deaths or injuries from flooding.

Previous Occurrences

Table 39. Charlevoix County Fluvial and Pluvial Flood Events

LOCATION	DATE	EVENT TYPE	DEATHS / INJURIES	PROERTY DAMAGE	CROP DAMAGE	FLOOD CAUSE
City of Charlevoix	6/18/2012	Flash Flood	0	$2,000	0	Heavy Rain
***Boyne Valley Township/Village of Boyne Falls**	3/15/2019	Riverine Flooding – S. Branch Boyne River, Boyne Valley Township and Village of Boyne Falls				Dam Failure
***Boyne Valley Township/City of Boyne City**	October 2016	Riverine Flooding- Boyne River downstream of Boyne USA dam				Dam mis-operation
TOTAL				**$ 2,000**	**$ -**	

Sources: NOAA National Centers for Environmental Information Storm Events Database; Michigan State Police's 2019 *Michigan Hazard Analysis*
Notes: * Event not listed in the NOAA Storm Events Database

The NOAA episode and event narratives for the June 18, 2012 flash flood in the City of Charlevoix is provided below:

> *A warm front allowed warm and moist air to surge north into Northern Michigan. Initial thunderstorms developed in Eastern Upper Michigan in the afternoon; some of these produced large hail. Incoming thunderstorms organized into a line as they crossed Northern Lake Michigan; this squall line produced many reports of 40 to 55 mph winds, but only a few pockets of wind damage, in addition to a single tornado.*
>
> *High water closed US-31 between Garfield and St Marys in the city of Charlevoix.*

The descriptions of the March 15, 2019 and October 2016 flooding incidents were obtained from https://truenorthtrout.com:

> *Friday evening March 15, 2019, after Thursday's daytime high of 57º, coupled with snowmelt and rain, a* [privately-owned, non-regulated] *dam located behind Weiss Acres along 131 gave way and washed out. The site was an old grist mill from many decades ago. There are cabin rentals along the river bank where vacationers could kayak up a couple hundred yards in slack water before they ran into two undersized culverts on the former entrance to Boyne Mountain, opposite Cherry Hill Road. This site was also looked at by Tip of the Mitt Watershed but complications and funding delayed removal because of buried utilities.*
>
> *The amount of sediment washed down stream is yet undetermined. Fish kill and macro invertebrate collateral damage is unknown. Biggest concern is young of the year brown and brook trout that may have little recourse in escaping plume of silt or heavy flows. The DNR, DEQ, and Tip of the Mitt have visited site along with Little Traverse Bay Tribe- who took water samples on Tuesday. A crew of surveyors from Elmer's Construction- general contractors on Maple River and Boardman River dam removals, were also on hand and forecast an involved remediation of river and hope for a quick recovery. The portion upstream is high quality trout stream, below former dam site is the Boyne Falls Mill Pond, which may have acted as a large sand trap. There is also evidence that when the dam broke free, the amount of water and sediment going downstream would have stirred and flushed the still water in the pond- pushing a larger plume of silt downstream. The turbid and murky water was visible for 4-5 days in Boyne City.*
>
> *The river has been through this before. In October of 2016, while performing routine maintenance on the Boyne Property Dam at Kircher's pond, a log became lodged in the floodgate and most of impounded water was released downstream. Anglers who were in the river fishing for salmon noticed the river suddenly rush from knee deep to over their waist's and became very murky. Some actually caught pike and large browns that were residents from the impoundment. Some property owners had to retrieve kayaks that were along their shoreline to be found in the mouth of Boyne at Lake Charlevoix.*

The following photos depict the streambank erosion and private property damage resulting from the 2019 flooding incident along the South Branch Boyne River in Boyne Valley Township and the Village of Boyne Falls: (all photos sourced from https://truenorthtrout.com/2019/03/south-branch-boyne-river-update/0)

Probability of Future Events and Vulnerability Assessment
Since 2012, Charlevoix County has had 3 inland flooding events, indicating there is a 25% annual chance of a riverine or urban flood event. The magnitude and severity depend on the area of impact's population, seasonal activity, and the spread of development. During the warm or summer months, the population expands to include both the permanent population and visitors to the area. Areas of urban development (City of Boyne City, City of Charlevoix and City of East Jordan) are more vulnerable to flash flooding than other rural areas of the county.

Floods can damage or destroy public and private property, disable utilities, make roads and bridges impassable, destroy crops and agricultural lands, cause disruption to emergency services, and result in fatalities. People may be stranded in their homes for several days without power or heat, or they may be unable to reach their homes at all. Long-term collateral dangers include the outbreak of disease, widespread animal death, broken sewer lines causing water supply pollution, downed power lines, broken gas lines, fires, and the release of hazardous materials.

Inland flooding will continue to occur at times in Charlevoix County. Years with exceptional snowfall levels will likely result in flooding events from snowmelt. Increasing Lake Michigan water temperatures will create more active storm systems and heavier rainfalls. Fluctuating Lake Michigan water levels will also increase inland flooding events as groundwater tables rise. Furthermore, increased development, reduction in green space, and subsequent soil erosion can cause sedimentation to accumulate in river and lake beds reduce the amount of water flow. Rivers and lakes with sedimentation buildup will experience water backups and flooding events unless mitigated. Also, seasonally high water tables, often occurring in late winter and the spring, can compromise aging or inadequate septic systems, leading to contamination of local lakes and streams.

In August 2023 the Tip of the Mitt Watershed Council was awarded a $323,672 grant from the MI EGLE's Nonpoint Source Fund to conduct work in the Lake Charlevoix Watershed. This 3-year project will allow them to install green stormwater infrastructure (a bioretention area) in downtown East Jordan, to be integrated into the City's new streetscape design. The grant funds will also assist in replacing two undersized road-stream crossings on the Jordan River (in southerly adjoining Antrim County) in partnership with the Conservation Resource Alliance, as well as make updates to the Lake Charlevoix Watershed Management Plan.

Members of the Natural Hazards Task Force identified the Boyne River corridor and Jordan River corridor and tributaries as areas of riverine flood hazard concern, particularly due to the risk of dam failure along those rivers. Areas around Six Mile Lake in South Arm Township, and other smaller sites of historic inland/flooding are also included in the Hazard Areas Map in Appendix A.

The Boyne River Hydropower Dam in Boyne Valley Township has a "low" hazard potential classification, meaning that the failure or misoperation of the dam is not expected to result in the loss of human life; economic losses and environmental damages are expected to be low and generally limited to the owner; and impact to lifeline interests are not expected. Boyne USA, Inc., as the owner/operator, maintains a current Emergency Action Plan (EAP) for the dam on file with the Federal Energy Regulation Commission (FERC) and Charlevoix County government.

The Boyne Falls Dam and the East Jordan Dam have a "significant" hazard potential classification, meaning that while the failure or misoperation of the dam is not expected to result in the loss of human life, there will be economic losses, environmental damages, and impact to lifeline interests. The owners of the dams are required to maintain an EAP for the dam with MI EGLE and Charlevoix County Emergency Management.

The December 20, 2021 EGLE Dam Safety Inspection Report for the Boyne Falls Dam provides the following conclusions and recommendations:

> *The Boyne Falls Dam is in Fair condition. No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action. The following recommended actions are listed by priority:*
> - *The void in the concrete of the primary spillway chute downstream of the retaining wall needs to be cleaned, filled and compacted, then resurfaced by June 30, 2022.*
> - *Review the dam's Emergency Action Plan (EAP) in coordination with Charlevoix County Emergency Management. Advise the Dam Safety Program of the findings of this review and submit any revisions to the Dam Safety Program and the County Emergency Management Coordinator by December 31, 2022.*
> - *Trees should be removed 10 feet past the toe of the embankment and along the left groin area by December 31, 2022.*
> - *Mow/weed the upstream slope of the embankment periodically.*

- *The deteriorating concrete in retaining walls both upstream and downstream of M-75 needs to be monitored for further deterioration. Consider resurfacing the areas with hairline cracks to mitigate growth of the cracks.*
- *Consideration should be given to improve access to the stoplog structures on both the primary and auxiliary spillways. Currently, the only access is from the water with no machinery to assist putting in and taking out the stoplogs.*
- *Monitor movement in mass concrete section.*

The dam's current Significant hazard potential rating remains appropriate.

The East Jordan Dam Inspection Report, dated February 29, 2023, provides the following conclusions and recommendations:

We estimate that the overall condition of the dam is "Fair" as defined by the "Role of Inspection and Condition Assessment in the United States Army Corps of Engineers Civil Works Infrastructure Management" (Uzarski et al. 15). The condition "Fair" indicates that the dam is currently functioning as it should with some observed minor deficiencies that require corrective action. These minor deficiencies include the following:

- *Deteriorated concrete spillway and walls*
- *Trees and brush on the dam*
- *Bare/exposed soil on the dam*
- *Minor erosion on the upstream slope*
- *Low point on the north embankment where overtopping could potentially occur*

As indicated in previous inspection reports, the dam appears to originally have had a powerhouse with a concrete spillway and other concrete components. While portions of the powerhouse have been removed, the spillway and some of the walls/foundation elements remain. The concrete spillway is currently functioning as intended. However, there is deteriorated concrete, along both walls on each side of the spillway, especially along the bottom joints.

We cannot predict how much longer the spillway will function, but if the spillway fails, this could potentially lead to a dam failure causing significant damage to the surrounding area. Review of Past Dam Safety Inspection Reports indicate the condition of the concrete spillway is continuing to deteriorate.

We recommend, at a minimum, that the following actions be taken:

1. Continue to monitor the concrete spillway condition during routine maintenance operations on the dam. Contact the Michigan Department of Environment, Great Lakes and Energy (EGLE) with major changes.
2. Monitor groundwater seepage coming out of southwest concrete embankment headwalls during drier summer months.
3. Fill in and repair animal burrow hole behind the south concrete spillway wall on downstream side and other areas as they appear.
4. Remove all trees and brush on the dam.
5. Repair areas of erosion by grading banks to a uniform slope and restore with topsoil, seed, fertilizer, and mulch.
6. Place topsoil on all sandy areas of the dam and seed to promote vegetation growth.
7. Place embankment on the top of the northern earthen dike to a uniform elevation match the top of the spillway.
8. Repair or replace the walls of the spillway. It is recommended that this be completed within one year.

No future studies or investigations appear to be required other than inspections as required by the Dam Safety Act. A permit and plans sealed by a Professional Engineer will be required for any alterations to the spillway. Hazard Potential Classification is HIGH and is appropriate.

The report also provides the following description of residences, buildings or structures that may be threatened by flooding from potential failure of the dam:

• M-32 Hwy. Bridge Crossing Downstream ½ Mile Downstream of East Jordan Dam: 10 ft. Clearance Height to Stream Level may be exceeded by Flood Wave.

• Residences Near the Confluence of Deer Creek and the Jordan River: There are no residences immediately downstream (within 1 mile) of the dam, but some residences upstream may be affected by back-up of Jordan River causing flooding.

An inspection report was issued in 2021 for the Walloon Lake Wier by a State of Michigan licensed professional engineer. The weir is a water control structure to control the elevation of Walloon Lake (per a court order) and is located just northwest of highway M-75 where the Bear River exits Walloon Lake. Melrose Township is responsible for the operation and maintenance of the weir. The inspection report listed the following recommendations by priority:

A. Short Term Recommendations

1. Monitor the condition of the weir especially the lower northeast section.

2. Seal the concrete walls of the weir with a high-quality concrete sealer to reduce water intrusion and damage from the freeze-thaw cycle.

3. Work with county and/or state road commissions to develop a drainage plan to prevent salt laden water runoff from flowing over the concrete wing walls of the weir.

B. Long Term Recommendations

1. Work with county and/or state road commissions to develop and implement a repair plan for the weir wing walls

While dams can provide flood protection, recreation, energy supply, and water security, they also pose a significant threat to the environment. Dams block fish from moving along their natural pathways between feeding and spawning grounds (upstream habitat), causing interruptions in their life cycles that limit their abilities to reproduce. Dams can degrade water quality because the water they impound warms up and holds less oxygen, which affects fish and other aquatic animals. Dam failures may cause problems like erosion, which puts properties at risk and accelerates sediment transport downstream. Too much sediment in a river can cover important gravel beds needed for fish and macroinvertebrate habitat, as well as wetlands in the floodplain.

The Infrastructure Map included in Appendix A illustrates the locations of road/stream crossings, bridges and Michigan-regulated dams with their currently available condition rating. It should be noted that data is not available for every infrastructure location.

NFIP Participation Status

Several Charlevoix County communities received an updated Flood Insurance Study and digital flood maps in 2019. Community input and coordination with FEMA will determine the extent, if any, of future mapped flood areas. Table 41 outlines the NFIP information for local communities.

Boyne Valley Township and Marion Township are a communities that had a FIRM issued in 2019; however, they are listed as non-participants in the NFIP as they have not submitted documentation of local adoption of the FIRM(s) to FEMA. During the development of this hazard mitigation plan, inquiries were made with local government officials from these communities as to the reason why they are a non-participant in the NFIP. The Boyne Valley Township Supervisor indicated that the township has inadequate staff to participate in NFIP activities. No response was received from Marion Township officials regarding this inquiry.

FEMA defines a “repetitive loss property” as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling ten-year period since 1978 (the year at which consistent claims data collection began). Three (3) claims have been paid since 1978 (Table 40). The MI EGLE Water Resources Division Floodplain Engineer for the Cadillac service area has indicated that they are not aware of any properties in Charlevoix County with structures that have suffered repetitive flood losses. The *2019 Michigan Hazard Analysis*, completed by the Michigan State Police provides the following National Flood Insurance statistics for Charlevoix County:

Table 40. National Flood Insurance Statistics, Charlevoix County

Total Premium	Policies	A-Zone Policies	Total Coverage	Claims since 1978	Total Paid Since 1978
$9,704	21	2	$6,045,000	3	$41,356

Source: MSP 2019 *Michigan Hazard Analysis*

Table 41. NFIP Information for Charlevoix County Communities

Municipality	Community ID	NFIP Participant?	Floodplain Management /FIRM Map Adoption*	Current Effective Map Date	Reg- Emerg Date**	Implementation Method***	Implementation of Damage Provisions****
Bay Township	26796B	Y	Y	9/15/2022	9/18/1987	The Charlevoix County Building Department is the designated agency to administer, apply, and enforce the floodplain management regulations as contained in the state construction code for these communities. The FIRMs are declared to be a part of Section 1612.3 of the Michigan Building Code and provide the content of the "Flood Hazards" section of Table R301.2(1) of the Michigan Residential Code. Local zoning ordinances regulate development pertaining to flood areas.	Per the State of Michigan Building Code, if more than 50% of a building is damaged, it would need to be brought up to current construction code standards.
City of Boyne City	260056C	Y	Y	5/16/2019	7/19/1982		
City of Charlevoix	260057B	Y	Y	9/15/2022	2/11/1983		
Charlevoix Township	260790B	Y	Y	9/15/2022	9/18/1987		
City of East Jordan	260372C	Y	Y	5/16/2019	7/19/1982		
Evangeline Township	260800B	Y	Y	9/15/2022	9/18/1987		
Eveline Township	260773B	Y	Y	9/15/2022	9/18/1987		
Hayes Township	260778B	Y	Y	9/15/2022	9/18/1987		
Melrose Township	261295C	Y	Y	5/16/2019 (M)	8/28/2019		
Norwood Township	260769B	Y	Y	9/15/2022	9/18/1987		
Peaine Township	261296B	Y	Y	9/15/2022	11/1/2019		
South Arm Township	260761C	Y	Y	5/16/2019	3/18/1987		
St. James Township	261297B	Y	Y	9/15/2022	8/28/2019		
Wilson Charter Township	261298C	Y	Y	NSFHA	11/18/2019		
Boyne Valley Township	261292C	N	N	5/16/2019	5/16/2020 (Sanction Date)	Per the Boyne Valley Township Supervisor, the township has inadequate staff to participate in [NFIP] activities.	
Marion Township	260808B	N	N	9/15/2022	5/16/2019 (S) (Sanction Date)	No response received from inquiry to Township officials as to the reason why they do not participate in the NFIP.	

Notes:
* Adoption of NFIP minimum Floodplain management criteria via local regulation.
** The date the community first joined the NFIP.
*** How local floodplain management regulations are implemented and enforced in Special Flood Hazard Areas.
**** How participants implement the substantial improvement/substantial damage provisions of their floodplain management regulations after an event.
“M” = no elevation determined; all Zone A, C, X
“NSFHA” = no special flood hazard areas; all Zone C
“S” = Suspended community
Data Source: FEMA Community Status Book Report, Accessed 10/8/2023

Lightning

Lightning is a random and unpredictable discharge of electricity in the atmosphere between the clouds, air, or ground to equalize the charged regions in the atmosphere. It is still being debated how the electrical charges build up in the clouds. Lightning generally occurs during thunderstorms; however, it can occur without a thunderstorm, such as during intense forest fires and heavy snowstorms. Lightning that occurs without nearby rain is most likely to cause forest fires.

Location
Lightning is not confined to geographic boundaries and is a regional event. Since lightning occurs randomly, it is impossible to predict where lightning will occur and how severe it will be. All of Charlevoix County is at risk to the occurrence and impacts from lightning.

Extent
Lightning can be measured by damages-caused including deaths, injuries, property damages, and/or crop damages. There have been no reports of damages or injuries attributed to lightning in the county.

Previous Occurrences
There has been one lightning incident reported to NOAA for Charlevoix County (Table 42).

Table 42. Lightning Events

LOCATION	DATE	DEATHS	INJURIES	PROPERTY DAMAGE
County/Region	9/1/2000	0	0	$0
TOTAL		**0**	**0**	**$0**

Source: NOAA: National Centers for Environmental Information

NOAA's narrative for the 2000 event is as follows:

> *These storms led to flooding across Leelanau County as well as the northern half of Benzie and Grand Traverse counties. Many secondary roadways across the central and western sections of Leelanau county were washed out. Sections of M-22 running near Suttons Bay received significant damage due to the force of the running water. Several businesses within the town of Glen Arbor were flooded. Many city streets around Traverse City became inundated with as much as 4 feet of standing water. Intense lightning also occurred with these storms. The lightning caused power outages to hundreds of homes and businesses in the Traverse City area.*
>
> *Lightning associated with these storms and many others that night was nearly continuous. One man was killed by the lightning when he and his 9 year old son climbed a small hill behind a shopping mall to view the approaching lightning. The 40 year old father was struck and killed by a lightning bolt. His son was thrown to the ground, but only sustained minor injuries. Emergency crews performed CPR on the father immediately and a police officer arrived quickly with a defibrillator. However, attempts to revive the man failed.*
>
> *Lightning that Friday night also disrupted numerous high school football games. Many games were cancelled or postponed until the following Saturday morning. Many of the schools which began play had lengthy delays and many waited an hour or more before fans and players could return to the field. This was widely covered by area newspapers and television stations. The cost of postponed games is not known.*

Probability of Future Events and Vulnerability Assessment
There has been one lightning event on record in the last 24 years for Charlevoix County. This indicates there is a 4.2% chance of an impactful lightning strike occurring in a given year. However, it is assumed that not all lightning events have been reported since events with injuries, deaths, and extensive damages tend to be the only ones reported. Therefore, the amount of damages from lightning strikes is likely higher.

Vegetation (especially in dry soils), buildings and infrastructure are at risk to damage from lightning events since it may cause structural and wildland fires, loss of electrical and telecommunications equipment, and damage to buildings or vehicles from falling trees struck by lightning.

One of the concerns indicated in the community survey for this plan was the possibility of a lightning strike at the location of the former Big Rock Nuclear Plant in Hayes Township, where underground casks of nuclear waste are stored. However, according to personnel responsible for management of the site, risk of public exposure to any radiation would likely be very minimal in the event of a direct lightning strike to the casks. Lightning rods surround the casks as a

preventative measure against lightning strikes, and any damage to the cask would only result in localized radiation at that site. Unlike an active nuclear power plant, the Big Rock site is not required to have protective action guidelines for a mass evacuation scenario (a plume of radioactive material would not be disbursed into the air if the casks were damaged). Areas of developed land are at least 1/3 mile away from the location of the stored nuclear waste.

People that work outside or participate in outdoor recreation activities are at a higher risk to be struck by lightning. Charlevoix County is rich in land and water-based outdoor recreation areas. The total acreage of land in parks and recreation use (27,179.21 acres) represents about 21% of the county's total land area (266,432 acres). Table 43 lists the amounts of acreage for public parks and recreation use in each community in the county.

Table 43. Parks and Recreation Acreage by Unit of Government

Unit of Government	Acreage
St. James Township	92.75
City of East Jordan	110.19
City of Charlevoix	122.88
Eveline Township	400.8
Marion Township	424.3
Charlevoix County	520.1
City of Boyne City	648.87
Charlevoix Township	660.4
South Arm Township	832.5
Hayes Township	906.5
Evangeline Township	1,017.61
Bay Township	1,189.41
Wilson Township	1,304.30
Norwood Township	2,282
Hudson Township	3,441.30
Boyne Valley Township & Village of Boyne Falls	4,946.50
Melrose Township	8,677.80
Peaine Township	12,791
Chandler Township	16,810
TOTAL	**57,179.21**

Source: Charlevoix County Parks and Recreation Plan, 2020-2024
Note: Acreage is based on all public land available for recreational use in each municipality within Charlevoix County.

Tornado

Tornadoes are rapidly rotating columns of air that impact the ground after forming from some of the severe thunderstorms that occur during Michigan's warm months. Tornadoes can cause catastrophic damage to either a limited or an extensive area. A tornado can have winds exceeding 200 miles per hour and can have widths over one mile. These storms are the most violent of the atmospheric storms since they have the potential to destroy buildings, uproot trees, hurl objects, and cause loss of life.

According to the National Oceanic and Atmospheric Administration/National Weather Service's Storm Prediction Center, tornadoes cause approximately 60 deaths and hundreds of millions of dollars in property damage each year. The Michigan State Police's *2019 Michigan Hazards Analysis*, Michigan is located on the northern fringe of the nation's tornado belt, and since 1996 has averaged about 18 tornadoes per year. The longer term annual average (since 1950) is 8 injuries and one death per year, and over $17 million in property damages statewide.

Between 1999 and 2019, Michigan has had 314 reported tornado events with 52.9% as EF0 (weak) or EF1 (moderate), 38.9% reported as F0 or F1 (weak), 6.7% as EF2 (significant) or EF3 (severe), and 1.6% as F2 (strong). In Northern Michigan, tornados are most likely in the summer months, although some have occurred in the spring and fall.

Location
Tornadoes are a regional event that are not confined to geographic boundaries and can affect several areas at one time. Also, the magnitude of tornadoes may range across the affected areas. All of Charlevoix County is at risk to the occurrence and impacts from tornadoes. It is impossible to predict where and with what magnitude a tornado will touch down. Approximate trajectories of recorded tornadoes with NOAA are illustrated on the Hazard Areas Map in Appendix A.

Extent
The Fujita Scale (Table 44) categorizes tornado severity based on observed damage. The six-step scale ranges from F0 (light damage) to F5 (incredible damage). As of February 2007, the National Weather Service uses the Enhanced Fujita Scale (EF Scale). This new scale ranges from EF0 to EF5. Based on the Fujita Scale, Charlevoix County's most damaging tornado occurred on April 3, 1956 with winds ranging from 210-261 mph. It caused no injuries or deaths, but $250,000 in property damages.

Table 44. Fujita and Enhanced Fujita Scale Comparison

Fujita Scale		EF Scale	
Fujita Scale	**3-Second Gust Speed (mph)**	**EF Scale**	**3-Second Gust Speed (mph)**
F0	45-78	**EF0**	65-85
F1	79-117	**EF1**	86-109
F2	118-161	**EF2**	110-137
F3	162-209	**EF3**	138-167
F4	210-261	**EF4**	168-199
F5	262-317	**EF5**	200-234

Source: FEMA

Previous Occurrences
Since 1955, Charlevoix County has had four reported tornados, which caused $3,000 in property damage (Table 45). As a result of these tornadoes, there were no deaths, no injuries, and no reported crop damage.

An F1 tornado occurred in Boyne Valley Township in 1955. It touched down north south of Moyer Creek and northwest of Metros Road and US-131 and headed northeast for 2.3 miles, ending northeast of Springbrook and Thumb Lake Road, near Three Bears Mountain. This tornado caused $2,500 in property damage.

An F2 tornado occurred in on July 31, 1977. It started in Antrim County (Warner Township), traveling 3.8 miles northeast, crossing US-131 and ending in the southern portion of Boyne Valley Township. This tornado caused $250 in property damage.

An F0 tornado occurred in Wilson Township on August 21, 1989, causing $250 in property damage. The exact location/trajectory of the tornado is unknown, but it is reported as being one mile long and 110 yards wide.

An F1 tornado occurred in Wilson Township/ Boyne City area in 2002; the exact location/trajectory is unknown. No property damages are reported for this event. The NOAA episode and event narratives for this event are provided below:

> *Four waves of severe thunderstorms impacted northern Michigan during the morning, afternoon, and evening hours on the 1st. The first wave of severe thunderstorms struck the area during the early morning hours, initially knocking trees down in Tahquamenon Falls State Park. The last of the storms exited northern Michigan into Lake Huron during the evening hours. Three tornadoes were associated with the severe thunderstorms, but none of these crossed county boundaries. Numerous trees down, some onto structures and vehicles. Roof damage to several buildings.*

Table 45. Tornado Events in Charlevoix County

LOCATION	DATE	MAGNITUDE	DEATHS	INJURIES	PROPERTY DAMAGE
Boyne Valley Township	6/19/1955	F1	0	0	$2,500
Boyne Valley Township	7/31/1977	F2	0	0	$250
Wilson Township	8/21/1989	F0	0	0	$250
Wilson Township/City of Boyne City	8/1/2002	F1	0	0	0
TOTAL	**4**		**0**	**0**	**$3,000**

Source: NOAA - National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

Since there have been four tornadoes events reported in the last 69 years, the data shows that there is a 5.8% annual chance a tornado would occur in a future year. While the chance for a tornado is low, if an event occurs, there is potential for a higher magnitude tornado to touch down. All reported historic events have caused significant property damage. The cities of Boyne City, Charlevoix and East Jordan and adjoining communities, where the densities of population and developed lands are highest, would bear the greatest amount of impact from a tornado. Mobile homes are also more at risk to damage from tornadoes than homes built on permanent foundations. Table 46 indicates the estimates of mobile homes in each community in the county.

Table 46. Mobile Home Estimates, Charlevoix County

Location	Mobile homes	% of Housing Units
Charlevoix County	1,247	7.00%
City of Boyne City	222	9.70%
Charlevoix Township	207	17.90%
Hayes Township	175	15.20%
Wilson Township	105	10.00%
Hudson Township	83	13.70%
City of East Jordan	76	6.40%
Boyne Valley Township	72	8.20%
South Arm Township	59	5.50%
Melrose Township	58	6.40%
Marion Township	38	4.20%
Evangeline Township	35	7.40%
City of Charlevoix	34	1.60%
Peaine Township	22	4.00%
Village of Boyne Falls	21	9.70%
Bay Township	17	1.90%
Eveline Township	17	1.20%
Norwood Township	14	2.90%
Chandler Township	10	6.00%
St. James Township	3	0.60%

Source: US Census, 2020 ACS 5-yr Estimates, DP04 Selected Housing Characteristics

Tornados can appear quickly and cause significant damage. Aside from the three cities, the county population is geographically spread out and notifying them of tornado warnings or watches can be difficult.

Charlevoix County currently uses the BeAlert public notification system, which is limited in efficacy as citizens must sign up for the service's phone alerts. As mentioned previously, outdoor recreation areas are abundant in every community in the county.

In 2008, the Grand Traverse Band Tribe of Ottawa and Chippewa Indians (GTB) completed construction on six underground severe storm "safe rooms" (shelters) located on tribal lands. Within Eveline Township in Charlevoix County, two of these storm shelters were installed near the playground area at the Charlevoix GTB Satellite Office, at 10085 Wa-Ba-Noong Mi-Kun, East Jordan. This $76,800 project was funded in part by a FEMA hazard mitigation project grant awarded to the GTB. Each shelter can accommodate approximately 24 people. That number may be reduced, depending on pets or belongings carried. The shelters were designed and installed for the safety and protection of residents without basements in their homes during severe storms and tornadoes.

The shelters were prefabricated and lowered into excavated areas. The units were then covered with dirt, graded and planted with grass to stabilize the soil and blend the site into the surrounding landscape. The only noticeable features are the ingress and egress hatch and the ventilation nubs (see Figure 17). For this reason, signs have been installed advising residents of the location and operation of the shelters. Public meetings and instructional sessions were also held by the tribal fire department to advise residents of the locations and operation of the shelters and how to react during periods of severe weather. These public education sessions also stressed the need for each household to have an emergency kit readily available within their home that they could take with them to the designated shelter. This eliminates the need to stock large quantities of supplies within the shelters. The shelters are open during the severe weather months (April 1 to September 30) and are locked for the remainder of the year.

Figure 17. GTB Tribe Storm Shelter Entrance

Source: *Michigan Hazard Mitigation Success Stories – October 2020*, Michigan State Police

Other emergency public notification methods available include:

- Integrated Public Alert & Warning System (IPAWS): FEMA's national system for local alerting that provides authenticated emergency and life-saving information to the public through mobile phones using Wireless Emergency Alerts, to radio and television via the Emergency Alert System, and on the National Oceanic and Atmospheric Administration's Weather Radio.
- The FEMA Mobile App: provides real-time weather alerts, locations of emergency shelters, and allows for notifications to be sent to loved ones.
- NOAA Weather Radio All Hazards: a nationwide network of radio stations broadcasting continuous weather information directly from the nearest National Weather Service office. NWR broadcasts official Weather Service warnings, watches, forecasts and other hazard information 24 hours a day, 7 days a week.
- The following communities have manually operated tornado sirens: City of East Jordan (2), City of Boyne City (1), and the City of Charlevoix (1).

Extreme Temperatures

Prolonged periods of very high or very low temperatures are often accompanied by other extreme meteorological conditions, such as high humidity, drought, heavy snowfall, or high winds. Extreme heat or extreme cold primarily affect the most vulnerable segments of the population, such as the elderly, children, impoverished individuals, and people in poor health.

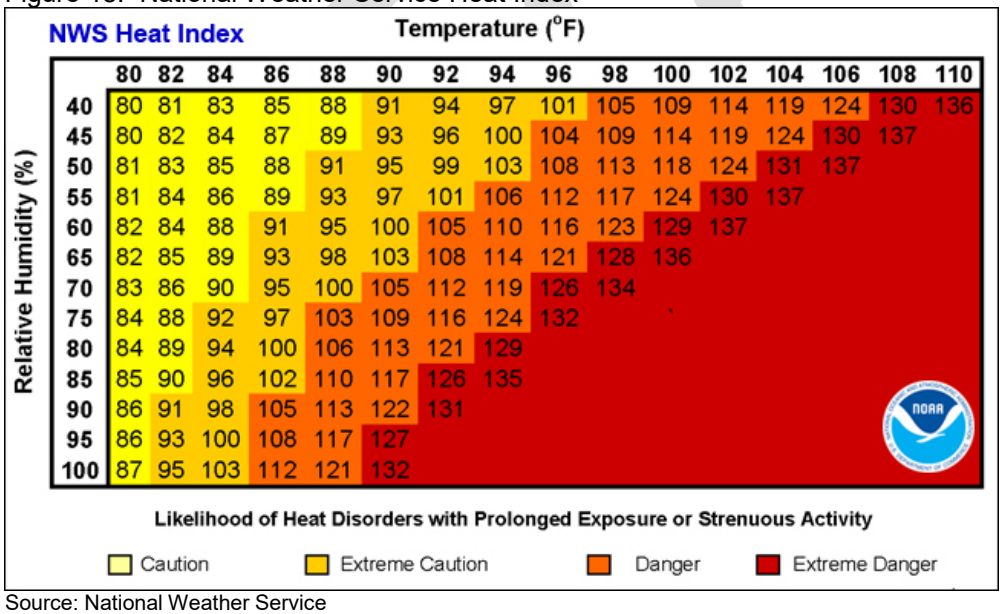
Nationwide, there have been approximately 175 deaths per year that are attributable to extreme heat according to the 2019 Michigan Hazard Analysis. The threats from extreme heat are heatstroke, sunstroke, muscle cramps, heat exhaustion, and fatigue. It is hazardous to livestock and agricultural crops, causes water shortages, exacerbates fire hazards, exacerbates respiratory problems, prompts excessive electrical energy demands, and causes infrastructure failures. Urban areas experience the most serious extreme heat with the combined high temperatures and high humidity that produce a heat-island effect.

According to the 2019 Michigan Hazard Mitigation Plan, Michigan has 11 average annual extreme heat events with 0.4 average annual deaths and 41 average annual injuries.

In the United States, approximately 700 people die each year as a result of severe cold temperature-related causes according to the 2019 Michigan Hazard Analysis, with a significant number of deaths occurring due to illnesses or disease that are negatively impacted by severe cold weather, such as stroke, heart disease, and pneumonia. Exposure to extreme cold temperatures can be life threatening and can cause hypothermia and frostbite. According to the 2019 Michigan Hazard Mitigation Plan, Michigan has 35 average annual extreme cold events with 1 death, 9.4 average annual injuries, and $6.4 million in average annual property and crop damage. Extreme cold affects transportation modes and power utilities, resulting in dead vehicle batteries and loss of power/heat.

Measuring Extreme Temperatures (Extreme Heat and Extreme Cold)
Extreme heat is measured with the National Weather Service's Heat Index Chart (Figure 18). The chart uses relative humidity and air temperature to determine the likelihood of heat disorders with prolonged exposure or strenuous activity. Individuals are unable to shed excess heat from their bodies when they experience prolonged exposure to hot temperatures, which results in heat disorders.

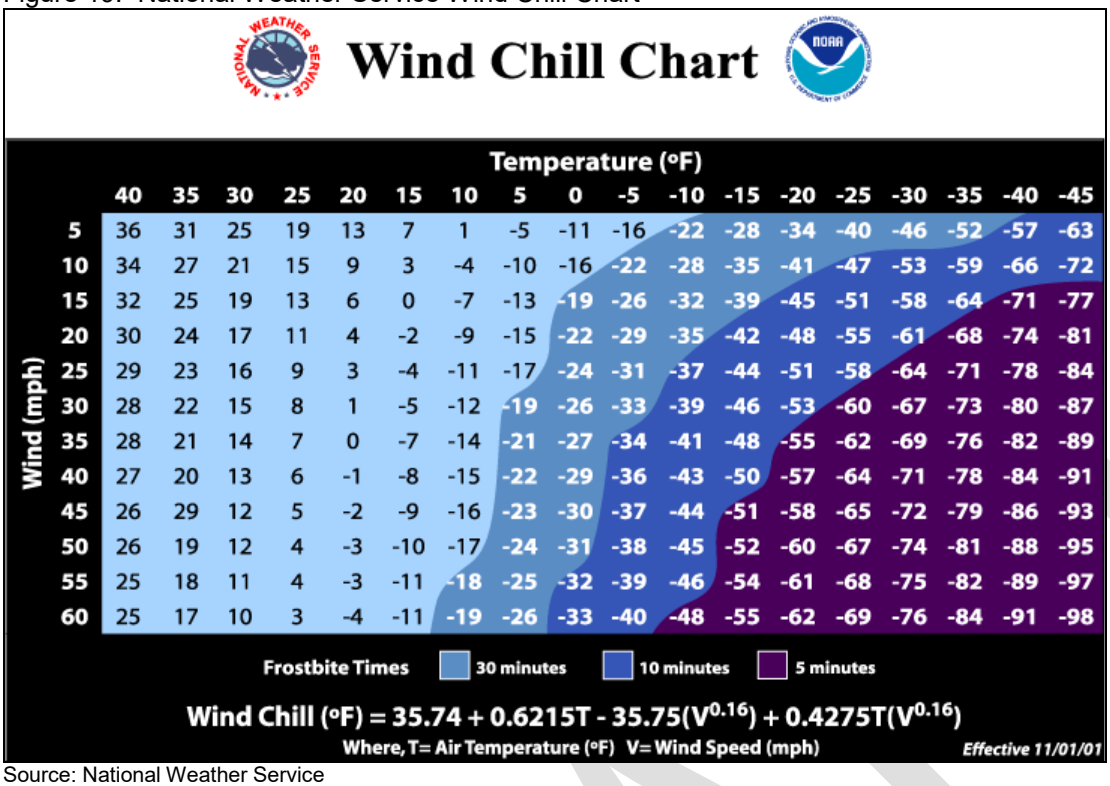
Figure 18. National Weather Service Heat Index



Source: National Weather Service

Extreme cold is measured with the wind chill index, which is a measure of the rate of heat loss from exposed skin caused by the combined effects of wind and cold. As the wind increases, heat is carried away from the body and reduces the external and internal body temperatures. Figure 19 shows the NOAA Wind Chill Chart as it corresponds to various temperatures and wind speeds.

Figure 19. National Weather Service Wind Chill Chart



Wind Chill Chart

Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: National Weather Service

Figures 21 and 22 illustrate the daily observed temperatures at the NOAA weather station at Beaver Island and East Jordan in 2022 (dark blue line) in comparison to daily record maximum temperatures (red line), the daily normals temperature range, and daily record minimum temperatures (light blue line). East Jordan experienced warmer temperatures in the spring and summer months and colder temperatures in the fall and winter months compared to Beaver Island.

Figure 20. Daily Temperature Data Comparison for Beaver Island, 2022

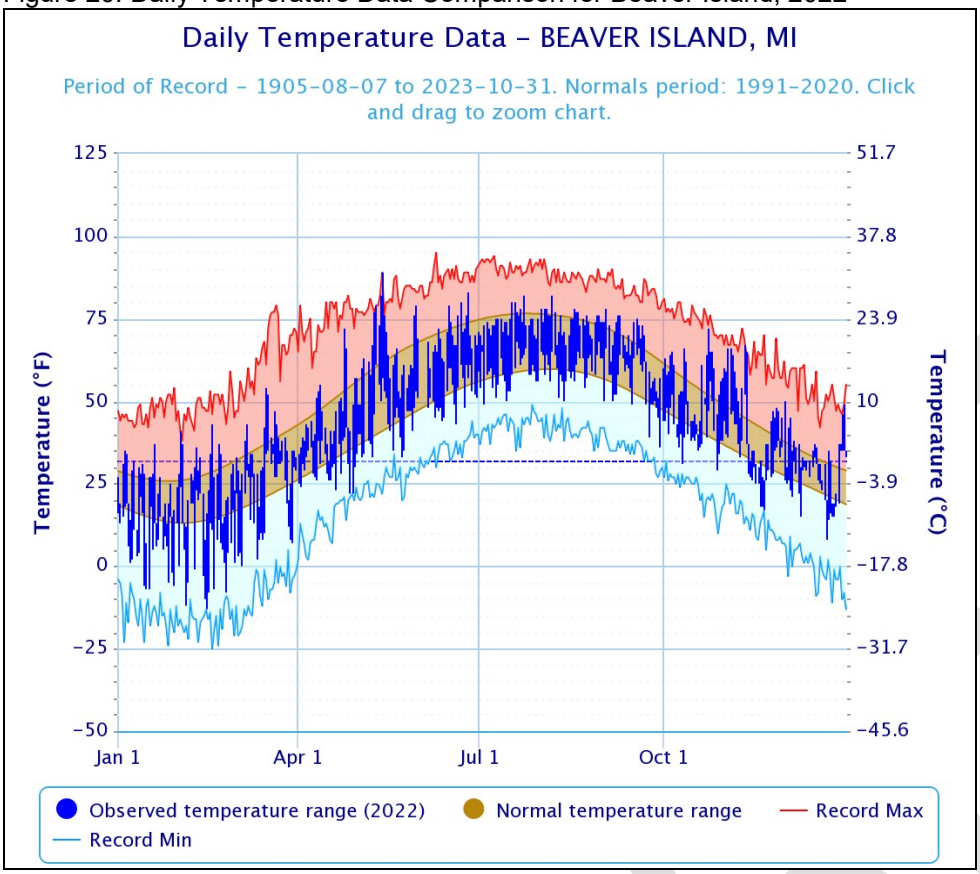
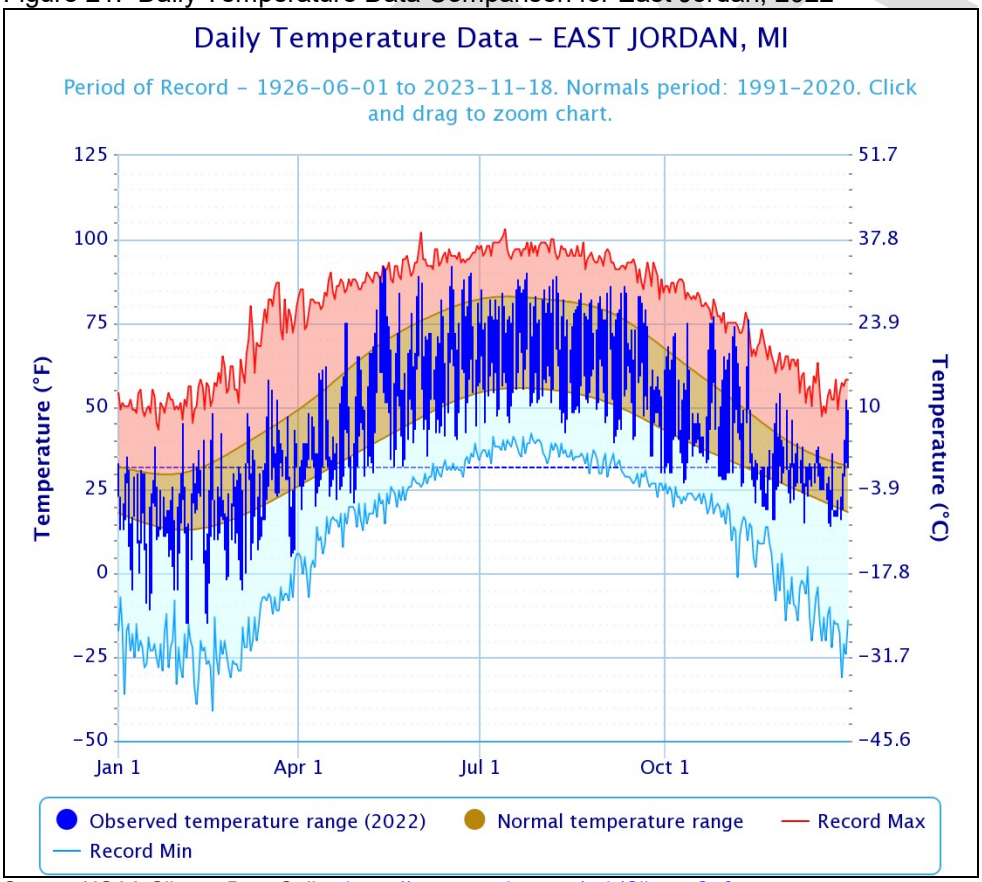


Figure 21. Daily Temperature Data Comparison for East Jordan, 2022



Source: NOAA Climate Data Online https://www.weather.gov/wrh/Climate?wfo=apx

Location and Extent
Extreme temperatures are a regional event that are not confined to geographic boundaries and range in severity across the affected areas. All of Charlevoix County is at risk to the occurrence and impacts from extreme temperatures.

Previous Occurrences
Charlevoix County has had two extreme heat events that occurred in the summers of 2001 and 2018 (Table 47). The events were not associated with any reported deaths, injuries, or property/crop damages. The heat events consisted of hot and humid conditions that caused outdoor events to be modified and attendance at outdoor events to be lower than normal. The NOAA episode narratives are provided below:

> *The first instance of reported excessive heat occurred on August 1, 2001. Excessive Heat was a problem the first two weeks in August across all of northern Michigan. Temperatures reach the mid to upper 90s, on average, a few days each year; however, for a 5 day (8/5 - 8/9) stretch overnight low temperatures failed to fall below the lower 70s in most areas. This very humid air mass was unusual for northern Michigan, an area which typically sees cool nighttime temperatures and for this reason has very few homes with air conditioners. No heat related deaths or injuries were reported; however, most outdoor events were modified due to the forecasts of hot and humid conditions. County fairs sent animals home, yet still there were livestock losses at fairs in Otsego and Alcona counties. Attendance at county fairs was well below normal and this was attributed to the heat. This period of excessive heat also brought on a drought event at the same time.*
>
> *The second instance of reported excessive heat occurred on June 30, 2018. The month of June closed with one of the hottest days in recent memory. Highs were well into the 90s, including 99 at Alpena, and 98 at Traverse City and Gaylord. The National Weather Service office near Gaylord also hit 98; that was (by several degrees) the warmest reading recorded at that location since observations began there in the late 1990s. Heat indices exceeded 105 degrees across most of northern Lower Michigan, and some locations exceed 110. The warmest reported heat index on the day was 114 near Indian River. There were estimated to be between 25 and 30 individuals who visited local hospitals due to heat-related illnesses.*

Table 47. Extreme Heat Events, Charlevoix County

LOCATION	DATE	EVENT TYPE	INJURIES, DEATHS, DAMAGES	EVENT DESCRIPTION
CHARLEVOIX (ZONE)	8/1/2001	Heat	0	Excessive Heat was also a problem the first two weeks in August across all of northern Michigan. Temperatures reach the mid to upper 90s, on average, a few days each year; however, for a 5 day (8/5 - 8/9) stretch overnight low temperatures failed to fall below the lower 70s in most areas.
CHARLEVOIX (ZONE)	6/30/2018	Excessive Heat	0	Highs were well into the 90s, including 98 at Traverse City and Gaylord. The National Weather Service office near Gaylord also hit 98; that was (by several degrees) the warmest reading recorded at that location since observations began there in the late 1990s.

Source: NOAA: National Centers for Environmental Information

There have been four extreme cold events reported for Charlevoix County (in 2007, 2015, and 2019; Table 48). The events were not associated with any deaths, injuries, or property/crop damages. The low temperatures caused schools to close. However, since cold temperatures typically occur during winter months, many events may have gone unrecorded.

A Governor Declared Emergency for extreme cold was enacted in January 2019 for all 83 counties in the state.

Table 48. Extreme Cold Events, Charlevoix County

LOCATION	DATE	EVENT TYPE	INJURIES, DEATHS, DAMAGES	EVENT DESCRIPTION
Charlevoix County and Cheboygan, Chippewa, Delta, Gogebic, Houghton, Mackinac, Marquette, Ontonagon, and Schoolcraft Counties	12/1993 through 5/1994	Underground Freeze*		Governor Declared Emergency and Presidential Declared Major Disaster (1028)
CHARLEVOIX (ZONE)	2/4/2007	Extreme Cold/wind chill	0	High temperatures on the 4th (Super Bowl Sunday) were around zero, with low temperatures that night from five to ten below zero. Gusty northwest winds produced hazardous wind chills of 20 to 30 below zero, along with blowing and drifting snow. Many area schools closed on the 5th, due to the extreme cold and poor road conditions.
Charlevoix County and Cheboygan, Chippewa, Delta, Emmet, Gogebic, Luce, Mackinac, and Marquette Counties	12/13/2014	Deep Frost*		Governor Declared Emergency
CHARLEVOIX (ZONE)	2/4/2015	Extreme Cold/wind chill	0	A clipper system passing just north and east of Michigan would bring a multitude of weather hazards. Widespread light snow occurred ahead of the system's cold front, but that snow was enhanced by Lake Michigan into northwest lower Michigan. Snowfall totals of 6 to 8 inches were seen, especially west and southwest of Traverse City, with the highest amounts near Wellston. The coldest air of the winter so far surged in behind the cold front, along with gusty northwest winds and lake effect snow. Considerable snowfall, blowing and drifting snow, and low wind chills were realized in northwest lower Michigan. Across the rest of northern Michigan, away from the temperature-mitigating effects of Lake Michigan, wind chills reached warning criteria. Wind chills reached 30 to 40 below zero in northern lower Michigan, and 40 to 50 below zero in eastern upper, bottoming out at -49 in Dafter early in the morning of the 15th.
STATEWIDE	1/29/2019	Extreme Cold/wind chill	0	Governor Declared Emergency – Wind chills of 15 to 30 below zero were common in northern lower Michigan. Wind chills were much colder in eastern upper Michigan, including -51 at Kinross, and -42 at Sault Ste Marie and Mackinac Island.

Source: NOAA: National Centers for Environmental Information
Notes: * not an event recorded in the NOAA NCEI database; sourced from MSP 2019 *Michigan Hazard Analysis*

Probability of Future Events and Vulnerability Assessment
Since 2001, there have been two extreme heat events in Charlevoix County. This indicates there is an 8.7% annual chance than an extreme heat event would occur in a future year.

Since 1993, there have been five extreme cold events in Charlevoix County. This indicates there is about a 16.7% chance an extreme cold event would occur in a future year. Since extreme cold events tend to occur during the winter months and are coupled with blustery winds and snowstorms, these events may have been reported as other hazards or not at all, which means there may have been more extreme cold events in the county.

Extreme heat and cold events are more likely to impact unsheltered populations, such as the urban homeless population and people working or recreating outside. There are several locations that can serve as temporary emergency shelters in the county in the event of an extreme heat/cold emergency. The Charlevoix County Emergency Management Department maintains agreements with public schools, local fire departments/government offices and some churches for use of their buildings as secondary shelter sites.

Anecdotally, emergency personnel see more fatalities during extreme temperature events. Vulnerable populations may not be able to find or access heating or cooling stations or are able to communicate their needs. In addition to human vulnerability to extreme temperatures, because heat is an additive, there are also environmental concerns when heat increases the risk of wildfire and drought.

The *Northwest Lower Michigan Coastal Resilience Atlas* written by the Land Information Access Association completed a Heat Vulnerability Assessment[6] of coastal communities. A community's vulnerability is their exposure to the hazard (determined by tree canopy and impervious surface coverage) + their sensitivity. Sensitivity is determined by these factors:

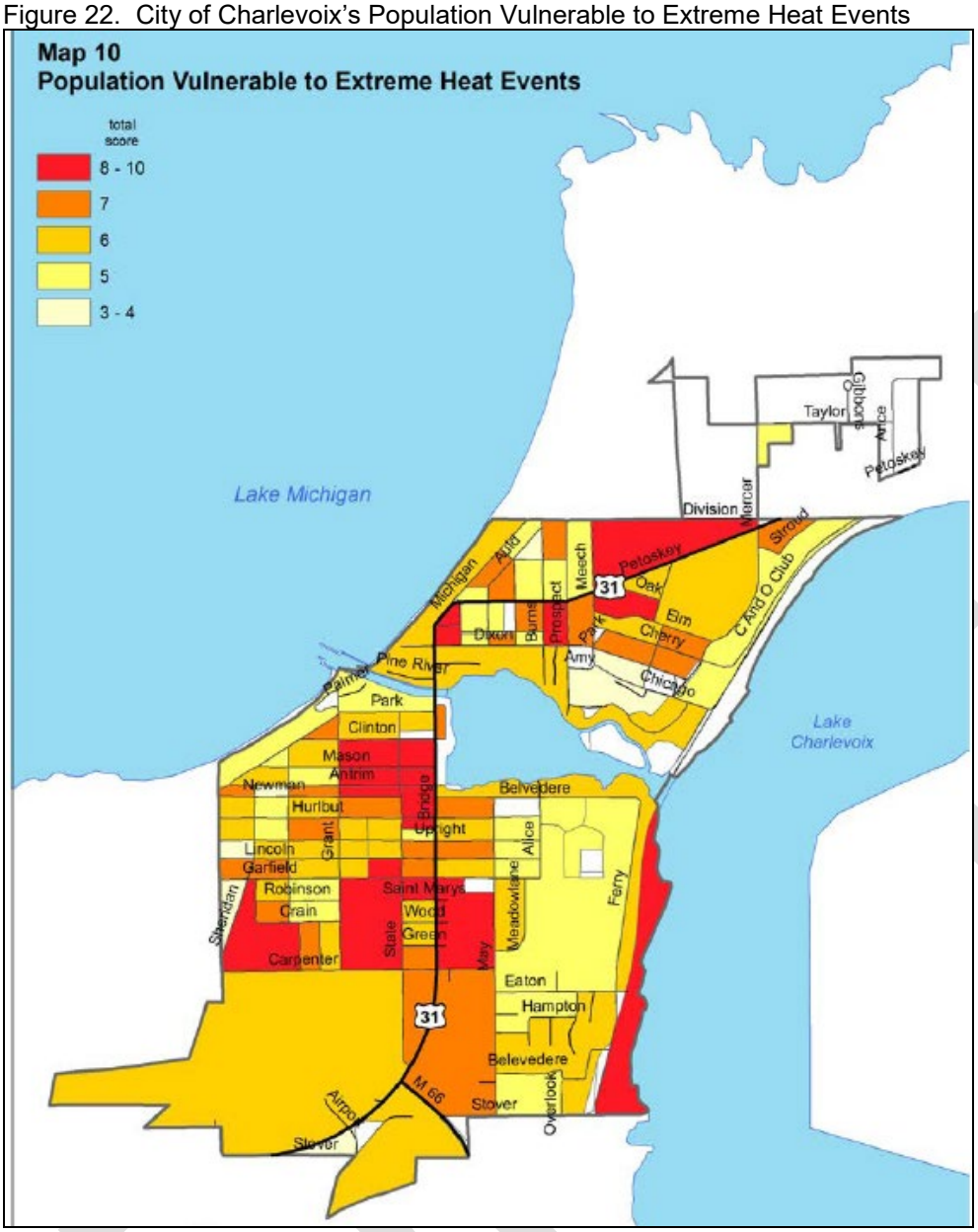
- Persons > 65 years
- Persons living alone
- Minority (non-white) persons
- Persons living below the poverty threshold
- People > age 25 with less than a high school education
- Disability status (i.e., ambulatory difficulty, mental disability)

Considering all of these factors, Figure 22 illustrates the vulnerability of the City of Charlevoix's population to extreme heat events. Similar maps were created in the *Atlas* for Hayes Township, Charlevoix Township, and Norwood Township.

According to US Census data, approximately 24.16% of Charlevoix County residents are over age 65; an estimated 9% of households are in poverty; an estimated 27% are considered "Asset Limited, Income Constrained, and Employed"; and an estimated 15.3% have one or more type of disability. Additionally, and estimated 55.62% of the housing stock in the county is over 40 years old. Many homes do not have central air conditioning, which may be needed more often with expected increasingly warmer summers in Michigan.

[6] Land Information Access Association. (2019). *Northwest Lower Michigan Coastal Resilience Atlas.* http://www.resilientmichigan.org/nw_atlas.asp

Figure 22. City of Charlevoix's Population Vulnerable to Extreme Heat Events



Source: LIAA *Northwest Lower Michigan Coastal Resilience Atlas, page 791*

Drought

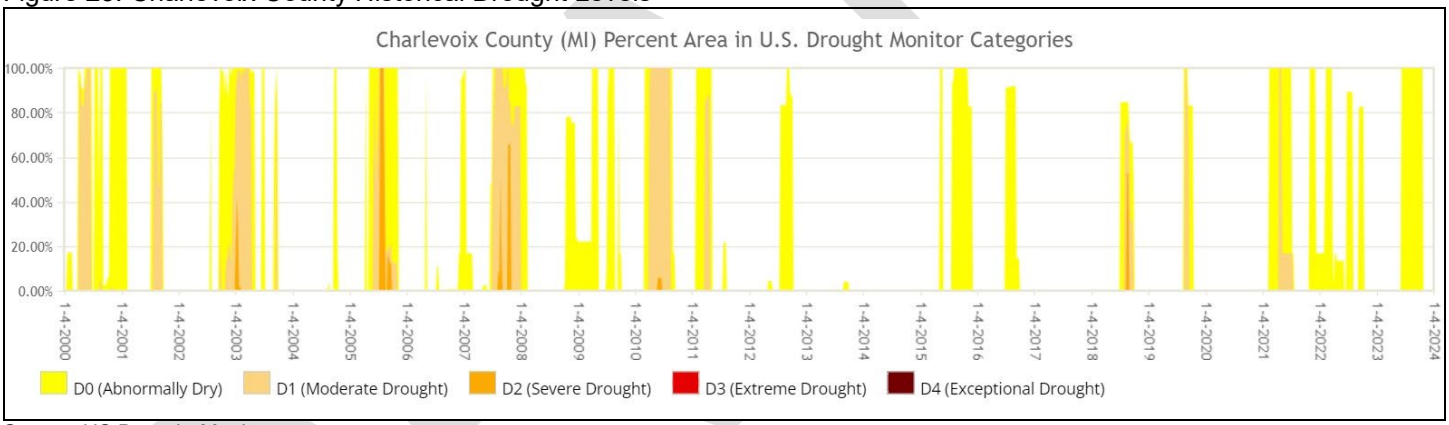
Drought is a normal part of the climate cycle. It is a slow-moving hazard, which causes people to underestimate the damage it can do, but losses from drought are as substantial as those from hurricanes, tornadoes and other faster-moving disasters. Drought can cause agricultural loss; affects domestic water supply, energy production, public health, and wildlife; and contributes to wildfire risk.

Location
Drought is a regional event that is not confined to geographic boundaries and range in severity across the affected areas. All of Charlevoix County is at risk to the occurrence and impacts from drought.

Extent
The Palmer Drought Severity Index (PDSI) uses readily available temperature and precipitation data to estimate relative dryness. It is a standardized index that generally spans -10 (dry) to +10 (wet). Maps of operational agencies like NOAA typically show a range of -4 to +4, but more extreme values are possible. The PDSI has been reasonably successful at quantifying long-term drought.

The U.S. Drought Monitor (Figures 23 and 24) combines several input sources including the PDSI and the Standardized Precipitation Index to prepare a weekly map showing parts of the U.S. that are in drought. The map uses five classifications: abnormally dry (D0), showing areas that may be going into or are coming out of drought, and four levels of drought: moderate (D1), severe (D2), extreme (D3) and exceptional (D4). Based on the historical data presented, Charlevoix County encountered its worst levels of drought D2 (severe drought) between 2000 and 2023 in the years 2003, 2005, 2007, 2010, and 2018.

Figure 23. Charlevoix County Historical Drought Levels



Source: US Drought Monitor

Figure 24. U.S. Drought Categories and Historically Observed Impacts

Category	Historically observed impacts
D0	Grass fires increase
	Lawns are brown; landscape and gardens are watered more frequently
D1	Most crops and vegetation are stressed; farmed Christmas trees are stressed
	Well levels decline
D2	Corn and soybean yields are low
	Mature trees are stressed
	Streamflow is extremely low, potentially too low to irrigate

Source: US Drought Monitor

Previous Occurrences
There have been three major drought events on record for in Charlevoix County (Table 49). There were no reported deaths, injuries, or damages are associated with these events.

Table 49. Major Drought Events in Charlevoix County

LOCATION	DATE	EVENT TYPE	INJURIES, DEATHS, DAMAGES	EVENT DESCRIPTION
Charlevoix County and 43 other counties	3/2/1977	Drought	0	Federally Declared Emergency (3035)
Charlevoix County (Zone)	8/28/2007	Drought	0	Drought conditions (severe, D2) expanded into the tip of Northern Michigan by the end of August. This was the result of a dry summer in the region. The dryness dated as far back as May, when only 1.09 inches of rain fell in Pellston. June rainfall was 1.92 inches. July rainfall was near normal and brought some respite, but August saw just 1.21 inches of rain at Pellston. A ban on burning was issued for most of the state in mid-August, the first such ban since 1998. Golf courses and farmers complained of very high utility bills, due to the need for near-constant irrigation. Corn and bean crops were severely impacted. Rains in September would partially alleviate drought conditions for a spell.
Charlevoix County (Zone)	9/1/2007	Drought	0	Drought conditions (severe, or D2), which carried over from August, eased thanks to wet weather early in the month. Charlevoix County was removed from severe drought when around an inch of rain fell from the 3rd into the 4th.

Sources: NOAA National Centers for Environmental Information; MSP 2019 Michigan Hazard Analysis

Probability of Future Events and Vulnerability Assessment
There have been four occurrences of a drought incident affecting Charlevoix County since 1977. This indicates an 8.5% annual chance of a future drought event in Charlevoix County. In Northern Michigan's forested regions, drought can adversely impact timber and agricultural production and some tourism and recreational enterprises. This can also cause a drop in income, which impacts other economic sectors.

The biggest problem drought presents, however, is the increased threat of wildfire. Every community in the county has scattered areas of pine trees which are highly vulnerable to wildfire in drought conditions (see the Environmental Features map in Appendix A). Public input sessions for the development of this plan indicated particular concern for orchard areas located in Norwood, Marion and Eveline Townships, as well as areas of cedar trees and juniper shrubs on portions of Beaver Island that local residents indicate are also prone to wildfire. Additionally, many remote areas on Beaver Island, the islands in the Beaver Island archipelago, and on rural areas throughout the mainland portion of the county have limited access (via seasonal, narrow roads, or limited to air or boat transportation) in the event of a wildfire.

Additionally, the threat to water sources should also be considered. Even drought events in category D1 experience water well level decline. Drought events combined with excessive heat can also have severe impacts on elderly and low income people.

Wildfire

A wildfire is an unplanned, uncontrolled fire in grassland, brushland, or forested areas. Wildfires can occur in any forest or grassland type under dry conditions; however, some forest types are more susceptible to wildland fires. For example, jack and red pine forest stands have a high risk for wildfires, as they dependent on fire to provide all the right conditions for regeneration, while aspen and white pine forest stands have a moderate risk.

The primary cause of wildfire is from human activities, specifically burning outdoor debris. Recently, only about 4% of all wildfires in Michigan were caused by lightning strikes, and most other causes have been attributed to human activity. Most Michigan wildfires occur close to where people live and/or recreate, which puts both people and property at risk. The immediate danger from wildfires is the destruction of property, timber, wildlife, and injury or loss of life of persons who live in the affected area or who are using recreational facilities in the area. Long-term effects include scorched and barren land, soil erosion, landslides/mudflows, water sedimentation, and loss of recreational opportunities.

Approximately 55% (20.4 million acres) of Michigan's total land area is forest cover. The vast forests provide Michigan with the largest state-owned forest system in the United States. In addition, Michigan has the fifth largest quantity of timberland acreage, with 19.3 million acres (including hardwoods and softwoods). That vast forest cover is a boon for both industry and recreation, and these areas have been gradually increasing in recent years. However, it also means that many areas of Michigan are vulnerable to wildfires.

Michigan's fire season starts in early spring, when leaves and grasses remain dry from fall and winter and trees are not yet green. Wildfires are often accompanied by drought where dry conditions increase the potential to burn. Often a thunderstorm will roll through and lightning will strike causing sparking of dry leaves and dead wood. High winds can then spread wildfire. Wildfires can become unpredictable in windy conditions or when the wind changes direction suddenly. Cooler nighttime temperatures often help suppress wildfires and the potential for wildfire; however Michigan has had several major fire events.

According to MDNR and U.S. Forest Service records, between 1910 and 1949, over 5.8 million acres of forest were burned in the state of Michigan; an average of 145,000 acres per year. By comparison, it was reported that between 1950 and 1996, the MDNR and U.S. Forest Service were involved in suppressing over 46,100 wildfires that burned 390,000 acres of forest, which averages only 8,300 acres burned per year. This drastic reduction in the acres of timber burned was largely the result of (1) increased use of specialized equipment to suppress the fires, and (2) intensified efforts toward fire prevention.

Location

All Charlevoix County communities and developed areas are vulnerable to wildfires since the community centers and rural residential developments interface with the high risk forest types (e.g. Red Pine, Eastern White Pine, and Jack Pine). In terms of tree type and coverage, there are_____ acres of Red Pine, ___ acres of Eastern White Pine, and ___acres of Jack Pine in Charlevoix County. As shown in the Environmental Features map in Appendix A, Red Pine and Eastern White Pine forest types are located throughout the county. Many of the pine forest areas overlap with publicly owned lands.

Extent and Previous Occurrences

Extent can be measured by the number of acres burned and the cost of property damage. According to the Michigan State Police's *2019 Michigan Hazard Analysis*, between 1981 and 2018 there were 173 reported fires on land in Charlevoix County under MDNR jurisdiction. This resulted in 522.2 total acres burned, with an average of 13.7 acres burned and 4.6 wildfires per year. No property damages were recorded.

Probability of Future Events and Vulnerability Assessment

There is a 100% annual chance there will be a wildfire on MDNR lands, and a small chance there will be a wildfire on lands outside of these areas. Red Pine, Eastern White Pine, and Jack Pine forest are scattered throughout the county and are susceptible to wildfires. Jack pine is the most flammable of the pine tree species, and can be found in parts of the following townships: Bay, Charlevoix, Eveline, Evangeline, Hayes, Marion, Melrose and Norwood.

Additional factors that increase fire risk include dead or dying trees as a result of disease/invasive species, invasive species itself, lightning strikes, and human factors such as the number of persons residing, camping, or traveling through the County. Historically, Michigan's landscape has been shaped by wildfire; however, over the last several decades, the

current landscape has transformed from wildland to residential development. With the increase in residential development in and around rural areas prone to wildfires, there is an increase in the potential for loss of life and property damage. Local fire departments have mutual aid agreements in order to provide additional coverage for rural, sparsely populated, or difficult to reach areas. Residential development in rural parts of the county is often isolated from town centers and emergency services. Many of these areas interface with public lands and local emergency services coordinate fire services with State fire protection agencies.

Every community in the county has scattered areas of pine trees which are highly vulnerable to wildfire in drought conditions (see the Environmental Features map in Appendix A).

Public input sessions for the development of this plan indicated particular concern for wildfire that could impact the orchard areas located in Norwood, Marion and Eveline Townships. Beaver Island stakeholders indicated that there are areas of cedar trees and juniper shrubs on portions of the island that are also prone to wildfire. Additionally, many remote areas on Beaver Island, including the islands in the Beaver Island archipelago (although only Trout and Squaw/Ojibwe Islands contain residential homes), and rural areas throughout the mainland portion of the county have limited access (via seasonal, narrow roads, or limited to air or boat transportation). Outer islands in the Beaver Island archipelago are subject to wildfires occurring from lightning strikes.

Ensuring proper access to water for emergency firefighting use was also brought up as a concern. In particular, there is a lack of an accessible water source (such as a standpipe) around Thumb Lake in Hudson Township. The Lake Louise Christian Community summer camp and many residential homes surround Thumb Lake.

Once Beaver Island's "Create a Community Wildfire Protection Plan" (CWPP) grant is created, apply for related grants to implement the plan. Part of this plan would be to add two buried 30,000 gallon water tanks (in addition to the existing tank at the east side fire hall) at the south and west ends of the Island, to provide water sources for firefighting use.

Dense Fog

Fog forms when water vapor condenses into tiny liquid water droplets that remain suspended in the air just above the Earth's surface, reducing visibility to values equal to or below locally/regionally established values for dense fog (usually 1/4 mile or less) and impacting transportation or commerce.

Two ways that air can become saturated with water are by cooling it to its dew point temperature, or by evaporating moisture into it to increase its water vapor content. Although most fog, by itself, is not generally a hazard because it does not actually apply damaging forces, the interaction between humans and fog can be a dangerous situation, sometimes resulting in disastrous consequences. It must be noted, however, that freezing fog (a hazard for which the National Weather Service issues special statements) can cause direct harm by causing slickness on roadways, walkways, bridges, and highway ramps, and therefore leading to serious transportation accidents.

Fog is not so easy to classify as a severe and high-impact hazard, although it has caused costs and casualties in the transportation sector, especially—sometimes with deadly consequences. Fog has played a contributing role in several multi-vehicle interstate highway pileups during recent years. While statistics suggest that highway accidents and fatalities, in general, have fallen, that trend is not evident with respect to accidents and fatalities caused by fog. The vast majority of automotive accidents are caused by unsafe driving habits and risk-taking behaviors, such as following too closely behind another vehicle, driving too fast for weather and visibility conditions, and distracted driving. Airplanes have their own inherent vulnerabilities when foggy conditions develop and make a safe landing more difficult.

Fog can be very dangerous when it reduces visibility. Although some forms of transport can penetrate fog using radar, road vehicles have to travel slowly and use their lights to become visible to each other. Localized fog is dangerous if drivers are surprised by it. At airports, some efforts have been made to develop methods (such as using heating or spraying salt particles) to aid fog dispersal, especially at temperatures near or below freezing.

One severe fog event is estimated to occur in Michigan approximately every two years. Property damage can be significant for vehicles, although real property and structures are usually unaffected. Fog has not yet been identified as one of the most significant hazards in any of Michigan's local hazard mitigation plans.

Location
Dense fog can be a local, regional, or state-wide event that is not confined to geographic boundaries and ranges in severity across the affected areas. All of Charlevoix County is at risk to the occurrence and impacts from dense fog.

Extent / Previous Occurrences
Dense fog can be measured by damages-caused including deaths, injuries, property damages, and/or crop damages. There is no record of a dense fog event in Charlevoix County in the NOAA NCEI database.

Probability of Future Events and Vulnerability Assessment
Dense fog events are likely to occur more frequently, but go unreported as injuries, deaths and damages do not occur. All of Charlevoix County, particularly road, air and water transportation systems, are at risk to the impacts from dense fog. The continued and increased use of NOAA Weather Radio and mobile alert systems can inform people of hazardous conditions and the appropriate precautions to take (such as limiting travel) during a dense fog event.

Coastal Hazards - Dangerous Currents

Dangerous currents and breaking waves are common in the Great Lakes region. Rip currents and other currents found near piers are extremely dangerous for swimmers and can lead to drownings. Currents in the Great Lakes can form from any combination of wind, waves, bottom formation, beach slope, water temperature, man-made structures, and natural outlets. In the Great Lakes, swimmers are most likely to encounter one of five common currents: rip, longshore, structural, outlet, and channel.

During rip currents, the water "piles up" between a sandbar and the beach. It has to find a way back out to sea. After the pressure builds up, the water creates a pathway and gushes from the shore back out to open water. That's a rip current: a narrow but powerful stream of water and sand moving (ripping) swiftly away from shore. Rip currents vary in size and speed and can be found on many beaches every day. They typically extend from the shoreline through the surf zone, and past the line of breaking waves. Typically, they form at breaks in sandbars, and also near structures, such as jetties and piers, as well as cliffs that jut into the water.

Rip currents carry swimmers into deeper water, where they may not be able to get their footing. These currents rarely extend far out, and will not pull a swimmer underwater. Rip currents vary in size from very narrow to more than 50 yards wide. Speeds can also vary. The average speed is 1-2 feet per second, but they have been measured as fast as 8 feet per second.

Longshore currents move parallel to or the "long" way along the shoreline. These currents will exert a force to move along shore, making it difficult to remain in front of a spot on the beach. They often happen between the first and second sandbars near the shore. Longshore currents become more dangerous when they combine with rip currents or structural currents since they can move a swimmer swiftly down a beach and into the path of another current or into a structure (pier or breakwall), making it more difficult to swim to shore.

Structural currents - the currents found alongside or as a result of structures like piers and breakwalls - are usually always present. Structural currents are dangerous on their own, but when paired with others like longshore or rip currents, the combination can create a washing machine effect, moving the swimmer from one dangerous current area to another with no clear path to safety.

Outlet currents can be found where rivers and streams empty into the Great Lakes. The flow of water from the river or stream can move quickly. As it enters the open water of a lake, it may take a while for that current to dissipate. Pair that with currents that are present in the lake and the situation can become dangerous.

Channel currents are like a river running parallel to shore. With a channel current, typically there is an island or structure such as a large group of rocks not far from shore. A channel current forms when the flow of water speeds up as it goes between the island and shore, like a bottleneck. This is made worse by the presence of a submerged or partially submerged sandbar connecting the beach to the island, which allows pressure to build behind the water and waves until it breaks through. When the wind speed increases, the waves also increase in intensity, and this causes the current to become stronger and faster.

According to the Great Lakes Current Incident Database, between 2002 and 2020, there have been 75 deaths and 274 persons rescued from dangerous current incidents along the Lake Michigan coastline of Michigan's Lower Peninsula.

It is important to note that there are no "rip tides" or "undertows" in the Great Lakes. Since there are no tides in the Great Lakes, and rip currents don't pull a person down under the water (it will carry them out to the open water, away from shore), "rip tides" or "undertows" are inaccurate coastal hazard terms.

Dangerous current-related incidents in the Great Lakes most often occur when:

- Winds are blowing towards the shore
- Wave heights reach 3 to 6 feet
- A cold weather front is passing through

Location

Dangerous currents are coastal events that are not confined to geographic boundaries and may occur anywhere in Lake Michigan waters. All coastal areas in Charlevoix County are at risk to the occurrence and impacts from dangerous currents.

Extent
The National Weather Service provides a Surf Zone Forecast to measure the risk level associated with rip current hazards. Surf Zone Forecasts contain three levels of Rip Current Outlooks:

- Low Risk: The risk for rip currents is low, however, life threatening rip currents often occur in the vicinity of groins, jetties, reefs, and piers.
- Moderate Risk: Life threatening rip currents are possible in the surf zone.
- High Risk: Life threatening rip currents are likely in the surf zone.

Dangerous currents can be measured by damages-caused including deaths and injuries.

Previous Occurrences
There are no records of dangerous current incidents (deaths/rescues) on record for Charlevoix County. However, it is likely that these events have occurred but gone unreported. There are instances of fatalities from rip currents in nearby coastal counties including Benzie, Emmet, and Leelanau Counties.

Probability of Future Events and Vulnerability Assessment
Dangerous current events are likely to occur, but may go unreported as injuries and deaths do not occur. Strong currents are dangerous to all swimmers, especially those who are unprepared to be swept up in them. Many Lake Michigan beaches do not have a lifeguard on duty who may identify potential hazardous swimming conditions. Swimmers who are caught unaware may panic when caught up in the fast-moving water, tire as they try to swim against the current, and drown. Public beaches with Lake Michigan access in Charlevoix County are located in Charlevoix Township, the City of Charlevoix, Hayes Township, Norwood Township, Peaine Township, and St. James Township.

Coastal Hazards - Seiche

According to the National Weather Service, a seiche is a standing-wave oscillation in any enclosed lake that continues after a forcing mechanism has ceased and results in shoreline flooding and/or damage. In the Great Lakes and large inland lakes, large pressure differences, high winds, or fast-moving squall lines may act as the forcing mechanism. In addition, earthquakes or debris flows can initiate a seiche. When the forcing mechanism ends, the water sloshes back and forth from one end of the lake to the other, causing water level fluctuations of up to several feet before damping out.

A seiche is usually limited to partially or fully enclosed basins, such as Lake Erie. Lake Erie is known for seiches, especially when strong winds blow from southwest to northeast. In 1844, a 22-foot seiche breached a 14-foot-high sea wall killing 78 people and damming the ice to the extent that Niagara Falls temporarily stopped flowing. As recently as 2008, strong winds created waves 12 to 16 feet high in Lake Erie, leading to flooding near Buffalo, New York.

In some of the Great Lakes and other large bodies of water, the time period between the "high" and "low" of a seiche can be as much as four to seven hours. This is very similar to the time period between a high and low tide in the oceans, and is often mistaken as a tide.

According to the NOAA-NCEI Storm Events Database, there have been 15 seiche events in Michigan since 1998. There are no deaths, no injuries, and $31,000 in property damages in Michigan due to seiche events.

Location
A seiche is a coastal event that is not confined to geographic boundaries and may occur anywhere in Lake Michigan waters or on large inland lakes. All coastal areas are at risk to the occurrence and impacts from a seiche.

Extent and Previous Occurrences
Seiche events can be measured by damages-caused including deaths, injuries, and property damages. There are no seiche events on record for Charlevoix County in the NOAA Storm Events Database.

However, the Lake Charlevoix Association's website describes the occurrence of seiche activity on Lake Charlevoix. Because Lake Charlevoix is directly connected to Lake Michigan through the Pine River Channel in Charlevoix, its water level fluctuates with that of Lakes Michigan and Huron. In fact, the Pine River can flow in both directions! Most of the time, water flows out of Lake Charlevoix through the channel, but sometimes the flow is reversed due to a seiche, when the rise in water level at one end of the lake caused is by wind-driven waves; in this case, westerly winds push water up along Lake Michigan's eastern shore, causing the Pine River to flow back into Lake Charlevoix. The current can be quite strong either way.

Probability of Future Events and Vulnerability Assessment
Seiche events have likely occurred along the Lake Michigan coastline in Charlevoix County, but may have been unreported if injuries, deaths, or significant property damages did not occur. However, persons and property along the lake shore, particularly marinas (such as those on Lake Charlevoix and in St. James Harbor), are vulnerable to high waves and temporary high lake levels caused by a seiche. Seiche events are also dangerous to all swimmers, especially those who are unprepared to be swept up in the current. Many Lake Michigan beaches do not have a lifeguard on duty who may identify potential hazardous swimming conditions.

Coastal Hazards - Waterspout

NOAA defines a waterspout as a "funnel which contains an intense vortex, sometimes destructive, of small horizontal extent and which occurs over a body of water." Tornadic waterspouts generally begin as true tornadoes over land in association with a thunderstorm, and then move out over the water. They can be large and are capable of considerable destruction, and are often accompanied by high winds and seas, large hail, and frequent dangerous lightning.

Fair weather waterspouts, on the other hand, form only over open water. They develop at the surface of the water and climb skyward in association with warm water temperatures and high humidity in the lowest several thousand feet of the atmosphere. They are usually small, relatively brief, and less dangerous. The fair weather variety of waterspout is much more common than the tornadic.

Waterspouts occur most frequently in northern Michigan during the months of August, September, and October, when the waters of the Great Lakes are near their warmest levels of the year. Waterspout formation typically occurs when cold air moves across the Great Lakes and results in large temperature differences between the warm water and the overriding cold air. They tend to last from about two to twenty minutes, and move along at speeds of 10 to 15 knots.

There are five stages of waterspout formation:

1. Dark spot. A prominent circular, light-colored disk appears on the surface of the water, surrounded by a larger dark area of indeterminate shape and with diffused edges.
2. Spiral pattern. A pattern of light and dark-colored surface bands spiraling out from the dark spot which develops on the water surface.
3. Spray ring. A dense swirling annulus (ring) of sea spray, called a cascade, appears around the dark spot with what appears to be an eye similar to that seen in hurricanes.
4. Mature vortex. The waterspout, now visible from water surface to the overhead cloud mass, achieves maximum organization and intensity. Its funnel often appears hollow, with a surrounding shell of turbulent condensate. The spray vortex can rise to a height of several hundred feet or more and often creates a visible wake and an associated wave train as it moves.
5. Decay. The funnel and spray vortex begin to dissipate as the inflow of warm air into the vortex weakens.

According to NOAA's National Weather Service, the best way to avoid a waterspout is to move at a 90-degree angle to its apparent movement.

Location, Extent and Previous Occurrences

Waterspouts are a common occurrence posing a great threat to marine traffic. According to the MSP's 2019 *Michigan Hazard Analysis*, Michigan waterspouts have been noted by National Climatic Data Center between 1993 and 2001. Many additional events have occurred since, which NCDC has classified according to the corresponding lake location rather than as part of Michigan itself. Waterspouts are less frequent on Lake Superior (8 events since 2001) than on Lakes Huron (23 events) or Michigan (51 events).

There are no Great Lakes waterspout events on record with NOAA's NCEI Storm Event Database for Charlevoix County.

Waterspouts typically last from about two to twenty minutes, and move along at speeds of 10 to 15 knots. They can overturn watercraft and cause damage to bridge structures and According to the MSP's 2019 *Michigan Hazard Analysis*, a waterspout caused $200,000 in damage to a boat house and storage building at Drummond Island (Lake Huron) on July 3, 1999.

Probability of Future Events and Vulnerability Assessment

Despite the lack of a recorded Lake Michigan waterspout event with the NOAA NCEI Storm Event Database for Charlevoix County, it is likely that waterspouts have occurred in the past, but have not been officially documented.

The National Weather Service (NWS) meteorologists consider forecasting waterspouts during the late summer and fall whenever large, cool air masses overspread the waters of the Great Lakes. Once the NWS has determined that waterspouts are possible, the threat is outlined in the Nearshore Marine Forecast and Hazardous Weather Outlook. The NWS strives to provide this information to the public 12 to 24 hours prior to waterspout occurrence.

When waterspouts have been detected by Doppler radar or reported by local law enforcement or spotters, the NWS issues a Special Marine Warning. Since it is not uncommon for numerous waterspouts to occur simultaneously over a

large area, these warnings tend to cover larger geographic areas than land-based tornado warnings which generally cover a single county.

In most cases, waterspouts which make landfall are much weaker than tornadoes, produce little or no damage, and dissipate quickly. Once on land, they tend not to be a great threat to life and property. In these instances, the NWS issues a Tornado Warning.

A mitigation strategy for marine vessel operators on the Great Lakes includes education and awareness about the prevailing weather conditions, appearance and destructive potential related to waterspouts. When warnings are issued for waterspouts, boaters should prepared to quickly seek safe harbor, or to find shelter out of the path of the waterspout. The best source for waterspout forecast information is NOAA Weather Radio (NWR). These continuous broadcasts from transmitters scattered around the Great Lakes provide forecasts and warnings 24 hours a day. Mobile emergency alert systems can also be utilized as an informational source for waterspout forecasts and warnings.

Coastal Hazards - Coastal Recession and Shoreline Flooding

Coastal recession (subsidence) is the wearing away of land, such as loss of riverbank, beach, shoreline, or dune material. It is measured as the rate of change in the position or displacement of a riverbank or shoreline over a period of time. Short-term erosion typically results from periodic natural events, such as flooding, hurricanes, storm surge, and windstorms, but may be intensified by human activities. Long-term erosion is a result of multi-year impacts such as repetitive flooding, wave action, sea level rise, sediment loss, subsidence, and climate change. Death and injury are not typically associated with erosion; however, it can destroy buildings and infrastructure. Waters of the Great Lakes may cause shoreline hazards to occur making the entire northwest Michigan coastline is susceptible to shoreline hazards. As indicated in Figure 50, large portions of the Lake Michigan shoreline throughout west Michigan are identified as “High Risk Erosion Areas in 2019.”

Coastal (shoreline) flooding results when Great Lakes water levels rise and push inland, or when rainfall or snowmelt accumulates along the shoreline and is not able to drain properly. Shoreline flooding may also be caused during storms and wind events with high-energy waves.

Most of the northwest Michigan coastline is susceptible to coastal recession and shoreline flooding.

Figure 50. Great Lakes Shorelines with High Risk Erosion Areas, 2019

Location
To reference the 2019 *Northwest Lower Michigan Coastal Resilience Atlas*, "Climate scientists predict that northwest Lower Michigan can expect more frequent storms of increasing severity in the decades ahead. The total amount of rainfall per year in also likely to increase. The potential for substantially larger rain events and severe storms raises concerns of harm to human health and damage to buildings and infrastructure, especially for areas along the Lake Michigan coastline."

The Land Information Access Association documented potential shoreline hazards for these communities in Charlevoix County in the *Northwest Lower Michigan Coastal Resilience Atlas*: Hayes Township, Charlevoix Township, the City of Charlevoix, and Norwood Township (Figure 51). This study did not include the Beaver Island townships of Peaine or St. James. Specific areas of shoreline hazards in the county, as identified by stakeholders during the public input process for the development of this plan, are marked as a "shoreline erosion" type of hazard area on the Hazard Area Maps in Appendix A.

Figure 51. Charlevoix County Shoreline Communities in LIAA's Northwest Lower MI Coastal Resilience Atlas

In developing the *Northwest Lower Michigan Coastal Resilience Atlas,* scenario planning was used to determine the potential impact of three differing levels of storms combined with high waters:

"Lucky" Future: Great Lakes water levels will continue to stay relatively low. Although there will be wave and wind action, major storm events and wave impacts will not encroach on properties landward of current beaches. A Lucky Future projection, indicating the land areas that would be affected by high-energy waves along the shorefront and/or adjacent riverine flooding under these conditions, is shown in green on the maps.

"Expected" Future: Great Lakes water levels will continue to fluctuate according to long-term decadal patterns, including recent extreme storm events incorporated into the ongoing Great Lakes Coast Flood Study being conducted by the Federal Emergency Management Agency (FEMA). Given those ongoing fluctuations, this Climate Future accounts for periods when Great Lakes still-water elevations are closer to the long-term average. In addition, this Climate Future anticipates the so-called "100-year storm event" (or 1% storm) becoming more like a 20- or 50-year storm event (i.e., an expected storm within the normal community planning time horizon) because of increased storminess. The Expected Future projection is shown in yellow on the maps.

"Perfect Storm" Future: Great Lakes water levels will continue to fluctuate according to decadal patterns, consistent with assumptions made for the Expected Future. However, for this Perfect Storm Climate Future, the estimated still-water elevation is set higher than the long-term average and closer to the long-term high (583 feet). In addition, this Climate Future anticipates the occurrence of a so-called "500-year storm event" (or 0.2% storm) occurring within the planning time horizon while lake levels are high. The Perfect Storm Future projection is shown in red on the maps.

Figures 52 and 53 illustrate the potential flooding scenarios in parts of the City of Charlevoix and Hayes Township as examples. “Lucky” scenario flooding is shown in green, “Expected” flooding scenario is shown in yellow, and “Perfect Storm” future scenario is shown in red. Note that parts of US-31 and Round Lake are expected to flood in certain scenarios.

Figure 52. Panel #53 Coastal Flooding Scenario, City of Charlevoix

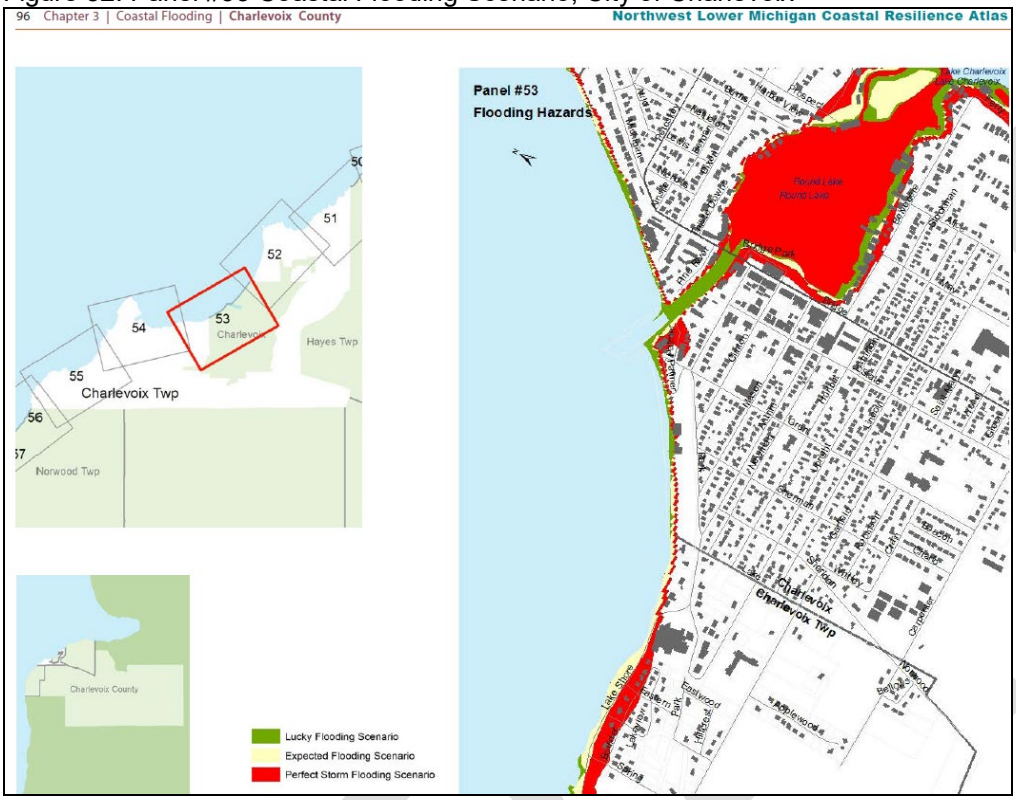
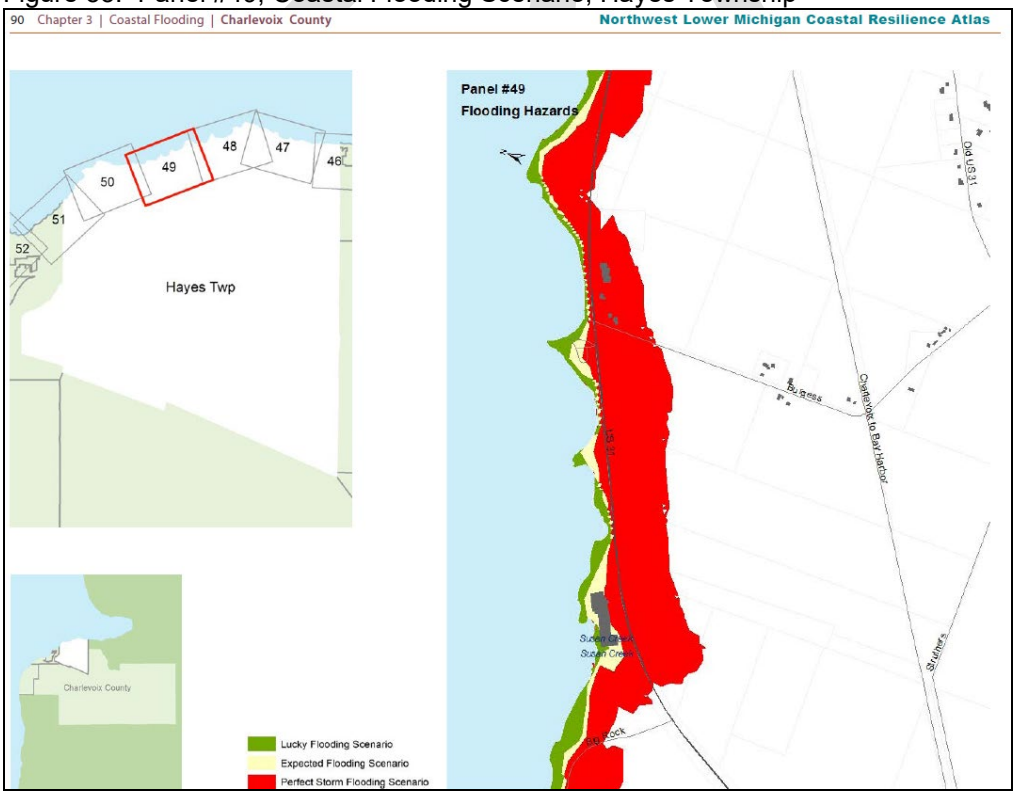
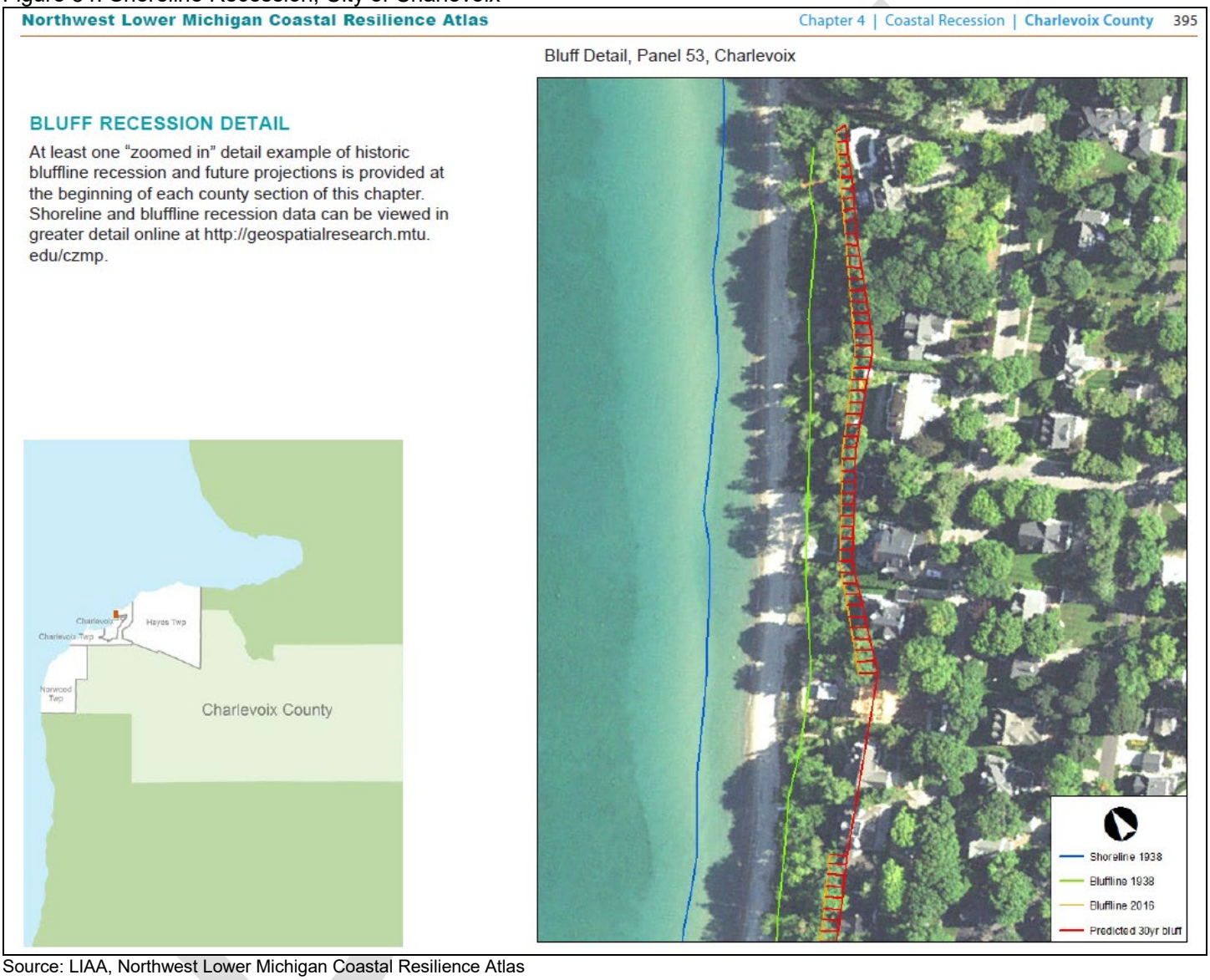


Figure 53. Panel #49, Coastal Flooding Scenario, Hayes Township



Coastal recession, or erosion, to Lake Michigan communities is a constant, but small wearing away of the shoreline. The Great Lakes are estimated to lose one foot of shoreline per year to normal wave and wind activity. However, storms and increased wave activity have caused increased coastal recession to varying degrees in Lake Michigan coastal communities. Chapter 4 of the *Northwest Lower Michigan Coastal Resilience Atlas* describes bluffline recession since the 1938 recorded shoreline location. The colored lines shown on the map in Figure 54 depict the recession of the bluffline in part of the City of Charlevoix. The blue line indicates the shoreline in 1938, the green line indicates the bluffline in 1938, the yellow line is the bluffline in 2016, and the red line is the predicted 30 year bluffline.

Figure 54. Shoreline Recession, City of Charlevoix



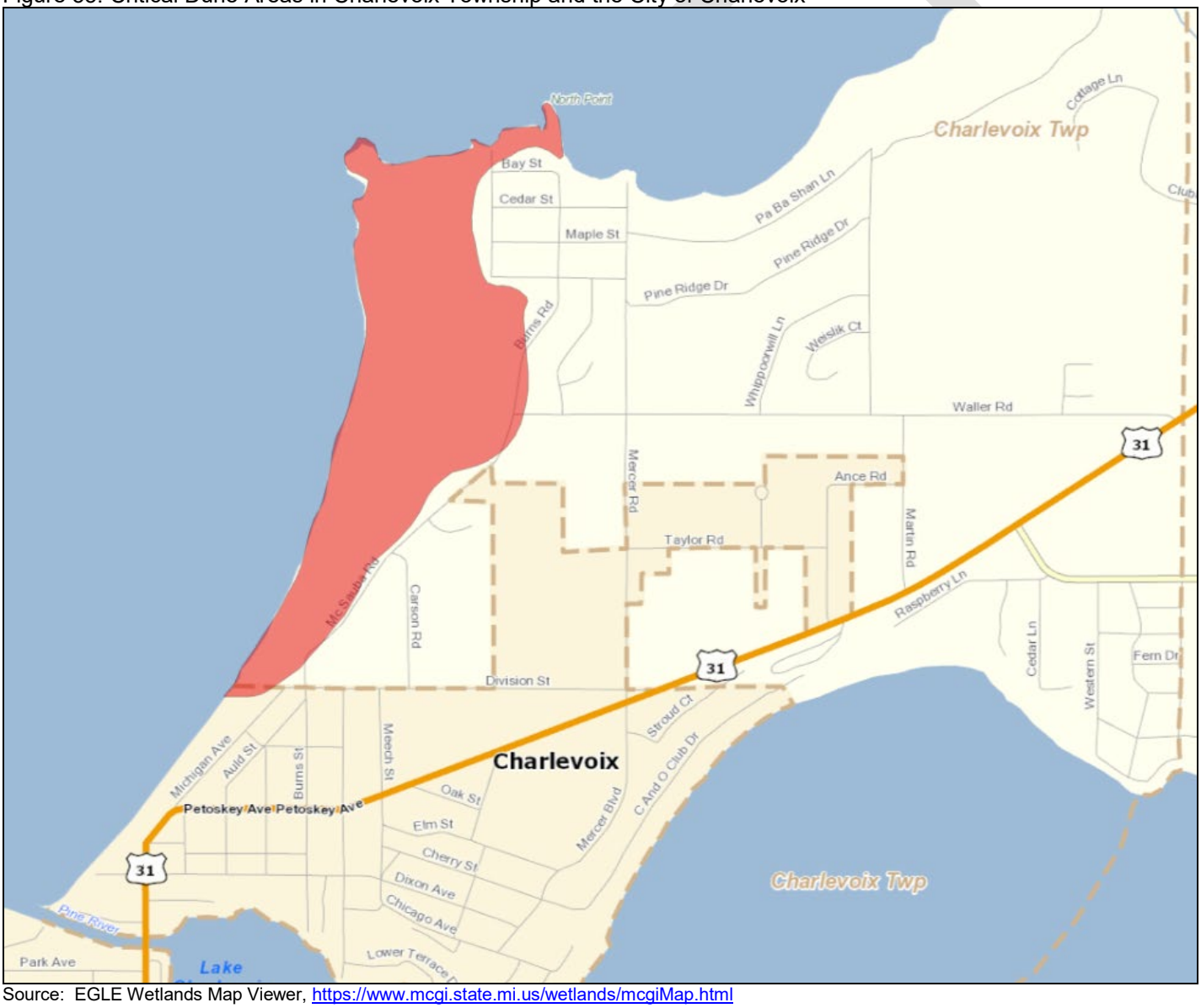
Source: LIAA, Northwest Lower Michigan Coastal Resilience Atlas

The communities of Charlevoix Township, Norwood Township, St. James Township, Peaine Township and small areas within the City of Charlevoix contain State-designated "Critical Dune Areas" (CDAs). Critical Dune Areas (CDAs) are a combination of coastal barrier dunes, land that has dune-like features, and unique plant communities along a Great Lake shoreline. Regulatory authority goes to the water's edge. The CDAs include public lands and private properties where developmental, silvicultural, and recreational activities are regulated and a permit is required under Part 353, Sand Dunes Protection and Management, of the NREPA. The law balances the benefits of protecting, preserving, restoring and enhancing the diversity, quality, functions, and value of the critical dunes with the benefits of economic development, multiple uses, and public access. A permit is required for activities that significantly alter the CDA, such as the construction of a house or garage, building a road or driveway, installing a septic system, installing retaining walls, and sand removal. Currently EGLE administers Part 353 for all CDAs within the mainland of Charlevoix County, while St. James Township and Peaine Township regulate CDAs within their local zoning ordinances.

The CDAs in Charlevoix County are shown as Figures 55 through 57, as well as on the Environmental Features Map in Appendix A. Detailed maps of CDAs provided by EGLE can be viewed at: https://www.michigan.gov/egle/about/organization/water-resources/sand-dunes/critical-dunes/maps.

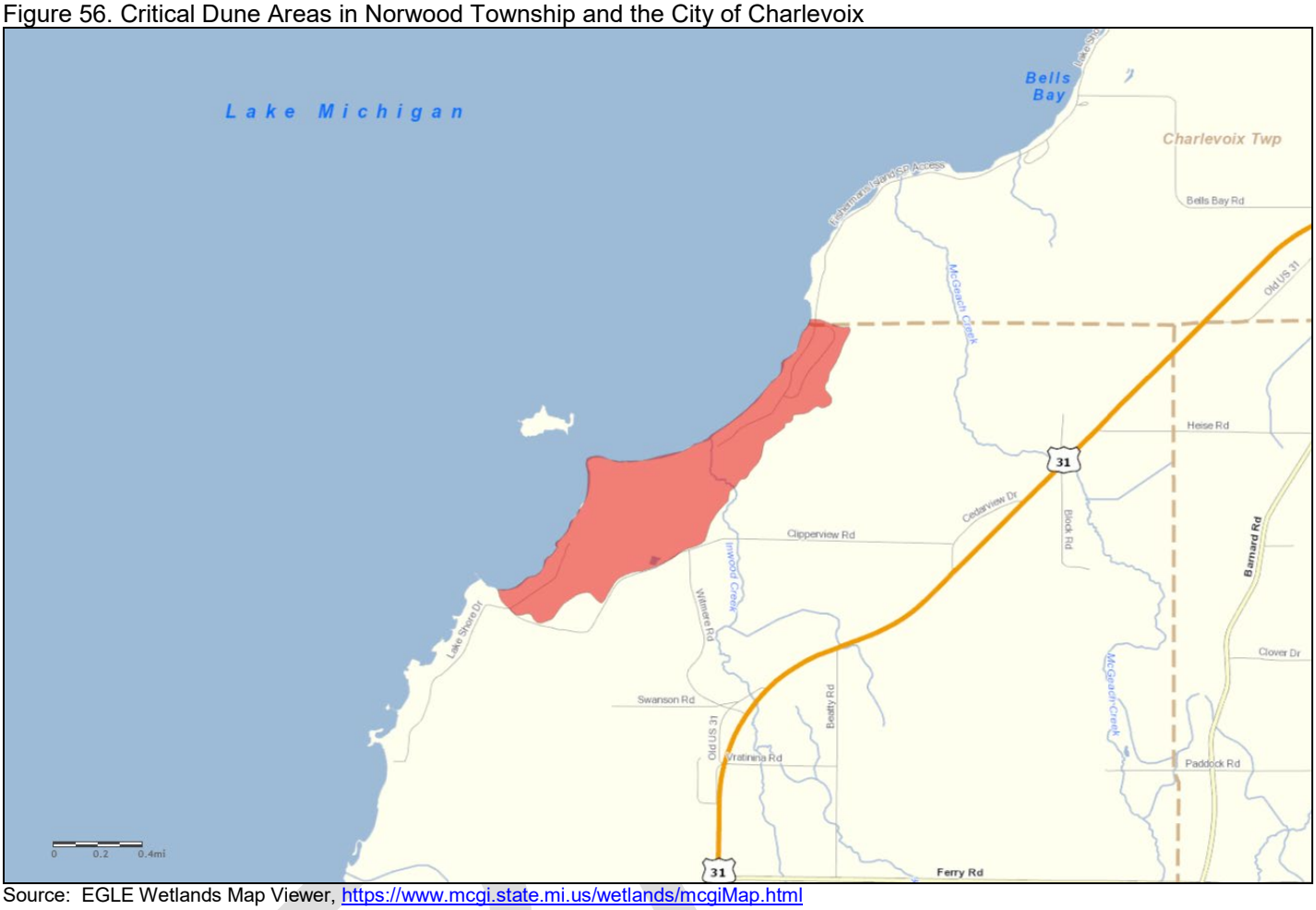
There are no High-Risk Erosion Areas (HREAs) within Charlevoix County. HREAs are shorelines of the Great Lakes where the land is receding at a rate of one foot or more per year for a minimum of 15 years. Recession rates change over time as water levels fluctuate and coastal conditions change. Along these shorelines, new structures are required to meet setbacks for their protection from a changing shoreline. When structures are not in danger, the shoreline does not need to be altered to protect the structure. A permit is required for construction of a structure on any portion of a designated High-Risk Erosion Area parcel regardless of how far the project is from the lakeshore. Common activities requiring a permit include construction of a house, garage, or addition, substantial reconstruction of an existing home, the installation of a septic system, covered porches, or a commercial building. HREAs are regulated by the Administrative Rules of Part 323, Shorelands Protection and Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.

Figure 55. Critical Dune Areas in Charlevoix Township and the City of Charlevoix



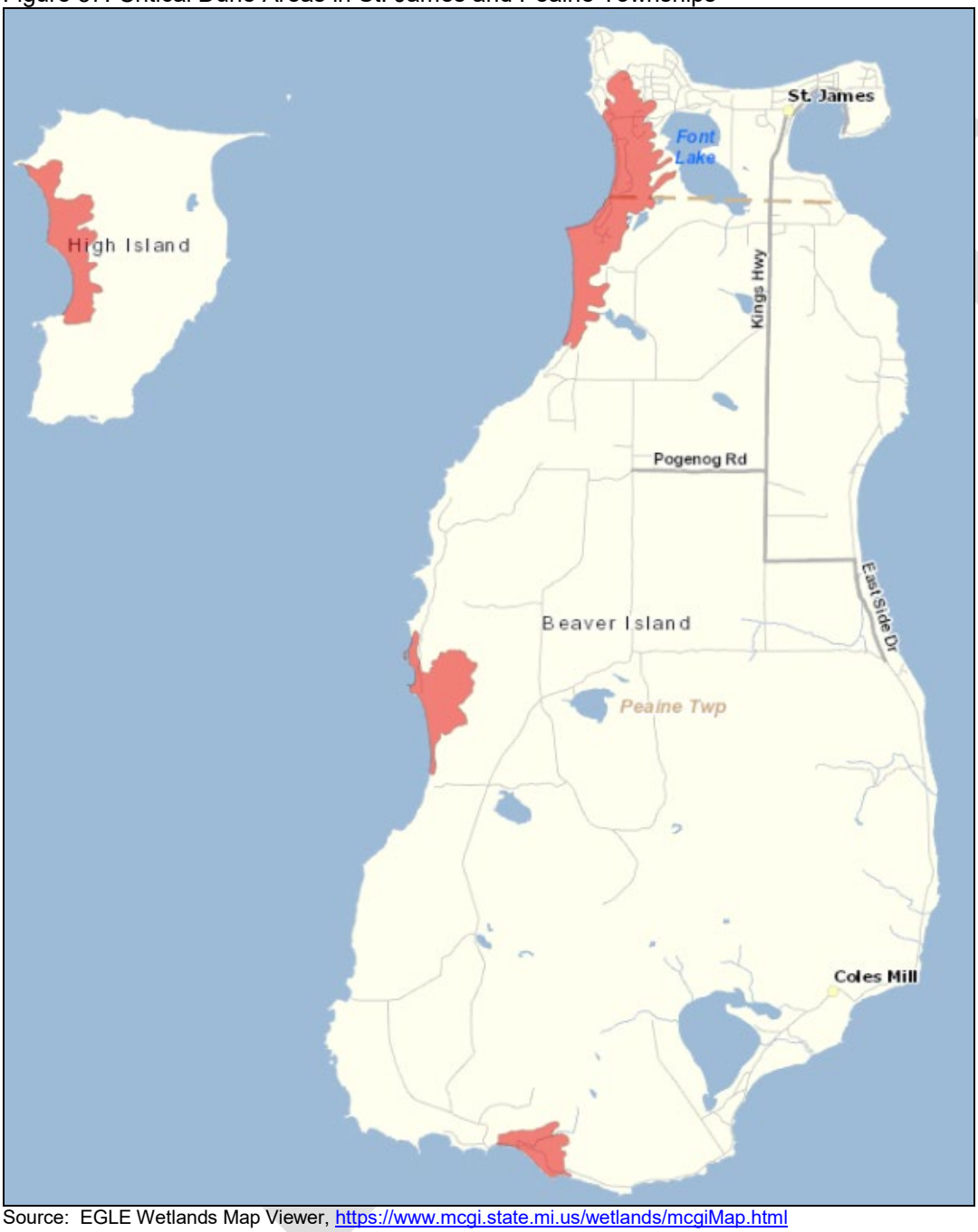
Source: EGLE Wetlands Map Viewer, https://www.mcgi.state.mi.us/wetlands/mcgiMap.html

Figure 56. Critical Dune Areas in Norwood Township and the City of Charlevoix



Source: EGLE Wetlands Map Viewer, https://www.mcgi.state.mi.us/wetlands/mcgiMap.html

Figure 57. Critical Dune Areas in St. James and Peaine Townships



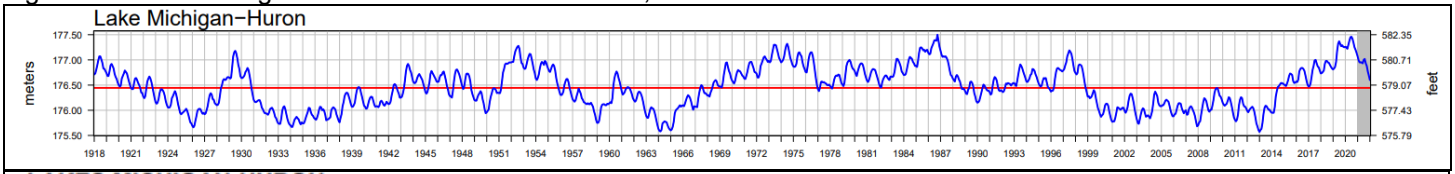
Source: EGLE Wetlands Map Viewer, https://www.mcgi.state.mi.us/wetlands/mcgiMap.html

Extent

Shoreline recession can be measured by feet of bluffline retreat and property damages. Bluffline retreat distances vary across the county, and there are no reported damages from bluffline recession. Shoreline flooding can be measured by flood water levels, inches of rainfall, lake water levels (shown in Figure 58), and damages. The three lakeshore flooding events in 2019 and 2020 caused $235,000 in property damages in Charlevoix County (Table 50).

In recent years, the swings in water levels have been unprecedented. In January 2013, Lake Michigan-Huron set an all-time record low of 576.02 feet, and seven years later in July of 2020 Lake Michigan-Huron reached a monthly record high of 582.22 feet, only second to the October 1986 monthly record high of 582.35 feet.

Figure 58. Lake Michigan-Huron Historic Water Levels, 1918-2021



LAKES MICHIGAN-HURON

2021	*580.94*	*580.68*	*580.54*	*580.54*	*580.54*	*580.48*	*580.71*	*580.77*	*580.48*	*580.41*	*579.95*	*579.69*	*580.48*
Mean	**578.48**	**578.44**	**578.48**	**578.77**	**579.07**	**579.30**	**579.40**	**579.33**	**579.17**	**578.94**	**578.77**	**578.61**	**578.90**
Max	581.56	581.53	581.43	581.69	581.96	582.19	582.22	582.09	581.96	582.35	581.96	581.56	
	2020	2020	2020	2020	2020	2020	2020	2020	1986	1986	1986	1986	
Min	576.02	576.08	576.05	576.15	576.57	576.64	576.71	576.67	576.64	576.44	576.28	576.15	
	2013	1964	1964	1964	1964	1964	1964	1964	1964	1964	1964	2012	

Source: US Army Corps of Engineers

Previous Occurrences

In the approximately the past four decades, the Great Lakes experienced record high lake levels in 1985-86, 1997-98, and most recently in 2019-20. Three lakeshore flood incidents have been reported in Charlevoix County, as described below.

Table 50. Shoreline Flooding Events

LOCATION	DATE	EVENT TYPE	DEATHS / INJURIES	PROERTY DAMAGE	CROP DAMAGE
Charlevoix County	10/21/2019	Lakeshore Flood	0 / 0	$8,000	$ -
Charlevoix County	4/13/2020	Lakeshore Flood	0 / 0	$150,000	$ -
Charlevoix County	11/15/2020	Lakeshore Flood	0 / 0	$5,000	$ -
TOTAL				**$235,000**	$ -

Source: NOAA NCEI Storm Events Database

The episode and event narratives of the October 21, 2019 lakeshore flood event:

> *Strong northerly to easterly winds resulted in another round of substantial coastal flooding and beach erosion, this time on both Lake Michigan and Lake Huron, for the 21st into the 22nd.*
>
> *Just west of Bayshore, a portion of the Little Traverse Wheelway Bike Path was destroyed* [in Hayes Township].

The narrative of the April 13, 2020 lakeshore flood event:

> *Strong low pressure passed just north of eastern upper Michigan on the morning of the 13th. Gusty west to northwest winds developed during the day, in the wake of the low. Gusts of 40 to 50 mph were common across northern Michigan, especially during the afternoon. The highest measured wind gust was 58 mph at the airport in Gaylord. Some localized power outages resulted. Lakeshore flooding also occurred along portions of the Lake Michigan coastline of northwest lower Michigan. The city boat launch in Frankfort experienced flooding of docks and the parking lot. And severe coastal erosion destroyed a portion of the Little Traverse Wheelway between Petoskey and Charlevoix* [in Emmet County].

The episode and event narratives for the November 15, 2020 lakeshore flood event:

> *Gusty winds increased on the 15th, as strong low pressure moved directly over northern Michigan before departing. Gusts of 50 to 55 mph were common along the Lake Michigan coastline. A peak gust of 59 mph was measured at Grand Traverse Light. Hunting activities were significantly disrupted (the 15th is opening day of the firearms season for deer in Michigan). Lakeshore flooding also developed along portions of Lake Charlevoix.*
>
> *Boyne City experienced flooding along the shore of Lake Charlevoix. Veterans Park and streets near the park flooded, resulting in a few vehicles being briefly stranded.*

Probability of Future Events and Vulnerability Assessment
There have been three lakeshore flooding events in Charlevoix County between 2019 and 2023. These events occurred at the same time as near-record high Great Lakes water levels.

As lake water levels fluctuate and increased storminess occurs, shoreline recession and flooding will continue. In 2021 the level of Lake Michigan began to decline, however, as historic data indicates, the water will begin to rise again. Historic lake level fluctuations have ranged between 3 to 16 year intervals (Figure 58).

Those communities that have already faced shoreline hazards are likely to experience issues in the future. Changes in land use practices and improvements to the shoreline such as natural vegetation plantings or shoreline armoring may reinforce the shoreline for a period of time, but is not a permanent solution.

Shoreline flooding can also result in soil erosion, which carries a risk of loss to shoreline properties. It may necessitate the relocation of homes or other structures as sand or soil is removed by flowing water (lake, river, etc.) and carried away over time. The foundation of a structure, or underground utility pipes in the area, may become fully exposed and vulnerable to weather, extreme temperatures, water damage, or other sources of risk. Shoreline banks that support roadways may erode and cause the road surface to crack, become unstable, or more prone to deposits of sand, snow, water, and ice. Shoreline flooding and erosion is especially relevant to those municipalities that contain residential and commercial development along Lake Michigan that experience seasonal shifts in water levels and possible ice erosion hazards.

In general, infill development of vacant lots or replacement of older houses with larger, new houses continues to occur near FEMA-designated FIRM flood zones along shorelines of the Lake Michigan, Lake Charlevoix or Walloon Lake.

In 2016, the Land Information Access Association (LIAA), a nonprofit community services organization based in Traverse City, Michigan, and the Tip of the Mitt Watershed Council (Watershed Council), a nonprofit committed to watershed protection in the northern portion of the Lower Peninsula of Michigan, worked with the seven townships and three cities around Lake Charlevoix[7] to develop recommended best zoning standards to protect the water quality of Lake Charlevoix. Zoning changes that assist with shoreline protection efforts were made for specific categories including:

- High water elevation
- Shoreline setbacks
- Greenbelts or vegetated buffer strips
- Engineered stormwater control systems
- Maximum impervious surface lot coverage
- Conditions for issuance of zoning permits
- Formal planning commission site plan review
- Shoreline protection structures
- Keyhole and funneling practices
- Number and use of docks

It was noted that due to existing development patterns (e.g., smaller lot sizes, shallow setbacks, etc.) and the presence of highly disturbed sites within the three cites, the application of some of the recommended shoreline zoning standards is impractical and adjustments could be made to meet each community's specific needs.

In 2022 and 2023, the Lake Charlevoix Association (LCA), a nonprofit that was established to protect the lake for present and future generations, worked with LIAA and the Watershed Council to build upon this work and create a unified vision for the lake. The resulting 2023 Lake Charlevoix Shoreline Protection Report contains three categories of recommendations. The first is lake-wide recommendations that all local governments around Lake Charlevoix should pursue. These include:

- Shoreline protection education for the public, realtors and contractors working on shoreline projects
- Coordination on permitting amongst local, state and federal governments
    - Local governments should comment on State permit applications
    - Invite State permitting staff to attend a planning commission/board of trustees meeting
    - Require all other relevant permits to be obtained prior to local zoning permit approval
- Ban construction of vertical seawalls

[7] Portions of seven townships (Bay, Charlevoix, Evangeline, Eveline, Hayes, South Arm, and Wilson) and three cities (Boyne City, City of Charlevoix, and City of East Jordan).

- Ban inland dredging for the creation of boat basins
- Use bonding or specific predetermined fines to ensure conditions of shoreline protection ordinances are met
- Reinvigorate the annual Charlevoix County Planner's Forum
- Attend the Lake Charlevoix Watershed Advisory Council Meetings
- Improve the permit application process
- Local government officials should attend training(s)

The second set of recommendations are zoning and is additional lake-wide consideration options that will require additional discussion, communication and collaboration among all the municipalities.

- Waterfront zoning protections
- Zoning overlay district
- Have an effective non-conforming use ordinance
- Enact a county-wide zoning ordinance/administration
- Contract with a third-party for review and enforcement of shoreline ordinances
- Adjust the Ordinary High Water Mark based on anticipated higher water levels and threats posed by storms due to climate change.
- Enact local short-term rental ordinances to protect against septic system failure

The third category is a list of recommendations tailored generally to cities and to townships, and also to each jurisdiction.

General City Recommendations:
1. Require greenbelts on all public waterfront properties within city limits
2. Require a greenbelt on newly developed or renovated properties
3. Consider parameters for greenbelt requirements
4. Integrate green stormwater infrastructure with existing gray stormwater infrastructure

City of Boyne City Recommendations:
1. Require formal planning commission site plan review for all waterfront uses
2. Prohibit the construction of vertical seawalls within the zoning ordinance in favor or revetments and engineered natural shorelines, except when there is no other practical alternative.
3. Require greenbelts on all public waterfront properties within city limits.
4. Require a greenbelt on newly developed or renovated properties
5. Consider parameters for greenbelt requirements.
6. Integrate green stormwater infrastructure with existing gray stormwater infrastructure and consider installation of trash capture technologies to address release of debris and plastics from stormwater systems.
7. Conduct a stormwater outfall inventory

City of Charlevoix Recommendations:
1. Redefine the Ordinary High Water Mark
2. Prohibit the construction of vertical seawalls within the zoning ordinance in favor or revetments and engineered natural shorelines, except when there is no other practical alternative.
3. Require greenbelts on all public waterfront properties within city limits.
4. Require a greenbelt on newly developed or renovated properties
5. Consider parameters for greenbelt requirements.
6. Integrate green stormwater infrastructure with existing gray stormwater infrastructure and consider installation of trash capture technologies to address release of debris and plastics from stormwater systems.

City of East Jordan Recommendations:
1. Require formal planning commission site plan review for all waterfront uses.
2. Institute a Waterfront Overlay District for the industrial district land owned by East Jordan Iron Works to ensure shoreline protections prior to development.
3. Require greenbelts on all public waterfront properties within city limits.
4. Require a greenbelt on newly developed or renovated properties
5. Consider parameters for greenbelt requirements.
6. Integrate green stormwater infrastructure with existing gray stormwater infrastructure and consider installation of trash capture technologies to address release of debris and plastics from stormwater systems.

General Recommendations for Townships:

- Need uniform and ubiquitous enforcement across all jurisdictions
- Need dissemination of educational information to contractors, realtors and homeowners.
- Ordinances vary greatly amongst communities; would like to see more universal ordinances but understand there are areas around the lake where that may not be possible; consistency among jurisdictions around the lake would make them easier to enforce.

Bay Township Recommendations:

1. Fulfill the recommendations from the *2016 Enacting Shoreline Zoning Protections around Lake Charlevoix/Charlevoix Watershed* report.
    - Redefine High Water Elevation Mark
    - Prohibit the sanding of beaches
    - Specifically regulate or prohibit keyhole/funnel development
    - Prohibit the alteration of the area between the water's edge and the high water elevation
    - Finalize Article Six, Waterfront Overlay Zoning District, ordinance language
2. Update permit application to coincide with Article six, Waterfront Overlay Zoning District language
3. Develop an online program for permit applications and examples of best management practices
4. Improve stormwater management ordinance requirements in Waterfront Overlay Zoning District *(Township has engaged with TOMWC to work on this effort)*

Charlevoix Township Recommendations:

1. Fulfill the recommendations from the *2016 Enacting Shoreline Zoning Protections around Lake Charlevoix/Charlevoix Watershed* report.
    - Require formal planning commission site plan review for all waterfront uses.
    - Redefine high water elevation
    - Specifically regulate number of docks allowed
    - Modify impervious surface coverage standards for waterfront lots
    - Prohibit the sanding of beaches
2. Regulate septic systems in the short-term rental ordinance

Evangeline Township Recommendations:

1. Fulfill recommendations from the *2016 Enacting Shoreline Zoning Protections around Lake Charlevoix/Charlevoix Watershed* report.
    - Prohibit the alteration of the area between the water's edge and the high water elevation
2. Pursue a pilot project to promote the use of bioengineering to restore critical shoreline functions
3. Add greenbelt requirements to the short-term rental ordinance
4. Prohibit placement of docks in greenbelts and wetlands

Eveline Township Recommendations:

1. Fulfill the recommendations from the *2016 Enacting Shoreline Zoning Protections around Lake Charlevoix/Charlevoix Watershed* report.
    - Require formal planning commission site plan review for all waterfront uses.
    - Modify impervious surface coverage standards for waterfront lots
    - Prohibit the sanding of beaches
2. Expand conditions in which greenbelts are required
3. Regulate greenbelts in the short-term rental license
4. Grant final permits/variances only after greenbelt is verified compliant

Hayes Township Recommendations:

1. Fulfill the recommendations from the *2016 Enacting Shoreline Zoning Protections around Lake Charlevoix/Charlevoix Watershed* report.
    - Specific prohibition of lawn in greenbelt
    - Require that new low-growing plantings be spaced for complete ground coverage in two years
    - Require that all county, state and federal permits be obtained prior to zoning permit approval
    - Require formal planning commission site plan review for all waterfront uses.
2. Prohibit reclamation of property lost to erosion/high water
3. Pursue a pilot project to promote the use of bioengineering for shoreline restoration

Regarding water quality and shoreline preservation efforts for Walloon Lake, Goal #4 of Walloon Lake Association & Conservancy's 2023-2027 Strategic Plan states: “Coordinate with agencies of the five townships, two counties and other concerned stakeholders on government policy to protect Walloon Lake and its watershed.” This goal refers to the idea of forming an intergovernmental body that would unify the Walloon Lake communities with common zoning ordinances to solve issues around the lake.

Space Weather and Electromagnetic Pulses

Space weather is a term that describes the patterns of emissions from our Sun. Ordinary radiation emissions can be considered calm "weather," but there are periodic flare-ups and blasts of much greater energies that send charged particles that impact upon the Earth's atmosphere and magnetosphere. These solar geomagnetic storms, coronal mass ejections, or similar phenomena can create electromagnetic pulses (EMPs) that may damage or destroy Earth's electronic satellite systems, interfere with radio communications and navigation systems, create health risks for air travelers, and disrupt electrical utility and pipeline systems.

An increase in ions (charged particles) that interact with the Earth's magnetosphere and then strike our upper atmosphere can cause a glow within the evening skies (which, in the northern hemisphere, includes the famous aurora borealis). Such "northern lights" become increasingly prominent, and extend farther to the south, during the most active solar storms. Government agencies actively monitor space weather, but for those who have not heard any government reports, their warning of solar storm activity may come from noticing these brighter glows in the night sky—especially in most Michigan locations where such "northern lights" are not normally seen.

According to the U.S. Department of Homeland Security, Science and Technology Directorate's 2022 report *Electromagnetic Pulse Shielding Mitigations: Best Practices for Protection of Mission Critical Equipment*, the civilian Critical Infrastructure (CI) within the United States faces threats from natural EMPs caused by major solar storms, as well as from manmade EMP attacks. As described in Executive Order (EO) 13865, Coordinating National Resilience to Electromagnetic Pulses (March 26, 2019). "An EMP event has the potential to disrupt, degrade, and damage technology and critical infrastructure systems."

Public awareness of manmade EMPs began on July 9, 1962 following the Starfish Prime test, during which the U.S. detonated a 1.4-megaton thermonuclear weapon 250 miles above Johnston Island in the mid-Pacific. On the Hawaiian Islands, 900 miles away, burglar alarms were triggered, circuit breakers opened, and over 300 streetlights in Honolulu failed nearly simultaneously. A few months later, to better understand EMP effects, the Soviet Union conducted a series of high-altitude nuclear tests over Southwestern Siberia, inadvertently demonstrating the weaponization potential of high-altitude EMP (HEMP), as revealed to U.S. scientists in 1995.

Location
Space weather is not confined to geographic boundaries and can be a regional, national or international event. Since space weather occurs more often during solar maximums, however, it is impossible to predict where space weather will occur and how severe it will be. All of Charlevoix County is at risk to the occurrence and impacts from solar geomagnetic storms.

Extent
Three space weather scales are in use by NOAA/NWS to summarize the intensity and estimated potential impacts of three different types of space weather effects. Each uses a 5-category classification scheme, and the three scales denote (1) geomagnetic storm intensity (G-scale), (2) solar radiation storms (S-scale), and (3) radio blackouts (R-scale). Weaker events are given a number of 1 on the scale, and extreme events are rated as a 5. In this document, selected material is summarized below. For more detailed information, refer to https://www.swpc.noaa.gov/noaa-scales-explanation

Previous Occurrences
Space weather is a term that denotes the impacts of the Sun's activity upon the bodies within this heliosphere (the volume of space inside the heliopause areas), including our own Earth. As is observable with ordinary weather on Earth, there are some clear patterns that are exhibited by space weather. More turbulent space weather is produced during times when more sunspots are present (called a solar maximum), and space weather is calm during times when sunspots are rare and small (or not even detectable at all, called a solar minimum). A sunspot cycle exists, in which sunspot activity periodically shifts between a minimum and maximum level. As with our Earthly seasons, however, it cannot be known in advance exactly how turbulent or calm things will be at a given moment during the sunspot cycle—only that calmer periods regularly give way to more turbulent periods. As to the regularity of the sunspot cycle itself, although it has been found that the average amount of time between a solar minimum and a solar maximum is about 11 years, the actual length varies quite a bit within each cycle. Within the documented cycles so far, the time interval between a minimum and maximum has been as long as 14 years and as short as 8 years.

In addition, it has been observed that long periods can occur with little or no apparent sunspot activity. The "Maunder minimum," which occurred between the years 1645 and 1715, is the primary example of such long-term variation from the normal cycle, but it is not yet known what caused it, or when it might recur.

The following is a list of significant solar weather events. While no specific impacts occurring in Michigan were mentioned, the events were either international or regional in their effects.

August 28 to September 2, 1859 – International, "Carrington Event"
After a couple days of visibly expanded auroras in the sky, telegraph disruptions were also noted in diverse parts of the world. On September 1, a large solar flare was briefly observed by astronomer Richard Carrington, and also independently recorded by Richard Hodgson. Just before dawn of the next day, however, brilliant auroras were visible in skies around the world, telegraph systems severely malfunctioned, and various damages (and minor injuries) resulted from sparks and equipment failures. This was the first solar flare observation and it was also clearly seen that the phenomenon was connected with malfunctions in electronic communications systems on Earth. No solar flare of this magnitude has been seen in the 150 years since this occurred. Based upon evidence from arctic ice, it was estimated that the 1859 solar geomagnetic storm was the most intense in the past 500 years, nearly twice as much as the second-largest event. (Even though certain intensities have since been matched, no storm since has been able to simultaneously match this one, on all types of intensity measures.) Were such an event to happen again today, it has been estimated that tens of billions of dollars in damage would be done to more than 1,000 satellites that orbit the Earth. These satellites are essential for the safe and smooth operation of airlines, spacecraft, and various communications systems.

May 16, 1921 – International, "Great Storm"
An extremely strong geomagnetic storm occurred—the strongest such storm since 1859. According to one study, if a storm of this magnitude were to occur today, it could result in large-scale electrical blackouts that would affect more than 130 million persons across the northwestern U.S. (including Michigan) and the Pacific Northwest. These figures were based upon estimates of regions susceptible to power grid collapse, and the 1921 storm was considered to be about 10 times as strong as the one that did cause power failures in 1989. Extra-high-voltage transformers were considered to be a particular vulnerability in these projected blackout areas, with places like New Hampshire, New Jersey, and Pennsylvania at particularly high risk in the interconnected grid. This has been estimated as a level of event that has a 1% annual chance of occurring in an average year.

August 4, 1972 – Illinois
A huge solar flare ended up causing the failure of long-distance telephone communications across Illinois. AT&T redesigned its power system for transatlantic cables as a result of this event. Electric grid disturbances were also reported in widespread locations around North America. This event involved the fastest "transit time" of ejected solar material that had been measured. Recently, a paper reported that these storms had an effect upon U.S. military operations, including the unintended detonation of many of its DST mines within the wartime Southeast Asian operational area (Knipp, Fraser, Shea, and Smart, 2018). In some ways, this may have been the most severe event seen during the space age. Had astronauts been in space at the time, it would have been dangerous for them.

March 13, 1989 – Canada and Eastern United States
Geomagnetic storms caused by a huge solar flare involved various disruptions in the transmission of electrical power, causing a widespread blackout across most of Quebec and affecting 6 million persons for a period of up to 9 hours. Specifically, when five transmission lines went down, the system was unable to withstand the loss of their 21,350-megawatt load, and collapsed within the subsequent 90 seconds. The blackout closed schools and businesses, shut down the Montreal Metro Airport, and delayed flights from other airports. Street traffic backups took place, since traffic signals and traffic control systems no longer functioned smoothly. Workers in downtown Montreal were stranded in dark offices, stairwells, and elevators. Elsewhere, power surges caused by the geomagnetic storm (geomagnetically induced currents, or GICs) caused power transformers in New Jersey to be overloaded and damaged. The functioning of long-distance telephone cables were also affected by auroral currents, major power substations experienced voltage swings, generators went offline, and the U.S. Air Force temporarily lost its ability to track satellites. Costs from the loss of power exceeded $100 million, including stalled production processes, idled workers, and spoiled products. This was considered to be the strongest geomagnetic storm of the space age, and it has been reported that the broader power grid covering the Northeastern and Midwestern U.S. was "within seconds of collapse."

January 11, 1997 – International
A satellite that had cost $200 million was incapacitated by the impact of a coronal mass ejection. After efforts to restore the satellite's function failed, it was officially decommissioned.

April-May, 1998 – International
The failure of the attitude control system of an expensive Galaxy IV satellite (the cost of such satellites is usually on the order of $200 to $250 million) disrupted the function of about 45 million electronic paging devices. Various other satellite problems were noted, and researchers eventually concluded that these problems were "caused, or at least exacerbated by" the impacts of geomagnetic conditions originating from "highly disturbed" solar conditions. Although the satellite problems occurred in May, weeks of problematic space weather that had started back in April was considered to have eventually led up to May's events.

October 19 to November 7, 2003 – International, "Halloween Storms"
Geomagnetic storms took place in late October and November, and although power grid operators had learned from the March 1989 event and were better able to withstand the storms' effects, there were some heavy impacts upon the aviation sector from this event. The Federal Aviation Administration had implemented a WAAS (Wide Area Augmentation System) to better guide navigation and aviation system control, and a part of what WAAS supports is the ability of air traffic to maintain safe distances from each other. The vertical navigation component of WAAS was disabled for approximately 30 hours across most of the United States during the late October storms. These "Halloween storms" interrupted GPS function, blocked high-frequency radio, damaged power transformers in South Africa, and forced emergency procedures to be implemented at nuclear plants in Canada and the northeastern United States.

January 2005 – International
Space weather at this time included solar radiation storms. In addition to the loss of HF radio communications, such storms can cause elevated radiation exposure to persons in aircraft flying at high latitudes (e.g. across polar regions). The use of polar routes has increased dramatically since the 1990s, since such routes can reduce travel time and fuel costs (by avoiding strong wintertime headwinds). Aircraft must divert to lower-latitude routes during such radiation events, resulting in delays, increased flight times, missed connections, higher costs, and greater fuel consumption.

December 2005 – International
A geomagnetic storm caused the disruption of satellite-to-ground communications and GPS (Global Positioning System) navigational signals. Although this disruption only lasted about 10 minutes, it threatened the safety of commercial air flights and marine traffic during that time.

December 6, 2006 – International
A burst of solar radio wave energy caused a disruption in the function of GPS units across the entire sunlit side of the Earth (the Western hemisphere in this case). Some users of navigation systems found their capacities disrupted for many minutes, which was of particular significance for military aircraft.

July 23, 2012 – International
The STEREO solar observatory detected and measured one of the largest solar storms ever recorded. The trajectory of the emissions were fortunately not directed at Earth during the time of the event, or it would have resulted in the type of extreme storm that has here been estimated as a "worst-case scenario." It has been calculated that if the solar eruption had taken place just one week earlier, then the Earth would have been aligned to receive the impacts, and the results would have been equivalent to another "Carrington Event" (see 1859 entry, above) but with far more extensive electronic systems and investments at risk than had been true in the past.

Probability of Future Events and Vulnerability Assessment

The Earth's atmosphere serves as a shield for us against many types of particles and radiation zipping across space, and Earth is also surrounded by a magnetosphere that similarly provides protection against most of the charged particles traveling through space. There are some weak spots in the Earth's magnetic field, however, that exist near its two magnetic poles and allow many ions to penetrate, where they collide with atoms in the Earth's upper atmosphere and glow to produce the beautiful auroras in the skies of the arctic regions of the north and south. In addition, the Earth is surrounded by "belts" of charged particles (called Van Allen belts) which are hazardous to spacecraft and astronauts. These are known and predictable conditions of calm space weather, however, and the actual hazard is the turbulence generated by large solar flares, causing problems with radio communications, damage to satellites, and even disruptions in power delivery networks on the Earth.

This hazard is considered fairly likely in the near term to cause notable disruptive effects, large economic impacts, and even some direct health risks to persons who are flying in aircraft in the far northern or southern areas of the planet, where the exposure to charged particles occurs in greater quantities.

In September 2022, the Department of Homeland Security (DHS) released a report titled Electromagnetic Pulse Shielding Mitigations. The report describes operational approaches to protect the National Public Warning System from an EMP, as well as best practices and design principles that can be implemented by critical infrastructure owners and operators who seek to secure their assets against EMP in a similar manner to the NPWS equipment. The report is a collaborative effort between the DHS Science and Technology Directorate (S&T), the Federal Emergency Management Agency (FEMA) Integrated Public Alert and Warning System (IPAWS) Program, and the Cybersecurity & Infrastructure Security Agency (CISA). Content of the S&T press[8] release pertaining to this report is as follows:

> "Electromagnetic pulses, whether caused by an intentional EMP attack or a naturally occurring geomagnetic disturbance from severe space weather, could disrupt critical infrastructure such as the electrical grid, communications equipment, water and wastewater systems, and transportation modes," said Kathryn Coulter Mitchell, DHS Senior Official Performing the Duties of the Under Secretary for Science and Technology. "This could impact millions of people over large parts of the country. It is critical to protect against the potential damage an EMP event could cause."
>
> The National Public Warning System ensures the President of the United States can communicate with Americans in the event of a national emergency. The FEMA IPAWS Program equips 77 private sector radio broadcast stations with EMP-protected backup transmitters, communications equipment, and power generators that would enable the station to broadcast national emergency information to the public in the event of an EMP event. "These stations represent a key public-private sector partnership and serve as the primary sources for a national emergency broadcast during a catastrophic disaster," said Antwane Johnson, FEMA IPAWS Program Director. The stations are located across the country providing radio broadcast coverage to more than 90 percent of U.S. population.
>
> As part of a broader DHS effort to ensure critical infrastructure and emergency response systems are protected against EMPs, FEMA conducted high-altitude electromagnetic pulse (HEMP) testing on the NPWS equipment to evaluate its operational resiliency. The testing confirmed the effectiveness of protection for NPWS stations, showing they could withstand the effects of an EMP in accordance with military specifications. "Protecting critical assets from EMP is part of a larger DHS effort to assess and mitigate EMP risk in both the public and private sector," said Acting CISA Assistant Director Mona Harrington. "CISA remains committed to working with our partners to implement requirements outlined in the Executive Order on Coordinating National Resilience to Electromagnetic Pulses, which strengthens our nation's preparedness from EMP."

[8] https://www.dhs.gov/science-and-technology/news/2022/09/06/dhs-releases-recommendations-protect-national-public-warning-system-emps

Public Health Emergency (Infectious Disease)

Public health emergencies occur when there is a widespread and/or severe epidemic, contamination incident, bioterrorist attacks, or other situation that negatively impacts the health and welfare of the public. These emergencies include disease epidemics, large-scale food or water contamination incidents, extended periods without adequate water and sewer services, harmful exposure to chemical, radiological or biological agents, and large-scale infestations of disease-carrying insects or rodents. A common characteristic of public health emergencies is that they impact or have the potential to impact a large number of people either statewide, regionally, or locally in scope and magnitude. These health emergencies can occur as primary events or as secondary events from another hazard or emergency (e.g. flood, tornado, or hazardous material incident).

Location
A public health emergency can be a worldwide, national, state or regional event that is not confined to geographic boundaries and range in severity across the affected areas. All persons in Charlevoix County are at risk to the occurrence and impacts from an infectious disease. Depending on the type of disease, different populations are more susceptible.

Extent
The extent of a public health emergency can be determined by the number of cases and deaths, and the amount of money spent to prepare for and respond to public health threats. In Charlevoix County, the Health Department of Northwest Michigan works with local, state, and federal agencies to prepare for and respond to public health threats. The Michigan Department of Health and Human Services (MDHHS) reports[9] that between March 1, 2020 and November 14, 2023, there were 6,091 cases and 76 deaths attributed to COVID-19. This includes confirmed and probable cases and deaths.[10] The Michigan statewide case fatality rate is 1.4%.

Of the reported deaths attributed to COVID-19 in Charlevoix County, the majority were of persons aged 80 years and older, followed by those in the 70-79 year old age group, and then the 60-69 year old group. All of the deaths reported in the county were of persons aged 60 years and older.

The extent of a public health emergency can also be measured in economic terms, such as expenditures related to disease preparation, response and prevention, as well as potential loss of income and jobs within industries that cannot solely operate on remote workers, such as hospitality, personal services, construction, manufacturing, and brick and mortar retailers.

Previous Occurrences
Throughout the years, there have been many pandemics. For example, there was an outbreak of severe acute respiratory syndrome (SARS) in 2003. This virus was a new coronavirus that resulted in over 8,000 illnesses worldwide. Of these, 774 died. Since 2012, Middle East respiratory syndrome (MERS), a coronavirus, has been reported in 27 countries where there have been approximately 2,494 people infected and 858 deaths. In 2017, the World Health Organization (WHO) put SARS and MERS on its priority pathogen list to spur further research into coronaviruses.

More recently in March 2020, federal/state disaster/emergency declarations were enacted in response to the international COVID-19 Pandemic. The U.S. Department of Health and Human Services ended the COVID-19 public health emergency (PHE) May 11, 2023. Variants of the coronavirus are still being found years after the initial spread; vaccinations are available to limit the reaction from exposure and limit the spread of the disease.

Probability of Future Events and Vulnerability Assessment
Pandemics will continue to result in widespread precautions around the world. The Michigan Department of Health and Human Services created a Pandemic Response Plan (Annex 12 of the MDHHS Emergency Operations Plan, June 2023) respond to a large-scale outbreak of influenza and other highly infectious respiratory diseases. The elderly, immune-compromised, and low income populations are most vulnerable to public health emergencies.

Broadband internet availability has recently expanded and will continue to expand throughout the rural areas of northern lower Michigan. Access to broadband internet is an essential tool that allows for remote work, schooling, commerce and communications to continue during a public health emergency.

[9] https://www.michigan.gov/coronavirus/stats
[10] MDHHS classification: Confirmed cases are those individuals who have had a positive diagnostic laboratory test for COVID-19. Probable cases include individuals who have a positive presumptive laboratory test for COVID-19. Confirmed deaths include individuals who had a confirmed COVID-19 infection AND are either classified as deceased during the case investigation OR have COVID-19 indicated as a cause of death on their death certificate. Similarly, probable deaths include individuals who had a presumptive COVID-19 infection AND are either classified as deceased during the case investigation OR have COVID-19 indicated as a cause of death on their death certificate.

Invasive Species

The National Invasive Species Council defines an invasive species as, "A species that is not native and whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health." The Council was formed under Presidential Executive Orders 13112 and 13751 to prevent the introduction and spread of invasive species, and to support efforts to eradicate and control invasive species that are established throughout the United States. NOAA's National Ocean Service identifies invasive species as "capable of causing extinctions of native plants and animals, reducing biodiversity, competing with native organisms for limited resources, and altering habitats." There are a wide variety of species considered invasive. Known and monitored species include:

- Mammals
- Birds
- Insects
- Fish
- Crustaceans
- Mollusks
- Worms
- Plants
- Diseases

Invasive species harmful to Michigan and Emmet County may be either terrestrial invasive species (TIS) or aquatic invasive species (AIS). Terrestrial invasive include non-native, land-based plants, insects, animals and diseases that harm Michigan's environment, economy, and human health. Aquatic invasive include non-native, water-dwelling plants, animals, and other organisms that have evolved to live primarily in water (aquatic habitats) rather than on land. Aquatic habitats are habitats that are covered with water all or part of every year. Michigan State Departments cooperated to prepare the Terrestrial Invasive Species State Management Plan and the 2013 Aquatic Invasive Species State Management Plan Update: Prevention, Detection, and Management in Michigan Waters. Each plan outlines a statewide strategy to reduce the environmental and economic damages caused by either TIS or AIS.

Non-native terrestrial and aquatic species are introduced to Michigan and the Great Lakes both intentionally and unintentionally. Aquatic invasive species are the result of unwanted fish and aquatic plants released from home aquariums, travelled across the ocean in ballast water carried by freighters, or entered from the ocean through human-built channels such as the Welland Canal[11].

The Midwest Invasive Species Information Network (MISIN) is a regional effort to develop and provide early detection and response resources for invasive species. Among many tools and resources, the website https://www.misin.msu.edu/ provides a catalog of species information and a report of occurrences submitted within each state. Animals, plants, and diseases are included in the catalog. The top reported invasive species in Michigan are:

- Phragmites (Invasive): 65,135
- Garlic mustard: 18,462
- Autumn olive: 17,120
- Spotted knapweed: 15,734
- Brown marmorated stink bug: 13,300
- Japanese knotweed: 12,922
- Purple loosestrife: 11,058
- Common buckthorn: 8,735
- Japanese barberry: 8,161
- Bush honeysuckle: 7,451

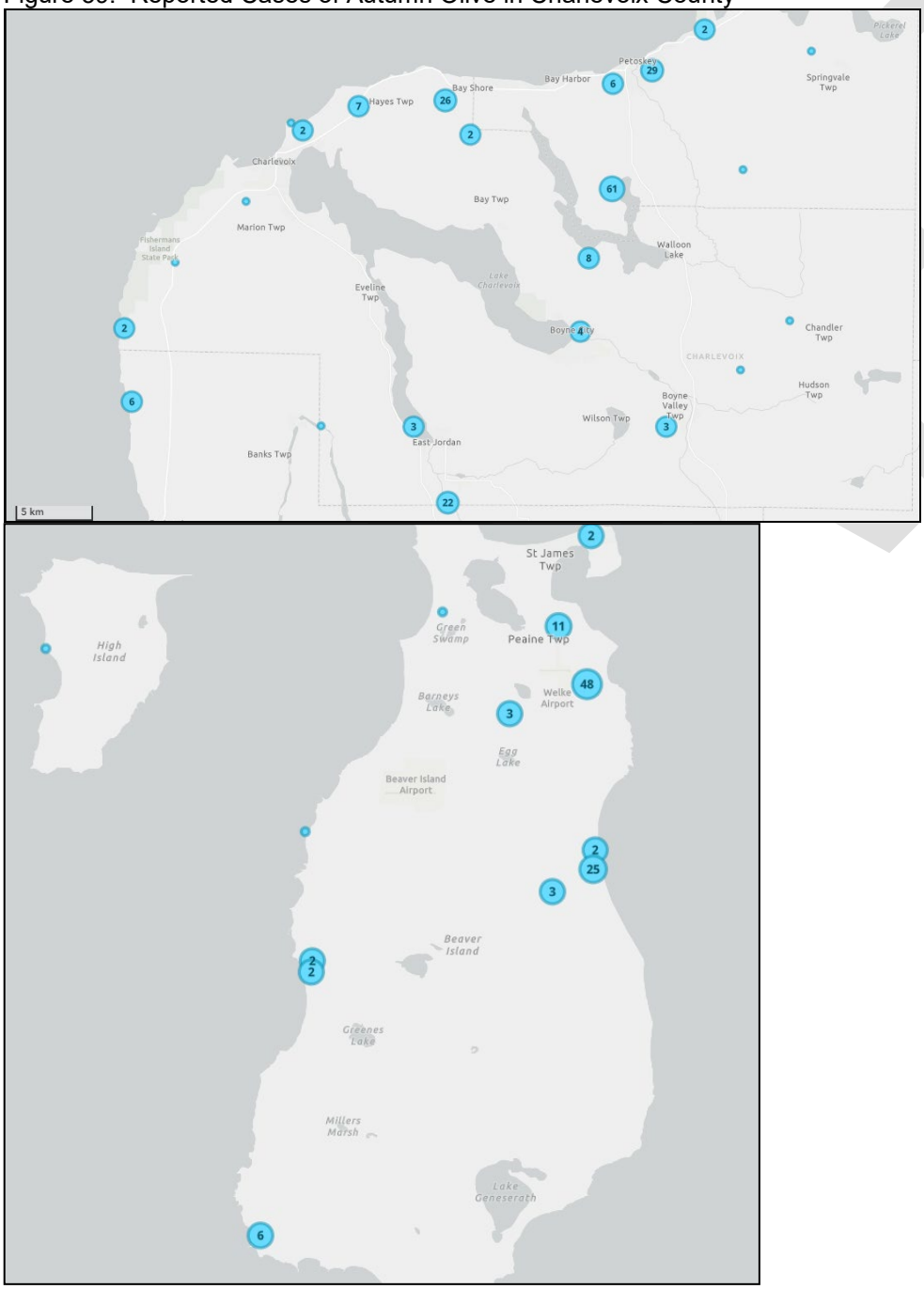
Location

Invasive species pose a significant threat to the County's lakes, wetlands, and forests. These non-native, introduced species outcompete native species; impact food chains and fish and wildlife habitat; reduce property values; impact water-based recreation and navigation; and among the many other environmental and economic problems, invasive species are costly to control and manage. Certain high profile species, such as phragmites and Eurasian watermilfoil, have been especially prolific, disruptive, and costly.

[11] The Welland Canal is a ship canal in Ontario, Canada, connecting Lake Ontario and Lake Erie.

Terrestrial and aquatic invasive species threaten sensitive ecosystems and may be present in Emmet County forest, wetland, farmland, grassland, aquatic, shoreline, and urban environments. “A Field Guide to Invasive Plants of Aquatic and Wetland Habitats for Michigan” (Campbell, Higman, Slaughter, Schools) identifies the Lake Michigan coastline as particularly vulnerable. “Lake-moderated climates along the Lake Michigan shoreline, Saginaw Bay, the Thumb, Lake St. Clair, and western Lake Erie are much milder than those in the state’s interior… These areas have the potential to harbor species typically found far south of Michigan.” TIS and AIS designation generally applies, however, several upland species appear to be spreading to wetland and aquatic areas. Regular monitoring and reporting introductions detected is the only way to know where an invasive species has infested. The MISIN website provides species observation maps of invasive animals, plants and diseases that can be created by selecting a species’ common name, scientific name or family type. Figure 59 is an example of a map generated when querying invasive species observations in Charlevoix County; in this case, for Autumn olive.

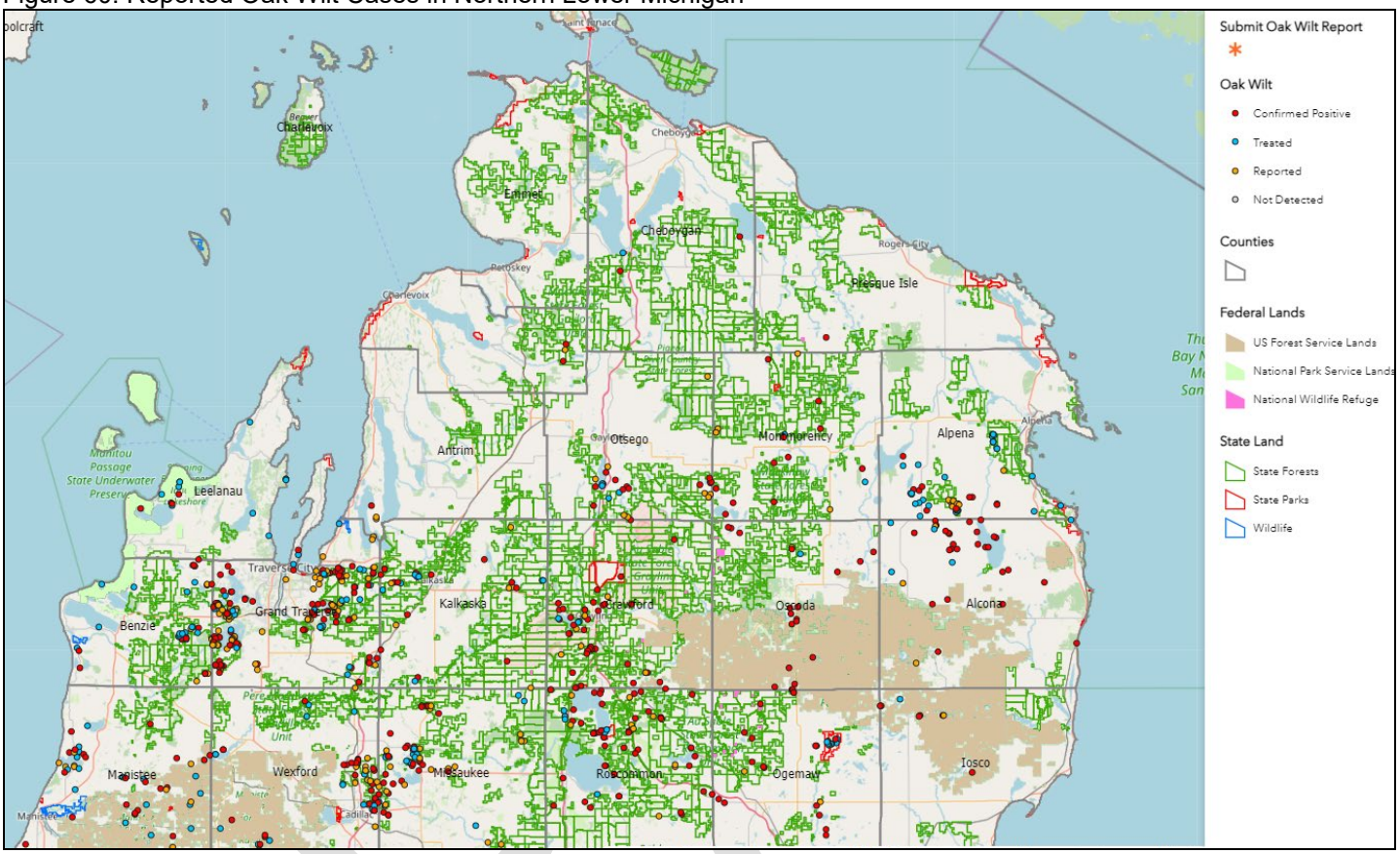
Figure 59. Reported Cases of Autumn Olive in Charlevoix County



Source: https://www.misin.msu.edu/distribution/?project=misin/ accessed 11/18/2023

Figure 60 is from the MDNR interactive mapping resource "Look for Oak Wilt," which allows users to view an interactive map to see the known extent of oak wilt throughout Michigan and report a possible infection location. Charlevoix County has two confirmed positive locations (in 2012 in Chandler and Hudson Townships) and one reported case (in 2015 in Chandler Township). Other counties south of Charlevoix County have several reported, tested, and confirmed positive cases of Oak Wilt.

Figure 60. Reported Oak Wilt Cases in Northern Lower Michigan



Source: https://www.michigan.gov/invasives/id-report/disease/oak-wilt Accessed 11/18/2023

Extent

Invasive species impact can be measured by its damaging effects. TIS cause billions of dollars in damage annually, are extremely costly to control, and often have irreversible ecological effects. Native habitats, agriculture lands and livestock, and the outdoor recreation economy are threatened or damaged by invasive species. *Michigan's Terrestrial Invasive Species State Management Plan* lists these state impacts:

- The State of Michigan estimates 42% of threatened or endangered species are considered at risk due to non-native species.
- Visitors spent over $22 billion dollars in Michigan in 2014, supporting nearly 327,000 jobs (Tourism Economics 2014). Invasive species impact the use and beauty of Michigan's shorelines, trails and parks, which may result in a reduction in visitor spending and citizen enjoyment
- Michigan's Forest Products Industry supports 96,000 jobs and contributes more than $20 billion to the state's economy each year (Michigan DNR 2015). Invasive forest pests including emerald ash borer, oak wilt and beech bark disease kill trees and significantly impact the value of urban properties, forests and timber resources. The estimated cost of treating or removing dead ash within developed land in Michigan's communities due to emerald ash borer was $230 million in 2009[12].

Estimated annual costs for some local invasive species management efforts:

- Beaver Island Association, Lake Charlevoix Association, Walloon Lake Association and Conservancy ?

[12] Kovacs, K.F., R.G. Haight, D.G. McCullough, R.J. Mercader, N.W. Siegert and A.M. Liebhold. 2010. Cost of potential emerald ash borer damage in U.S. communities, 2009−2019. Ecological Economics 69: 569-578.

Previous Occurrences
The Department of Environment, Great Lakes, and Energy oversees invasive species programs for the State. The State has produced prohibited and restricted species lists, watch lists, and state management plans for terrestrial and aquatic species. Many of the species listed in this plan are also listed as a prohibited or restricted species: it is unlawful to possess, introduce, import, sell, or offer that species for sale as a live organism, except under certain circumstances. A full list of prohibited and restricted species can be found at Michigan.gov/invasives.

On a regional level, the following terrestrial invasive species are causing significant harm in the northwestern Lower Peninsula:

- Japanese knotweed, Giant knotweed and Bohemian knotweed, *Polygonaceae*, can be a concern to homeowners, and municipalities because of these plants' ability to grow into a structure's foundation, through sidewalks and road surfaces. These plants can also be spread by root fragments and stem sections. It can create monocultures that shade out desirable vegetation, creating poor habitats for native species. This is of particular concern along water bodies and has been shown to be extremely detrimental to waterways in the Eastern US.
- (Invasive) Phragmites is a large-scale clonal grass that rapidly colonizes wetlands. Phragmites crowds out native plants and alters habitat for native fauna. In doing so, Phragmites also alters human access to water resources and has adverse economic effects, including decreasing property value, inhibiting recreational use, and limiting populations of game species. It can become a fire hazard when it dries down
- Cypress spurge is an erect, herbaceous to semi-woody perennial with bright yellow-green flowers that turn to purple-red as they mature. Cypress Spurge is toxic to horses and cows.
- Black Swallow Wort is a rapidly growing, herbaceous perennial in the Milkweed family. However, Black Swallow Wort is toxic to animals and the monarch butterfly.
- Oriental bittersweet is a vine plant that can strangle a tree and causes tree mortality. This impacts ecosystem health and economic health that is associated with trees' health.
- Autumn olive is very widespread in Michigan. It is spread by birds and is recolonizing old farm fields. Its value to wildlife is relatively low (low in protein and other nutrients compared to our natives). It also is known for its nitrogen-fixing abilities. Specific areas of problematic autumn olive infestation provided by a participant in this plan development include these areas of Forest Home Township: properties along Miley Pointe Drive down to Cottage Drive, and along sections of Steiner Road between Clam Lake Road and SE Torch Lake Drive.
- Oak wilt is an infectious vascular disease that can affect all species of oak. Red oaks get the disease more often and succumb more readily than white oak. The disease spreads via root grafts and sap-feeding beetles.
- Beech bark disease is caused by the combination of the *Neonectria* fungus and beech scale. Beech scales are yellow, soft-bodied insects that are 0.5 to 1.0 mm long as adults. The insects, found on the tree trunk and branches, feed on sap in the inner bark. The minute wounds caused by the scale insects eventually enable the Nectria fungus to enter the tree. The Nectria kills areas of woody tissue.
- Garlic mustard is an herbaceous biennial, up to 4 feet in height. Forms round basal rosette the first year, flowers the second year and dies. Grows in forests, particularly floodplain forest, open wetlands, parking lots, campgrounds, paths, and roadsides.

On a regional level, the following aquatic invasive species are causing significant harm in the northwestern Lower Peninsula:

- Didymo or “rock snot” is an aquatic diatom that is brown, tan, or yellow in color. Unlike most algae, it feels like wet cotton and is not slimy. Grows in rivers, streams, and lakes. It occurs particularly in cool, oligotrophic, clear water.
- Purple loosestrife is an herbaceous wetland perennial reaching 5 feet with reddish-purple flowers with five to seven petals are held in dense terminal cluster. Grows in moist soils, in wet meadows and prairies, shallow marsh, ditches, waste areas, and along lakes, ponds, streams, and rivers.
- Eurasian water-milfoil is a submergent, aquatic perennial that reached 3-10 feet or more in length. Grows in ponds, lakes, and low-energy zones in rivers and streams. Specific areas of autumn olive infestation provided by a participant in this plan development include Six Mile Lake in Echo and Banks Townships, the Clam River and Alden Harbor on Torch Lake.
- New Zealand mudsnail is an aquatic mollusk with an elongated shell 1/8 inch long with 7-8 whorls. Shell color varies from gray and dark brown to light brown. Grows in flowing freshwater with silt/sand to very brackish rivers; lives in water as deep as 60 feet in lakes or reservoirs.
- Red swamp crayfish is an aquatic crustacean with a dark red body and claws with spiky, bright red bumps, and black wedge-shaped stripe on underside. Grows in flowing to non-flowing freshwater or salt water; permanent ponds; areas of streams and ditches with organic debris; agricultural areas; wetlands.
- Zebra mussel is an aquatic mollusk with striped shells or dark or light shells with no stripes. They attach to objects (pipe, boats, etc.) causing major damage as colonies can block pipes, affecting power and water-treatment plants.

Many of the species listed above are monitored and managed in Charlevoix County. However, the list of all invasive species impacting the county and region is extensive and many established species are treated on a case-by-case basis. Other species of concern include: Honeysuckle (non-native), Glossy buckthorn, Common buckthorn, Wild parsnip, Multiflora rose, and Periwinkle.

It is important to note that Beaver Island and the Archipelago Islands act as a refuge for native plants and animals, as invasive pests and diseases have more difficulty accessing these locations. The Emerald Ash Borer (EAB) is one example. This pest has eradicated many if not all of the ash trees in the Lower Peninsula of Michigan. EAB was first detected on Beaver Island in 2017 after a decade of monitoring. Islanders have worked with the USDA's Animal and Plant Health Inspection Service (APHIS) to release EAB parasitoids on Beaver and Garden Islands as a bio-control effort to preserve the ash trees on the islands.

The Charlevoix, Antrim, Kalkaska, and Emmet counties Cooperative Invasive Species Management Area (CAKE CISMA) current Strategic Plan (updated April 2023) contains a priority list for aquatic, terrestrial, and invertebrate invasive species in the service area. The list is sorted into aggregate tiers (indicated below) intended to be used as a framework to guide management decisions. Rankings are subject to change at a county level, depending on the spatial distribution of certain species within each county. The list also indicates which species are present in the CAKE area. The list is a living document and is reviewed and updated annually by CAKE CISMA staff to be approved by a majority vote from the CAKE CISMA steering committee.

- Tier 1- Prevention/Early Detection: These species are not yet present in the service area. They pose a great ecological threat to the region if introduced. Tier 1 species are a high priority to the State of Michigan and are either very limited in their presence or not yet detected in Michigan. Management actions for these species include detection surveys, rapid response, and eradication if effective tools exist. Prevention, education, and outreach are important for Tier 1 species.

- Tier 2- Eradication - Rapid Response: Species that are not yet present in the service area or confined to a limited area. Small, localized populations make eradication possible for these species. Management actions for Tier 2 species are delimitation, containment, and eradication where feasible.

- Tier 3: Containment Species that are rapidly increasing in distribution throughout the CISMA region. Managed on a site-by-site basis based on ecological importance. Management actions for Tier 3 species are determined through project-based planning with the objective to slow spread and improving existing habitat function.

- Tier 4: Local Control/ Asset Protection Species that are widespread throughout the State of Michigan and can no longer be eradicated. As such, these species are managed by CISMA only on sites of high ecological value and where partnerships exist. CISMA will assist the public with Tier 4 species through education and outreach.

CAKE CISMA prioritizes invasive species management based on the ecosystem and management feasibility. Some species, like spotted knapweed (Centaurea stoebe) or Autumn olive (Elaeagnus umbellata), are so widespread that it is no longer feasible to eradicate them. That means that when CAKE CISMA does manage those species, efforts are focused on areas of high ecological importance - like a fen or a dune community, or the Beaver Island archipelago, which doesn't have the same variety of invasive species as are present on the mainland. Initiatives such as not allowing mainland firewood on the island have helped maintain pristine habitats throughout the archipelago. Because there are fewer invasives and more endangered/rare species, the invasives they do have are a higher priority on the island than on the mainland. For example, CAKE CISMA often treats Autumn Olive on the island, a species far beyond control on the mainland.

Invasive species that are not yet widespread or recently detected in the service area are the highest management priority for CAKE CISMA. Special consideration is also given to "satellite" populations of more established species, as they are easier to control than large source populations (and treatment prevents them from turning into source populations themselves!). In these cases, we offer no-cost treatment for public and private landowners.

Throughout 2024, CAKE CISMA will be targeting 1,000 acres of Fresh Water Dune Swales, Fens, and Rich Conifer Swamps for restoration. These natural communities identified by MNFI are significant in maintaining resiliency to the changing climate.

Probability of Future Events and Vulnerability Assessment
The services and collaborative efforts of CAKE-CISMA, Charlevoix Conservation District, Tip of the Mitt Watershed Council, Little Traverse Land Conservancy, LTBB Tribe, GTB Tribe, MDNR and other land and water management agencies are crucial to make progress on invasive species management and prevention in Charlevoix County for established invasive species, as well as for the monitoring of "watchlist" species.

Invasive species on Michigan's "Invasive Species Watchlist" are priority species that have been identified as posing an immediate and significant threat to Michigan's natural resources. These species have either never been confirmed in Michigan, have very limited distribution, or are localized. Early detection and timely reporting of occurrences of these species is crucial for increasing the likelihood of stopping an invasion and limiting negative ecological and economic impacts. Species are listed below by category. This list is reviewed and updated periodically, and the most current list is available at www.michigan.gov/invasives. Potential impact from the species listed on watch list could be catastrophic for Charlevoix County's natural resources, agriculture, recreation, tourism, and economy.

Insects and Tree Diseases (Tree diseases list the scientific name for the pathogen or fungus associated with the disease)
• Asian longhorned beetle (*Anoplophora glabripennis*)
• Balsam woolly adelgid (*Adelges piceae*) (*description of local monitoring efforts on the following page)
• Hemlock woolly adelgid (*Adelges tsugae*)
• Thousand cankers disease (*Geosmithia morbida*)
• Beech leaf disease *(Litylenchus crenatae and potential associates)*
• Spotted lanternfly (*Lycorma delicatula*)

Mammals
• Nutria (*Myocastor coypus*)

Terrestrial Plants
• Asiatic sand sedge (*Carex kobomugi* Ohwi)
• Chinese yam (*Dioscorea oppositifolia* L.)
• Himalayan balsam (*Impatiens glandulifera*)
• Japanese stiltgrass (*Microstegium vimineum* (Trin.) A. Camus)
• Kudzu (*Pueraria montana* var. *lobata*)
• Mile-a-minute weed (*Persicaria perfoliata*)
• Japanese chaff flower (*Achyranthes japonica*)

Aquatic Plants
• Parrot feather (*Myriophyllum aquaticum*)
• Yellow floating heart (*Nymphoides peltata*)
• European frog-bit (*Hydrocharis morsus-ranae*)
• European water-clover (*Marsilea quadrifolia*) – This species is currently allowable for sale and possession. Please contact EGLE if these plants are observed outside of cultivation.
• Brazilian elodea (*Egeria densa*)
• Hydrilla (*Hydrilla verticillata*)
• Water chestnut (*Trapa natans*)
• Water hyacinth (*Eichhornia crassipes*) – This species is currently allowable for sale and possession. Please contact EGLE if these plants are observed outside of cultivation.
• Water lettuce (*Pistia stratiotes*) – This species is currently allowable for sale and possession. Please contact EGLE if these plants are observed outside of cultivation.
• Water soldier (*Stratiotes aloides*)

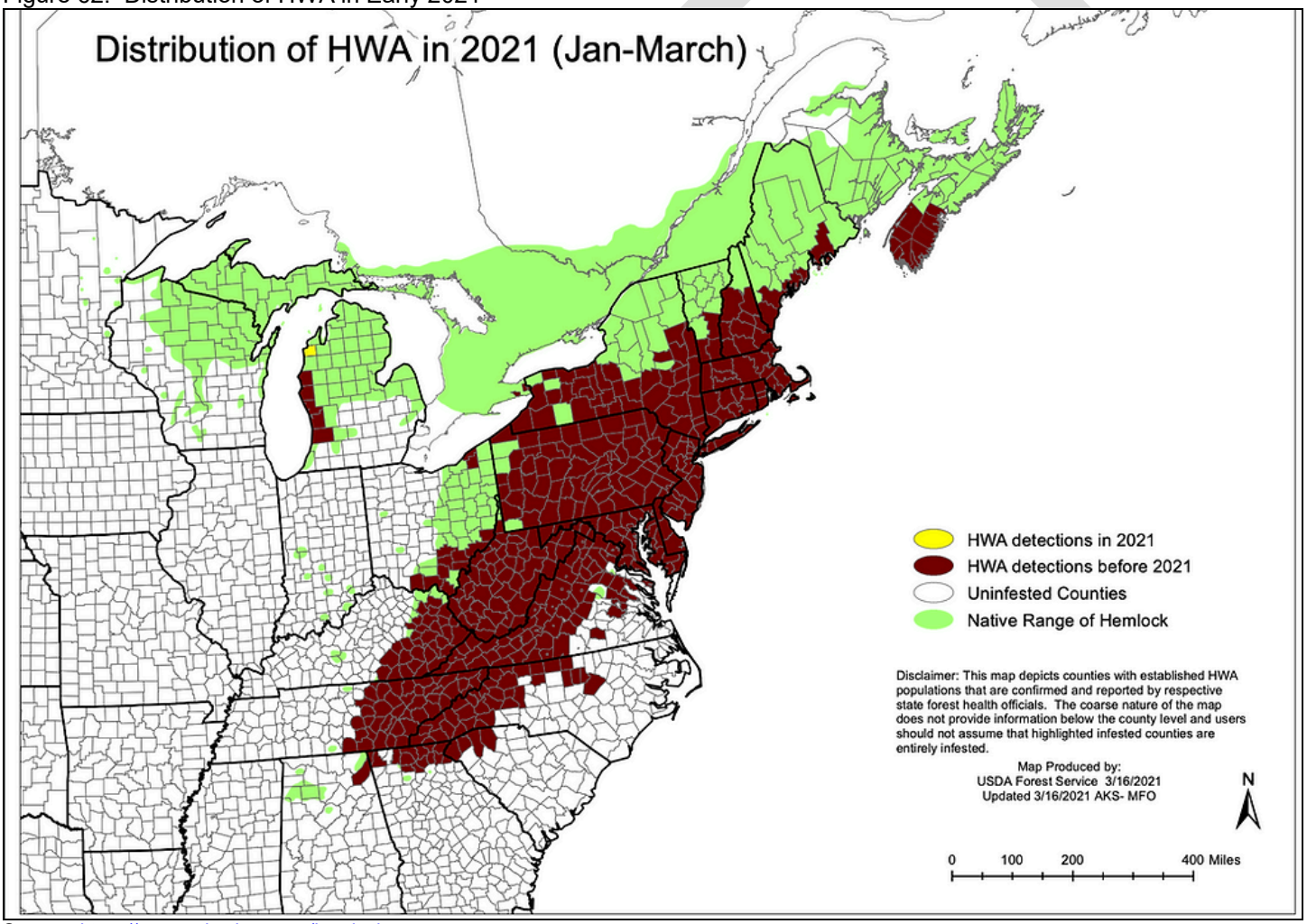
Fish and other Aquatic Animals
• Invasive carps
    - Silver carp *(Hypophthalmicthys molitrix)*
    - Bighead carp *(Hypophthalmichthys noblis)*
    - Grass carp *(Ctenopharyngodon idella)*
    - Black carp *(Mylopharyngodon piceus)*
• Northern snakehead *(Channa argus)*
• Marbled crayfish *(Procambarus virginalis)*
• Red swamp crayfish *(Procambarus clarkii)*
• New Zealand mud snail *(Potamopyrgus antipodarum)*

One of the “watchlist” species that CAKE CISMA is currently monitoring for is the hemlock woolly adelgid (HWA) (Adelges tsugae), which has affects eastern hemlock trees (*Tsuga canadensis*). HWA have specialized mouthparts that enable it to pierce the base of a needle, then suck out nutrients from cells in the shoots of their host tree. A host tree can die in as little as four years. HWA decimated stands of native hemlock in the eastern United States, particularly in the Smokey Mountains National Park. While HWA has been detected in Michigan, its distribution is believed to still be limited to only a few counties (Figure 62).

Often found along ravines, hillsides, and stream banks, eastern hemlock offer habitat for wildlife and provide shade for streams, effectively lowering stream temperatures and increasing oxygen for fish and other aquatic species. Hemlocks provide aesthetic value and are loved by homeowners. It is estimated that Michigan is home to 170 million eastern hemlock trees. Areas near the Lake Michigan shoreline are the most probable for new infestations, as the adelgids tend to favor the temperatures and conditions found near the lake more than those inland.

CAKE CISMA is offering free surveys of hemlock trees for HWA. Property owners within 5 miles of Lake Michigan can fill out the survey request form on CAKE CISMA’s website. Surveys will be conducted this upcoming winter and property owners will be notified prior to the survey.

Figure 62. Distribution of HWA in Early 2021



Source: https://www.cakecisma.org/hemlock

Known aquatic invasive species in Lake Charlevoix include Curly-leaf pondweed, Eurasian watermilfoil, Invasive phragmites, Purple loosestrife, Round goby, Sea lamprey, Zebra mussels and Quagga mussels. The open connection with Lake Michigan allows any invasive species present in Lake Michigan to enter Lake Charlevoix unimpeded. The Lake Charlevoix Association, Charlevoix County Conservation District, and Tip of the Mitt Watershed Council have worked diligently to educate residents about invasive species, as well as document and control specific invasives. In particular, watershed partners have focused much of their work on mapping and treating invasive Phragmites. The invasive

Phragmites control efforts, which began in 2008, have been successful in preventing the spread and dominance of this aggressive invader along the Lake Charlevoix and Lake Michigan shorelines.

In 2008, Peaine Township and St. James Township adopted phragmites control ordinances. They provide procedures intended to comply with federal and state due process requirements so that all property along the Lake Michigan shoreline with a phragmites infestation can be included in a phragmites eradication zone and can receive effective treatment.

Hayes Township also has a Phragmites Ordinance applicable to the properties in the township along the Lake Michigan and Lake Charlevoix shorelines. Norwood Township and Eveline Township adopted their phragmites ordinances in 2009.

The following communities' local ordinances require that native vegetation be placed in greenbelt areas: the townships of Bay, Charlevoix, Evangeline, Eveline, Hayes, Marion, Peaine, St. James, and South Arm.

The Friends of the Boyne River have made progress with Purple loosestrife control efforts by purchasing and releasing beetles that eat the invasive plant along the river. In 2023 the group's efforts eliminated the loosestrife along Spring Street in Riverside Park, Boyne City.

Public use of boat wash stations removes plant and animal particles from boats, thereby reducing the chance of spreading or transporting invasive species in and out of lakes. Four (4) permanent boat wash stations have been installed to-date on Walloon Lake, two of which are located within Charlevoix County: the Melrose Township Boat Launch and the Sumner Road Boat Launch in Bay Township. Additionally, the Tip of the Mitt Watershed Council's (TOMWC) Mobile Boat Washing Station (MOBO) Program was started in Northern Michigan in 2020. TOMWC volunteers visit various Northern Michigan lake landings and wash boats for free throughout the summer, using heated, pressurized water.

TOMWC staff conducts surveys on inland lakes to document current aquatic plant species and communities, with a particular emphasis on documenting the presence of Eurasian watermilfoil, phragmites, or other invasive aquatic plant species.

The following organizations in Charlevoix County work with TOMWC, CAKE-CISMA, and other partners to monitor, treat and eradicate aquatic invasive species and improve water quality:

- Walloon Lake Association and Conservancy (Melrose, Evangeline and Bay Townships within Charlevoix County; Bear Creek and Resort Townships within Emmet County)
- Lake Charlevoix Association (Hayes, Charlevoix, Marion, Eveline, South Arm, Evangeline, and Bay Townships; Cities of Boyne City, East Jordan and Charlevoix)
- Lake Louise Christian Community (Thumb Lake in Hudson Township)
- Beaver Island Association (Peaine and St. James Townships)
- The Beaver Island Archipelago Terrestrial Invasive Species program
- Friends of the Jordan River (South Arm, Wilson, and Boyne Valley Townships; City of East Jordan)
- Friends of the Boyne River (Boyne Valley Township, Village of Boyne Falls, City of Boyne City, Evangeline Township)

Local government master plans and recreation plans have included goals and objectives related to invasive species management and protection (Appendix F).

Impacts from Climate Change

Climate describes the average weather conditions for a particular location and over a long period of time. The changing climate impacts society and ecosystems in a broad variety of ways. For example, climate change can alter rainfall, influence crop yields, affect human health, cause changes to forests and other ecosystems, and even impact our energy supply. Climate-related impacts are occurring across the country by increasing the severity of storms and weather-related events. Natural disasters then have a direct impact on our economy.

According to a new comprehensive report from the World Meteorological Organization (WMO), "A disaster related to a weather, climate or water hazard occurred every day on average over the past 50 years – killing 115 people and causing $202 million (US $) in losses daily The number of disasters has increased by a factor of five over the 50-year period, driven by climate change, more extreme weather and improved reporting. But, thanks to improved early warnings and disaster management, the number of deaths decreased almost three-fold[13]" (World Meteorological Organization, 2021).

The impacts of climate change already are, and continue to be, deep and widespread in the Great Lakes Region and Michigan as a whole. The National Climate Assessment (NCA) assesses the science of climate change and variability and its impacts across the United States, now and throughout this century. Chapter 21 of the NCA *Fourth National Climate Assessment Volume II: Impacts Risks, and Adaptation in the United States reports,* the Great Lakes influence regional weather and climate conditions and impact climate variability and change across the region. The lakes influence daily weather by:

1) Moderating maximum and minimum temperatures of the region in all seasons,
2) Increasing cloud cover and precipitation over and just downwind of the lakes during winter, and
3) Decreasing summertime convective clouds and rainfall over the lakes.

The Great Lakes Integrated Sciences and Assessments (GLISA) is one of 11 NOAA Regional Integrated Sciences and Assessments teams that focus on helping the nation prepare for and adapt to climate variability and change. A summary of findings from NCA and the GLISA report, *Climate Change in the Great Lakes Region*[14], are provided to show the impacts of climate change throughout the state of Michigan.

Temperature

Warm-season temperatures are projected to increase more in the Midwest than any other region of the United States.[15] Since 1951, annual average air temperatures have increased by 2.3°F (1.3°C) in the U.S., Great Lakes region. By mid-century (2050), average air temperatures are projected to increase by 3°F to 6°F (1.7°C to 3.3°C). By end of century (2100), average air temperatures are projected to increase by 6°F to 11°F (3.3°C to 6.1°C).

The frost-free season is projected to increase 10 days by early this century (2016–2045), 20 days by mid-century (2036–2065), and possibly a month by late century (2070–2099) compared to the period 1976–2005 according to the higher scenario (RCP8.5).[16]

Precipitation

Since 1951, total annual precipitation has increased by 14% in the U.S., Great Lakes Region. Future projections suggest more precipitation on average, but not necessarily during all seasons (summer to be drier) and not for all locations depending on which model is used. Reduced lake ice cover and enhanced evaporation may lead to increased lake-effect snowfall in the near-term, but rising temperatures will cause more winter precipitation to fall as rain as opposed to snow across the region by late century.

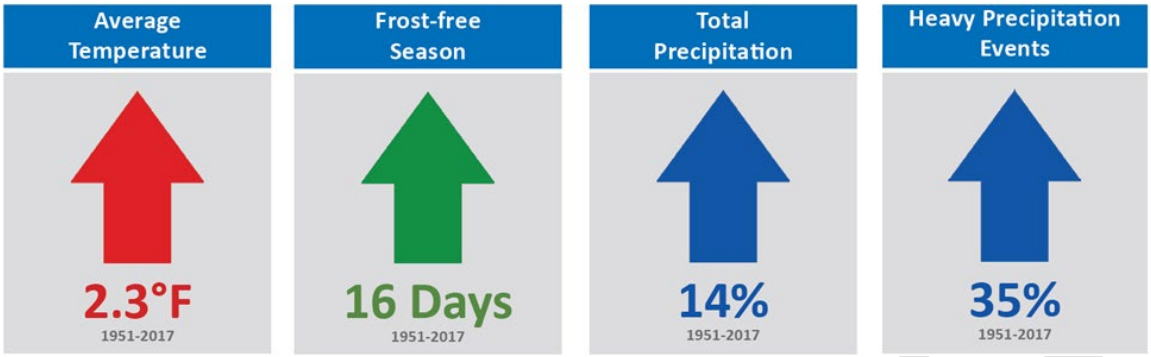
[13] *World Meteorological Organization*. (2021, August 31). Retrieved from Weather-related disasters increase over past 50 years, causing more damage but fewer deaths: https://public.wmo.int/en/media/press-release/weather-related-disasters-increase-over-past-50-years-causing-more-damage-fewer

[14] (2019, February 14). Retrieved from Climate Change in the Great Lakes Region: https://glisa.umich.edu/wp-content/uploads/2021/04/GLISA-2-Pager.pdf

[15] Vose, R. S., D. R. Easterling, K. E. Kunkel, A. N. LeGrande, and M. F. Wehner, 2017: Temperature Changes in the United States. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, Eds., U.S. Global Change Research Program, Washington, DC, USA, 185–206. doi:10.7930/J0N29V45.

[16] Hibbard, K. A., F. M. Hoffman, D. Huntzinger, and T. O. West, 2017: Changes in Land Cover and Terrestrial Biogeochemistry. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, Eds., U.S. Global Change Research Program, Washington, DC, USA, 277–302. doi:10.7930/J0416V6X.

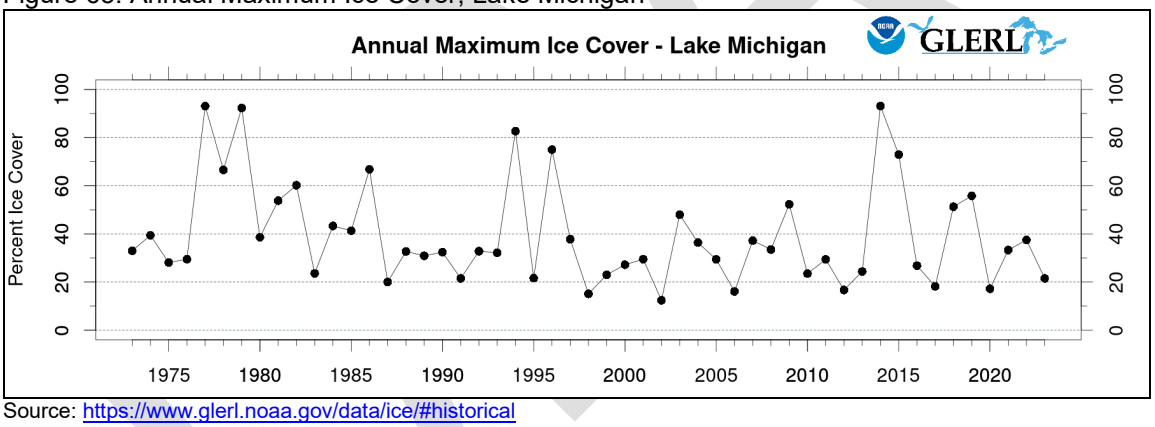
From 1951-2017, the United States, Great Lakes Region, overall, has seen increases in average temperature, frost-free season, total precipitation, and heavy precipitation events.



Snow, Ice Cover, Lake Temperature, and Lake Levels
Summer lake surface temperatures have been increasing faster than the surrounding air temperatures, with Lake Superior increasing by 4.5°F between 1979 and 2006. Annual average ice cover on the Great Lakes shifted from higher amounts prior to the 1990s to lower amounts in recent decades. There remains strong year-to-year variability, and high ice years are still possible. Lake-effect snowfall has increased in northern areas and may continue to increase through mid-century.

Lake Michigan has experienced seven winter seasons where the maximum ice coverage was sixty percent or greater since 1973 (Figure 63). The last major freeze of the lake occurred in the 2013-14 winter season. This freeze over reduced the ability to transport people, goods and services via ferry and fuel barges between Charlevoix and Beaver Island.

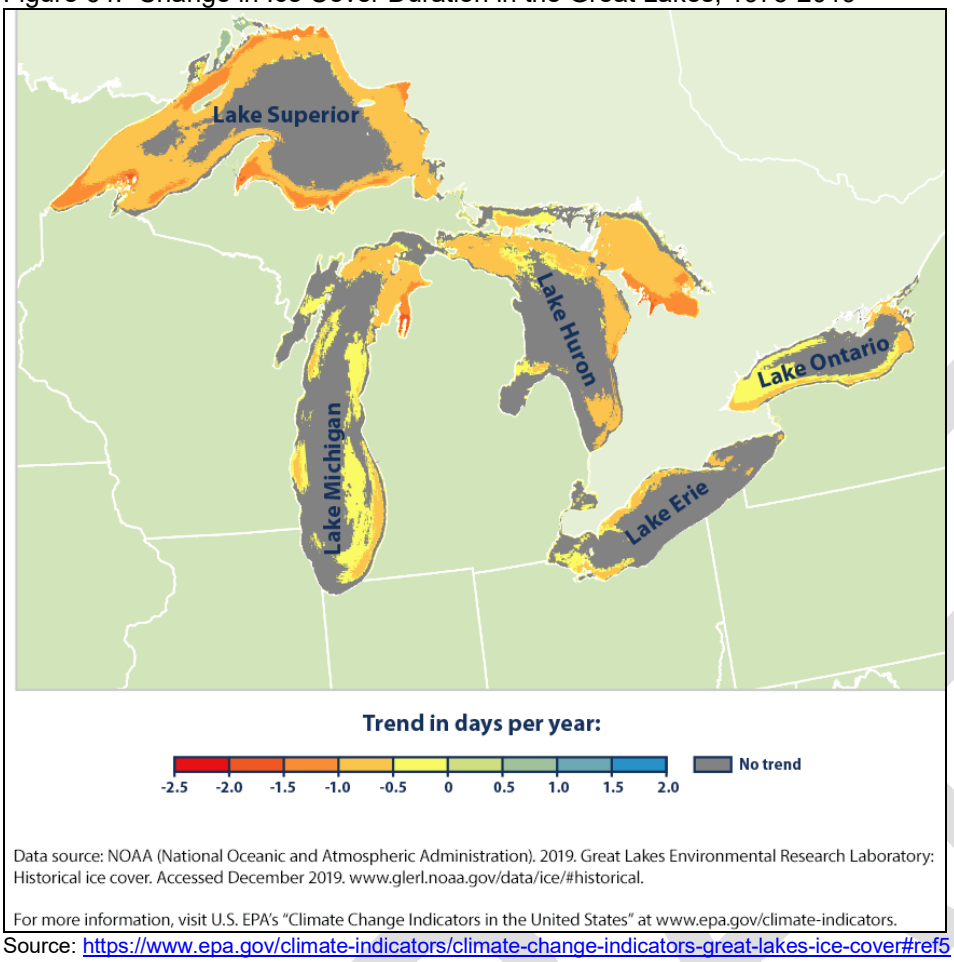
Figure 63. Annual Maximum Ice Cover, Lake Michigan



Source: https://www.glerl.noaa.gov/data/ice/#historical

Figure 64 shows that many areas of the Great Lakes have experienced significant decreases in ice cover duration, but other parts of the lakes have not changed significantly. Duration has decreased the most in areas near the shore, such as the area of Lake Michigan between the Beaver Island archipelago and the mainland of Charlevoix County.

Figure 64. Change in Ice Cover Duration in the Great Lakes, 1973-2019



Source: https://www.epa.gov/climate-indicators/climate-change-indicators-great-lakes-ice-cover#ref5

Current information from the *GLISA's Sustained Assessement of the Great Lakes*[17]*:*

Changes in regional climate have affected the patterns of Great Lakes precipitation, runoff, evaporation, and lake ice, and will continue to drive changes in the future. The following observational trends affect the water supply of the Great Lakes and water levels:

- Since 1951, there has been an 14% increase in region-total precipitation as well as a 35% increase in the amount of precipitation falling in the heaviest 1% of storms.
- Annual average air temperatures have increased by 2.3°F in the U.S. Great Lakes region since 1951, with lake temperatures increasing even faster.
- Annual average ice cover on the Great Lakes underwent a shift from higher amounts prior to the 1990s to lower amounts in recent decades. There remains strong year-to-year variability, and high ice years are still possible.
- The timing of spring snowmelt is changing. During the period of 1960-2000, observed snow depths in the late winter and early spring decreased, implying an earlier onset of spring thaw.

Changes in lake levels are the result of these different competing physical processes. For example, warming temperatures enhance evaporation over the lakes and in the drainage basin, and can lead to more years with low lake ice cover. Increases in evapotranspiration coupled with reduced ice cover duration can subsequently lead to lower water levels. Warmer temperatures can also reduce snowpack and soil moisture contributing to weaker runoff and lower water levels. Conversely, increases in precipitation frequency and intensity could lead to rising water levels. Any water level changes will depend on how one or more of these processes will dominate another in the future.

[17] https://glisa.umich.edu/sustained-assessment/lake-ice/

The future may hold another shift in ice cover but not necessarily in the downward direction. There is still the possibility of years with very high ice cover, as experienced in the 2013-2014 season. Practitioners should prepare for increased variability – high ice cover years followed by low ice cover years, and vice versa. Most certainly, ice will continue to form first where it always has, in protected areas near the shore, but it may not persist for as long.

Extreme Weather

The frequency and intensity of severe storms has increased. This trend will likely continue as the effects of climate change become more pronounced. The amount of precipitation falling in the heaviest 1% of storms increased by 35% in the U.S. Great Lakes region from 1951 through 2017. More severe storms may have a negative economic impact due to resulting damages and increased costs of preparation, clean up, and business disruption.

According to the NCA *Fourth National Climate Assessment Volume II: Impacts Risks, and Adaptation in the United States, "*Climate change is transforming where and how we live and presents growing challenges to human health and quality of life, the economy, and the natural systems that support us. Risks posed by climate variability and change vary by region and sector and by the vulnerability of people experiencing impacts. Social, economic, and geographic factors shape the exposure of people and communities to climate-related impacts and their capacity to respond. Risks are often highest for those that are already vulnerable, including low-income communities, some communities of color, children, and the elderly" (*Ch. 14: Human Health, KM 2*; *Ch. 15: Tribes, KM 1–3*; *Ch. 28: Adaptation, Introduction*).

Climate Change Vulnerability Assessment

The report *Climate Change in the Great Lakes Region* by GLISA at https://glisa.umich.edu/wp-content/uploads/2021/04/GLISA-2-Pager.pdf lists key challenges in the Great Lakes Region from climate change:

- **Public Health**
  - Increased risk of extreme heat and humidity may amplify the number of heat-related deaths and illnesses.
  - More storm activity and flooding, resulting in increased point- and non-point source pollution, will likely increase watershed contamination and water-borne illnesses, while warmer surface waters amplify the risk of toxic algal blooms and fish contamination.

- **Tourism and Recreation**
  - *Winter recreation/tourism are likely to suffer* due to reduced snow cover and shorter winters. Reduced lake ice cover and enhanced evaporation may lead to increased lake-effect snowfall in the near-term, but rising temperatures will cause more winter precipitation to fall as rain as opposed to snow across the region by late century.
  - Increasing temperatures and a longer summer season may *increase the demand for lake and beach use*.
  - Overall, *summer tourism may grow before temperature rise becomes unfavorable* for outdoor recreation.
  - *The fishing industry* (commercial and recreation) is likely to be impacted by the *decline of coldwater species of fish, such as lake trout and whitefish*.

- **Natural Environment**
  - Despite increasing precipitation, land surfaces in the region are expected to become drier overall due to increasing temperatures and evaporation rates.
  - More frequent summer droughts could affect soil moisture, surface water, and groundwater supply.
  - Increased evaporation rates and sustained levels of high or low water levels may change wetland areas in the region.
  - The rate of warming may *outpace the rate at which ecosystems are able to migrate and adapt*.
  - *Wildlife populations better adapted to cold temperatures will continue to decline* as competing species migrate into the region with rising air and surface water temperatures.
  - *Forest productivity will likely increase in the short term*, until other impacts of climate change such as increased drought, fire and invasive species present additional stressors to forests.

- **Community Services and Local Economy**
  - Despite a general warming climate trend, it is likely that the area of Lake Michigan between Beaver Island and the mainland of northern lower Michigan will still experience future episodes of significant ice cover. According to input from a Beaver Island resident/local official as part of this plan development, past instances of major ice coverage have resulted in significant issues with maritime transportation logistitics between the island and the mainland. Effective planning and coordination amongst transportation entities and safety personnel will be needed to mitigate logistical issues in a future Lake Michigan freeze event.

GLISA has partnered with Great Lakes city adaptation practitioners to produce a set of plausible climate scenarios to aid in city and local planning. These scenarios can also be used at larger spatial scales (e.g., county) and are intended to be transferable across cities or communities, meaning the basic scenario details are relevant for any city in the Great Lakes region with the option to customize them further. While the scenarios are informed by climate model projections, they provide much greater detail than what models alone tell us; although still backed by models and projections, GLISA's scenarios make it easier to understand what projected climate changes could look like in reality. This combination of model data and real-world experience represents a holistic and practitioner-driven approach to scenario development.

Each scenario consists of a narrative description of weather conditions or events with details about sector-specific community impacts (e.g., city transportation, emergency response, etc.). Communities can customize the impacts described in the scenarios based on their own vulnerabilities and planning priorities to make the scenarios more relevant for their planning needs. Example customizations are provided with each scenario and this scenario planning workbook also helps guide these customizations. The scenarios can be used as a starting point for thinking about a future that may look different than the past and to develop ideas, recommendations, and plans to better prepare for that future.

For additional background information about GLISA's scenarios and access to the scenarios: https://glisa.umich.edu/climate-data/climate-scenarios/

For a list of GLISA's past scenario planning projects and examples: https://glisa.umich.edu/engagement/scenario-planning/#examples

IV. Community Vulnerabilities and Capabilities

The tables on the following pages summarize much of the information presented in Sections III (Community Profile) and IV (Hazard Identification and Assessments) as it pertains to hazard vulnerabilities and mitigation capabilities for each community in Charlevoix County. While most types of hazards considered in this plan could affect every jurisdiction in the County, certain characteristics of people, property, the economy and the environment were considered to evaluate each community's unique vulnerabilities and assets regarding each type of hazard. For reference, the locations of some of these characteristics (i.e., public lands, pine forest area, infrastructure, campgrounds, mobile home areas, hazard areas) are illustrated in the maps provided in Appendix A.

V. Goals and Objectives

The mission of the Charlevoix County Natural Hazards Mitigation Plan is to protect the health and safety of the public and property in the County which includes prevention of: injury, loss of life, property damage, liability issues, a breakdown in vital services like transportation and infrastructure, economic slumps, and tourism loss. This is done by taking action to permanently eliminate or reduce the long-term risks from natural hazards.

Specific goals and objectives have been established based upon the community's natural hazards analysis, as well as input from the Task Force participants and the public through meetings, request for comments on the draft plan, and the presentation of the plan to the Local Emergency Planning Team.

Goal 1: Increase local awareness and participation in natural hazards mitigation strategies
Objectives:

A. Encourage cooperation and communication between planning and emergency management officials
B. Encourage additional local governmental agencies to participate in the natural hazards mitigation process
C. Encourage public and private organizations to participate in the natural hazards mitigation process

Goal 2: Integrate natural hazards mitigation considerations into the community's comprehensive planning process
Objectives:

A. Enforce and/or incorporate natural hazards mitigation provisions in building code standards, ordinances, and procedures; and into the county's comprehensive master plan
B. Incorporate natural hazards mitigation into basic land use regulation mechanisms
C. Update or create zoning ordinances to reflect any new building codes, shoreline protection rules, etc.
D. Incorporate natural hazard area classifications into standard zoning classifications
E. Improve community education efforts about hazard preparedness and prevention
F. Increase public awareness and use of available emergency warning systems
G. Strengthen the role of the Local Emergency Planning Committee in land development processes
H. Integrate hazard mitigation into the capital improvement planning process so that public infrastructure does not lead to development in hazard areas
I. Encourage county agencies to review local roads, bridges, dams, and related transportation infrastructure for natural hazards vulnerability

Goal 3: Utilize available resources and apply for additional funding for natural hazard mitigation projects
Objectives:

A. Provide a list of desired community mitigation measures to the State for possible future funding
B. Encourage the application for project funding from diverse entities

Goal 4: Develop and complete natural hazards mitigation projects in a timely manner
Objectives:

A. Encourage public and business involvement in natural hazards mitigation projects

VI. Mitigation Strategies and Priorities

Types of Mitigation Actions

The mitigation planning regulations requires that each participating jurisdiction identify and analyze a comprehensive range of specific mitigation actions and projects to reduce the impacts of the hazards identified in the risk assessment. The emphasis is on the impacts or vulnerabilities identified in the risk assessment, not on the hazards themselves. The types of mitigation actions can be classified into the following types:

- Local Plans and Regulations
- Building and Infrastructure Projects
- Natural Systems Protection
- Education and Awareness Programs

Furthermore, a set of evaluation criteria was developed to determine which mitigation strategies were best suited to address the identified problems in Charlevoix County.

- The measure must be technically feasible.
- The measure must be financially feasible.
- The measure must be environmentally sound and not cause any permanent, significant environmental concerns.
- The measure must be acceptable to those participating in the strategy and/or primarily affected by the strategy.

By anticipating future problems, the County can reduce potential injury, structure losses, loss of utility services such as electric and internet connectivity, and prevent wasteful public and private expenditures. The County Infrastructure, Vulnerability, and Hazard Maps in Appendix A can assist with the determining future problem areas.

Emergency Warning System Coverage

Integrated Public Alert & Warning System (IPAWS)

- FEMA's national system for local alerting that provides authenticated emergency and life-saving information to the public through mobile phones using Wireless Emergency Alerts, to radio and television via the Emergency Alert System, and on the National Oceanic and Atmospheric Administration's Weather Radio.

Mobile Warning Systems

- If there is a major emergency, or if a Local State of Emergency is declared, community notifications will be conducted utilizing the “Be Alert” emergency notification system, which is an electronic, high-speed, outbound notification service available at no charge to the general public. The system notifies a participant via their mobile phone, land-line phone and/or email address.
- The FEMA Mobile App is also a publicly available mobile warning system providing real-time weather alerts, locations of emergency shelters, and allows for notifications to be sent to loved ones.
- The National Weather Service may concurrently utilize their mobile warning notification system when deemed necessary in severe weather event situations to send phone notifications to users within signal of a cellular tower.

Radio Warning Systems

- Charlevoix County uses radio channels 580 AM and 103.5 WTCM for emergency alerts.
- NOAA Weather Radio All Hazards is a nationwide network of radio stations broadcasting continuous weather information directly from the nearest National Weather Service office. NWR broadcasts official Weather Service warnings, watches, forecasts and other hazard information 24 hours a day, 7 days a week.

Tornado/Severe Weather Warning Systems

- The BeAlert system is primarily used in the event of a potential or current severe weather or tornado event.
- Manually operated tornado sirens are located at:
    - City of Boyne City (located at City Hall)
    - City of Charlevoix (located at city hall)
    - City of East Jordan (Behind EJ Fire Department and at Sportsmen’s Club Park)

Flood Warning Systems

- For dam failures that would result in downstream flooding, the dam owners would immediately notify the County Emergency Manager, who would then post a notification on the BeAlert Emergency Communications Network.

Website and Social Media Platforms

- Charlevoix County 911/Dispatch Department posts emergency preparedness information or emergency alerts on their website or via social media.
- Local police and the county Sheriff's Department, in coordination with the County Emergency Manager, post information on emergency events and preparedness on the county Sheriff's Department Facebook page.

Shelter Sites

Table 51: Temporary Shelter Sites in Charlevoix County

Name	Address	Type	Capacity (Schools only list capacity in Gym)	Use	Features
Peaine Twp. Hall	Beaver Island	Other		Warming/ Cooling Center	Handicap Accessible, Power, Air Conditioning, Heat, Water, Lavatories, Back-up Generator, Kitchen Accessible
Boyne City Hall	319 North Lake Street, Boyne City	Other	150	Warming/ Cooling Center	Handicap Accessible, Power, Air Conditioning, Heat, Water, Medical, Lavatories, Back-up Generator, Kitchen Accessible
Boyne City Veterans Park Pavilion	211 North Lake Street, Boyne City	Other	50	Warming/ Cooling Center	Pet Friendly, Handicap Accessible, Power, Air Conditioning, Heat, Water, Lavatories, Kitchen Accessible
St. Matthews Catholic Church	1303 Boyne Ave., Boyne City	Church	300	Warming Center	Handicap Accessible, Power, Heat, Water, Lavatories, Kitchen Accessible
Community Reformed Church	109 Elm St. Charlevoix	Church	400+	Warming Center	Handicap Accessible, Power, Heat, Water, Lavatories, Kitchen Accessible, Counselor(s)
St. Joseph's Catholic Church	207 Nicholls St. East Jordan	Church	250	Warming Center	Handicap Accessible, Power, Water, Lavatories, Kitchen Accessible
East Jordan Emergency Services Building	555 Maple St East Jordan	Fire/EMS Station	30 in Conference Room only	Warming/ Cooling Center	Handicap Accessible, Power, Air Conditioning, Heat, Water, Medical, Lavatories, Back-up Generator, Kitchen Accessible
Lighthouse Missionary Church	7824 Rogers Rd, East Jordan	Church	200	Warming/ Cooling Center	Handicap Accessible, Power, Air Conditioning, Heat, Water, Lavatories, Kitchen Accessible, Shower facilities, Counselor(s), Medical (EMT's)

Source: Charlevoix County Office of Emergency Management

The American Red Cross also maintains Memorandums of Understanding with __ for use of their facilities as shelter sites in the event of a disaster.

Boat Access Sites for Emergency Use (such as for water withdrawal or lake rescue access)

Table 52. Boat Launch Sites in Charlevoix County

Jurisdiction	Description	Water Body	Owner
Bay Township	Lake Charlevoix Access Site (Lake Street)	Lake Charlevoix	Charlevoix County Road Commission
	Walloon Lake Access Site (Wildwood Drive)	Walloon Lake	Charlevoix County Road Commission
	Walloon Lake Access Site (Stolt Road)	Walloon Lake	Charlevoix County Road Commission
	Sumner Road	Walloon Lake	Charlevoix County Road Commission
	Walloon Lake (Lily Pad Bay) Access Site (Eagle Island Road)	Walloon Lake	Township
Boyne Falls Township	Deer Lake Access Site	Deer Lake	State of MI
Boyne Falls Village	Boyne Falls Pond Boat Launch	Boyne River	Village
Charlevoix Township	South Point Boat Launch (Lakeshore Drive)	Lake Michigan	Township
	Pine Point Boat Launch	Lake Charlevoix	Township
City of Boyne City	Lake Charlevoix Access Site (Lakeview Drive)	Lake Charlevoix	City
	Veteran's Park (small boat launch)	Lake Charlevoix	City
City of Charlevoix	Ferry Avenue Boat Launch	Lake Charlevoix	City
	US Coast Guard Station	Round Lake/Lake Charlevoix	US Coast Guard
City of East Jordan	Tourist Park Boat Launch	S. Arm of Lake Charlevoix	City
Eveline Township	Whiting Park Boat Launch	Lake Charlevoix	County
	Ironton Boat Launch off of 5th St	Lake Charlevoix	State of MI
Hayes Township	Kennedy Park (Burgess Road)	Lake Michigan	State of MI
	Nine Mile Point Boating Access Site	Lake Michigan	State of MI
	John W. Keschick Sr. Access Site	Lake Michigan	Little Traverse Bay Bands of Odawa Indians
	Hayes Township Park (Camp Sea-Gull)	Lake Charlevoix	Township
	Susan Lake Access (Shrigley Road)	Susan Lake	State of MI
Marion Township	Adams Lake Access site off of Pops Road	Adams Lake	State of MI
	Nowland Lake Access site off of Nowland Lake Trail	Nowland Lake	State of MI
South Arm Township	Duthchman's Bay Boat Ramp	Lake Charlevoix	State of MI
	Six Mile Lake Access off of Miles Road	Six Mile Lake	State of MI
	Jordan River access at Rogers Road and Old Point Ridge Road	Jordan River	State of MI
	Jordan River access at Alba Road	Jordan River	State of MI
Hudson Township	Thumb Lake Access Site (West End, off of Thumb Lake Rd)	Thumb Lake	Privately owned but leased to the State of MI
	Bows Lake Access Site	Bows Lake	Township
	Huffman Lake Access Site	Huffman Lake	Township
Melrose Township	Melrose Township Boat Launch	Walloon Lake	Township
Peaine Township	Lake Geneserath Access Site	Lake Geneserath	State of MI
	Fox Lake Access Site	Fox Lake	Township
St. James Township	Font Lake Access Site	Font Lake	Road Commission and Township
	Boat Launch at Gallagher Ave. & Main St.	St. James Harbor (Lake MI)	Road Commission
Data sources: Charlevoix County Parks and Recreation Plan, 2020-2024; MDNR			

Mitigation Strategies
Strategies were developed based on discussions amongst the Task Force, local officials and a review of FEMA best practices for hazard mitigation. A list of alternative strategies considered is included as Appendix D. The strategies table is grouped according to purpose. Purpose types include: Awareness & Preparation, Shelters, Buildings & Development, Utilities & Technology, and Environment & Natural Resources. The table also includes: a description of each strategy; what natural hazards they address; where the strategy applies; who is responsible for implementing the strategy; how the strategy will be implemented (what resources are available to help execute the strategy); when the strategy could feasibly begin; the level of priority; and what type of strategy it is. Strategies are intended to be action items completed during the 5-year timeframe in which the plan is active. Some strategies may extend beyond the 5-year timeframe due to feasibility or level of difficulty.

Appendix C provides a review of mitigation strategies included in the 2015 plan, their current status, and how they have or have not been incorporated into this plan update. Note that the 2016 mitigation strategies were not given a priority level of "high", "medium", or "low", as they are in this plan. The 2016 strategies were simply identified as the following top five natural hazards priority areas:

1. *Potential of severe thunderstorms, high winds and severe winter storms: Concerns about transportation and utilities at a countywide level and also specifically at the US-31 Bridge in the City of Charlevoix*

2. *Boyne River and East Jordan areas: Potential flooding if dams were to fail*

3. *Eastern portion of the county: Potential wildfire and the possibility of tornadoes near a natural gas transmission facility in Chandler Township [located north of Great Lakes Road and west of Magee Road).*

4. *Wildfires in the rural areas of the County, specifically at Beaver Island and other small islands in the archipelago; Near Thumb Lake Road/Lake Louise Christian Community summer camp (lots of pine forest) in Hudson Township; and in the Hoffman Lake area in Hudson Township, which is growing in population.*

5. *Festival events at seasonal population centers throughout the County: Potential severe thunderstorms, high winds, and tornadoes.*

Rationale for Prioritization of the Mitigation Strategies
The Charlevoix County Emergency Manager and Local Emergency Planning Committee considered factors like level of need, economic impact, ease of execution/level of effort, cost, and range of benefit (short term, long-term, small group/area, large group/area) when determining the level of priority for each strategy. In general, strategies were given either a high, medium, or low priority level based on the following rationale:

PRIORITY LEVEL	RATIONALE
HIGH	High priority strategies are considered critical to preserve life and property, and will have the largest benefit for the community. High priority strategies often address human health, community safety, and protection of property and critical infrastructure. Many of these strategies have an enforcement standard and financing in place; a high level of need and/or anticipated economic benefit; or a high probability of immediate benefit public health or safety if the hazard event were to occur.
MEDIUM	Medium priority strategies address hazards that do not appear to have immediate impacts to public health or safety, but may have impacts to specific residents or visitors. Many of these strategies consist of education or planning efforts. If the action item pertained to an entity that was not at the table during discussion, we defaulted to "Medium" to respect that they may have a different interpretation of the priority which could not be identified at the current discussion.
LOW	Low priority strategies are considered to be long-term mitigation efforts that will be worked on as resources (such as staff or financing) become available. Regarding foreseeable short- or long-term health and safety benefits (which may change within 5 years), the word "consider" was used in the action item. The probability of an event occurring in the geographic area is low, but not impossible, so it should be considered. The strategy's priority level may also change based on natural events or time.

The key for the strategy types in the far right columns of the strategies table are as follows:

STRATEGY TYPES

1	**Local Planning & Regulations**
2	**Building & Infrastructure Projects**
3	**Natural Systems Protection**
4	**Education & Awareness Efforts**

VII. IMPLEMENTATION

Hazard mitigation is any action taken before, during, or after a disaster to permanently eliminate or reduce the long-term risk to human life and property from natural and technological hazards. Mitigation is an essential element of emergency management, along with preparedness, response, and recovery. Emergency management includes four phases: actions to mitigate a disaster, a community prepares for a disaster; responds when it occurs; and then there is a transition into the recovery process. The process is cyclical and mitigation measures are evaluated and adopted constantly. The evaluation improves the preparedness posture of the County for the next incident, and so on. When successful, mitigation will lessen the impacts of natural hazards to such a degree that succeeding incidents will remain incidents and not become disasters.

Resources to Assist with Implementing the Strategies
To assist with the funding and/or enacting of the proposed natural hazards mitigation strategies, the Resources Table on the previous pages lists multiple resources that can help fund, staff or otherwise support the implementation of hazard mitigation strategies. Each potential entity or program is assigned a letter code, listed in the "Resources" column of the strategies table.

The following is a general list of some of the financial assistance entities to help fund strategic actions of the Plan.

- Federal Emergency Management Administration – Hazard Mitigation Grant and Building Resilient Infrastructure and Communities Programs
- U.S. Environmental Protection Agency
- U.S. Department of Agriculture Natural Resources Conservation Service
- U.S. Department of Agriculture Rural Development: Rural broadband opportunity – high speed telecommunication funding from the Public Telecommunications Facilities Planning and Construction grants
- U.S. Department of Housing and Urban Development
- Michigan Department of Environment, Great Lakes, and Energy
- Michigan Department of Natural Resources
- National Oceanic and Atmospheric Administration
- Community, Regional Foundations
- Businesses

Plan Review, Monitoring, and Evaluation
This Plan is intended to be a resource for building coordination and cooperation within a community for local control of future mitigation and community preparedness. The County Board will lead the implementation of the Natural Hazards Mitigation Plan with assistance from the Emergency Management Coordinator and the Administration. The Local Emergency Planning Team (LEPC) is an inter-agency partnership led by the county's Emergency Management Coordinator and will collaborate to accomplish the goals and objectives of the Plan. The LEPC meets on a regular basis to carry out its duties and has expanded its role to function as the Natural Hazards Task Force. The Natural Hazards Task Force will be responsible for monitoring and implementing the mitigation plan. Staff support will be provided by the Charlevoix County Emergency Management Coordinator and will coordinate with the County Board of Commissioners.

The Natural Hazards Task Force will perform an annual review of the Charlevoix County Hazard Mitigation Plan and consider the list of mitigation strategies identified in the plan. The Task Force will identify projects that have been completed and identify new projects to be completed. The following agencies will be encouraged to actively participate in revising, updating, and maintaining the plan.

- Charlevoix County Government Staff
- Charlevoix County Road Commission
- Townships and Villages (elected and appointed officials)
- Little Traverse Bay Band of Odawa Indians
- Grand Traverse Bands of Ottawa and Chippewa Indians
- Charlevoix Conservation District
- Charlevoix, Antrim, Kalkaska and Emmet Coordinated Invasive Species Management Area
- Little Traverse Conservancy
- Tip of the Mitt Watershed Council
- Walloon Lake Association and Conservancy
- Lake Charlevoix Association
- Beaver Island Association

- Friends of the Jordan River
- Munson Hospital – Charlevoix
- Charlevoix Chamber of Commerce
- Networks Northwest
- Health Department of Northwest Michigan
- Michigan State University Extension
- Michigan Department of Environment, Great Lakes, and Energy
- Michigan Department of Natural Resources
- Michigan State Police
- U.S. Environmental Protection Agency
- U.S. Coast Guard
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture Natural Resources Conservation Service
- American Red Cross
- National Weather Service (Gaylord)
- Insurance and real estate companies

In addition, the townships, cities and village within the county have indicated to the county emergency manager that they will follow the county's lead in identifying hazard mitigation projects and developing grant applications to fund those projects. Land use issues associated with those projects (where applicable) will be handled by each jurisdiction that have an adopted Master Plan and regulate zoning in the project area (all communities except for the Village of Boyne Falls). Professional planners assist the individual communities in developing plans and zoning ordinances, provides resource information and technical assistance, and convenes communities to address land use issues of common interest.

Building permits, soil erosion permits, and storm water permits are issued for applicable construction projects in all Charlevoix County communities by the County's Department of Building Safety. Permits related to water well and septic systems are issued by the Health Department of Northwest Michigan. Permits related to State-designated Critical Dune Areas are issued by the Michigan Department of Environment, Great Lakes, & Energy (EGLE) for all communities except for Peaine and St. James Townships on Beaver Island (they issue their own CDA permits though the enforcement of their local zoning ordinances).

Plan Integration

All communities, local and state agencies in Charlevoix County will consider integrating information from the hazard mitigation plan into their comprehensive and operations plans. As part of the education and outreach aspect of the hazard mitigation effort, the local communities will be encouraged to adopt zoning regulations to minimize the risk and impact from hazards.

All natural hazards mitigation planning could be pursued using Michigan Public Act 226 of 2003, the Joint Municipal Planning Act. This Act provides for joint land use planning by cities, villages, and townships, and allows two or more municipalities' legislative bodies to create a single joint planning commission to address planning issues. This tool helps with planning for the "big picture" issues such as natural hazards that cross jurisdictional boundaries. The intent of this legislation is for local governments to consider the following:

- Individual units of government modifying their ordinances simultaneously to include language that would incorporate aspects of protection
- Developing an overlay zoning district that would cross jurisdictional boundaries which would be incorporated into existing independent units of government's zoning ordinances
- Forming a new joint (multi-jurisdictional) planning commission or zoning board
- Sharing zoning administration and enforcement activities

Peaine and St. James Townships in the Beaver Island archipelago have indicated in their 2023 Beaver Island Master Plan that a "very high priority" action item pertaining to social services and leadership is to consolidate the two townships into one township government.

Five Year Plan Review and Update

The Stafford Act, as amended by the Disaster Mitigation Act of 2000, requires the County's Hazard Mitigation Plan to be updated, adopted, and re-submitted for Federal Emergency Management Agency (FEMA) approval every five years. The plan will be reviewed by the Natural Hazards Task Force every five years in alignment with federal regulations. The update will include determining changes in the county, such as changes in development; an increase in exposure to hazards; an increase or decrease in the communities' capability to address hazards; addition and/or removal of mitigation

actions and strategies; reviewing goals; and a change in federal or state legislation. Upon completion, the updated plan will be sent to the State Hazard Mitigation Officer at the Michigan State Police for final review and approval in coordination with FEMA. When the plan has received an “approved pending adoption” status from FEMA, the Charlevoix County Board of Commissioners, along with individual local units of government that participated in the plan’s development, can formally adopt the plan. In order to properly update the plan in the future, Charlevoix County will need to seek funding from appropriate state and/or federal agencies.

Continued Public Involvement

Charlevoix County is committed to keeping the public involved in the implementation and update of the Hazard Mitigation Plan. Copies of the plan will be available at the county libraries, county clerk’s office, and all township offices, and will be posted on the community websites and/or regional planning agency website. The Emergency Management Office will be responsible for keeping a record of public comments on the plan.

APPENDIX A: MAPS

APPENDIX B: COMMUNITY SURVEY RESULTS

APPENDIX C: PUBLIC INPUT SESSIONS - FEEDBACK

APPENDIX D: CURRENT STATUS OF 2016 PLAN STRATEGIES

APPENDIX E: CONSIDERATION OF ALTERNATIVE MITIGATION STRATEGIES

APPENDIX F: LOCAL COMMUNITY PLANS – ALIGNMENT WITH HM STRATEGIES

APPENDIX G: PARTICIPATION TABLE

APPENDIX H: MEETING AND PUBLIC INPUT DOCUMENTATION