

Chapter 2

Hazard Analysis

In this chapter the hazards that Mackinac County is most susceptible to are discussed. Descriptions of some of the major hazards are included. Information on hazard history is included where that information was available. A short description of the technological hazards is included. Some of the technological hazards described are due to humans such as with war, or from human error such as accidents, but many of the technological hazards are also due to natural hazards that affect the County. This Plan is concentrating mainly on the natural hazards, which are explained in more detail starting on page 41.

Technological Hazards

Nuclear Attack

World events in recent years have greatly changed the nature of the nuclear attack threat against the United States. Even though an International Nuclear Non-Proliferation Treaty is in place, several countries are known to be actively pursuing the development of nuclear weapons.

The population of Mackinac County could be vulnerable to a nuclear attack as the neighboring Chippewa County Airport, centrally located in the Eastern U.P., is recognized as one of 25 potential target by the Michigan State Police Emergency Management Division in the Michigan Hazard Analysis of December, 2001. For that reason, as well as the limited evacuation routes and the county's ability to handle such an emergency make this hazard rated as the number one hazard in the County.

In response to the threat of a nuclear attack, FEMA has in the past advocated a population protection strategy using a combination of evacuation and in-place sheltering. In Michigan, evacuation areas have been determined for the 25 target areas within the state and the four target areas bordering the state. The immediate primary threat, for the vast majority of the county's population, is from fallout radiation rather than direct weapons effects.

It makes sense to continue to prepare for the nuclear attack hazard as part of an overall emergency management strategy. The Emergency Management Division, Department of State Police, through its planning guidance and training, assists local governments in planning for and implementing this concept as part of an overall emergency management capability.

Hazardous Materials Incidents

Fixed Sites Hazardous Materials Incident: Over the past few decades, new technologies have developed at a stunning pace. As a result, hazardous materials are present in quantities of concern in business and industry, agriculture, universities, hospitals, utilities, and

other facilities in our communities. Hazardous materials are materials or substances which, because of their chemical, physical, or biological nature, pose a potential risk to life, health, property, or the environment if they are released. Examples of hazardous materials include corrosives, explosives, flammable materials, radioactive materials, poisons, oxidizers, and dangerous gasses.

Hazardous materials are highly regulated by federal and state agencies to reduce risk to the general public and the environment. Despite precautions taken to ensure careful handling during the manufacture, transport, storage, use, and disposal of these materials, accidental releases do occur. Often, these releases can cause severe harm to people or the environment if proper mitigative action is not immediately taken. Most releases are the result of human error. Occasionally, releases can be attributed to natural causes, such as a flood that washes away barrels of chemicals stored at a site. However, those situations are the exception rather than the rule.

Industrial Accidents: Industrial accidents differ from hazardous material incidents in the scope and magnitude of offsite impacts. Whereas hazardous material incidents typically involve an uncontrolled release of material into the surrounding community and environment that may necessitate evacuations or in-place sheltering of the affected population, the impacts from industrial accidents are often confined to the site or facility itself, with minimal physical outside impacts. Nonetheless, industrial accidents such as fires, explosions, and excessive exposure to hazardous materials, may cause injury or loss of life to the workers at the facility, and often significant property damage. In addition, industrial accidents can cause severe economic disruption to the facility and surrounding community, as well as significant, long-term impacts on the families of the workers injured or killed.

Transportation: As a result of the extensive use of chemicals in our society, all modes of transportation – highway, rail, air, marine, and pipeline – are carrying thousands of hazardous materials shipments on a daily basis through local communities. A transportation accident involving any one of those hazardous material shipments could cause a local emergency affecting many people.

Mackinac County has had occasional hazardous material transportation incidents that have affected the immediate vicinity of an accident site or a small portion of the surrounding community. Those types of incidents, while problematic for the affected community, are fairly commonplace. They are effectively dealt with by local and state emergency responders and hazardous material response teams. Larger incidents, however, pose a whole new set of problems and concerns for the affected community. Large-scale or serious hazardous material transportation incidents that involve a widespread release of harmful material (or have the potential for such a release), can adversely impact the life safety and/or health and well-being of those in the immediate vicinity of the accident site, as well as those who come in contact with the spill or airborne plume. In addition, damage to property and the environment can be severe as well. Statistics show that almost all hazardous material transportation incidents are the result of an accident or other human error. Rarely are they caused simply by mechanical failure of the carrying vessel.

Being surrounded by the Great Lakes, one of the most dangerous hazardous material transportation accident scenarios that could occur in Michigan would be a spill or release of oil, petroleum or other harmful materials into one of the lakes from a marine cargo vessel. Such an incident, if it involved a large quantity of material, could cause environmental contamination of unprecedented proportions. Fortunately, the Great Lakes states, working in partnership with oil and petroleum companies and other private industry, have taken significant steps to ensure that a spill of significant magnitude is not likely to occur on the Great Lakes.

Transportation Accidents

Air Transportation Accidents: There are four circumstances that can result in an air transportation accident: 1) an airliner colliding with another aircraft in the air; 2) an airliner crashing while in the cruise phase of a flight due to mechanical problems, sabotage, or other cause; 3) an airliner crashing while in the takeoff or landing phases of a flight; or 4) two or more airliners colliding with one another on the ground during staging or taxi operations. When responding to any of these types of air transportation accidents, emergency personnel may be confronted with a number of problems, including: 1) suppressing fires; 2) rescuing and providing emergency first aid for survivors; 3) establishing mortuary facilities for victims; 4) detecting the presence of explosive or radioactive materials; and 5) providing crash site security, crowd and traffic control, and protection of evidence.

Land Transportation Accidents: A land transportation accident in Mackinac County could involve a local public transit bus, or a school bus, as well as typical vehicles and recreational vehicles. On Mackinac Island land transportation accidents could involve pedestrian, bicycles or horse ridden/drawn. Although these modes of land transportation have a good safety record, accidents do occur. Typically, accidents are caused by inclement weather, or colliding with another vehicle or animal. Train accidents usually involve a collision with a vehicle attempting to cross the railroad tracks before the train arrives at the crossing. Unless the train accident results in a major derailment, serious injuries are usually kept to a minimum. Bus accidents, on the other hand, can be quite serious – especially if the bus has tipped over. Numerous injuries are a very real possibility in those types of situations.

Mackinac County has hundreds of miles of recreational trails used by both non-motorized and motorized vehicles. Accidents in remote areas with lack of communication capability or location identification can make it difficult on the emergency response team. The many trails located in the eastern U.P. are beginning to draw many ATV/ORV users. The use of these types of vehicles along shoulders of highways and county roads, traveling between the trails, is causing an increase in concern from local transportation departments and emergency personnel, due to the damage they are causing as well as increased potential for accidents.

Highway US-2 is one of Mackinac County's most dangerous highways. It travels west out of St. Ignace along the Lake Michigan Shoreline. This highway starts out of St. Ignace with four lanes, eventually narrowing down to two lanes with a posted speed of 55 MPH. On the southern side is the shoreline of Lake Michigan which is considered by the Michigan Department of Environmental Quality (MDEQ) as a Critical Dune Area and is protected as such. It is also a popular swimming area for tourists and county residents, which leads to parking along the

shoulders. The area is flat so during times of high wind in the summer sand will blow across the road causing accumulation. In winter, blowing snow and accumulating snow drifts make driving hazardous. Run-off from severe thunderstorms can also cause problems. This also happens to be a “dead-zone” for cellular communication and the National Weather Service.

Water Transportation Accidents: A water transportation accident involving one of the 3 commercial marine passenger ferries operating from Mackinac County’s Great Lakes shoreline communities could have significant life safety consequences. Most of these marine ferry services operate on a seasonal basis (typically May through November). Vessel sizes vary, but it is not uncommon for 100-200 passengers or more to be on board many of the ferries at peak tourist season. In a typical year, these ferries make thousands of trips across Great Lakes waters. Although the vessels have an excellent safety record, and they must pass rigorous Coast Guard inspections, the potential for an accident is always present. Accidents in other states or countries involving similar vessels validate the need for rigorous emergency preparedness actions to prevent loss of life in an open water setting such as the Great Lakes.

According to records from the U.S. Coast Guard Base located in the City of St. Ignace, there have been 229 search and rescue operations from January, 2002 to June, 2005. This base is responsible for all of Mackinac County as well as parts of northern Lower Michigan and assists the Sault Ste. Marie base if needed.

The one commonality all transportation accidents share – whether air, land or water-based – is that they can result in mass casualties. Air transportation accidents, in particular, can result in tremendous numbers of deaths and injuries, major victim identification, and crash scene management problems. Water transportation accidents, on the other hand, may require a significant underwater rescue and recovery effort that few local jurisdictions may be equipped or trained to handle. Accidents on the Islands in Mackinac County pose an even greater threat, as assistance from the mainland may take up to 4 hours and, in a worse case scenario, possibly even days, depending on the weather.

Petroleum and Gas Pipeline Accidents

Though often overlooked, petroleum and natural gas pipelines pose a real threat in many Michigan communities. Petroleum and natural gas pipelines can leak or fracture and cause property damage, environmental contamination, injuries, and even loss of life. The vast majority of pipeline accidents that occur in Michigan are caused by third party damage to the pipeline, often due to construction or some other activity that involves trenching or digging operations.

Mackinac County has a major gas and petroleum pipeline running through the majority of the County from the Mackinac Bridge westward. (See Map 16 - Major Gas Pipeline.)

Infrastructure Failures

Mackinac County’s citizens are dependent on the public and private utility infrastructure to provide essential life supporting services such as electric power, heating and air conditioning, water, sewage disposal and treatment, storm drainage, communications, and transportation. When one or more of these independent, yet interrelated systems fail due to

disaster or other cause – even for a short period of time – it can have devastating consequences. For example, when power is lost during periods of extreme heat or cold, people can literally die in their homes if immediate mitigative action is not taken. When the water or wastewater treatment systems in a community are inoperable, serious public health problems arise that must be addressed immediately to prevent outbreaks of disease. When storm drainage systems fail due to damage or an overload of capacity, serious flooding can occur.

These are just some examples of the types of infrastructure failures that can occur, and all of these situations can lead to disastrous public health and safety consequences if immediate mitigative actions are not taken. Typically, it is the most vulnerable members of society (i.e., the elderly, children, impoverished individuals, and people in poor health) that are the most heavily impacted by an infrastructure failure. If the failure involves more than one system, or is large enough in scope and magnitude, whole communities and possibly even regions can be severely impacted.

Historical Events: Beginning on July 22, 2000 Mackinac Island began to experience intermittent power outages that escalated two days later into a complete power blackout. The outage continued until July 28 when several large generators were brought to the island by Edison Sault Electric Company to provide temporary power until the island’s electrical infrastructure could be repaired. The cause of the outage was later determined to be overheating damage to five of the seven underwater cables that provide power to the island from the mainland. The damaged cables were subsequently replaced in hopes of eliminating any future problems.

The outage came at the worst possible time for the residents, visitors, and businesses on Mackinac Island – at the height of the tourist season (with more than 35,000 tourists on the island) and during the week of the popular Chicago to Mackinac yacht race. Somehow, the island’s businesses and visitors managed to cope, but not without significant inconvenience, additional operating costs, and some loss of revenues.

Bois Blanc Island Township also experiences frequent power outages and needs updated equipment and technology to reduce failures.

Each winter, the City of St. Ignace Department of Public Works experiences pipes freezing and breaking. A number of residents need to let their water run, which may or may not prevent the water mains from breaking. In one instance, the end of a sewer pipe that was capped off broke and, once thawed, flowed into the nearby snow bank concealing the leakage. Until it was discovered, melting snow and discharge flowed into Lake Huron causing some environmental contamination.

Frequency: Mackinac County can expect power/communication outages possibly numerous times a year usually due to severe weather conditions. Freezing ground is also expected annually.

Safety: Typically, it is the most vulnerable members of society (i.e., the elderly, children, impoverished individuals, and people in poor health) that are the most heavily impacted by an infrastructure failure. If the failure involves more than one system, or is large enough in scope and magnitude, whole communities and possibly even regions can be severely impacted. The islands of Mackinac and Bois Blanc would become vulnerable if ferry service were lost for an extended period of time. There would be no easy means to transport fuel or food supplies.

Health: When the water or wastewater treatment systems in a community are inoperable, serious public health problems arise that must be addressed immediately to prevent outbreaks of disease. When storm drainage systems fail due to damage or an overload of capacity, serious flooding can occur.

Buildings: During cold weather months, homes that rely on electric heat are more vulnerable.

Critical Facilities: Hospitals, emergency response facilities, shelters should all have back-up power capabilities.

Economic Impact: Loss of infrastructure has a great economic impact on all area businesses and people within the County.

Potential Losses: Depending on the situation, loss of infrastructure such as electric power can affect area businesses due to having to close. Citizens may experience loss of heat, which may lead to frozen pipes and damage if power outage occurs during the cold months for an extended period of time. In warmer months, an extended power outage could result in loss of food and business. Damage caused by heaving to the road system can be very costly to repair. In some cases, whole sections of the road must be re-built.

Vulnerable Areas: County-wide, City of St. Ignace, Mackinac Island, Bois Blanc Island, Clark Township, Moran Township

Sabotage/Terrorism/WMD/School Violence

In today's world, sabotage / terrorism can take on many forms, although civilian bombings, assassination and extortion are probably the methods with which we are most familiar. Internationally, such acts have become quite commonplace, as various religious, ethnic, and nationalistic groups have attempted to alter and dictate political and social agendas, seek revenge for perceived past wrongdoing, or intentionally disrupt the political, social and economic infrastructure of individual businesses, units of government, or nations. The Middle East and European continent, in particular, have been hard hit by acts of sabotage and terrorism over the past several decades.

Mackinac County relies heavily on the tourism business which brings in people from all over the world, making it vulnerable to such threats.

Public Health Emergencies

Public health emergencies can take many forms – disease epidemics, large-scale incidents of food or water contamination, 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 – to name just a few. Public health emergencies can occur as primary events by themselves, or they may be secondary events to another disaster or emergency such as a flood, tornado, or hazardous material incident. The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people.

Perhaps the greatest emerging public health threat would be the intentional release of a radiological, chemical or biological agent with the potential to adversely impact a large number of people. Such a release would most likely be an act of sabotage aimed at the government or a specific organization or segment of the population. Also becoming a threat is the pandemic flu, which may overwhelm existing resources.

Frequency: Infectious illness outbreaks: Small-scale outbreaks of infectious disease occur nearly weekly. Many are single cases that may signal the beginning of a larger outbreak and therefore, are usually investigated. Larger outbreaks involving 5 to 10 people occur several times each year and widespread illness outbreaks occur once every year or two.

Safety: The greatest emerging public health threat would be the intentional release of a radiological, chemical or biological agent with the potential to adversely impact a large number of people. Such a release would most likely be an act of sabotage aimed at the government or a specific organization or segment of the population. The spread of communicable disease or epidemics, such as the pandemic flu, is also an area for concern.

Health: Although no area in Mackinac County is immune to public health emergencies, areas with high population concentrations will always be more vulnerable to the threat. In addition, the more vulnerable members of society – the elderly, children, impoverished individuals, and people in poor health – are also more at risk than the general population.

Critical Facilities: Medical facilities, nursing homes, schools would be areas that are most vulnerable as they house a number of the most vulnerable populations – the elderly, children or those who are sick.

Economic Impact: The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people. Public health emergencies can be statewide, regional, or localized in scope and magnitude. Hospitals and medical facilities are often stretched to the limit of their resources. Depending upon the emergency, the economic impact can be devastating for area residents. When one or more of these independent, yet interrelated systems fail due to disaster or other cause – even for a short period of time – it can have devastating consequences. For example, when power is lost during periods of extreme heat or cold, people can literally die in their homes if immediate mitigation action is not taken.

Potential Losses: Depending on the extent of an emergency the potential loss could include a school having to close due to illness, disinfecting costs, extending operations to make-up time, loss of employment. Contamination of a critical facility such as the only hospital that serves the entire county as well as neighboring communities could be devastating for the area and would cause severe economic losses as well as loss of a major health care facility. Contamination of water supplies could result in communities having to boil their water or having to buy clean water as well as the cost of cleaning up and fixing the source of contamination.

Vulnerable Areas: Communities with schools, health facilities, water/sewer services including the City of St. Ignace, St. Ignace Township, Moran Township, Garfield Township, Clark Township, Portage Township, the City of Mackinac Island, and Bois Blanc Island Township.

Structural Fires

In terms of average annual loss of life and property, structural fires – often referred to as the “universal hazard” because they occur in virtually every community – are by far the biggest hazard facing most communities in Michigan and across the country.

The communities in Mackinac County rely on volunteer fire departments to respond to such fires. Mutual aid agreements are made with neighboring communities and State and federal agencies. Recognizing the need for county-wide address signage, the County is currently developing this GIS layer which will greatly assist the emergency responders in locating addresses within the County.

Because the County relies on volunteers it is very important to have affordable training opportunities as the funding for such opportunities is continuing to diminish.

Civil Disturbances

Large-scale civil disturbances rarely occur, but when they do they are usually an offshoot or result of one or more of the following events: 1) labor disputes where there is a high degree of animosity between the participating parties; 2) high profile/controversial judicial proceedings; 3) the implementation of controversial laws or other governmental actions; 4) resource shortages caused by a catastrophic event; 5) disagreements between special interest groups over a particular issue or cause; 6) a perceived unjust death or injury to a person held in high esteem or regard by a particular segment of society; or 7) a “celebration” of an important victory by a sports team.

Prison uprisings are normally the result of perceived injustice by inmates regarding facility rules, operating policies and/or living conditions, or insurrections started by rival groups or gangs within the facility.

There are no prisons located in Mackinac County. There are annual car shows, boat races and fairs that bring in a lot of people together in one place, but historically there have been no major civil disturbances in Mackinac County.

Natural Hazards

Wildfire

A wildfire is an uncontrolled fire in forested areas, grass or brushlands. The most immediate dangers from wildfires are the destruction of homes and timber, wildlife, and injury or loss of life to persons who live in the affected area or who are using the recreational facilities in the area. Long-term effects can be numerous and include scorched and barren land, soil erosion, landslide/mudflows, water sedimentation, and loss of recreational opportunities.

Forests cover the largest area in Mackinac County, covering almost three quarters of the County. The forest cover is good for both industry and recreation. However, it also makes many areas of the county potentially vulnerable to wildfires. Most Michigan wildfires occur close to where people live and recreate, which puts people, property and the environment at risk. Development in and around rural forested areas often increases the potential for loss of life and property from wildfires. (See Map 17 - Wildfire Fuel Types.)

The MDNR Forest Management Division directs and coordinates wildfire prevention, containment and suppression activities on all non-federal lands in the state, as well as Indian Reservations (under contract with the U.S. Bureau of Indian Affairs). The MDNR places great emphasis on wildfire prevention and public education, since the vast majority of wildfires in Michigan are caused by human activity. The MDNR Forest Management Division's philosophy is that preventing fires from starting in the first place, and taking precautionary measures around rural homes to stop the spread of wildfires, are the best means of avoiding or minimizing wildfire losses. When conditions of extreme fire hazard exist, the MDNR can request the Governor to issue an outdoor burning ban to mitigate the potential for wildfire in all or part of the state. Such a ban restricts smoking, fireworks, and outdoor burning activities to approved locations.

Historical Events: Information for the Department of Natural Resources show that in 2003 there were a total of 18 fires in the Sault area, which covers most of Chippewa County and parts of Mackinac County. This number was up significantly from 2001, in which only 7 fires were recorded and 8.1 acres burned. Overall, debris burning remains the leading cause of wildfires whose causes were determined.

Frequency: Records from the Department of Natural Resources indicate that State land in Mackinac County experienced 260 wildfires over a twenty year period for an average of 13 wildfires per year. The amount of land that burned was 2,731 acres or 137 acres per year. Many township volunteer fire departments may respond to calls that are not recorded by MDNR. The Hiawatha National Forest records show that one major fire occurs every ten years.

Safety: Evacuation from an area may be needed.

Health: Potential loss of life, burns and/or smoke inhalation can result from fire.

Buildings: Rural cabins, hunting shacks, seasonal homes, etc. would be most vulnerable, especially those which have fuels that feed a fire or which may not have the necessary access for responding vehicles.

Critical Facilities: Places of assembly such as campgrounds are vulnerable as many are located in rural areas. Power lines can be destroyed by heat or falling trees.

Economic Impact: Destruction of potential forestry products could mean a serious loss of income to the forestry industry. Loss of recreational property and scenic vistas could possibly bring fewer tourists to the area which would have a great economic impact on this area. Potential crop loss for area agriculture industry.

Potential Losses: Wildfires can cause potential loss of property and lives. Destruction of vegetation and contamination of soils can occur. Emergency response is necessary. There is a good probability that there will be some form of function loss such as power if lines are destroyed or transportation re-routing.

Vulnerable Areas: Remote areas of the county not easily accessible by emergency vehicles. Forested, cropland and grassland areas as well as wetland habitation can be destroyed if the area is dry enough. (See Map 4 – Land Use, page 12.) Areas of pine trees and shrub/scrubland in central and western Mackinac County are high risk areas. (See Map 17 – Wildfire Fuel Types.)

Thunderstorms

Thunderstorms are most likely to happen in the spring and summer months and during the afternoon and evening hours but can occur year-round and at all hours. The biggest threats from thunderstorms are flash flooding and lightning. In most cases, flash flooding occurs in small drainage areas where water quickly accumulates before it drains to the flood plains. When taken together, these local drainage problems can be as great a problem as overbank flooding.

Lightning, which occurs during all thunderstorms, can strike anywhere. Generated by the buildup of charged ions in a thundercloud, the discharge of a lightning bolt interacts with the best conducting object or surface on the ground. The air in the channel of a lightning strike reaches temperatures higher than 50,000°F. The rapid heating and cooling of the air near the channel causes a shock wave which produces thunder.

Other threats from thunderstorms include downburst winds, high winds, hail and tornadoes. Downburst winds are strong, concentrated, straight-line winds created by falling rain and sinking air that can reach speeds of 125 mph (200 km/h).

Hailstones are ice crystals that form within a low-pressure front due to warm air rising rapidly into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight, they fall as precipitation. The size of hailstones is a direct function of the severity and size of the storm. Significant damage does not result until the stones reach 1.5 inches in diameter, which occurs in less than half of all hailstorms.

The National Weather Service classifies a thunderstorm as severe if its winds reach or exceed 58 mph, produces a tornado, or drops surface hail at least 0.75 inch in diameter. Compared with other atmospheric hazards such as tropical cyclones and winter low pressure systems, individual thunderstorms affect relatively small geographic areas. The average

thunderstorm system is approximately 15 miles in diameter (75 square miles) and typically lasts less than 30 minutes at a single location. However, weather monitoring reports indicate that coherent thunder-storm systems can travel intact for distances in excess of 600 miles.

Historical Events: During the period January, 1984 through April, 2004 the National Weather Service recorded 24 Thunderstorms/High Wind events and 7 Hail events that affected Mackinac County. (See Map 18 - Thunderstorm/High Wind Map, Map 19 - Historic Hail Storm Map.)

On October 21, 1993 a thunderstorm passed through the region spanning several counties including all of the Eastern Upper Peninsula as well as some Northern Lower Michigan Counties. This storm produced sustained winds of 25-40 mph with gusts up to 75 mph around the county, and as a result many trees and power lines went down.

On July 13, 1995 a thunderstorm passed through the county, with measured wind gusts of 67 mph reported by the Curtis area. Numerous trees went down in and around Curtis. Traveling eastward, the storm hit Engadine about 15 minutes later, which also reported numerous tree downs. Twenty minutes later, the storm, still traveling eastward, hit Epoufette which reported gusts of up to 60 mph with big trees down. Brevort Lake was the next hardest hit with reports of over 100 trees in Brevort Lake Campground that fell over tents and campers. As the storm traveled still further east a trailer was blown over on the Mackinac Bridge. This storm caused \$55,000 in property damage. The next night, July 14, 1995 wind gusts of 90 mph were measured on the Mackinac Bridge. The sustained winds of 85-88 mph lasted for about 10 minutes. Lightning damaged the main bridge power generator with property damage loss of \$1,000.

One of the strongest storms ever recorded in the Great Lakes crossed the region on November 10th and 11th, 1998. The storm originated over the Central Plains and lifted across the western portions of Lake Superior. South to southeast winds increased steadily during the morning of the 10th and by late morning, wind gusts of 40 to 50 mph were common over areas away from Lake Huron. Along the Lake Huron shoreline, winds were gusting to 60 to 70 mph with a peak gust of 95 mph reported on Mackinac Island. The wind shifted to the southwest during the afternoon, with the strongest winds generally developing along the Lake Michigan shoreline. During the afternoon and evening of the 10th, wind gusts of 70 to 80 mph were common along the Lake Michigan shoreline, with 50 to 60 mph gusts across the rest of the region. Similar winds persisted into the morning of the 11th and then began to diminish during the afternoon. A large number of trees were uprooted or snapped off, with many branches also torn off. Many of the trees and branches fell on power lines, resulting in widespread power outages regionwide. Falling trees also blocked many roads and several accidents were reported as cars collided with debris on the roadways. Several homes and cars received damage from falling trees and branches. The strong winds generated 15 to 20 foot waves on Lake Michigan. Most ships took shelter with the approach of the storm and rode out the storm in protected waters. The strong winds on Mackinac Island toppled several trees onto a condominium.

A strong cold front, associated with a storm system moving across southern Canada, moved across the northern Great Lakes from the evening of the 25th of December, 1999 to the

early morning hours on the 26th. Strong winds behind this cold front affected the entire Great Lakes region. The strongest wind speeds were felt in Emmet and Mackinac counties along the Lake Michigan shoreline. Sustained winds during this time period were at 30 to 40 MPH, with occasional gusts to 50 MPH. Wind speeds up to 62 MPH were recorded in the straits of Mackinac.

A line of thunderstorms moved across eastern Upper and far northern Lower Michigan during the early afternoon hours of the 8th of August, 2001. These storms produced numerous reports of severe hail. Winds from these storms also downed numerous trees.

Four waves of severe thunderstorms impacted northern Michigan during the morning, afternoon, and evening hours on the 1st of August, 2002. 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. Damage to patrol car was reported in Moran.

Frequency: Thunderstorms occur on about 29 days each year, and most occur during the summer season. There is over 100 percent chance that the County will receive a thunderstorm in any given year.

Safety: The threat to life varies by the cause of death. Toppling trees, debris in roadways can cause potential accidents. Downed power lines and lightning are potential killers.

Health: No special health problems are attributable to thunderstorms, other than the potential for tetanus and other diseases that arise from injuries and damaged property.

When lightning strikes a human being, serious burns or death are the common outcomes. For every person killed by lightning, three people are injured. For those who survive their injuries can lead to permanent disabilities. Seventy percent of the survivors suffer serious long-term effects, such as memory loss, sleep disorders, depression, and fatigue.

Buildings: As with tornadoes, mobile homes/recreational vehicles are at a high risk of damage from thunderstorms. Wind and water damage can result when windows are broken by flying debris or hail. Lightning can cause direct damage to structures (especially those without lightning protection systems) and can cause fires that damage forests and structures.

Hail can inflict severe damage to roofs, windows and siding, depending on hailstone size and winds.

Critical Facilities: Critical facilities are susceptible to the same damage and disruption from thunderstorms as other buildings. Emergency operations can be disrupted as thunderstorms and lightning affect radio communications, and antennas and navigational markers are a prime target for lightning.

Economic Impact: Thunderstorms, flash flooding, wind and hail can all (or each) destroy crops in the field. Long stemmed vegetation, such as corn and wheat, is particularly vulnerable to hail.

Winds greater than 39 miles per hour can damage crops during the growing season. Lightning is one of the major causes of forest fires. Fortunately, these impacts are relatively localized.

Thunderstorms can impact transportation and utilities. Airplanes have crashed when hit by downbursts or lightning. Automobiles and their windshields are subject to damage by hail.

Power lines can be knocked out by lightning or knocked down by wind and debris. Lightning can also cause power surges that damage appliances, electronic equipment and computers.

Potential Losses: Power outages, power surges, damages from wind and hail could create potential loss of function and property damage. Emergency response may be required and there is a potential for casualties.

Vulnerable Areas: The whole county can be affected by the weather. Heavily wooded areas, communication towers, power facilities are more vulnerable to damage.

Tornadoes

A tornado is a swirling column of air extending from a thunderstorm to the ground. Tornadoes can have wind speeds from 40 mph to over 300 mph. A majority of tornadoes have wind speeds of 112 mph or less. Tornadoes in Michigan are most frequent in the spring and early summer when warm, moist air from the Gulf of Mexico collides with cold air from the polar regions to generate severe thunderstorms.

Debris hurled by the wind can hit with enough force to penetrate walls. Window, chimneys and roofs are the most vulnerable parts of building to tornado damage.

Tornadoes can move forward at up to 70 mph, pause, slow down and change directions. Most have a narrow path, less than 100 yards wide and a couple of miles long. However, damage paths can be more than 1 mile wide and 50 miles long.

The northern Michigan tornado season runs from March into October with the most active period occurring during June and July. The most active time of the day for tornadoes is during the late afternoon and early evening.

The Fujita Scale of Tornado Intensity

F-Scale Number	Intensity Descriptor	Wind Speed (mph)	Type/Intensity of Damage
F0	Gale tornado	40-72	Light damage. Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	Moderate tornado	73-112	Moderate damage. The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	Significant tornado	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.

F-Scale Number	Intensity Descriptor	Wind Speed (mph)	Type/Intensity of Damage
F3	Severe tornado	158-206	Severe damage. Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.
F4	Devastating tornado	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible tornado	261-318	Incredible damage. Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged; incredible phenomena will occur.
F6	Inconceivable tornado	319-379	These winds are very unlikely. The area of damage they might produce would be unrecognizable.

NOTE: When describing tornadoes, meteorologists often classify the storms as follows:
 F0 and F1 - weak tornado; F2 and F3 - strong tornado; F4 and F5 - violent tornado

(Source: The Tornado Project; Storm Data, National Climatic Data Center)

Historical Events: According to the National Weather Service, during the time frame of 1950-2004 Mackinac County has experienced three tornadoes. Of these three, two tornados were rated an F1 and one reached an F2 level.

On July 14, 1984 a F2 tornado touched down causing \$25,000 in property damage. With the other tornados, one occurring August 16, 1988 and one on July 13, 1995 there was no damage reported.

Frequency: Given the historical information it is expected that there is a 5.6 percent chance that Mackinac County can expect a tornado to occur in a given year.

Safety: People and property and animals are at high risk from structure collapse, flying debris, trees blowing down.

Health: The major health hazard from tornadoes is physical injury from flying debris or being in a collapsed building or mobile home. Based on national statistics for 1970-1980, for every person killed by a tornado, 25 people were injured and 1,000 people received some sort of emergency care.

Within a building, flying debris or missiles are generally stopped by interior walls. However, if a building has no partitions, any glass, brick or other debris blown into the interior is life threatening. Following a tornado, damaged buildings are a potential health hazard due to instability, electrical system damage, and gas leaks. Sewage and water lines may also be damaged.

Building Damage: Although tornadoes strike at random, making all buildings vulnerable, three types of structures are more likely to suffer damages:

1. Mobile Homes
2. Homes on crawlspaces (more susceptible to lift), and
3. Buildings with large spans, such as airplane hangers, gymnasiums and factories.

Structures within the direct path of a tornado vortex are often reduced to rubble. However, structures adjacent to the tornadoes path are often severely damaged by high winds flowing into the tornado vortex, known as inflow winds.

Critical Facilities: Because a tornado can hit anywhere in the County, all critical facilities are susceptible to being hit. Schools are a particular concern, though for two reasons:

1. They have a large number of people present, either during school or as a storm shelter, and
2. They have large span areas, such as gyms and theaters.

Economic Impact: The major impact of a tornado on the local economy is damage to businesses and infrastructure. A heavily damaged business, especially one that was barely making a profit, often has to be closed.

Infrastructure damage is usually limited to above ground utilities, such as power lines. Damage to utility lines can usually be repaired or replaced relatively quickly.

Damage to roads and railroads is also localized. If it can't be repaired promptly, alternate transportation routes are usually available, although emergency access may be impeded.

Public expenditures include search and rescue, shelters, and emergency protection measures. The large expenses are for repairs to public facilities and clean up and disposal of debris. Most public facilities are insured, so the economic impact on the local treasury may well be small.

Potential Losses: Property damage and loss of function are potential losses as well as emergency response and casualties.

Vulnerable Areas: The entire County is at risk, but mobile homes within the County, campgrounds, and denser populated areas are more vulnerable especially along the shoreline areas which have no protection from the wind. Older homes, trailers and recreational rv's may not be able to withstand the high wind associated with tornadoes.

Severe Winter Weather

There are many ways for winter storms to form, but certain key ingredients are needed. First temperatures must be below freezing in the clouds and near the ground. There must be a source of moisture in the form of evaporating water. Then lift in the atmosphere causes the moisture to rise and form clouds of precipitation.

Winter storms in the Midwest are caused by Canadian and Arctic cold fronts that push snow and ice deep into the interior region of the United States. Our area is also subject to lake effect snowstorms that develop from the passage of cold air over the relatively warm surface of Lake Michigan and Lake Huron which can cause heavy snowfall and blizzard conditions.

Winter storms can occur as heavy snowfalls, ice storms or extreme cold temperatures. Winter storms can occur as a single event or they can occur in combination, which can make an event more severe. For example, a moderate snowfall could create severe conditions if it were followed by freezing rain and subsequent extremely cold temperatures. The aftermath of a winter storm can impact a community or region for weeks, and even months.

Snow: Heavy snowfalls can range from large accumulations of snow over many hours to blizzard conditions with blowing snow that could last several days. The National Weather Service’s snow classification is in the table below.

Snow Classifications	
Blizzard	Winds of 35 miles per hour or more with snow and blowing snow reducing visibility to less than ¼ mile for at least 3 hours.
Blowing Snow	Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.
Snow Squalls	Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant.
Snow Showers	Snow falling at varying intensities for brief periods of time. Some accumulation possible.
Snow Flurries	Light snow falling for short duration with little or no accumulation.
<i>Source: National Weather Service</i>	

Winters and summers are later than those in other northern inland areas due to the temperatures of the surrounding large bodies of water. The climate is not as harsh as other, more inland areas of the Midwest.

Weather changes are frequent because many pressure systems pass eastward through this section of the United States and Canada. Winter snows are most often associated with northwest winds.

The average seasonal snowfall is about 112.6 inches. The greatest snow depth at any one time during the period of record was 43 inches. On the average, 125 days of the year have at least 1 inch of snow on the ground. The number of such days varies greatly from year to year. The table below depicts the average snowfall during each month:

Snowfall Threshold Climatology Derived from 1973-2000 Averages *Annual/seasonal totals may differ from the sum of the monthly totals due to rounding. St. Ignace Mackinac Bridge				
Month	# Days Total ≥ 0.1"	# Days Total ≥ 1.0"	# Days Total ≥ 2.0"	# Days Total ≥ 5.0"
JAN	9.2	6.4	4.2	1.2
FEB	4.7	3.2	2.2	0.4
MAR	3.1	2	1.3	0.3
APR	1.3	0.9	0.5	0.1

Snowfall Threshold Climatology cont.				
Derived from 1973-2000 Averages				
*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.				
St. Ignace Mackinac Bridge				
Month	# Days Total ≥ 0.1 "	# Days Total ≥ 1.0 "	# Days Total ≥ 2.0 "	# Days Total ≥ 5.0 "
MAY	0	0	0	0
JUN	0	0	0	0
JUL	0	0	0	0
AUG	0	0	0	0
SEP	0	0	0	0
OCT	0	0	0	0
NOV	1.9	1.5	0.8	0.2
DEC	7.2	5	3.1	0.9
Annual	22.1	15.2	9.8	2.5

Ice Storms: An ice storm occurs when freezing rain falls from clouds and freezes immediately upon impact. Freezing rain is found in between sleet and rain. It occurs when the precipitation falls into a large layer of warm air and then does not have time to refreeze in a cold layer (near or below 32°F) before it comes in contact with the surface which is also near or below 32°F.

Historical Events: Mackinac County has experienced 42 Snow and Ice Events according to the National Weather Service in the period between January, 1950 and April, 2004. Of the 42 events 27 were categorized as heavy snow, nine as winter storms, two as freezing rain, two ice storms, one lake-effect snow, and one combination of heavy snow and freezing rain.

Following are some descriptions of historical events. The entire County is affected by these types of storms.

In January, 1993 snow began across central Lower Michigan late in the evening of the 12th and quickly spread north across northern Lower Michigan during the early morning hours of the Wednesday the 13th. The combination of heavy snow, northeast winds of 15 to 25 mph and temperatures in the lower to mid 20s created near blizzard conditions at times most of Wednesday. The snow tapered to flurries by early evening hours of Wednesday with total snowfall ranging from six to twelve inches.

In March, 1994 a storm system moved northeast across central Lower Michigan during the morning of the 21st, causing a combination of snow, sleet, and freezing rain over the northern third of Lower Michigan and Eastern Upper Michigan. Over eastern Upper Michigan, about 0.2 to 0.3 inches of ice accumulated on two to three inches of snow. Surprisingly few accidents were reported with this event.

A southwest flow lake effect snow event began during the early morning hours of December 18th, 1996 and continued into the morning of the 19th. A persistent snow band

developed across Lake Michigan. The onshore flow produced 18 to 24 inches of snow in a zone between Naubinway and Brevort.

Low pressure moved east across northern Lake Superior, pushing a cold front into and through the northern Great Lakes on the night of the 21st in January, 2004. Out ahead of the front, widespread snow fell, which was enhanced by southwest winds off of Lake Michigan. This contributed to heavy snow over Eastern Upper Michigan during the day on the 21st. Winds gusted up to 40 mph, producing substantial blowing and drifting snow, and at times zero visibility. US-2 was closed west of St Ignace due to the snowy and windy conditions. After the cold front went through, winds turned northwest and ushered in a more classic lake effect snow event.

Heavy snow fell on Eastern Upper Michigan, mainly west of I-75, from the night of the 12th in March, 2004 into the morning of the 13th. Accumulations of eight to ten inches were common from Paradise to Rexton.

Frequency: There is a 78 percent chance that Mackinac County will get a severe winter weather event in a given year. The County can expect 2.5 days each year that snowfall will be greater than 5 inches. The majority of these times the entire County will be affected.

Safety: Loss of power is a major concern during the winter months for those who rely on electric for heat. Driving conditions are also a major concern during winter storms.

Health: People and animals are vulnerable when winter shows its fury.

Buildings: Snow and ice accumulation upon roofs make all buildings vulnerable to damage. Some, with flat roofs, wide spans, insufficient slopes, or ice dam susceptibility may be more vulnerable than others.

Critical Facilities: Critical facilities are susceptible to the same damage from winter storms as other buildings. Emergency operations can be disrupted as travel may become extremely difficult or impossible.

Economic Impact: Winter storms can shut down entire communities which would result in the economic loss of many businesses. Snow removal costs are increased which increases the burden on the County Road Commission.

Potential Losses: Potential losses from severe winter weather could include structure collapses, increased cost in snow removal, increased potential for transportation accidents, increased potential for infrastructure failures, and possibly severely limiting emergency response time and ability.

Vulnerable Areas: The whole County would be vulnerable during severe winter weather. Areas along the southern shoreline typically get hit hard with a south wind.

Extreme Temperatures

Prolonged periods of extreme temperatures, whether extreme summer heat or extreme winter cold, can pose severe and often life-threatening problems for Michigan's citizens. Although they are radically different in terms of initiating conditions, the two hazards share a commonality in that they both primarily affect the most vulnerable segments of the population – the elderly, children, impoverished individuals, and people in poor health. Due to their unique characteristics, extreme summer heat and extreme winter cold hazards will be discussed individually.

Extreme Summer Heat

Extreme summer weather is characterized by a combination of very high temperatures and exceptionally humid conditions. When persisting over a long period of time, this phenomenon is commonly called a heat wave.

Because the combined effects of high temperatures and high humidity are more intense in urban centers, heatstroke and heat exhaustion are a greater problem in cities than in suburban or rural areas. Nationwide, approximately 200 deaths a year are directly attributable to extreme heat. Extreme summer heat is also hazardous to livestock and agricultural crops, and it can cause water shortages, exacerbate fire hazards, and prompt excessive demands for energy. Roads, bridges, railroad tracks and other infrastructure are susceptible to damage from extreme heat.

Air conditioning is probably the most effective measure for mitigating the effects of extreme summer heat on people. Unfortunately, many of those most vulnerable to this hazard do not live or work in air-conditioned environments, especially in major urban centers where the vulnerability is highest. The use of fans to move air may help some, but recent research indicates that increased air movement may actually exacerbate heat stress in many individuals.

Extreme Winter Cold

Like heat waves, periods of prolonged, unusually cold weather can result in a significant number of temperature-related deaths. Each year in the United States, approximately 700 people die as a result of severe cold temperature-related causes. This is substantially higher than the average of 200 heat-related deaths each year. It should be noted that a significant number of cold-related deaths are not the direct result of “freezing” conditions. Rather, many deaths are the result of illnesses and diseases that are negatively impacted by severe cold weather, such as stroke, heart disease and pneumonia. It could convincingly be argued that, were it not for the extreme cold temperatures, death in many cases would not have occurred at the time it did from the illness or disease alone.

Historical Events:

Excessive Heat was a problem the first two weeks in August, 2001 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 some counties. Attendance at county fairs was well below normal and this was attributed to the heat.

Frequency: The annual average temperature ranges from 41 degrees to 43 degrees F. The average winter temperature is 17.3 degrees F and the average daily minimum temperature is 9.4 degrees. The lowest temperature on record, which occurred on January 26, 1927, is -30 degrees. In summer, the average temperature is 62.2 degrees and the average daily maximum temperature is 73.7 degrees. The highest recorded temperature occurred on July 13, 1936, is 103 degrees. The tables below shows the average number of days that the temperatures were above 90 F or below freezing level over a period of 27 years and the temperature extremes for that time period.

Temperature Threshold Climatology Derived from 1973-2000 Averages *Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.				
St. Ignace Mackinac Bridge				
Month	# Days Total \geq 90 F	# Days Max \leq 32 F	# Days Min \leq 32 F	# Days Min \leq 0 F
JAN	0	23.3	30.7	5.3
FEB	0	19	27.5	5.8
MAR	0	10.3	28.6	1.8
APR	0	0.8	16.6	0
SEP	0	0	0.2	0
OCT	0	0	5.5	0
NOV	0	4.3	17.9	0
DEC	0	15.9	28.5	1

Temperature Extremes Period of Record: 1973-2001 St. Ignace Mackinac Bridge				
Month	1-Day Max Degrees F	Date	1-Day Min Degrees F	Date
JAN	48	1/11/1975	-27	1/4/19
FEB	54	2/27/2000	-29	2/16/1987
MAR	65	3/14/1995	-15	3/1/1980
APR	80	4/25/1990	1	4/7/1979
MAY	84	5/28/1987	15	5/11/1981
JUN	88	6/15/1976	29	6/5/1983
JUL	90	7/26/1999	39	7/6/1983
AUG	93	8/4/1985	38	8/30/1976
SEP	89	9/5/1999	26	9/28/1981
OCT	77	10/1/1995	20	10/19/1974
NOV	65	11/1/1999	6	11/30/1986
DEC	60	12/6/2001	-16	12/11/1977
Annual	93	8/4/1985	-29	2/16/1987

Health: The major threats of extreme summer heat are heatstroke (a major medical emergency), and heat exhaustion. **Heatstroke** often results in high body temperatures, and the victim may be delirious, stuporous, or comatose. Rapid cooling is essential to preventing permanent neurological damage or death. **Heat exhaustion** is a less severe condition than heatstroke, although it can still cause severe problems such as dizziness, weakness and fatigue. Heat exhaustion is often the result of fluid imbalance due to increased perspiration in response to the intense heat. Treatment generally consists of restoring fluids and staying indoors in a cooler environment until the body returns to normal. Other, less serious risks associated with extreme summer heat are often exercise-related and include heat syncope (a loss of consciousness by persons not acclimated to hot weather), and heat cramps (an imbalance of fluids that occurs when people unaccustomed to heat exercise outdoors).

Hypothermia (the unintentional lowering of core body temperature), and **frostbite** (damage from tissue being frozen) are probably the two conditions most closely associated with cold temperature-related injury and death. Hypothermia is usually the result of over-exposure to the cold, and is generally thought to be clinically significant when core body temperature reaches 95 degrees or less. As body temperature drops, the victim may slip in and out of consciousness, and appear confused or disoriented. Treatment normally involves re-warming the victim, although there is some controversy in the medical community as to exactly how that should be done. Frostbite rarely results in death, but in extreme cases it can result in amputation of the affected body tissue.

Hypothermia usually occurs in one of two sets of circumstances. One situation involves hypothermia associated with prolonged exposure to cold while participating in outdoor sports such as skiing, hiking or camping. Most victims of this form of hypothermia tend to be young, generally healthy individuals who may lack experience in dealing with extreme cold temperatures. The second situation involves a particularly vulnerable person who is subjected to only a moderate, indoor cold stress. A common example would be that of an elderly person living in an inadequately heated home. In such circumstances, hypothermia may not occur until days or perhaps weeks after the cold stress begins.

The special vulnerability of elderly persons to hypothermia has become readily apparent. Over half of the approximately 700 persons who die each year due to cold exposure are 60 years of age or older, even though this age group only represents about 20% of the country's population. This remarkable statistic may be due, in part, to the fact that elderly persons appear to perceive cold less well than younger persons and may voluntarily set thermostats to relatively low temperatures. In addition, high energy costs and the relative poverty among some elderly people may discourage their setting thermostats high enough to maintain adequate warmth. Because many elderly people live alone and do not have regular visitors, the cold conditions may persist for several days or weeks, thus allowing hypothermia to set in.

Babies and very young children are also very vulnerable to hypothermia. In addition, statistics indicate that death due to cold is more frequent among males than females in virtually all age groups. Part of that may be explained by differences in risk factors, and part may be due to different rates of cold exposure between the sexes.

Potential Losses: Loss of heat in extreme cold can lead to frozen pipes and loss of infrastructure. Prolonged periods of extreme heat can cause loss of crops and potential livestock loss, drought and greater potential for wildfires. Function loss from heaving ground can also occur along the transportation network. The potential for casualties and emergency response will also factor into potential losses.

Vulnerable Areas: The entire county would be susceptible to extreme temperatures. Shoreline areas may experience a greater temperature difference than inland areas. Nursing homes, senior citizens complexes, and hospitals would have concentrations of population that would be more vulnerable.

Flooding

Floods are the most common and widespread of all natural disasters--except fire. Most communities in the United States have experienced some kind of flooding, after spring rains, heavy thunderstorms, or winter snow thaws.

A flood, as defined by the National Flood Insurance Program is: "A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties (at least one of which is your property) from:

- Overflow of inland or tidal waters,
- Unusual and rapid accumulation or runoff of surface waters from any source, or
- A mudflow.

[The] collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood."

The following terminology is used when describing floods:

The term **Minor Flooding** is used to indicate minimal or no property damage. However, some public inconvenience is possible.

The term **Moderate Flooding** is used to indicate the inundation of secondary roads. Transfer to higher elevation may be necessary to save property. Some evacuation may be required.

Riverine Flooding: The most common and most damaging floods occur along rivers and streams and this is called overbank flooding. Overbank flooding of rivers and streams can be caused by one or more of three factors:

1. Too much precipitation in the watershed for the channels to convey.
2. Obstructions in a channel, such as an ice jam or beaver dam, and
3. Large release of water when a dam or other obstruction fails.

All three of these factors are reviewed in this section, but most floods are caused by the first, too much precipitation in the watershed.

Flooding can also occur in streets when rainwater cannot flow into a storm sewer. Basements can flood when rainwater cannot flow away from the house or when the sewers back up. These problems are usually caused by heavy local rains and are often not related to overbank flooding or floodplain locations.

Shoreline Flooding

Flooding and erosion of shoreline areas caused by high Great Lakes water levels, storm surges, or winds is known as shoreline flooding.

Mackinac County has over 100 miles of shoreline (including islands) on Lakes Michigan and Huron and the Straits of Mackinac. Great Lakes water level information is shown in the following table:

Lakes Michigan-Huron												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean	578.54	578.48	578.54	578.81	579.13	579.33	579.43	579.36	579.20	579.00	578.81	578.64
Max	581.30 1987	581.07 1986	581.10 1986	581.46 1986	581.63 1986	581.79 1986	581.99 1986	581.99 1986	581.96 1986	582.35 1986	581.96 1986	581.56 1986
Min	576.12 1965	576.08 1964	576.05 1964	576.15 1964	576.57 1964	576.64 1964	576.71 1964	576.67 1964	576.64 1964	576.44 1964	576.28 1964	576.18 1964
Chart Datum 577.5 feet						International Great Lakes Datum of 1985						

Chart Datum, also known as Low Water Datum, is a reference plane on each lake to which water depths on navigation charts are referred. The International Great Lakes Datum of 1985 has its zero base at Rimouski, Quebec near the mouth of the St. Lawrence River (approximate sea level).

Lake Huron at Detour Village, MI Possible Storm Induced Rises (in feet)

	Probability of Exceedance				
	20%	10%	3%	2%	1%
January	0.70	0.70	0.80	0.80	0.90
February	0.50	0.60	0.70	0.70	0.80
March	0.50	0.60	0.70	0.80	0.90
April	0.60	0.60	0.70	0.80	0.90
May	0.40	0.50	0.50	0.50	0.60
June	0.40	0.50	0.60	0.60	0.60
July	0.40	0.40	0.50	0.60	0.60

NOTE:
The rises shown here, should they occur, would be in addition to still water levels indicated on the Monthly Bulletin. Values of wave runup are not provided in this table.

Lake Huron at Detour Village, MI Possible Storm Induced Rises (in feet) Probability of Exceedance					
August	0.40	0.40	0.50	0.50	0.50
September	0.50	0.50	0.60	0.60	0.60
October	0.60	0.70	0.80	0.80	0.90
November	0.70	0.70	0.80	0.90	0.90
December	0.70	0.70	0.80	0.80	0.90

NOTICE: All data contained herein is preliminary in nature and therefore subject to change. The data is for general information purposes ONLY and SHALL NOT be used in technical applications such as, but not limited to, studies or designs. All critical data should be obtained from and verified by the United States Army Corps of Engineers, Detroit District, Engineering and Technical Services, Great Lakes Hydraulics and Hydrology Office, 477 Michigan Ave., Detroit, MI 48226. The United States of America assumes no liability for the completeness or accuracy of the data contained herein and any use of such data inconsistent with this disclaimer shall be solely at the risk of the user.

Precipitation: The total annual precipitation is 32.36 inches. Of this, 18.18 inches, or about 56 percent, usually falls in April through September. The growing season for most crops falls within this period. The heaviest 1-day rainfall on record was 4.10 inches on September 1, 1937.

Precipitation Threshold Climatology Derived from 1973-2000 Averages St. Ignace Mackinac Bridge				
*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.				
Month	# Days Total ≥ 0.01 "	# Days Total ≥ 0.10 "	# Days Total ≥ 0.50 "	# Days Total ≥ 1.00 "
JAN	11.7	4.7	0.7	0
FEB	8	3.2	0.3	0
MAR	7.4	3.9	1	0.1
APR	8.5	5.2	1.1	0.2
MAY	8.4	5.8	1.8	0.4
JUN	8.6	5.5	1.7	0.5
JUL	7.6	5.2	1.8	0.7
AUG	8.2	5	1.8	0.6
SEP	11.5	7.3	2.1	0.4
OCT	11.7	7.3	2	0.3
NOV	10.8	7	1.4	0.3
DEC	10.4	4.6	0.7	0.1
Annual	112.6	64.8	16.5	3.9
Winter	30.2	12.6	1.7	0.2
Spring	24.3	14.9	3.9	0.8
Summer	24.4	15.7	5.4	1.9
Fall	34.1	21.6	5.4	1

Precipitation Extremes						
Period of Record: 1973-2000						
St. Ignace Mackinac Bridge						
Month	High (in)	Year	Low (in)	Year	1-Day Max (in)	Date
JAN	2.37	1987	0	2001	1.07	1/20/1974
FEB	2.62	1985	0.02	1998	1	2/24/1977
MAR	4.91	1977	0	2001	3.05	3/26/1996
APR	4.37	1981	0.38	1998	1.75	4/9/1980
MAY	4.85	1983	0.45	1992	1.6	5/25/1989
JUN	5	1990	0.4	1988	2.35	6/7/1987
JUL	6.7	1977	0	2001	3	7/3/1977
AUG	7.76	1975	0.28	1991	2.82	8/9/2001
SEP	7.9	1986	0.73	1989	1.56	9/14/1993
OCT	5.15	2001	0.54	2000	1.68	10/14/2001
NOV	6.26	1988	0.55	1999	2.26	11/5/1988
DEC	3.67	1996	0	1994	1.3	12/28/1984
Annual	38.33	1985	17.38	1900	3.05	3/26/1996
Winter	6.78	1997	1.19	1998	1.3	12/28/1984
Spring	8.92	1979	1.96	1999	3.05	3/26/1996
Summer	14.04	1975	3.84	1983	3	7/3/1977
Fall	13.35	1985	3.53	1976	2.26	11/5/1988

Watersheds:

The county has more than 24,000 acres of lakes and ponds. These bodies of water range in size from 5 to 7,000 acres. Manistique lake is the largest in the county, at 7,000 acres. Other lakes in the county are Brevort Lake, 4230 acres; Millecoquins Lake, 1,000 acres; South Manistique Lake, 4,000 acres; Milakokia Lake, 1,956 acres; and East Lake, 995 acres.

The major rivers are the Black, Brevort, Carp, Hendrie, Milakokia, Millecoquins, Munuscong, and Pine Rivers. The Carp and Pine Rivers flow into Lake Huron on the eastern side of the county. The Hendrie River in the north-central part of the county flows north into the Tahquamenon River. The other rivers flow into Lake Michigan on the western side of the county. Most of the riverbeds are silts or sands and have a few rocky rapids. The Pine and Carp Rivers have clay or silt bottoms (Davis and Frey, 1984). (See Map 20 - Watershed Basins and Map 21 - Major Lakes and Rivers)

A watershed (drainage basin) of a river comprises all the land that contributes to a river's flow. Large river basins are an aggregate of many smaller watersheds. A basin collects precipitation, which it stores and later transports to lakes, streams, or underground. During the storage and transportation process the water is purified by sunlight, aeration, or filtration. This water is available when needed by the basin's inhabitants, such as man, animals, and plants.

Therefore, a drainage basin functions as a municipal water system in collecting water.

The topography, or surface features of the land, governs the direction and speed of surface water flow, and consequently, the size and shape of watersheds. Usually, a watershed's outer edges form a "ridge" that prevents the flow of surface water from one watershed to another. However because this area is virtually flat, there is some flow of water between watersheds. The major river basins draining Mackinac County are the Carp River Basin, Waishkey River Basin, Pine River Basin. These basins are located in Chippewa and central part of Mackinac Counties. Water quality in these basins is generally excellent with no known sources of waste.

There are many short, minor river basins located along the coastline of the Upper Peninsula, which cover small areas and discharge to Lake Superior, Lake Michigan, Lake Huron or the St. Mary's River. Practically the whole southern portion of Mackinac County is included in these many small basins. There are no known sources of pollution. Water quality in these basins depends on natural factors because most of the areas are wilderness or very sparsely populated with-out any population centers or industries. Agricultural runoff (phosphates and nitrogen, principally, from farm fertilizers) in these areas would be minor.

Flash Floods: Flash floods are generated by severe storms that drop much rainfall in a short time, dam failures or possibly even ice jams. All flash floods strike quickly. Areas with steep slopes and narrow stream valleys are particularly vulnerable to flash flooding, as are the banks of small tributary streams. In hilly areas, the high-velocity flows and short warning time make flash floods hazardous and very destructive.

Obstructions: Obstructions can be channel obstructions, such as small bridge openings or log jams, or floodplain obstructions, such as road embankments, fill and buildings. Channel obstructions will cause more frequent floods, while floodplain obstructions impact the larger, less frequent floods where most of the flow is overbank, outside the channel.

Obstructions can be natural or man made. Natural obstructions, like log jams, can be cleared out or are washed away during larger floods. The great problem is man made obstructions, which tend to be more permanent.

Ice Jams: Ice jams occur when warm weather and rain break up frozen rivers or any time there is a rapid cycle of freezing and thawing. The broken ice floats downriver until it is blocked by an obstruction such as a bridge or shallow area. An ice dam forms, blocking the channel and causing flooding upstream. Ice jams present three hazards:

1. Sudden flooding of areas upstream from the jam, often on clear days with little or no warning,
2. Sudden flooding of areas downstream when an ice jam breaks. The impact is similar to a dam break, damaging or destroying buildings and structures.
3. Movement of ice chunks that can push over trees and crush buildings.

Dam Failures: Dams are made to hold back large amounts of water. If they fail or are overtopped, they can produce a dangerous flood situation because of the high velocities and large volumes of water released. A break in a dam can occur with little or no warning on clear days when people are not expecting rain, much less a flood. Breaching often occurs within hours after the first visible signs of dam failure, leaving little time for evacuation.

Dam failures are usually caused by either structural problems with the dam or by hydrologic problems. Structural problems include seepage, erosion, cracking, sliding and overturning that are a result of the age of the dam or lack of maintenance. Hydrologic problems typically occur when there is excessive runoff due to heavy precipitation. A dam failure can occur if the dam has to impound (hold back) more water than it is designed to, or if the spillway capacity is inadequate for the amount of water needing to pass downstream.

The series of tragic dam failures that occurred across the United States in the 1970s prompted government action to more stringently regulate dams, and heightened public concern about hazards created by unsafe dams. Both the Michigan Department of Environmental Quality (MDEQ) and the Federal Energy Regulatory Commission (FERC) classify and regulate dams in Michigan. This statute requires the MDEQ to rate each dam as either "high", "significant", or "low" hazard potential, according to the potential downstream impact if the dam were to fail (not according to the physical condition of the dam). The MDEQ has identified and rated over 2,400 dams in Michigan. Dams over 6 feet in height that create an impoundment with a surface area of more than 5 acres are regulated by this statute. Mackinac County has six dams five of which have been rated a low hazard, one a significant hazard. (See Map 14 – Critical Facilities Dams and Bridges.)

Transportation: Loss of road access is a major flood impact that affects all residents and businesses, not just those who own property in the floodplain. Sometimes the loss is temporary, such as during the flood.

Sometimes the loss of transportation lasts well after the disaster. When roads, bridges or railroads are washed out by a flood, it can be weeks or months before they are repaired and reusable.

Historical Events:

In 1993 three flooding events were recorded in January, March and April. Mackinac Co. was part of the affected counties although Lower Michigan counties were the most affected.

On July 31, 1999 a few inches of standing water developed on local streets in Engadine. A bow echo moved east across much of eastern upper and northern lower Michigan ahead of a cold front moving over the upper Midwest. Numerous reports of straight line wind damage were associated with the bow. Storms with heavy rain ahead of the bow caused some flooding across Mackinac County.

In April, 2001 a combination of runoff from snowmelt and rainfall resulted in minor flooding primarily along the Pine River in the Upper Peninsula.

Garfield Township has experienced flooding in Mill Pond Park when water levels were high. Some walkways and sitting structures were exposed to the increased water level. Increased development along lake shorelines also can be exposed to flooding situations when water levels are high.

Bois Blanc Island Township has experienced flooding problems when lake levels are high which has caused erosion and problems with septic systems.

All townships, with the exception of Portage Township, have Great Lake shorelines which, during times of high water tables, is exposed to flooding and erosion. Portage Township has inland lakes which are extensively developed and is also exposed to flooding during times of high water levels.

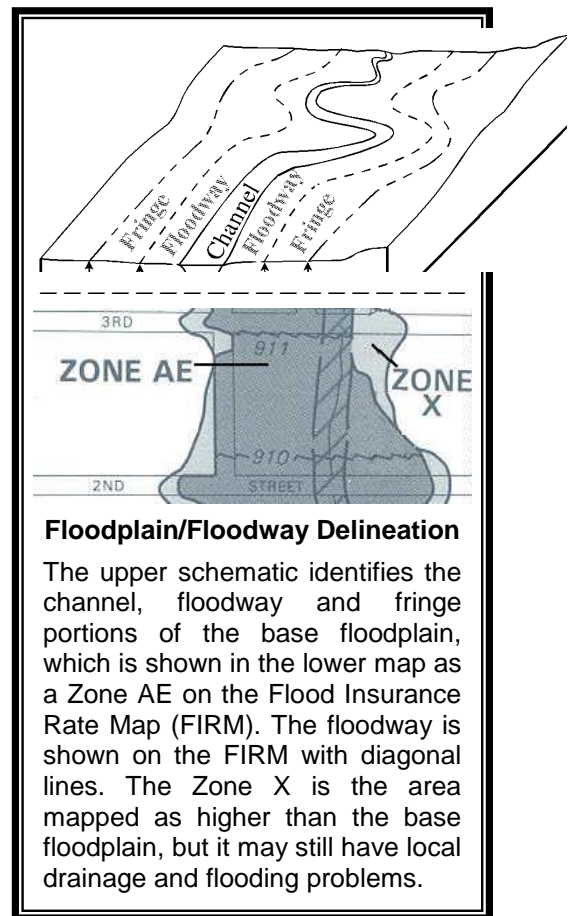
Future Flood Risk: Past floods are indications of what can happen in the future, but flood studies and mitigation plans are based on the *risk* of future flooding. Flood studies extrapolate from historical records to determine the statistical potential that storms and floods of certain magnitude will recur. Such events are measured by their “recurrence interval,” i.e., a 10-year storm or a 50-year flood.

These terms are often misconstrued. Commonly, people interpret the 50-year flood definition to mean “once every 50 years.” This is incorrect. Statistically speaking, a 50-year flood has a 1/50 (2%) chance of occurring in any given year. In reality, a 50-year flood could occur two times in the same year, two years in a row, or four times over the course of 50 years. It is possible to not have a 50-year flood over the course of 100 years.

The base flood is the one percent chance flood, i.e., the flood that has a one percent (one out of 100) chance of occurring in any given year. The one percent chance flood has also been called the 100-year flood. This *Plan* uses the base flood as a basis for determining the flood risk in Mackinac County.

Another term used is the “500-year flood.” This has a 0.2% chance of occurring in any given year. While the odds are more remote, it is the national standard used for protecting critical facilities, such as hospitals and power plants.

The base floodplain: The area inundated by the base flood is the “base floodplain.” FEMA maps (called Flood Insurance Rate Maps, or FIRMs) also call this the Special Flood Hazard Area or A Zone. The base



floodplains for Mackinac County are the ones shown on Map 22 - Flood Insurance Rate Map. An example of a FIRM is shown on the previous page.

The central part of the floodplain is called the “floodway.” The floodway is the channel and that portion of the adjacent floodplain which must remain open to permit passage of the base flood. Floodwaters generally are deepest and swiftest in the floodway, and anything in this area is in the greatest danger during a flood. The remainder of the floodplain is called the “fringe,” where water may be shallower and slower.

The depth and velocity of a river are also important considerations in mitigation efforts. The faster the water moves, the more pressure it puts on a structure and the more it will erode stream banks and scour the earth around a building’s foundation.

While buildings may be easy to protect in areas of low velocities, people are not always safe. The total impact of moving water is related to the depth of the flooding. Studies have shown that deep water and low velocities can cause as much damage as shallow water and high velocities. Any summary data presented in this Plan should be augmented by site-specific data, such as depths and velocities, when looking at mitigation alternatives at any single location.

Impact: Impacts can be classified in four categories: impact on people (e.g., safety and health), damage to buildings, damage to critical facilities, and economic disruption (damage to businesses and infrastructure).

Safety: A car will float in less than 2 feet of moving water and can be swept downstream into deeper waters. This is one reason floods kill more people trapped in vehicles than anywhere else.

Victims of floods have often put themselves in perilous situations by ignoring warnings about travel or mistakenly thinking that a washed-out bridge is still there. People die of heart attacks, especially from exertion during a flood fight. Electrocuting is a cause of flood deaths, claiming lives in flooded areas that carry a live current created when electrical components short out. Floods also can damage gas lines, floors, and stairs, creating secondary hazards such as gas leaks, unsafe structures, and fires. Fires are particularly damaging in areas made inaccessible to fire-fighting equipment by high water or flood-related road or bridge damage.

Warning and evacuation: The threat to life posed by a flood can be avoided if people can evacuate before the waters reach their buildings or close their evacuation routes. This requires advance notice that a flood is coming and a system to disseminate flood warnings.

Transportation: Loss of road access is a major flood impact that affects all residents and businesses, not just those who own property in the floodplain. Sometimes the loss is temporary, such as during the flood. Bridges that can be expected to go under water are shown

Sometimes the loss of transportation lasts well after the disaster. When roads, bridges or railroads are washed out by a flood, it can be weeks or months before they are repaired and reusable.

Bridges: A key evacuation and safety concern is when roads and bridges go under water. Generally, the larger the road, the more likely it will not flood, but this is not always the case.

Health: While such problems are often not reported, three general types of health hazards accompany floods. The first comes from the water itself. Floodwaters carry whatever was on the ground that the upstream runoff picked up, including dirt, oil, animal waste, and lawn, farm and industrial chemicals. Pastures and areas where cattle and hogs are kept can contribute polluted waters to the receiving streams.

Flood waters saturate the ground, which leads to infiltration into sanitary sewer lines. When wastewater treatment plants are flooded, there is nowhere for the sewage to flow. Infiltration and lack of treatment lead to overloaded sewer lines, which back up into low lying areas and some homes. Even though diluted by flood waters, raw sewage can be a breeding ground for bacteria, such as e coli, and other disease causing agents.

The second type of health problem comes after the water is gone. Stagnant pools become breeding grounds for mosquitoes, and wet areas of a building that have not been cleaned breed mold and mildew. A building that is not thoroughly and properly cleaned becomes a health hazard, especially for small children and the elderly.

Another health hazard occurs when heating ducts in a forced-air system are not properly cleaned after inundation. When the furnace or air conditioner is turned on, the sediments left in the ducts are circulated throughout the building and breathed in by the occupants.

If the water system loses pressure, a boil order may be issued to protect people and animals from contaminated water.

The third problem is the long-term psychological impact of having been through a flood and seeing one's home damaged and irreplaceable keepsakes destroyed. The cost and labor needed to repair a flood-damaged home puts a severe strain on people, especially the unprepared and uninsured. There is also a long-term problem for those who know that their homes can be flooded again. The resulting stress on floodplain residents takes its toll in the form of aggravated physical and mental health problems.

Building damage: In a few situations, deep or fast moving waters will push a building off its foundation, but this is rare. More often, structural damage is caused by the weight of standing water, known as "hydrostatic pressure."

Basement walls and floors are particularly susceptible to damage by hydrostatic pressure. Not only is the water acting on basement walls deeper, a basement is subjected to the combined weight of water and saturated earth. In addition, water in the ground underneath a flooded building will seek its own level, resulting in uplift forces that can break a concrete basement floor.

The most common type of damage inflicted by a flood is caused by soaking. When soaked, many materials change their composition or shape. Wet wood will swell and, if dried too

quickly, will crack, split or warp. Plywood can come apart. Gypsum wallboard will fall apart if it is bumped before it dries out. The longer these materials are wet, the more moisture, sediment and pollutants they will absorb.

Soaking can cause extensive damage to household goods. Wooden furniture may become so badly warped that it cannot be used. Other furnishings such as upholstery, carpeting, mattresses, and books usually are not worth drying out and restoring. Electrical appliances and gasoline engines will not work safely until they are professionally dried and cleaned.

In short, while a building may look sound and unharmed after a flood, the waters can cause a lot of damage. To properly clean a flooded building, the walls and floors should be stripped, cleaned, and allowed to dry before being recovered. This can take weeks and is expensive.

Damage data: A source of damage data is past claims paid by the National Flood Insurance Program. These are shown in the following table:

NFIP INSURANCE REPORT BY COMMUNITY						
Community Name	Total Premium	Current	A-Zone	Total Coverage	Claims since 78 Total	Doll since 78 Total
CLARK TWP	10,393	0	20	2,845,400	0	0
GARFIELD TWP	6,559	0	9	2,005,900	2	2,257
HUDSON TWP.	1,740	0	3	415,500	0	0
MORAN TWP.	1,217	0	2	324,000	0	0
ST. IGNACE CITY	278	0	0	155,000	0	0
ST. IGNACE TWP.	1,531	0	3	74,900	1	0
County Total	21,718	0	37	6,621,700	3	2,257

Flood insurance claims figures do not include items not covered by a flood insurance policy, such as landscaping and automobiles, and the value of lost family heirlooms. They also do not include damage to uninsured or underinsured properties.

Floods can be slow, or fast rising but generally develop over a period of days. Investing in mitigation steps now, such as engaging in floodplain management activities, constructing barriers, such as levees, and purchasing flood insurance, will help reduce the amount of structural damage to a home and financial loss from building and crop damage should a flood or flash flood occur. Monitoring of current weather conditions and weather forecasts gives advanced notification of potential flooding. Hazardous weather outlooks and forecasts give vital information on the amounts of precipitation, wind intensity and direction, time and extent, etc. Thus, the severity of potential flooding can be assessed and prepared for effectively.

Potential Losses: Property damage, loss of function, and emergency response costs.

Vulnerable Areas: Shoreline communities and areas that have major rivers and more of a clay soil base.

Drought

Drought is a normal part of the climate of Michigan and of virtually all other climates around the world – including areas with high and low average rainfall. Drought differs from normal arid conditions found in low rainfall areas in that aridity is a permanent characteristic of that type of climate. Drought is the consequence of a natural reduction in the amount of precipitation expected over an extended period of time, usually a season or more in length. The severity of a drought depends not only on its location, duration, and geographical extent, but also on the water supply demands made by human activities and vegetation. This multi-faceted nature of the hazard makes it difficult to define a drought and assess when and where one is likely to occur.

Drought differs from other natural hazards in several ways. First, it is difficult to determine the exact beginning and end of a drought, since its effects may accumulate slowly and linger even after the event is generally thought of as being over. Second, the lack of a clear-cut definition of drought often makes it difficult to determine whether one actually exists, and if it does, its degree of severity. Third, drought impacts are often less obvious than other natural hazards, and they are typically spread over a much larger geographic area. Fourth, due primarily to the aforementioned reasons, most communities do not have in place any contingency plans for addressing drought. This lack of pre-planning can greatly hinder a community's response capability when a drought does occur.

Droughts can cause many severe impacts on communities and regions, including: 1) water shortages for human consumption, industrial, business and agricultural uses, power generation, recreation and navigation; 2) a drop in the quantity and quality of agricultural crops; 3) decline of water quality in lakes, streams and other natural bodies of water; 4) malnourishment of wildlife and livestock; 5) increase in wildfires and wildfire-related losses to timber, homes and other property; 6) declines in tourism in areas dependent on water-related activities; 7) declines in land values due to physical damage from the drought conditions and/or decreased economic or functional use of the property; 8) reduced tax revenue due to income losses in agriculture, retail, tourism and other economic sectors; 9) increases in insect infestations, plant disease, and wind erosion; and 10) possible loss of human life due to food shortages, extreme heat, fire, and other health-related problems such as diminished sewage flows and increased pollutant concentrations in surface water.

Historical Events: In the September, 2001 Mackinac County was one of 73 counties in Michigan requesting federal assistance from devastating crop losses due to severe drought. The request was based on 30 percent or more loss estimates in at least one commodity. From the middle of June through the middle of August, less than $\frac{3}{4}$ inch rain fell in most areas and, in addition, temperatures exceeding 100 degrees F were common during the last two weeks of July, exacerbating the already dry conditions.

Frequency: In 2 years out of 10, the rainfall in April through September is less than 14 inches at St. Ignace. The growing season for most crops falls within this period.

Potential Losses: With a severe drought the County can expect function loss of some sort and possible casualties and emergency response costs.

Vulnerable Areas: Mainly inland areas, but possibly the whole County would be affected.

Subsidence

Subsidence is the lowering or collapse of the land surface due to loss of subsurface support. It can be caused by a variety of natural or human-induced activities. Natural subsidence occurs when the ground collapses into underground cavities produced by the solution of limestone or other soluble materials by groundwater. Human-induced subsidence is caused principally by groundwater withdrawal, drainage of organic soils, and underground mining.

Historical Events: Parts of Highway U.S.-2 near the Cut River Bridge were washed away due to land movement after an intense rain storm in the summer of 2004.

Historical Fort Mackinac located on Mackinac Island experienced partial loss of stone wall on steep slope, due to a combination of poor drainage, steep slopes and the aging material of the wall.

Potential Losses: Function loss, environmental contamination, property damage, possible casualties and emergency response.

Vulnerable Areas: Areas with steep slopes such as those greater than 35%.

Conclusions

This chapter provides information on the hazards that can affect Mackinac County: transportation accidents, hazardous materials incidents, public health emergencies, severe winter weather, thunderstorms, wildfires, extreme temperatures, tornadoes, flooding, drought and subsidence. Data on the hazards are provided in terms of severity, frequency and historical occurrences. Technological hazards such as hazardous materials incidents and nuclear attack will need more in-depth analysis than this plan provides, which is concentrating more on the natural hazards.

The impact of these hazards are reviewed under four categories: how they impact people, how they impact property, what critical facilities may be damaged, and economic disruption (damage to businesses or infrastructure).

While it is hard to compare different natural phenomena, a general summary can show how they impact the County. This is done in Table 1, "Impact of the Hazards."

Frequency: The annual chance column in the table shows the likelihood of occurrence in any given year. These numbers are discussed in the “Frequency” section of each hazard.

Location: The location and area affected by a single occurrence is shown.

Safety: The safety hazard rating in Table 1 for thunderstorms and winter/ice storms is relatively high because of the dangerous conditions they may cause.

Property Damage: The property damage column is a factor of the estimated damage per structure times the number of structures likely to be damaged by the hazard.

Critical Facilities: The types of critical facilities and infrastructure that are affected are listed.

Economic disruption: Typical impacts on businesses and utilities are listed in this column.

Table 2 “Vulnerable Areas” shows the hazards and the municipalities which may be impacted.

Overall, there is adequate data on the hazards affecting the County as a whole. However, to measure the impact on individual communities and locations, such as critical facilities, requires addition effort beyond the scope of this county-wide plan. It is recommended that each critical facility be investigated further to determine its vulnerability to damage by the hazards reviewed in this chapter.

