



DROUGHT HAZARDS

Hazard Profile

Drought is a normal, periodic feature of climate, although many erroneously consider it rare and random. It occurs in virtually all climatic zones, but characteristics vary significantly from one region to another. A drought is an extended period of unusually dry weather any time of the year, which may be accompanied by extreme heat (temperatures which are 10 or more degrees above the normal high temperature for the period). Drought differs from aridity (desert conditions), which is restricted to low rainfall regions and is a permanent feature of the climate.

Drought is commonly considered a summertime event, associated with heat and dry weather; however, winter drought may prove equally hazardous in northern climates, including the City of Superior. Winter drought may or may not involve higher than normal temperatures. Cold temperatures coupled with low precipitation (snow) and high winds increase the evaporation of water from soils, increasing the depth of ground freezing, thus affecting soil conditions further into spring.

Two basic types of drought occur: hydrologic and agricultural. Hydrologic drought is a dry period of sufficient length and intensity which affects lake and stream levels and the height of the groundwater table. Agricultural drought is a dry period of sufficient length and intensity that markedly reduces crop yields. While agricultural crops are not prevalent in the City, agricultural drought affects forests, parks, gardens, trees, and other natural resources. These two types of drought may, but do not necessarily, occur at the same time.

Drought may impact structural, economic, and social assets throughout the City. Droughts are relatively common in the state, but less common in the northwest corner. Extended, widespread droughts have been infrequent in Wisconsin.

Agricultural Drought

Agricultural drought is defined as dry weather of sufficient length and severity which significantly reduce crop yields. Both summer and winter droughts can affect summer crop yields. Heat and dry conditions affect plants during the growing season. In the winter, lack of snow equals lack of insulation to the soil, allowing frost to penetrate deeper into soils. The lack of snow also allows higher evaporation of water from the soil, leaving soils with less water to nourish new seedlings. Even small droughts of limited duration can significantly reduce crop growth and yields, adversely affecting farm income.

There are no parcels zoned for agriculture in the City, though a few hobby farms exist with horses or cows.

Hydrologic Drought

Dry weather in both winter and summer limit the amount of precipitation as runoff or snowmelt, replenishing the lake. Lake Superior receives approximately 40% of its annual input in the form of snowmelt. When winter temperatures persist above normal, ice cover is limited and the lake is vulnerable to cold, dry winds that increase water loss by evaporation. This exacerbates low lake levels when the spring shipping season begins. Dry spells persisting for as little as 5 weeks can show significant lake level changes.

Compared to agricultural drought, the City is more vulnerable to hydrologic drought, since the shipping industry and recreational boating are dependant on lake levels and agricultural industry is limited within the City limits.

Historical Events

- Wisconsin's longest recorded period of drought occurred during the "dust bowl" years of the 1930's, when the state had eight consecutive years of below average precipitation.
- The state of Wisconsin as a whole has been affected more frequently and severely by drought events than has the City of Superior. Statewide, droughts have affected municipal and private water supplies. Federal assistance was provided to the state and counties during the 1976-1977 and 1987-1988 droughts, including Douglas County in 1976; however, the City of Superior did not apply for assistance.
- A severe drought in Northwestern Wisconsin spanned nearly 5 years, between 1999 and 2003. Low lake levels in 1999 and 2000 caused severe impacts to business, industry, and private property throughout the Lake Superior region. Low winter and summer precipitation, La Niña effects, and high temperatures year-round led to low water input into the lake and little ice cover to protect the lake from evaporation during winter months. Summer heat accelerated evaporation rates, thus increasing overall evaporation rates. It was estimated that Lake Superior lost 63 trillion gallons of water in 3 years, causing a 9-inch drop in lake levels in 1999 and an 18-inch total drop by 2000.
- These low lake levels continued through the El Niño – La Niña cycle to 2003. Normally, lake levels fluctuate more cyclically, with high water alternating with low water. However, when the warm, dry El Niño cycle began in 2001, the lakes were already at low levels. The summer lake level in 2003 was predicted to be barely a foot above the record 1926 low water level of 599.5-feet (IGLD 1985). The period from December 2002 to February 2003 was the second driest in 108 years. Lake levels rose to the 601.0-foot mark by April 2004.
- During late 2006 and 2007, lake levels in the upper Great Lakes plummeted. Lake Superior dropped at least one-foot, which was the lowest level since record keeping began. This caused severe problems for the shipping industry and recreational boating. Low water levels cost the shipping industry millions of dollars due to vessels carrying lighter loads to avoid running aground in shallow channels.

- The combination of short and long term precipitation deficits caused extreme drought conditions in the fall of 2009. During the 3 previous years, the City saw a prolonged period of dry weather. Precipitation deficits during this period were 15-20 inches below normal. This caused exceptionally low lake levels.
- The City has been included as being involved in several other drought events affecting the State of Wisconsin. The impacts of these events on the City are unclear, due to a lack of documentation.
- According to USGS September 2011 streamflow was below to much below normal in the Lake Superior and Menomonic drainage basins, and near normal in Lake Michigan drainage basins.
- In December of 2012 NOAA and the University MN Watershed Council recorded Lake Superior's water level was considered well below its historical average.

Probability & Predictability

The probability of a drought causing damage in the City is low (<1%). Typically, droughts occur in Wisconsin approximately once every 10-12 years, though severe droughts lasting more than 2 years appear to occur once every 50-75 years. Although the City is vulnerable to drought cycles approximately once every 10 years, lesser effects may be detected at three-year intervals. Monthly precipitation for 1995-2008 data is shown in Figure 6.2.

Lake level predictions can be made based on weather trends, including temperature and precipitation data and the 30-day forecast. The United States Army Corps of Engineers-Detroit District, in coordination with the National Oceanic and Atmospheric Administration, produces drought predictions in 1-week to 1-year intervals for the Great Lakes.

The map of Wisconsin in Figure 6.1 shows the general vicinity of the City of Superior in relation to severe droughts in the state of Wisconsin 1929-1988.

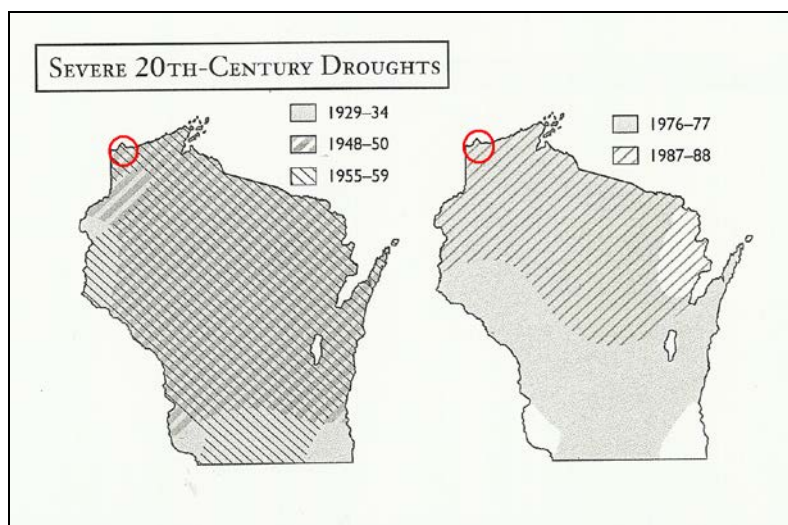
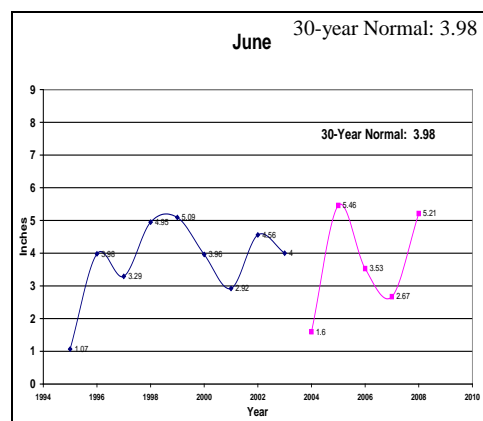
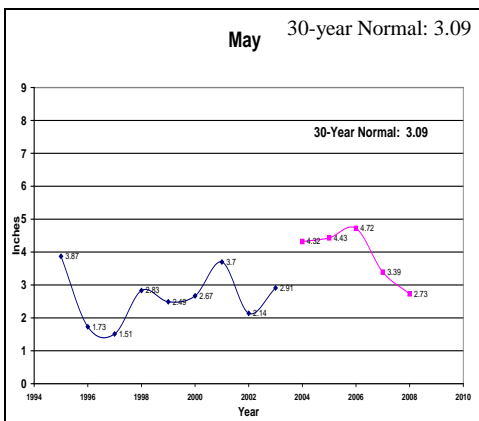
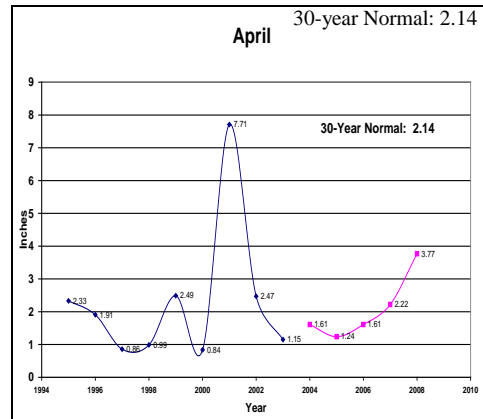
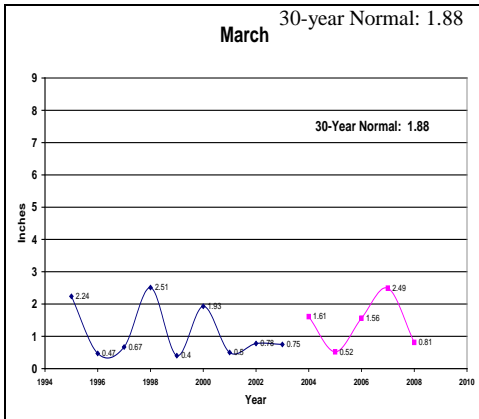
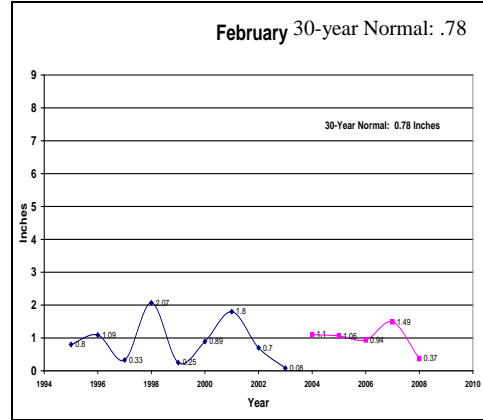
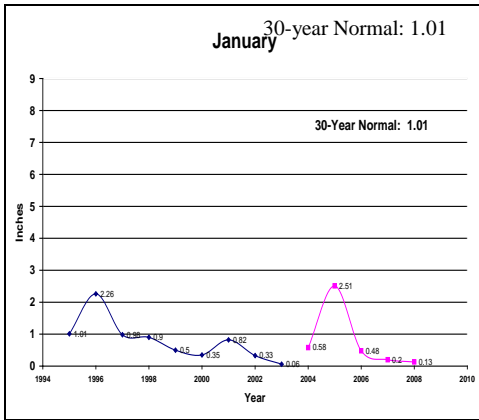


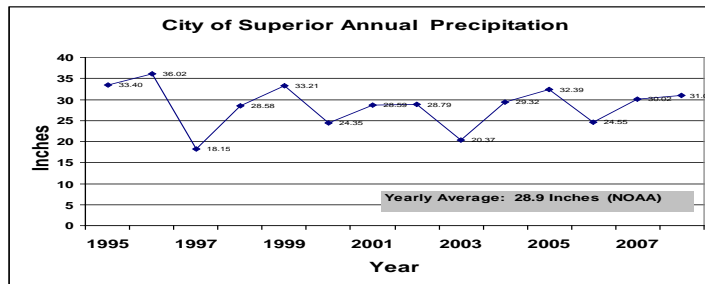
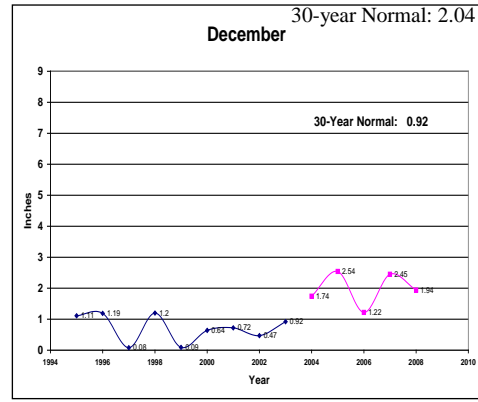
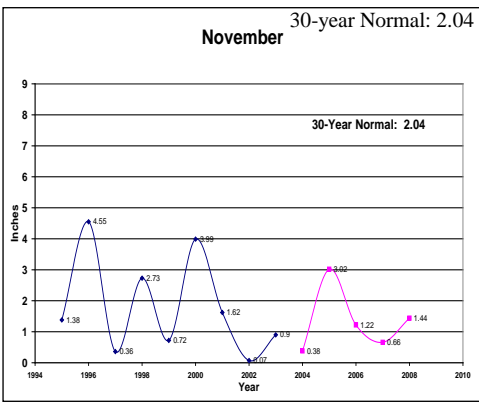
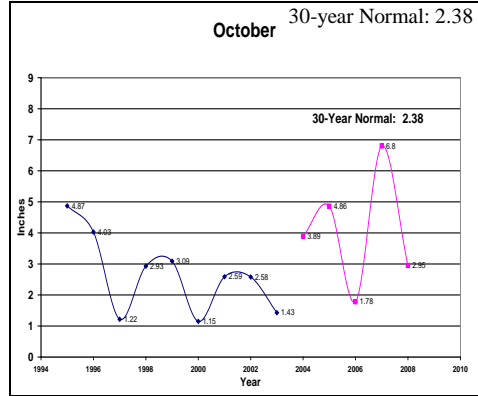
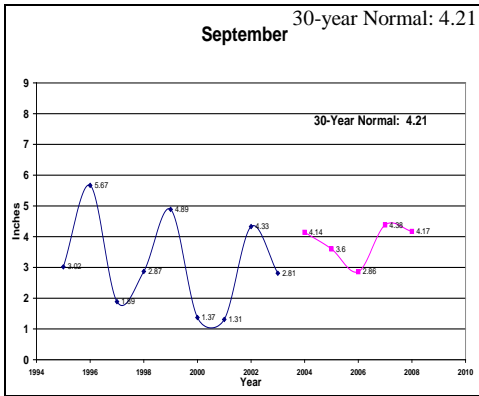
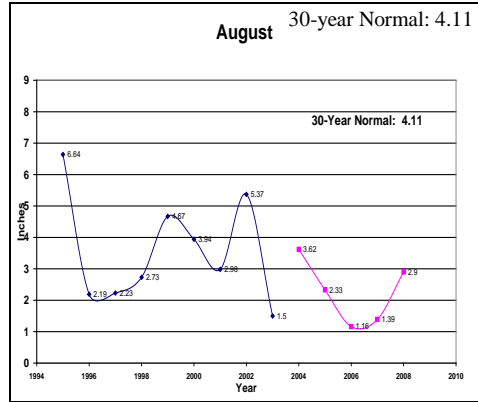
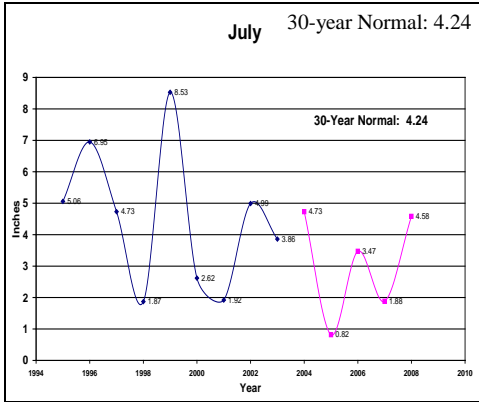
Figure 6.1 Source: Wisconsin's Past and Present, A Historical Atlas by the Wisconsin Cartographers Guild (University of Wisconsin Press 1998).

Section 6: Drought Hazards

Figure 6.2: Average monthly precipitation: 1995 – 2008



Section 6: Drought Hazards



Extreme Heat

Extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for several weeks. In addition, high humidity contributes to extreme heat by retarding the body’s ability to cool from evaporation of perspiration, causing the body to work much harder to cool down. According to the National Oceanic and Atmospheric Administration (NOAA), heat is the number one weather-related killer.

Summer heat waves are the biggest weather-related killers in Wisconsin for the past 50 years, far exceeding tornado and other storm-related deaths. In 1995, two major killer heat waves affected most of Wisconsin resulting in 154 heat-related deaths and over 300 heat-related illnesses. Extreme heat has no boundaries and can extend over all areas of the City.

Table 6.1 Heat Disorders and Symptoms

Heat Disorder	Symptoms
Sunburn	Redness & pain; in severe cases swelling of skin, blisters, fever, headaches
Heat Cramps	Painful spasms usually in muscles of legs & abdomen possible; heavy sweating
Heat Exhaustion	Heavy sweating, weakness, skin cold, pale & clammy, pulse thready; normal temperature possible; fainting & vomiting
Heat Stroke	High body temperature (106 or higher); hot dry skin; rapid & strong pulse; possible unconsciousness

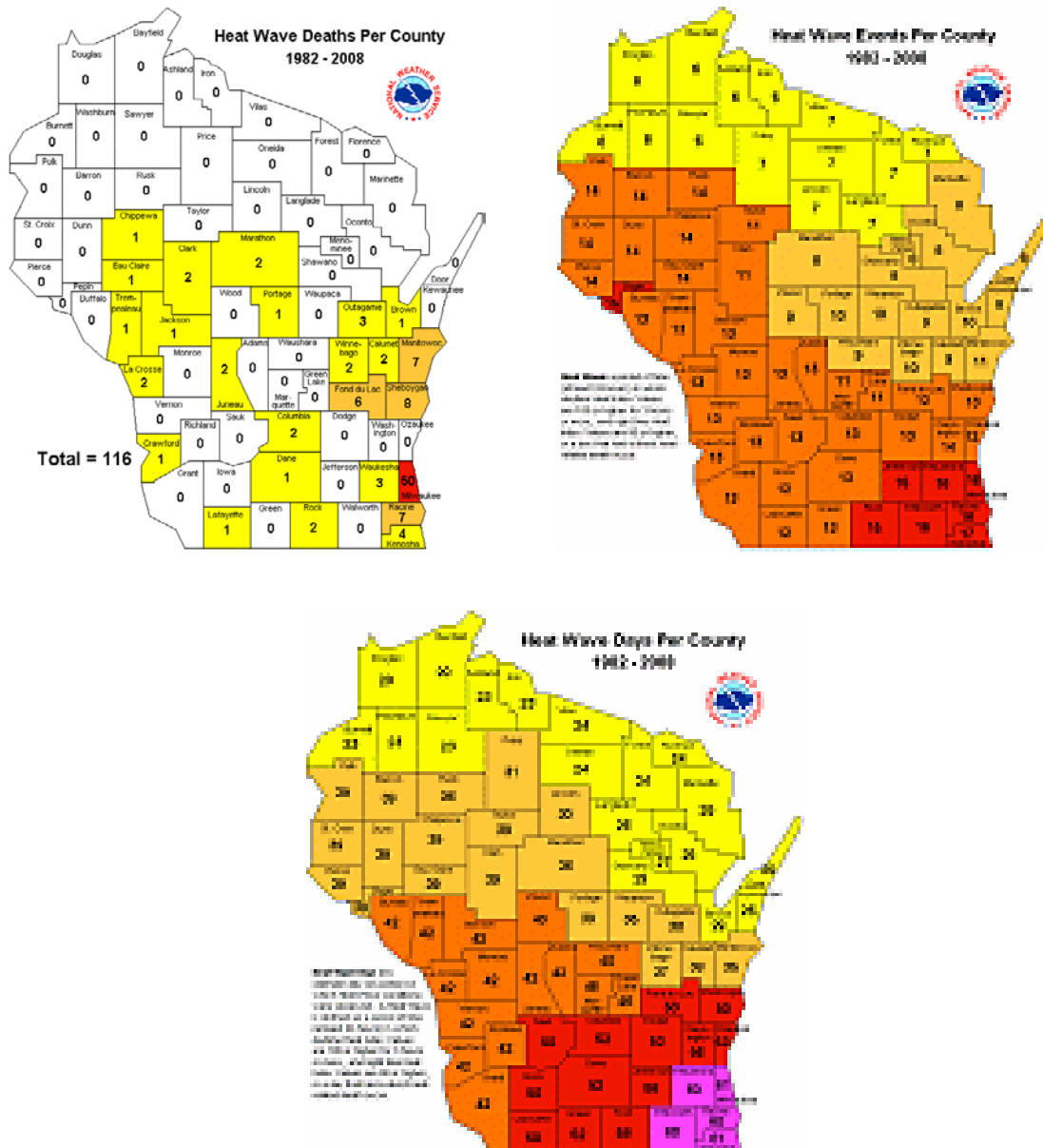
Source: NOAA

Historical Events

Since 1982 heat waves have been responsible for more deaths in Wisconsin than all other natural disasters combined. For the period of 1982-2012, at least 137 people have died in Wisconsin in which heat was the direct or primary cause of death. This comes out to an average of about 4 deaths per year. For the same period of time, at least 95 people have died in Wisconsin when heat was an indirect or secondary cause. In the summer of 1995, several heat waves affected most of Wisconsin and resulted in 154 fatalities, 82 directly and 72 indirectly. The heat waves occurred from late June through mid-August. In addition, approximately 400 people received medical treatment due to heat-related causes. The 1995 summer heat waves hold the record as the number one weather-related killer in Wisconsin since it became a state in 1848. Most deaths occurred in the major urban cities in southeast Wisconsin. As in every state hit by the heat wave that year, the elderly and young age groups were hit the hardest. Preliminary statistics from the NWS Office at Milwaukee/Sullivan indicate that northern Wisconsin has experienced between 6 to 15 heat waves between 1982 and 2012 each lasting from 1 to 10 days. The total number of heat wave days in northern Wisconsin during this period has totaled between 20 to 40 days. No recorded incidents of death due to excessive heat in Superior were found.

According to the National Weather Service, on July 17, 2011, the 4-day heatwave claimed 5 lives in Wisconsin when apparent temperatures peaked in the 110-117 range. At least 108 people were hospitalized. And again on July 1-7, 2012 Wisconsin endured a heat wave that claimed 10 lives state-wide. None resided in the City, nor in Douglas County.

Figure 6.3: Heat Wave Deaths, Days & Events in Wisconsin 1982-2008



Probability & Predictability

Although extreme heat events do occur in Superior, there are no references to deaths from extreme heat recorded in Superior. Extreme heat events may be predicted with

reasonable notice using meteorological techniques to determine likely intensity and duration. The National Weather Service Heat-Wave Program in Wisconsin will issue a Heat Advisory or Excessive Heat Warning if these conditions are anticipated, 2 to 7 days in advance of the event. Based on the 6 Heat Wave Events in Douglas County from 1982-2008, the probability of an extreme heat event occurring is high (3), greater than 5% in a given year.

Vulnerability Assessment

Not unlike the effects noted in the coastal hazards section, drought can threaten the shipping industry. Map 6.1 shows potential areas that could be affected by low lake levels.

Populations that are particularly susceptible to illness, injury and death from extreme temperatures include the elderly, low-income persons (affordability of sufficient heating or cooling) young children, sick, overweight and/or people with alcohol problems, and men in general. Usually victims have been overexposed to heat or have over-exercised for their age and physical conditions. Excessive heat also puts strain on a person's respiratory and cardiovascular system, particularly impacting toddlers and the elderly.

Critical Facilities

Superior Water, Light & Power (SWL&P) uses wells to draw the City's water supply from Lake Superior. However, these wells are structurally designed against any predictable drought conditions, thus drought would not affect the potable water supply in most of the City.

Private Wells

Private wells in the City are vulnerable to drought. Private wells that provide the sole source of potable water for a property exist on residential and commercial parcels south and west of Chipmunk Hollow, south of Billings Park and adjacent to Superior Municipal Forest, around Kimball's, Kelly, and Kilner bays. Other wells exist in the City as a supplement to water supplied from SWL&P.

Fire

Droughts greatly increase the risk of forest fires and wildfires because of the extreme dryness, making the 4,400-acre Superior Municipal Forest and the nearby residences vulnerable. The City's Urban Forest consists of over 4,000 trees planted in parks and along streets throughout the City. The loss of vegetation from drought conditions can result in flooding, even from average rainfall. Droughts also increase the incidence for grass fires that may be human-set or set by lightning strikes. Lightning induced wildfires, influenced by drought or not, are discussed under Lightning and Lightning Induced Wildfire in the Thunderstorm section of this plan.

Utilities

When snow cover is minimal, such as during winter droughts, buried water lines can freeze, causing rupture of water pipes or disruption of water service to a home or

business. SWL&P is responsible for water mains; however, customers are responsible for their own lateral service lines.

Tourism

Drought can also impact economic aspects of the City's tourism base and the social aspects of residents' ability to enjoy outdoor resources. The City of Superior Parks and Recreation Division of Public Works supports a number of fishing docks and boat launches, including the Loon's Foot Landing, Arrowhead Pier, and a few areas in the Superior Municipal Forest. These facilities may be rendered useless during periods of extremely low water. Aesthetic richness of the City's Urban Forest and Superior Municipal Forest are degraded during drought, resulting in decreased use of available recreational resources including forest hiking trails during summer drought and of winter ski trails and snowmobile trails during winter droughts. Retail sales of winter sports equipment and accessories can decrease during winter droughts, causing hardship to local vendors.

Natural Resources

Hydrologic droughts can have significant environmental impacts to natural resources in the City. Lake and shoreline ecosystems do not tend to be damaged from high and low lake levels, since they are dynamic. Some actually thrive on the variability. Research on the fishing industry revealed little impact on fish populations, since fish move to water of the desired depth. Fish spawning habitat may show slight negative impacts when spawning grounds near shore are unsuitable, but research does not show impact for the short-term (<5 year). Many plant systems actually thrive on variable lake level situations as it provides opportunity for submerged and buried seeds of aquatic and emergent plants to become exposed, initiating germination. Low water levels can impact major resting and feeding areas and nesting areas for migrating ducks, geese, swans and other waterfowl.

Future Development

Future development in the City of Superior is outlined in the City's 2010-2030 Superior Comprehensive Plan online. Future commercial development in the Superior Harbor would be impacted no differently than existing harbor development. The economic benefits of development in the harbor far outweigh the cost of drought vulnerability.

*Water main break along
Belknap Avenue, February 2004*



Loss and Replacement Estimates

While drought threatens social and economic assets primarily, structural damages are likely minimal. Drought effects are usually those of inconvenience and limited to the shipping industry, Parks and Recreation Division of Public Works and a few private water wells throughout the City.

Based on past incidents, structural damages resulting from drought may occur to less than 1% of the commercial property in the port area of the City, totally approximately \$1,398,903 in improvement value damages. However, the effects of drought are seen primarily in damages to the shipping industry, as loss of income due to limited operations.

Table 6.2 City of Superior Value of Drought Properties

Parcel Land Classification	Total Parcels	Acreage	Land Value	Improvement Value	Total Value
Commercial	94	544	\$37,704,500	\$139,890,300	\$177,594,800
Manufacturing	25	170	\$88,600	\$1,324,300	\$1,412,900
City	143	2770	n/a	n/a	n/a

Source: City of Superior's GIS data of parcels located within 50 feet of Lake Superior coastline.

Commercial

The shipping industry suffers the greatest risks from drought resulting in low lake levels. In 2011, the Duluth-Superior Harbor reported a total economic impact between the two cities of \$200+ million and over 2,000 jobs. The Duluth/Superior Port handles 36.5 million metric tons of cargo, 90% of which is coal, iron ore, and grain. Low lake levels force cargo ships to reduce loads by 15% or more, a calculated loss of \$31.5 million. Details of the history, economic structure, and land use planning for Superior's Port are discussed in Superior's Port Plan, developed by the Arrowhead Regional Development Commission - Metropolitan Interstate Committee.

Parks and Recreation

Prolonged summer drought may complicate the City's Urban Forest and garden planting efforts made by the Parks and Recreation Division of Public Works. In 2003, \$10,000 was spent on new deciduous saplings. During a prolonged drought, these resources would either perish without water, or additional labor efforts and water resources would have had to be spent to water trees by hand. Labor efforts spent on what natural rain events could accomplish are not considered cost effective.

Loss of function for recreational facilities during droughts can render loss of income to the City through reduced recreational user fees. During summer drought, the City may see a decreased use of boaters using the city boat launch and in the winter a decreased use of winter ski trails, resulting in a loss of fee income.