Climate Change

Water Implications for Michigan Communities, Landsystems and Agriculture

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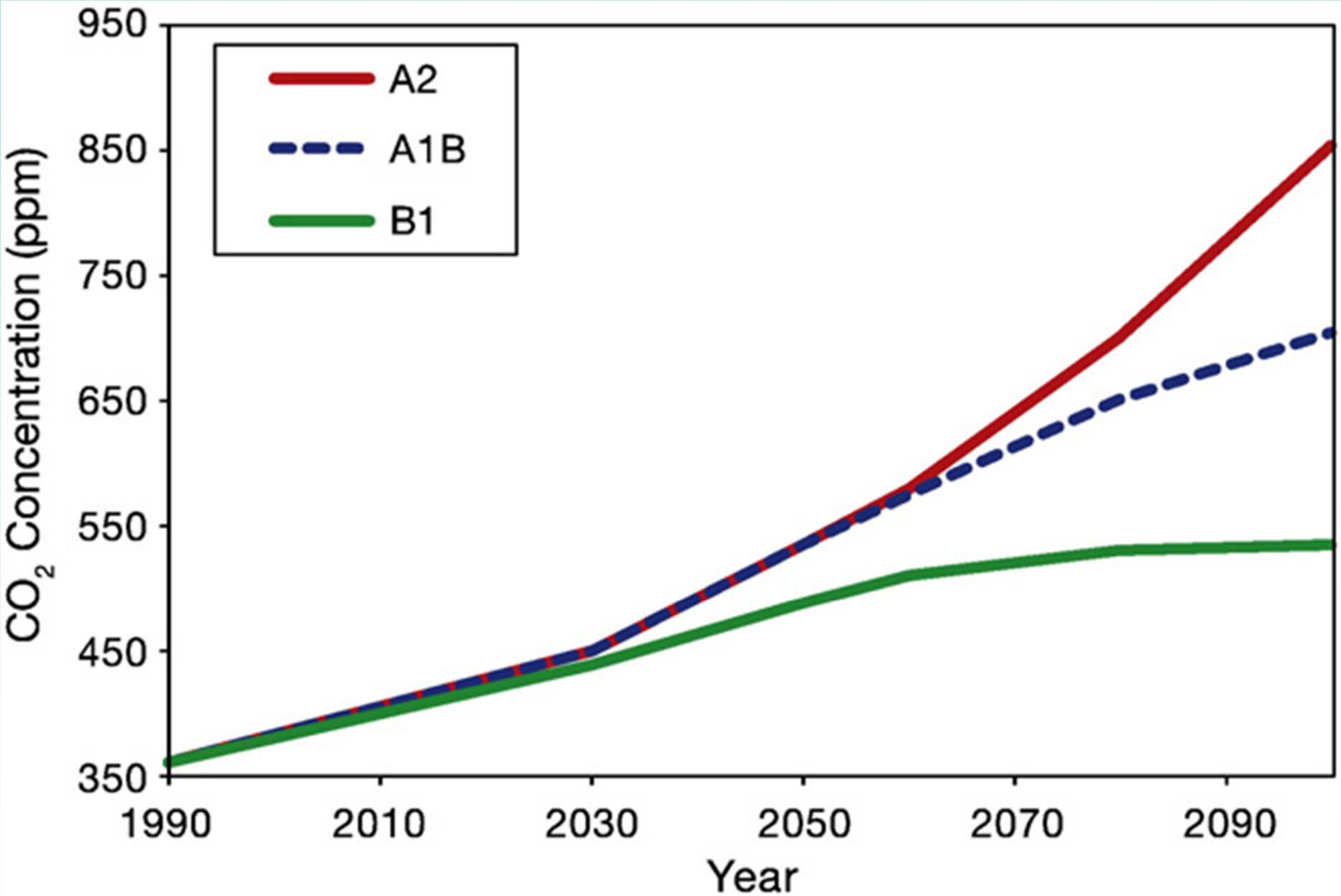
Climate Change Summary

- **Angel and Kunkel (2010)** **The response of Great Lakes water levels to future climate scenarios with an emphasis on Lake Michigan-Huron. *Journal of Great Lakes Research,* 36: 51–58.**
  - Output of 565 model runs from 23 global climate models (from *IPCC Fourth Assessment Report*) were applied to a lake-level model developed by GLERL - *Advanced Hydrologic Prediction System*.
  - Three future emission scenarios were used:
    - B1 - low emission scenario
    - A1B - moderate emission scenario
    - A2 - high emission scenario

Climate Change Summary

- **Angel and Kunkel (2010)** **The response of Great Lakes water levels to future climate scenarios with an emphasis on Lake Michigan-Huron. *Journal of Great Lakes Research,* 36: 51–58.**
  - Change functions were computed for maximum, minimum, and mean temperature, precipitation, humidity, wind speed, and solar radiation for each of three future 30-yr periods (2005–2034, 2035–2064, and 2065–2094).
  - The first 15 years of each 30-year period were used as a "spin-up period" for the GLERL model to adjust to the new climate state. Then averages were taken of the second 15 years.

Climate Change Summary



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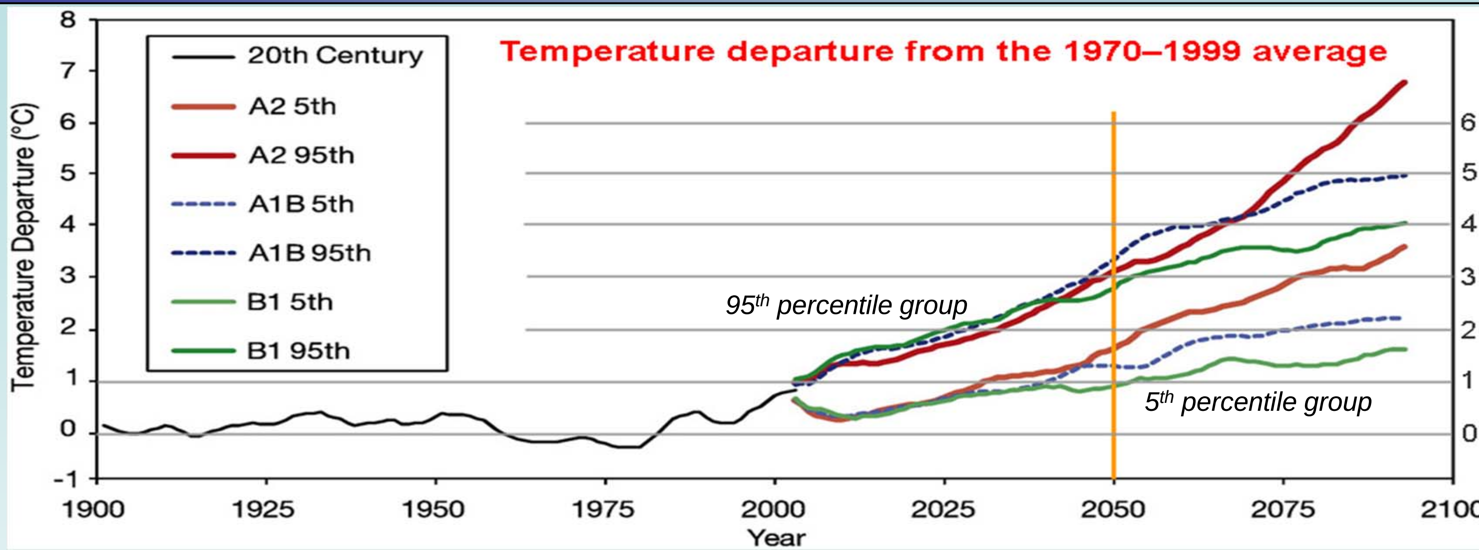
Climate Change Summary

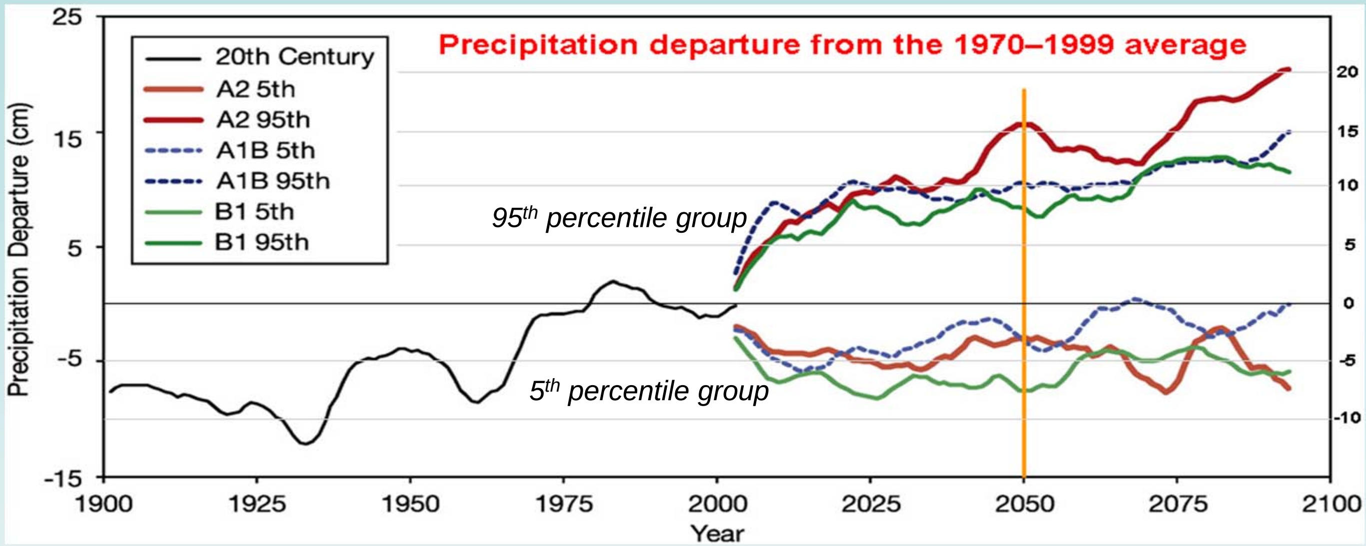


– All scenarios show steadily increasing temperatures over the basin, with good agreement through ~ 2040.

– By the end of the 21st century, the projected increases in AT ranged from

- 1.5 to 4.0 °C (B1 scenario)
- 2.0 to 5.0 °C (A1B scenario)
- 3.5 to 7.0 °C (A2 scenario)

Climate Change Summary



– Modeled precipitation changes were similar for all three scenarios.

– Some model simulations showed drying over the basin, but the majority of cases showed wetter conditions (7 - 15 cm increase by mid-century).

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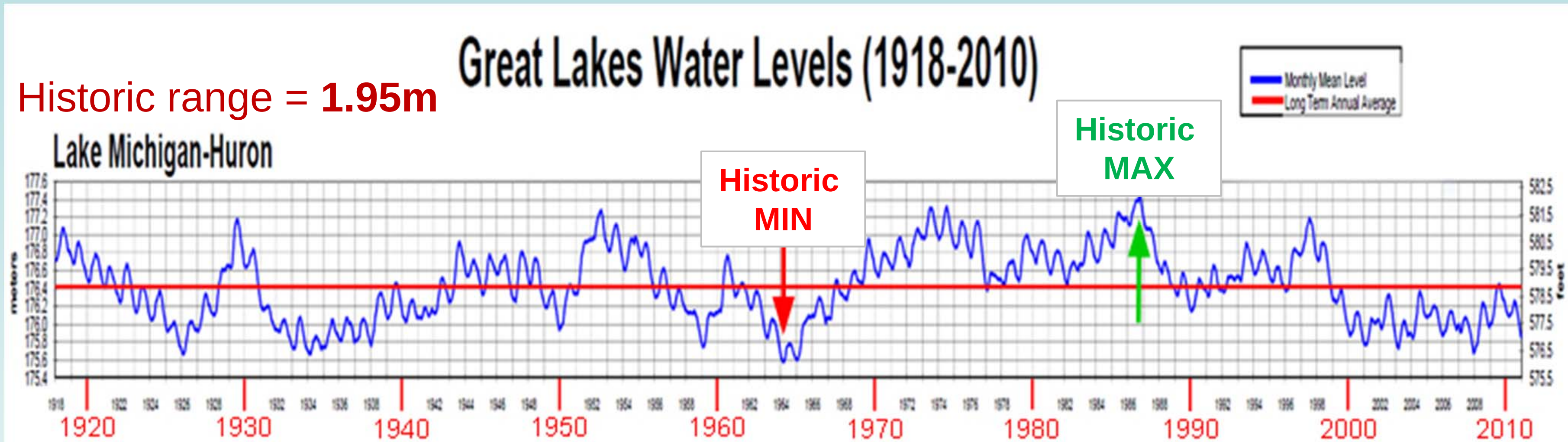
Great Lakes Levels Summary



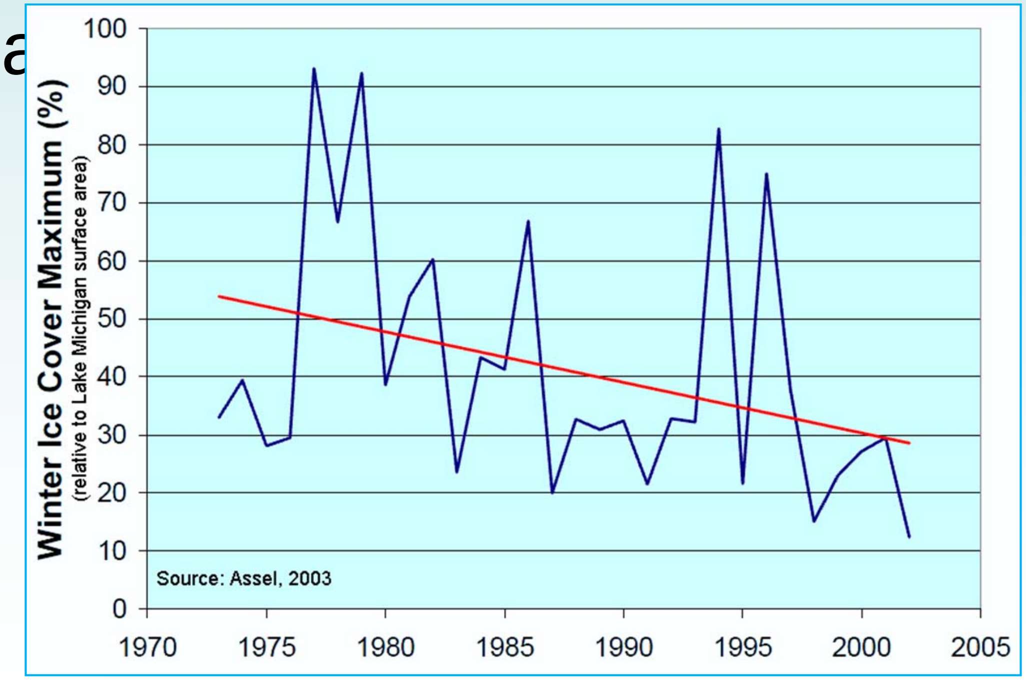
Lake Michigan Water Balance

Inputs	*%*	*Outputs*	*%*
Precipitation on lake surface	**51.7**	**Outflow to Lake Huron**	**50.7**
Baseflow of streams entering the lake	**31.2**	**Evaporation from lake surface**	**40.0**
Direct surface runoff to the lake	8.6	Withdrawals from the lake	7.3
Return flows from water users	5.9	Groundwater withdrawals from the basin	2.0
Direct groundwater discharge to the lake	2.6		
Diversions into the lake	< 1		

Impacts on Great Lakes Levels

– Warming air temperatures increase lake evaporation.

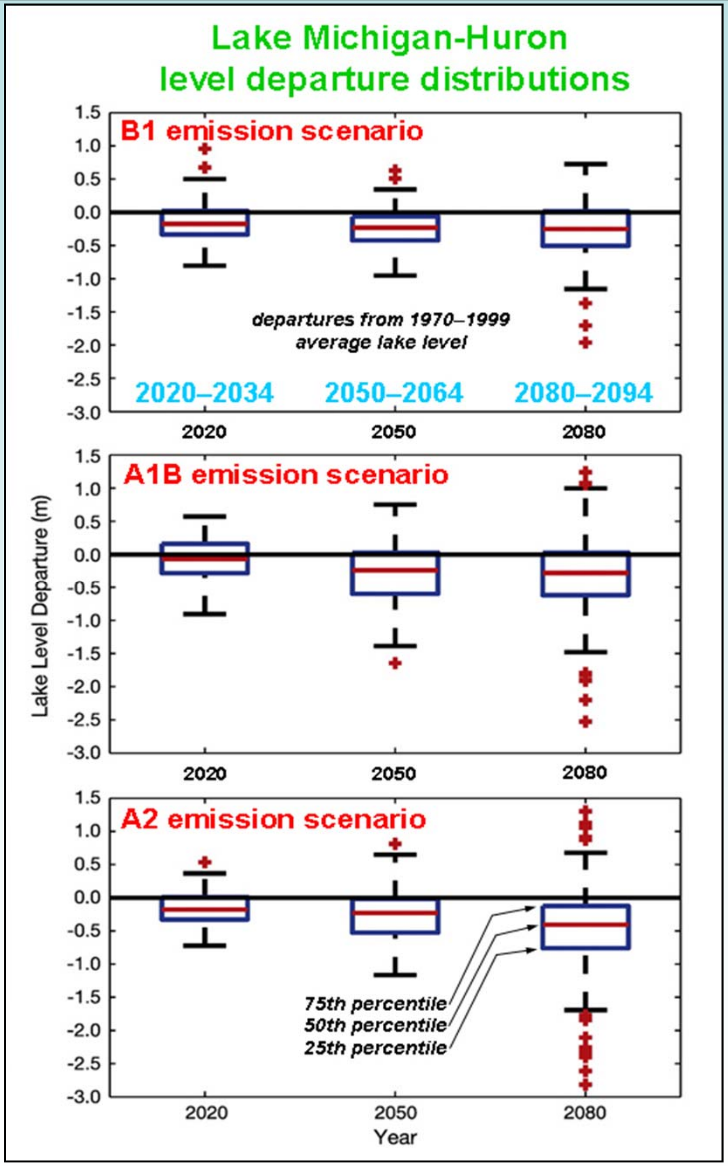
– Increasing air temperatures decrease (or eliminate) winter ice cover on the Great Lakes, which also increases lake evapora



Impacts on Great Lakes Levels

– There is a large range of uncertainty regarding potential future Great Lake levels, but a majority of the projections indicate a **modest decrease** in lake levels with time.

– At least 75% of the model runs show steady or declining lake levels.



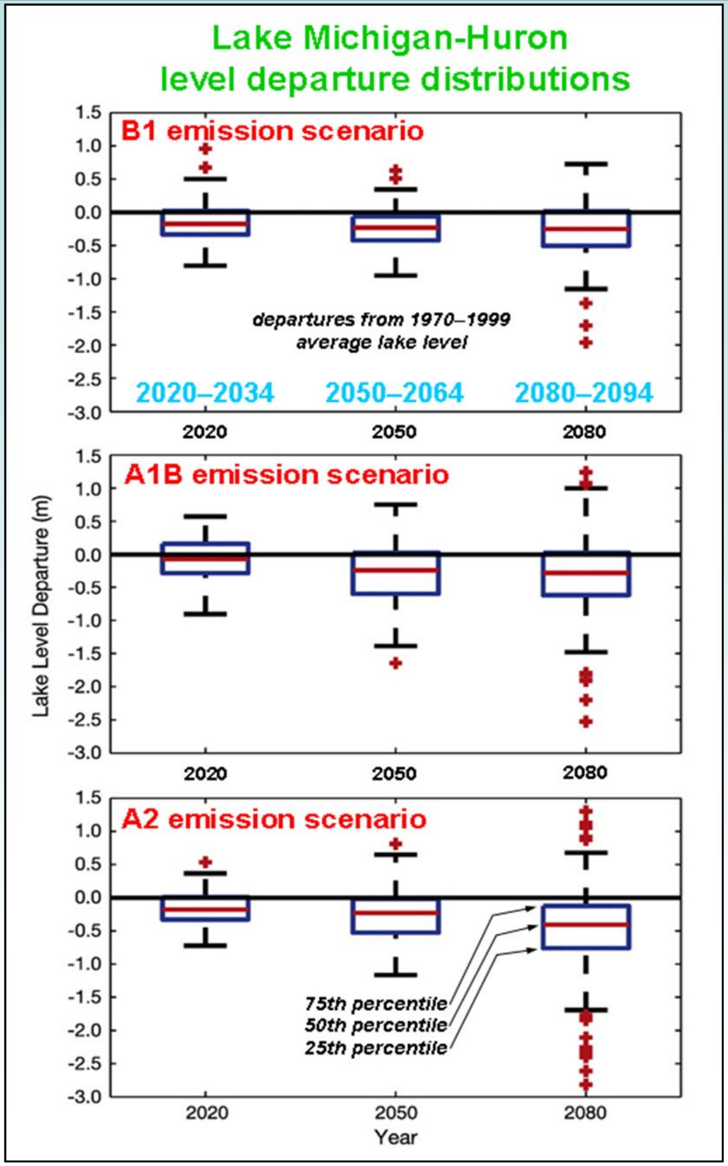
Impacts on Great Lakes Levels

– B1 model runs show median declines of **0.18 m**, **0.23 m** and **0.25 m** through time.

– A1B model runs show median declines of **0.07 m**, **0.24 m** and **0.28 m**.

– A2 model runs show median declines of **0.18 m**, **0.23 m** and **0.41 m** **.

** the historic low in 1964 was 0.40 m below current levels.



Climate Change Impacts

- **Weather System Changes**
  - Although total annual precipitation will probably increase, precipitation during key seasons may decrease.
  - More precipitation may fall as rain and less as snow.
  - Intensity of precipitation events may increase.
  - Total annual runoff decreases, but more runoff may occur in winter.
  - Potential evapotranspiration will increase with warmer air temperatures.
  - The frequency of both droughts and intense rain events may increase.

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Climate Change Impacts

- **Hydrology Changes**
  - Spring freshet may occur earlier and have less flow.
  - Summer and fall low flows in streams may be lower and last longer.
  - Peak flows in streams may increase due to extreme precipitation events.
  - Groundwater recharge and levels may decrease
    - more of the total annual precipitation may come during intense rain events
    - the infiltration capacity of many soils may be exceeded more frequently, generating more runoff and less infiltration (recharge).

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Climate Change Impacts

- **Hydrology Changes**
  - Baseflow may increase during the winter (less snow accumulation and more winter rain and runoff), but decrease during summer (drought conditions).
  - Inland lake and wetland water levels are likely to decline, modestly (< 0.5 m*?*).

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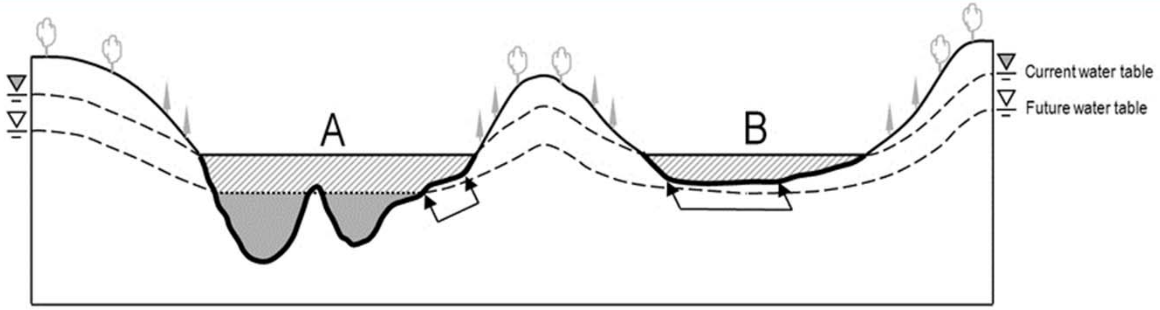
Climate Change Impacts

- **Impacts on Lakes**
  - Modest declines in both inland lakes and the Great Lakes are expected as winter ice coverage decreases, the water table drops and summer low-flows in streams decline.
  - Inland lake management and associated tourism will be challenged by lower lake levels.



Lake "A" is deep with a more complex bottom topography. Lake "B" is shallow with a simple basin topography. In response to a large decline (2 m) in the elevation of the water table, Lake "A" becomes two lakes of much smaller area, flanked by a palustrine wetland (arrows). In contrast, Lake "B" drains completely and likely becomes a palustrine wetland of smaller area (arrows).

Climate Change Impacts

- **Impacts on Lakes**
  - Declines in the duration and thickness of winter ice will diminish the availability of safe ice fishing opportunities.
  - Loss of winter ice may reduce winterkill of fish in shallow inland lakes.
  - Loss of winter ice on the Great Lakes may jeopardize reproduction of whitefish, where ice cover protects the eggs from winter storm disturbance.
  - In all lakes, the duration of summer stratification will increase, adding to the risk of oxygen depletion and formation of deep-water “dead zones” for fish and other organisms.

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Climate Change Impacts

- **Impacts on Lakes**
  - The reduced summer water levels in inland lakes will likely increase areas of submerged aquatic vegetation.
  - Increased summer water temperatures in lakes may promote larger and more frequent harmful algal blooms.

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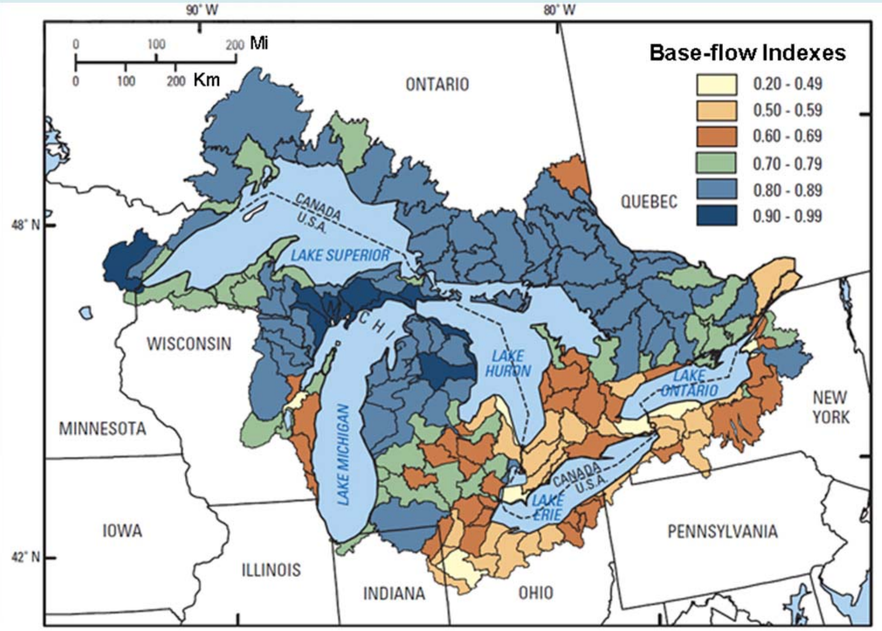
Climate Change Impacts

- **Impacts on Steams**
  - As the amount and timing of baseflow changes, the hydrology of streams with moderate to low base-flow indexes (central and SE Lower Michigan) will change more dramatically than streams with large base-flow indexes.

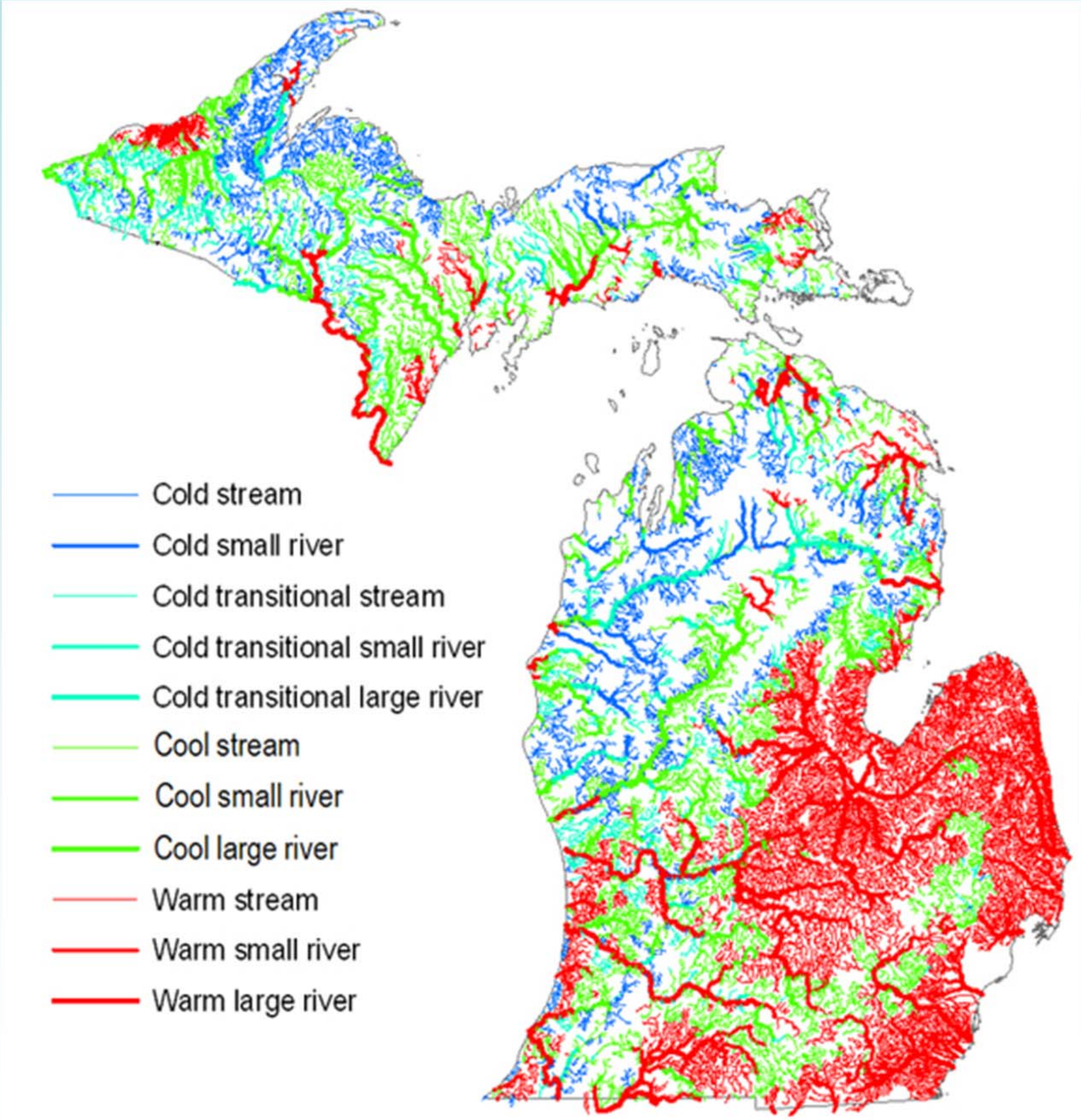


Base-flow indexes for 8-digit Hydrologic Unit Codes in the U.S. and the tertiary watersheds in Canada based on the G-SW Model calibrated using PART hydrograph analysis results

Neff, B., Day, S., Piggott, A., Fuller, L. 2005. Base Flow in the Great Lakes Basin. U.S. G.S. Scientific Investigations Report 2005-5217, 23 p.

Climate Change Impacts

- **Impacts on Steams**
  - The thermal regime of some cold, cold-transitional and cool streams will likely shift (warm) and the distributions of many fish and other organisms in the streams will change accordingly.

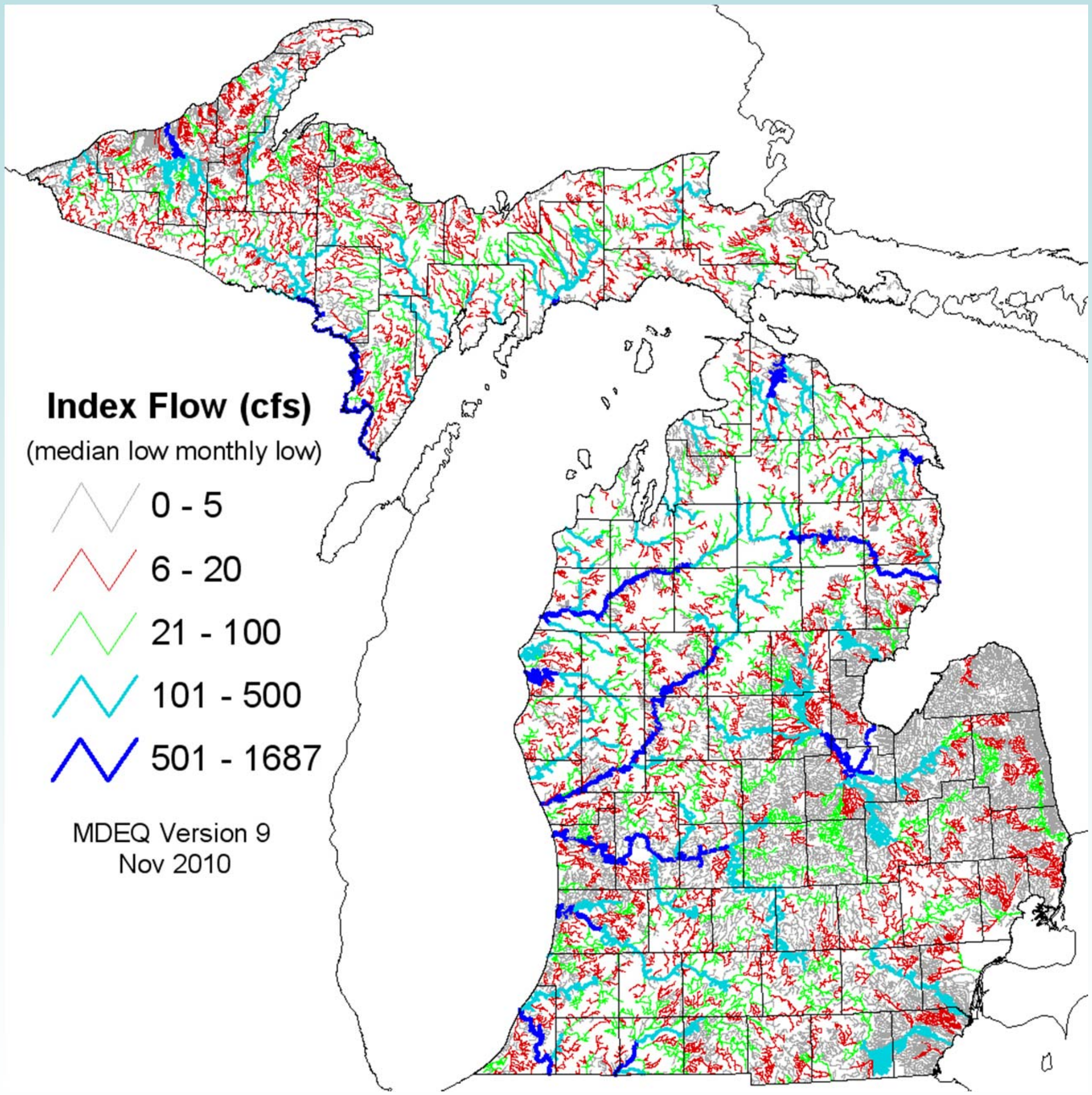


Climate Change Impacts

- **Impacts on Steams**
  - Earlier ice breakup and earlier peaks in spring runoff will change the timing of stream flows.
  - Increases in heavy rainstorms will likely cause more frequent flooding, especially in urbanized watersheds.
  - Most geomorphic change in river systems results from less frequent, but not least frequent, high-intensity events. The projected increases in the intensity and frequency of storm events will likely lead to significant alterations to the channel and bed forms of our rivers.
  - Increases in heavy rainstorms may increase nonpoint source sediment loading to streams with serious ecological consequences.

Climate Change Impacts

- **Impacts on Steams**
  - Reduced summer low flows are likely to cause small streams to dry up, especially in southern Lower Michigan.
  - Reduced summer low flows place additional ecological stress on all streams.



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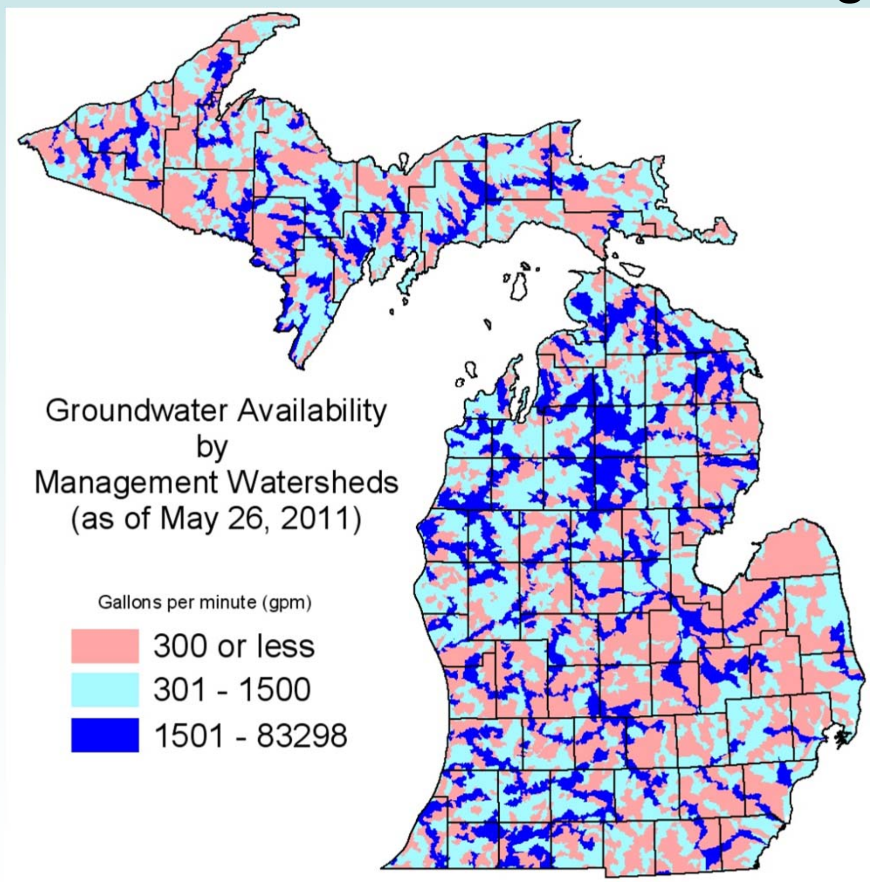
Climate Change Impacts

- **Impacts on Agriculture**
  - Growing season length will continue to increase. By the end of the century, it may be 4 – 9 weeks longer than it was in the period 1961–1990.
  - A lengthened growing season, coupled with increased CO_2 fertilization, could boost crop yields, especially in the northern parts of Michigan.
  - Potential yield increases may be offset by the predicted changes in the distribution of rain - wetter periods are expected during times that could delay planting or harvest and mid-growing season droughts are more likely.

Climate Change Impacts

- **Impacts on Agriculture**
  - An increased reliance on irrigation is likely, causing additional pressures on surface water and groundwater resources.



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Climate Change Impacts

- **Impacts on Agriculture**
  - Increased frequency of severe storms will likely result in more ponding and flooding which will likely depress crop yields and increase soil erosion and non-point pollution.
  - Warmer summer temperatures will likely suppress livestock appetites and decrease livestock weight gain. Extreme heat decreases milk productivity in dairy cows.
  - The likely increases in the frequency and intensity of heat waves have serious implications for CAFO management (*e.g*., reduced stocking rates or investments in improved ventilation or cooling equipment).

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Climate Change Impacts

- **Impacts on Urban Areas**
  - Currently, 8,000 - 10,000 wildfires (most burning 5 - 50 acres) occur each year in Michigan, damaging or destroying 100 - 200 structures. With hotter and drier summers, more and larger wildfires are probable. The need for more ***FireWise*** education will increase for both individual homeowners and rural communities.
  - Increases in heavy rainstorms will likely cause more frequent and severe flooding in urbanized watersheds.
  - The FEMA *Flood Insurance Rate Maps* for many riparian communities have likely underestimated the 100-year flood area because they have not accounted for the likely increases in the frequency and intensity of rain events.

Climate Change Impacts

- **Impacts on Urban Areas**
  - Currently, there are 46 CSO communities in Michigan with 262 outfalls. Increases in the intensity and frequency of heavy rainstorms will likely increase the number and severity of untreated CSO releases.
  - The most common methods used to calculate storm runoff volume, peak rate of discharge, hydrographs and storage volumes required for floodwater reservoirs in the eastern U.S. are based on 24-hour rainfall data published by the National Weather Service in **1961**! **Even new stormwater systems are probably ill-prepared for the likely increases in the frequency and intensity of heavy rainstorms.**

Climate Change Impacts

- **Impacts on Urban Areas**
  - Reduced summer low flows in streams result in lower dissolved oxygen concentrations which could adversely impact
    - BOD limits of existing NPDES permits for wastewater treatment facilities
    - existing or future TMDLs

Climate Change Impacts

- **Impacts on Transportation**
  - Predicted lake-level declines in the Great Lakes will likely increase costs of dredging harbors and channels and of adjusting dockage.
  - The longer ice-free season will lengthen the shipping season on the Great Lakes.
  - The increased frequency and intensity of lake-effect snows will make road travel more hazardous in some parts of Michigan and burden state, county and municipal snow-removal budgets in these areas.

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Climate Change Impacts

- **Impacts on the Economy**
  - Increased lake-effect snows will benefit winter recreational activities, but the shorter, warmer winters will diminish skiing, ice fishing and snowmobiling days over much of the state.
  - Climate warming may lower heating costs in winter, but this may be offset by higher costs for air conditioning in summer. The electric power grid will be increasingly burdened by the increased need for air conditioning.
  - Water withdrawal regulation is already contentious and pressures for more irrigation and drinking water will likely intensify water use conflicts as water shortages develop.

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The End

Any Questions?