



Climate Trends Affecting Lakes & Rivers



Dan Petrik, Shoreland Program Manager

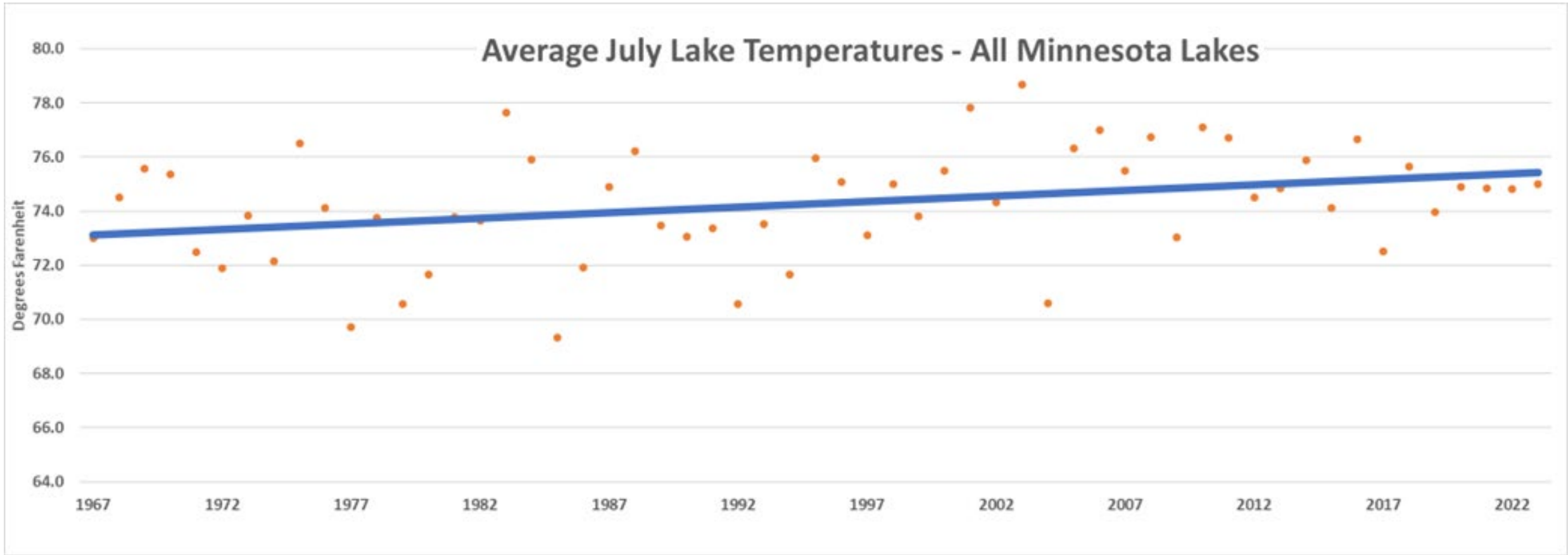
The ability to maintain normal patterns of nutrient cycling and biomass production after being subjected to disturbances.





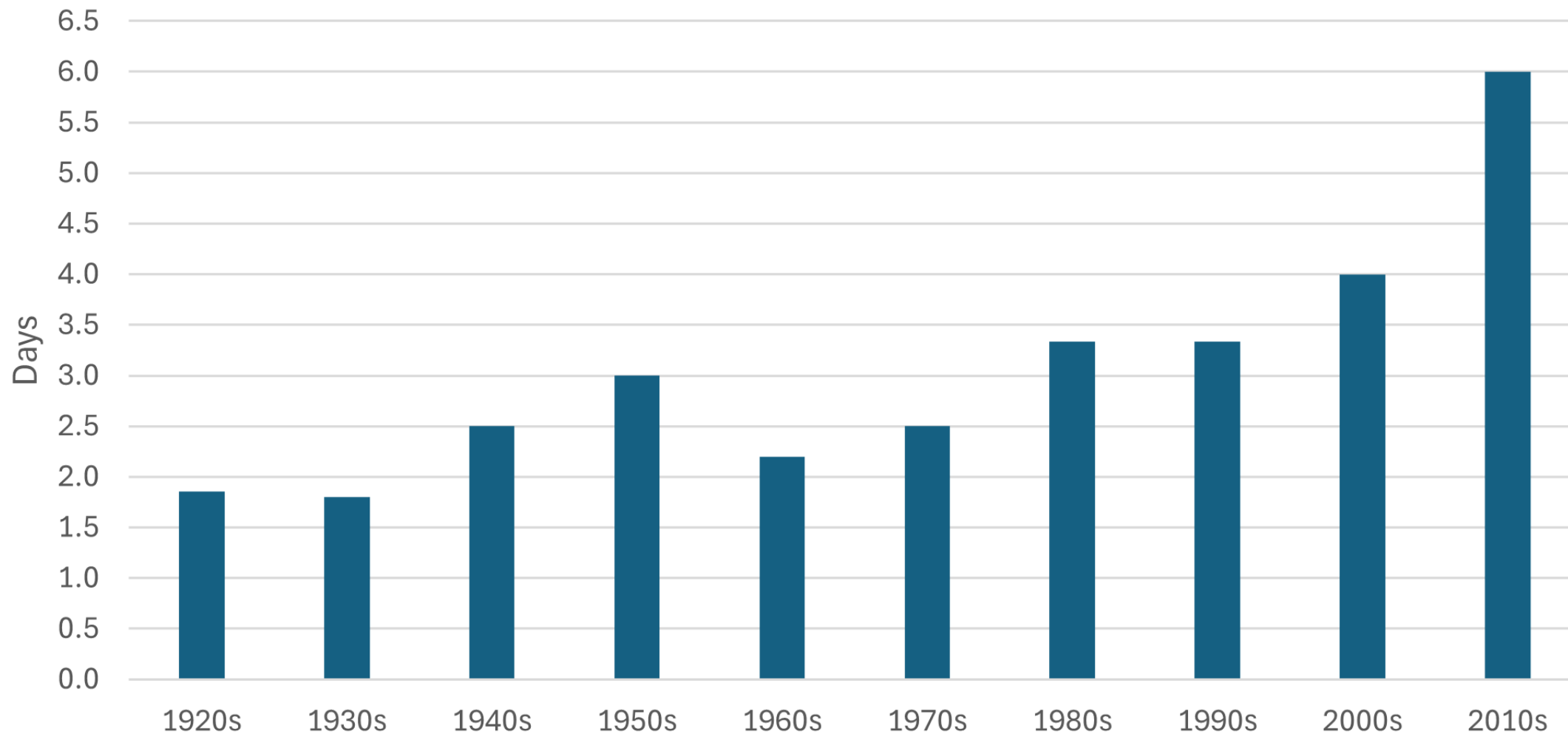
This Photo by Unknown Author is licensed under [CC BY-SA](#)

Ecological disturbances: wind, fire, drought, floods, intense rain events, air and water temperature increases



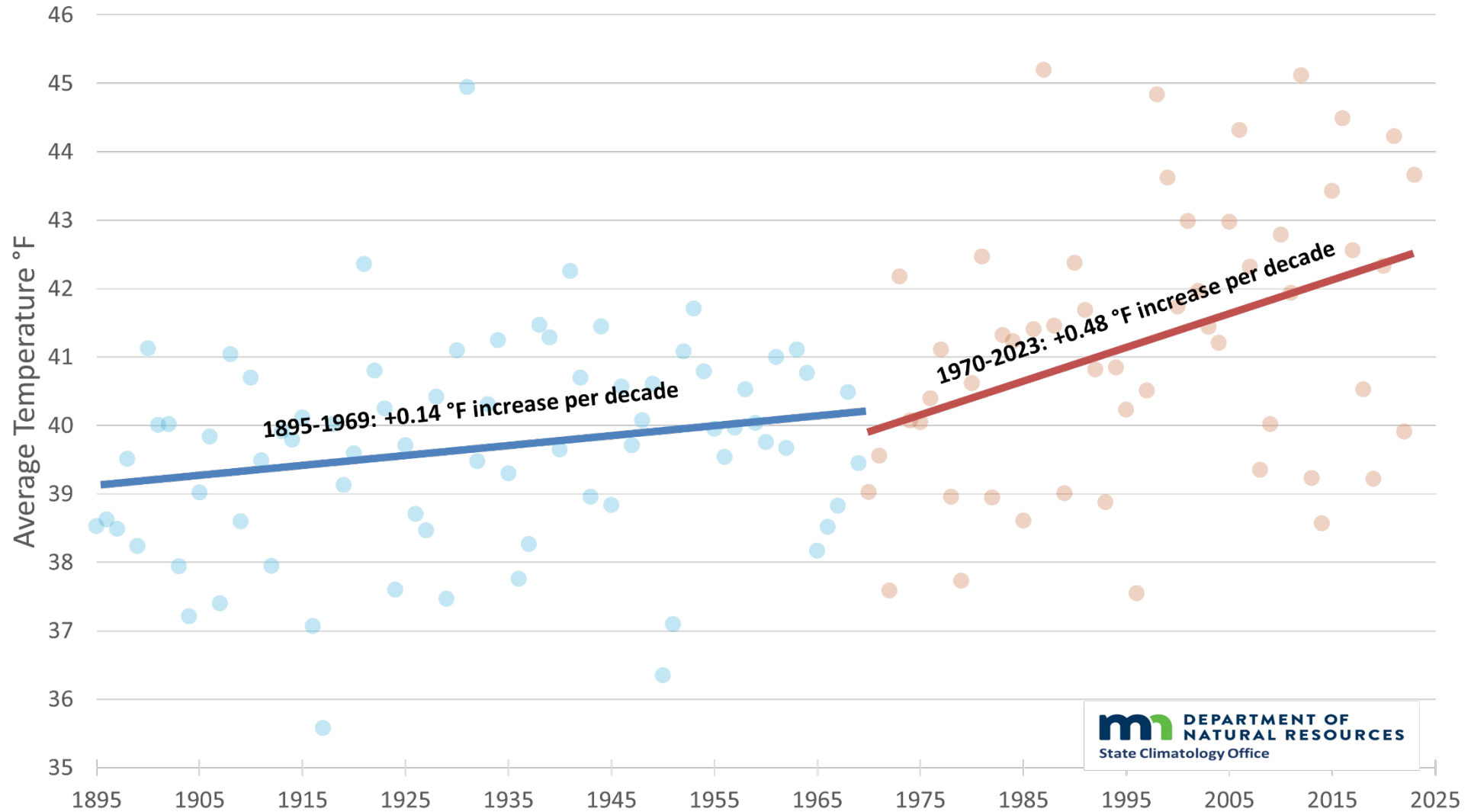
Lakes and Rivers are Getting Warmer

Number of Days per Decade with a 4-Inch, or more, Rainfall

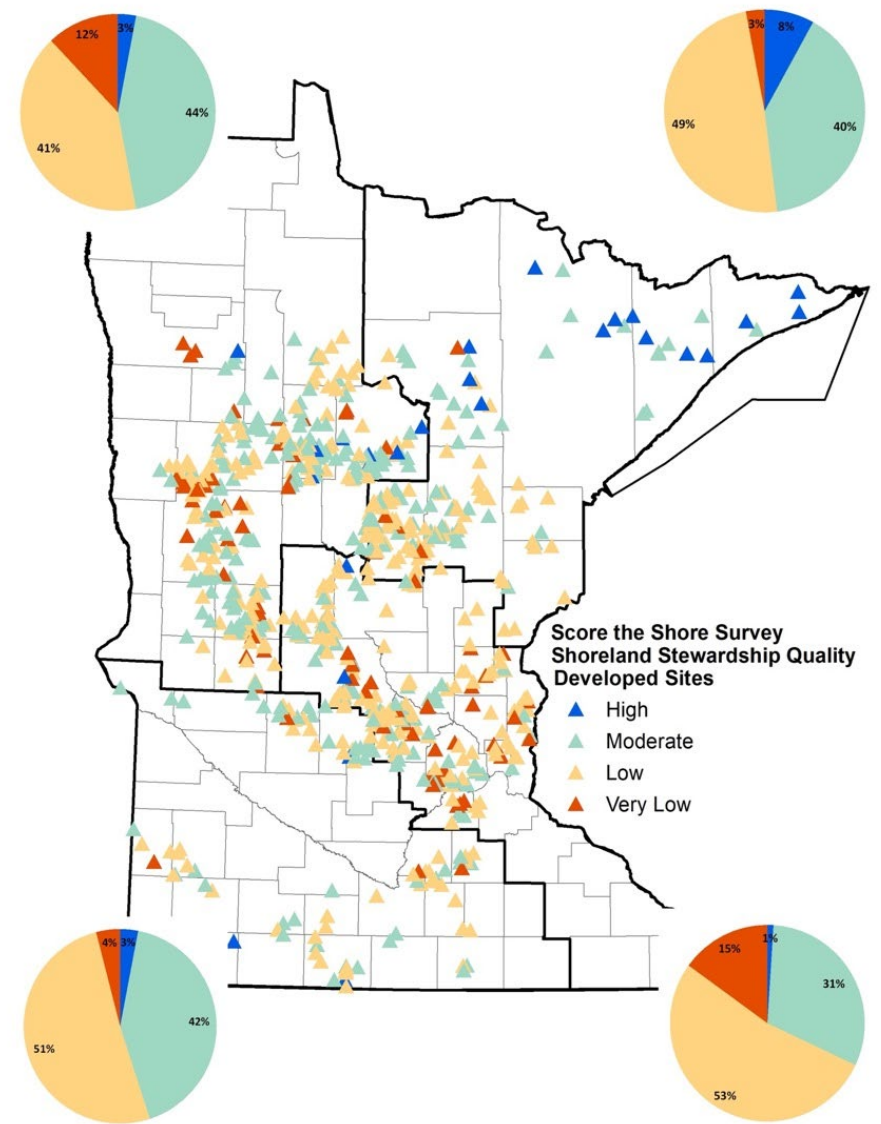


More Frequent & Extreme Rain Events

Minnesota Average Temperature, 1895-2023

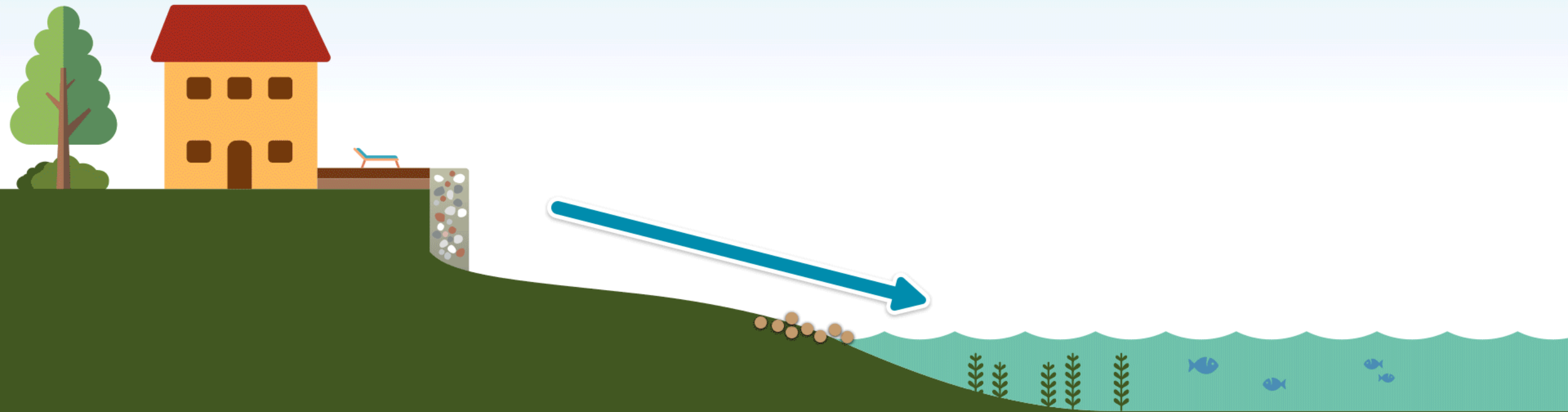
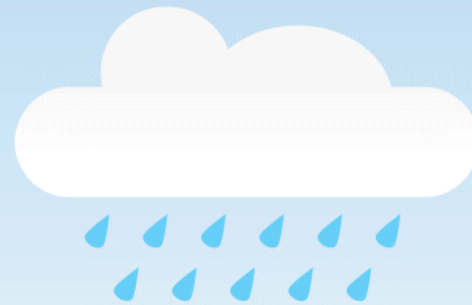


The Rate of Change or Disturbance is Accelerating



We've Lost 40-50% of our Natural Shorelines

GIF



GIF2





- Loss of nesting habitat is a substantial threat to loons
- Loons prefer vegetated, marshy habitat with good protective cover

Loss of Habitat & Species

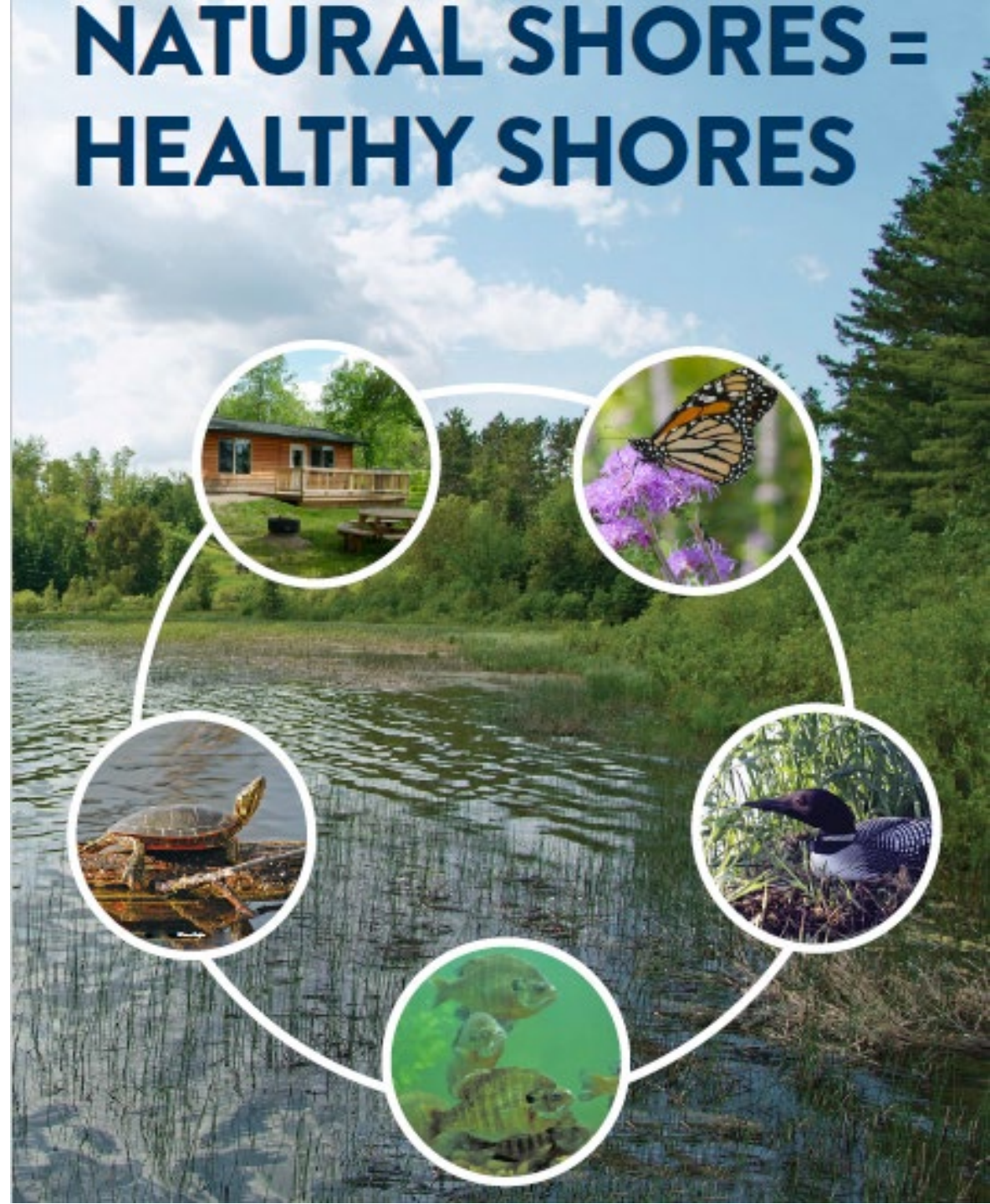


Source of Human Resiliency

Natural shorelines are our best defense against climate-related disturbances:

- **Warming waters**
- **Intense rain events**
- **Drought**
- **Floods**

NATURAL SHORES = HEALTHY SHORES





So, how do we protect and restore this important natural Defense when:

- Property owners value suburban-style landscaping
- State shoreland regulations are insufficient
- Silo approach for dealing with water quality and habitat



Local partnerships & collaboration!!

- **Local planning and zoning – regulation development & administration**
- **SWCD – habitat, restoration, practical solutions including regulations**
- **WD/WMO – Water quality expertise**
- **Lake Associations – local knowledge**



Hydrological Impacts from Intense Rain Events – Current Regulations & Gaps

Ceil Strauss, State Floodplain Manager

Climate Change Challenges

- MNDNR Climate trends site
- Includes interactive climate trends map – state or HUC8 level
- Minnesota is getting warmer and wetter, more intense storms
 - ✓ 8 of 13 “mega rains” since 2000
 - ✓ Rain event >3” increased 65% since 2000
 - ✓ Widespread rains of more than 6” are 4x more common than previous 3 decades

m DEPARTMENT OF NATURAL RESOURCES

RECREATION DESTINATIONS NATURE EDUCATION & SAFETY LICENSES, PERMITS & REGULATIONS EVENTS & SEASONS ABOUT DNR

Home > Nature > Climate > Climate Change Information

Climate Change and Minnesota

Main page
Climate trends
Impacts of climate change
What's the DNR doing?
Climate change resources

Climate Apps

Hourly Roundup
Last 3 Days MSP
Mark Seeley's WeatherTalk
Twin Cities Data
Retrieve Past Data (Twin Cities Data)
MN Climate Trends Tool
Climate Journal
Climate Change
NWS Data Retrieval
Data Summary Tables
MNgage
CoCoRaHS
Kuehnast Lecture Series

Climate

Main page
Frequently asked questions
Current conditions
Climate Change
Drought
Floods
Climate data

Climate trends

Climate trends

Minnesota's climate already is changing rapidly and will continue to do so for the foreseeable future. Temperatures are increasing -- especially in winter -- and larger, more frequent extreme precipitation events are occurring.

Substantial warming during winter and at night, increased precipitation, and heavier downpours already have affected our natural resources, and how we interact with and use them. The decades ahead will bring even warmer winters and nights, and even larger rainfalls, along with the likelihood of increased summer heat and the potential for longer dry spells.

Explore available data on historic temperature and precipitation trends throughout the state with our [Minnesota Climate Trends map](#).

Explore climate changes in Minnesota

Expand all sections

- + Minnesota keeps getting warmer and wetter
- + More damaging rains
- + Cold weather warming

Minnesota Climate Trends Site

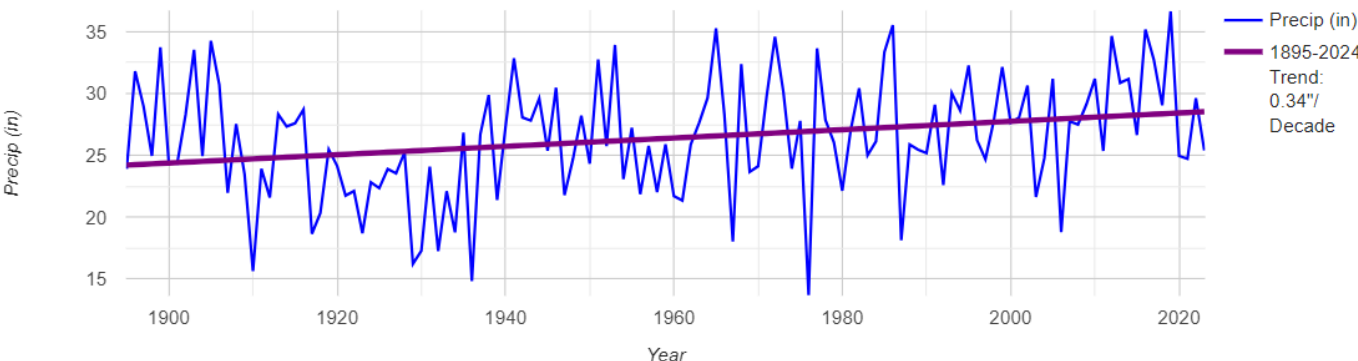
Evaluate:

- Temperature
- Precipitation

Evaluate by:

- County
- Major watershed
- Deer permit areas
- State forests or parks
- Whole state

Precipitation For Crow Wing, January-December



Download:

Year	Precip (in)	1895-2024 Trend: 0.34"/Decade
1895	23.91	24.21
1896	31.81	24.25
1897	28.98	24.28
1898	24.96	24.32
1899	33.74	24.35
1900	24.4	24.38
1901	24.34	24.42
1902	28.31	24.45
1903	33.54	24.48
1904	24.93	24.52
1905	34.26	24.55

Other Risks

- Storms during more of the year – Rain (!) in late December and January (also, ice jams & related risk in more areas and times of year)
- Shorter ice cover periods
- Longer periods of high water - Mississippi above flood stage 42 days in St. Paul (2019)
- Groundwater/high water tables
- Landslides & stream bank erosion
- Pluvial (e.g., urban flooding)
- Other unmapped: not mapped since not development pressure in 1970s/1980s (when current maps done), but now there's development; old stormwater systems

Climate Trends Outreach

- September 2024: New [Climate trends affecting lakes and river webpage](#)
- See [September 2024 Water Talk article about new site](#)

The screenshot shows the Department of Natural Resources website. The header includes the logo and navigation menu with categories: RECREATION, DESTINATIONS, NATURE, EDUCATION & SAFETY, LICENSES, PERMITS & REGULATIONS, EVENTS & SEASONS, and ABOUT DNR. A search bar is located in the top right. The breadcrumb trail reads: Home > Ecological and Water Resources > Water Management > Shoreland. The main heading is "Climate trends affecting lakes and rivers". A sidebar on the left lists "Climate trends" with sub-links: "Main page", "What is happening?" (highlighted with a red box), "What does it mean?", and "What can you do?". The main content area features a large photograph of a residential property with a significant bank erosion along a water body. A text overlay on the photo reads: "Climate trends are accelerating harm to our lakes and rivers not protected by natural shoreline vegetation". A photo credit at the bottom right states: "Photo courtesy of Murray County".

Climate Trends: What is happening?

The screenshot shows the Minnesota Department of Natural Resources website. The main heading is "Climate Trends: What is happening?". Below this, there is a photograph of a stone bridge over a stream with the text "More extreme rain events. Lakes and rivers are getting warmer". To the right of the photo is a list of bullet points: "Lakes and rivers are getting warmer", "During July and August, Minnesota lakes are about 5.05 + 5.78° Fahrenheit warmer now, on average, than 50 years ago.", and "Minnesota lakes have lost an average of 10 to 14 days of ice cover in the past 50 years." Below the text is a line graph titled "Average July Lake Temperatures - All Minnesota Lakes" showing a steady upward trend from 1950 to 2015. Further down, there is a bar chart titled "Number of Days per Decade with a 1-inch, or more, rainfall" showing an increasing number of days over time. At the bottom, there is a line graph titled "Maximum July Stream Temperature, 1918-2015" showing a significant increase in temperature over the period.

What are the climate trends in my community?

Most Minnesota communities are experiencing similar trends, but there are some variations throughout the state. These climate resource tools can help understand climate trends for your community:

[Minnesota Climate Explorer](#) - This DNR-developed web tool allows users to view, graph, and download historical and projected future data for average, minimum and maximum temperature, and precipitation statewide, as well as at the county, watershed, and other management levels.

[Surface Water and Climate Data Viewer](#) - This MPCA-developed web tool allows users to view, graph, and download surface water temperatures for lakes and streams for individual lakes and streams or lakes and streams grouped by county, region and statewide.

[Minnesota CliMAT](#) - This University of Minnesota interactive online tool offers highly localized future climate information for Minnesota communities down to a 2.5-mile scale.

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Minnesota Climate Explorer Site – Includes Projected (Future) Options

Minnesota Climate Explorer
 DNR Analyze Minnesota's historical or projected future climate. [FAQs](#)
 Questions? climate.dnr@state.mn.us

HISTORICAL | **PROJECTED (FUTURE)**

AREA

Select a geographic unit: ①
Counties ▾

Select area(s):
If selecting multiple areas, they must be adjacent.

Crow Wing ▾

Selected areas CLEAR

Crow Wing

DATA OPTIONS

Select a climate variable: ①
Precipitation ▾

Portion of year to analyze: ①
Time scale (sum): Annual ▾
Month ending: January ▾

PLOT DATA CLEAR DATA OPTIONS

Metadata Download Data:

Recent and Projected Future Precipitation For Crow Wing: January-December
 Graph generated by Minnesota Department of Natural Resources using data from University of Minnesota climate modeling. These values may differ from those published in national and global climate assessments.

Legend: Model Mean (blue), BCC-CSM1-1 (green), CCSM4 (yellow), CMCC-CM (red), CNRM-CM5 (cyan), GFDL-ESM2M (teal), IPSL-CM5A-LR (orange), MIROC5 (purple), MRI-CGCM3 (pink)

Time Period	Model Mean	BCC-CSM1-1	CCSM4	CMCC-CM	CNRM-CM5	GFDL-ESM2M	IPSL-CM5A-LR	MIROC5	MRI-CGCM3
1980-1999 Modeled Present	30	25	30	50	30	30	75	30	30
2040-2059 Mid-Century (RCP 4.5)	25	20	25	55	25	25	60	25	25
2080-2099 Late-Century (RCP 4.5)	20	15	20	80	20	20	65	20	20
2080-2099 Late-Century (RCP 8.5)	15	10	15	70	15	15	75	15	15

Evaluate:

- Temperature
- Precipitation

Evaluate by:

- County
- Major watershed
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Climate Trends: What does this mean?

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RECREATION DESTINATIONS NATURE EDUCATION & SAFETY LICENSES, PERMITS & REGULATIONS EVENTS & SEASONS ABOUT DNR

Home > Ecological and Water Resources > Water Management > Shoreland > Climate trends

Climate trends

- Main page
- What is happening?
- What does it mean?**
- What can you do?

Climate Trends: What does this mean?



Lakes and rivers not protected by natural vegetation are more vulnerable


Photo courtesy of Rick Moore

Natural vegetation along shorelines and steep slopes protects property along lakes and rivers with functional and attractive natural engineering systems that hold soil in place in the face of more intense rain events. Natural vegetation also reduces phosphorus from entering our warming waters limiting rapid algae growth and the loss of fish, wildlife, and human health and recreational use of our lakes and rivers.

More shore erosion, land loss, and flooding

Increased rain and intense driving rainfall increases flooding risk and erosion, especially on slopes and shorelines with no natural vegetation to hold soil in place. See how vegetation loss makes property more vulnerable to climate trends.


[How vegetation loss makes property more vulnerable to erosion and flooding »](#)



More algae - loss of clean water and habitat

Algae needs phosphorus to grow, and algae grows faster in warmer water. Phosphorus is a common nutrient in sediment and in the runoff from lawns and hard surfaces. Limited amounts of phosphorus are important but too much increases algae growth resulting in loss of clean water, habitat and wildlife. See how vegetation loss makes lakes and rivers more vulnerable to climate trends.

[How vegetation loss makes lakes more vulnerable to algae growth »](#)



Climate Trends: What does this mean?



Photo courtesy of Rick Moore

Climate Trends Webpage

In “What does it mean?” section, animations help tell the story

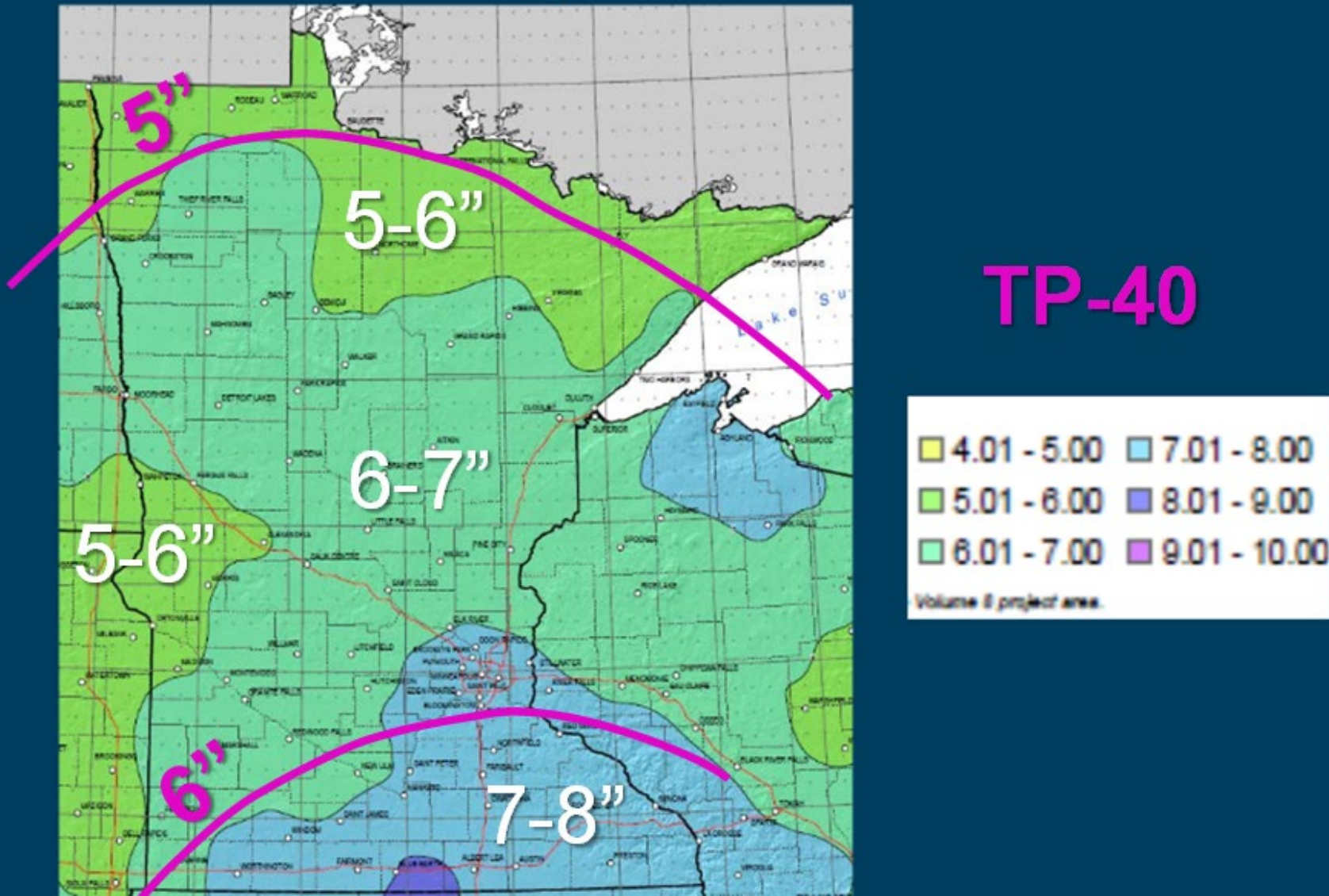
- [Water quality webpage](#)
- [Shore erosion/flooding webpage](#)

Contemporary shoreline development + climate trends

Contemporary shoreline development + climate trends



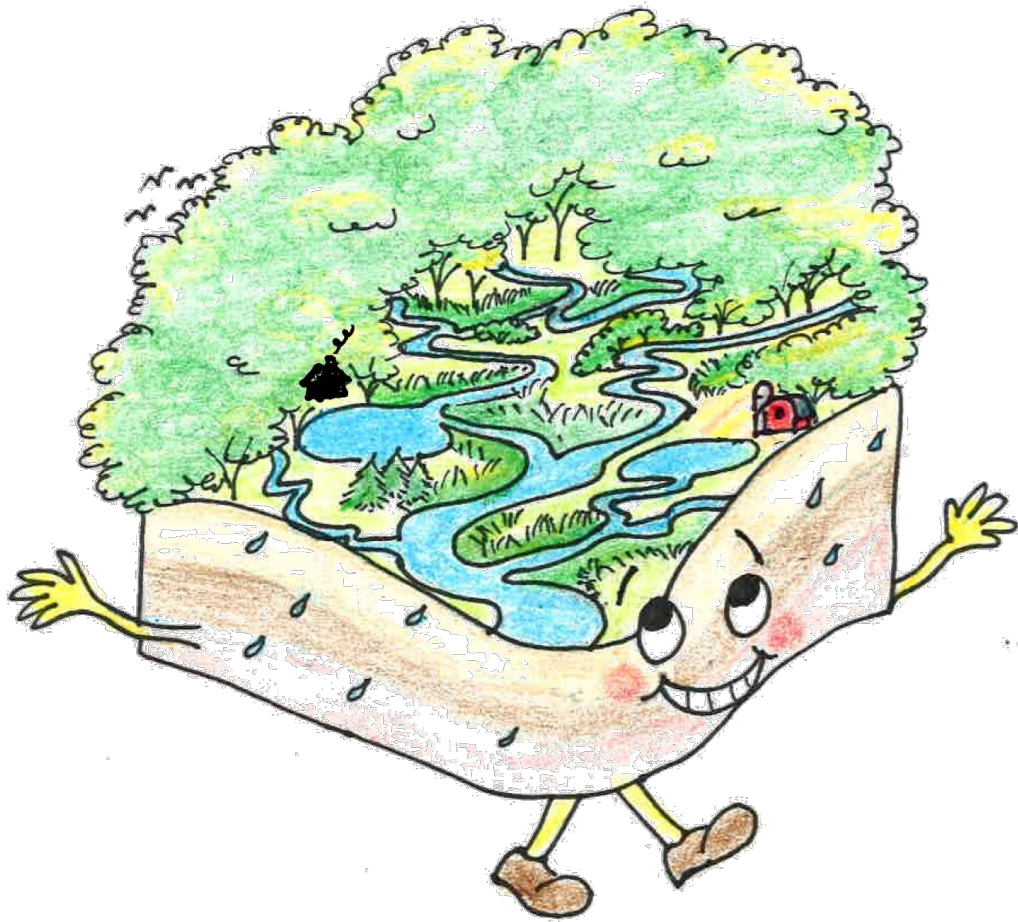
Technical Paper 40 (1960) versus Atlas 14 (2013) versus Future Trends



- Older maps based on TP 40 versus Atlas 14 (or other more up to date methods, e.g. gages, regression equations)
- Atlas 14 is based on updated historical records (no future projections)
- New Atlas 15 just coming out – includes future trends

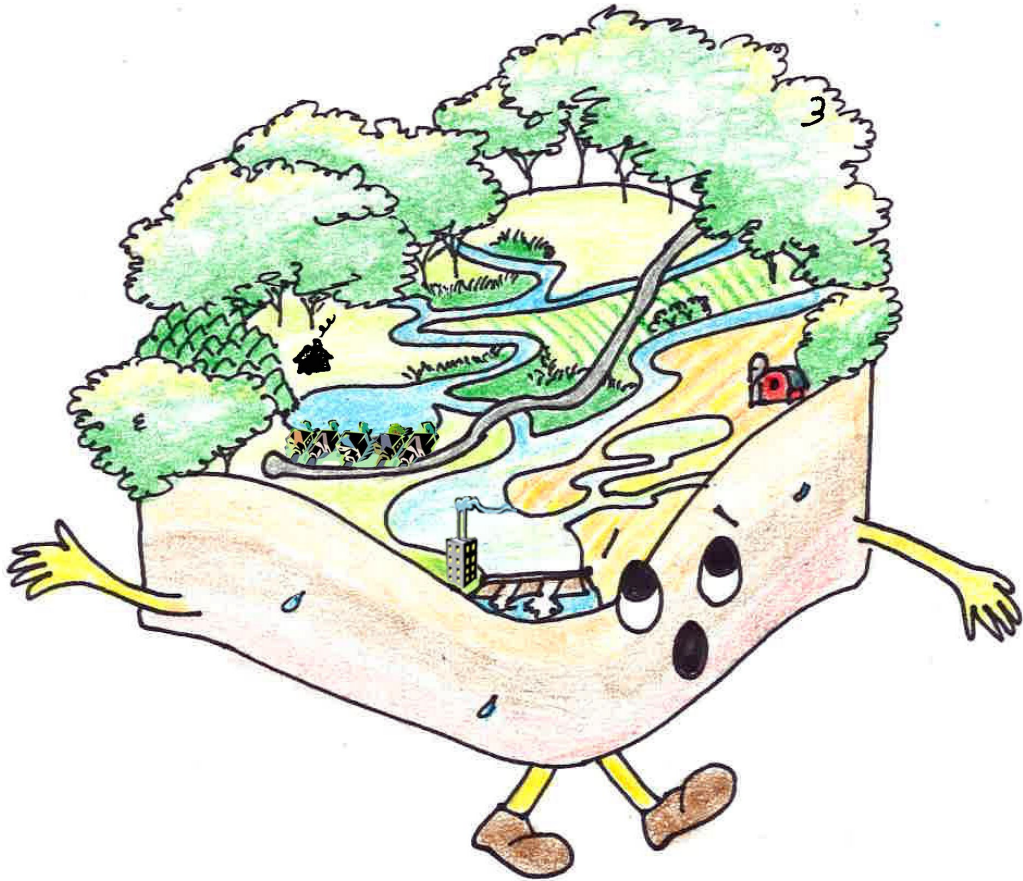
Meet Walter Watershed!

Walter was a healthy watershed.



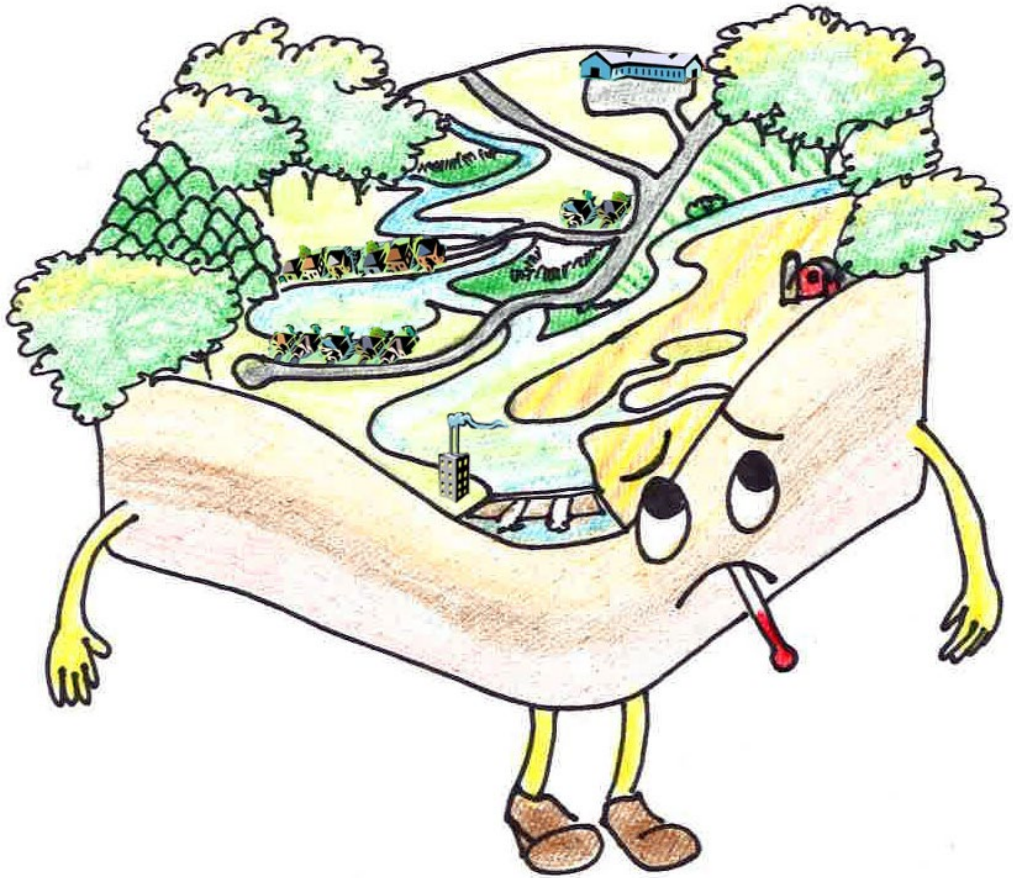
- Free flowing streams & rivers
- Diverse plants & animals
- Clean water
- Stable stream banks & soils
- Good infiltration & storage

Over time, Walter began noticing some changes...



- Interrupted flow & diversions
- Receding tree line
- Chemicals & sediments in water
- Eroding stream banks & soil loss
- Clogged pores & less infiltration

Today, Walter isn't feeling so hot. How can we help Walter?



- Disconnected & blocked waterways
- Unwanted vegetation loss
- Brown water & algae blooms
- Undercut banks & severe erosion
- Poor drainage & infiltration

Overall Impacts We Want to Reduce/Prevent

- More runoff

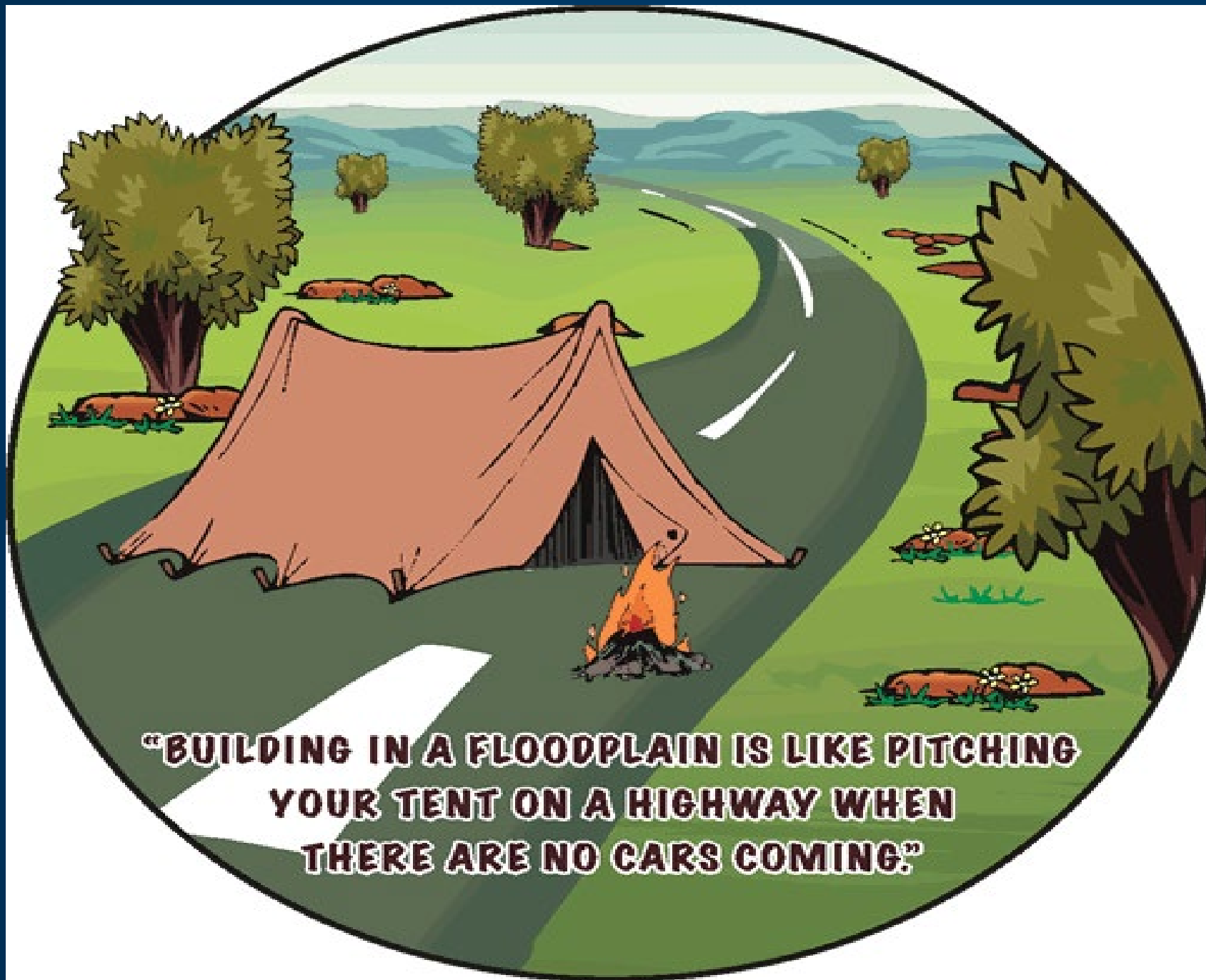
- ✓ Retain/restore/add natural vegetation
- ✓ Retain/restore/add storage areas
- ✓ Reduce impervious surfaces

- Eroded banks/shorelines

- ✓ Reduce runoff quantity
- ✓ Reduce runoff peaks
- ✓ Retain/restore natural vegetation

- Higher water levels

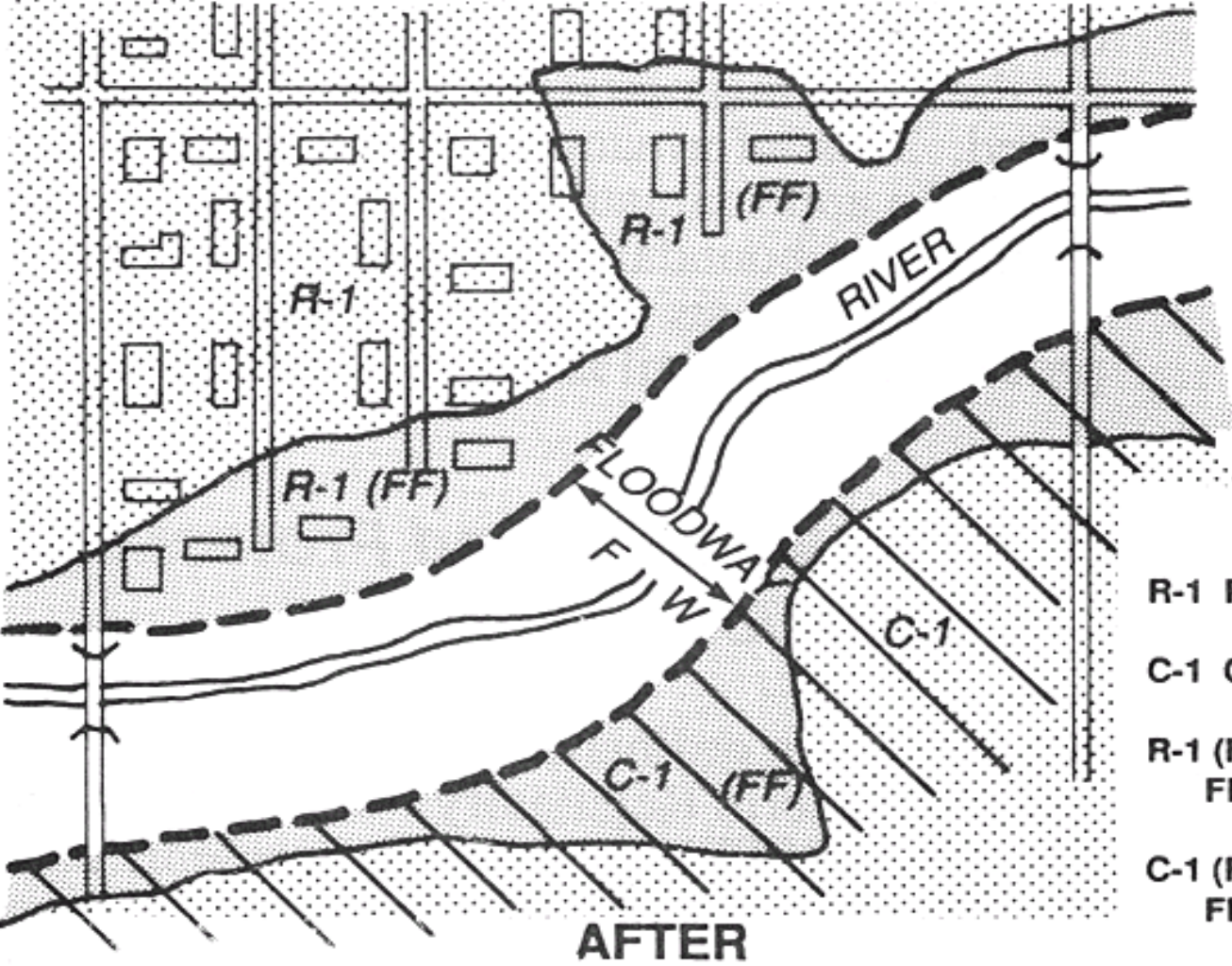
- ✓ Keep new construction out of floodprone areas and setback from banks/shorelines
- ✓ Elevate any new construction/reconstruction/additions that are allowed








Very Basics for Floodplain Zoning Requirements

Source: Rob Pudim

Top View of Floodway vs Flood Fringe

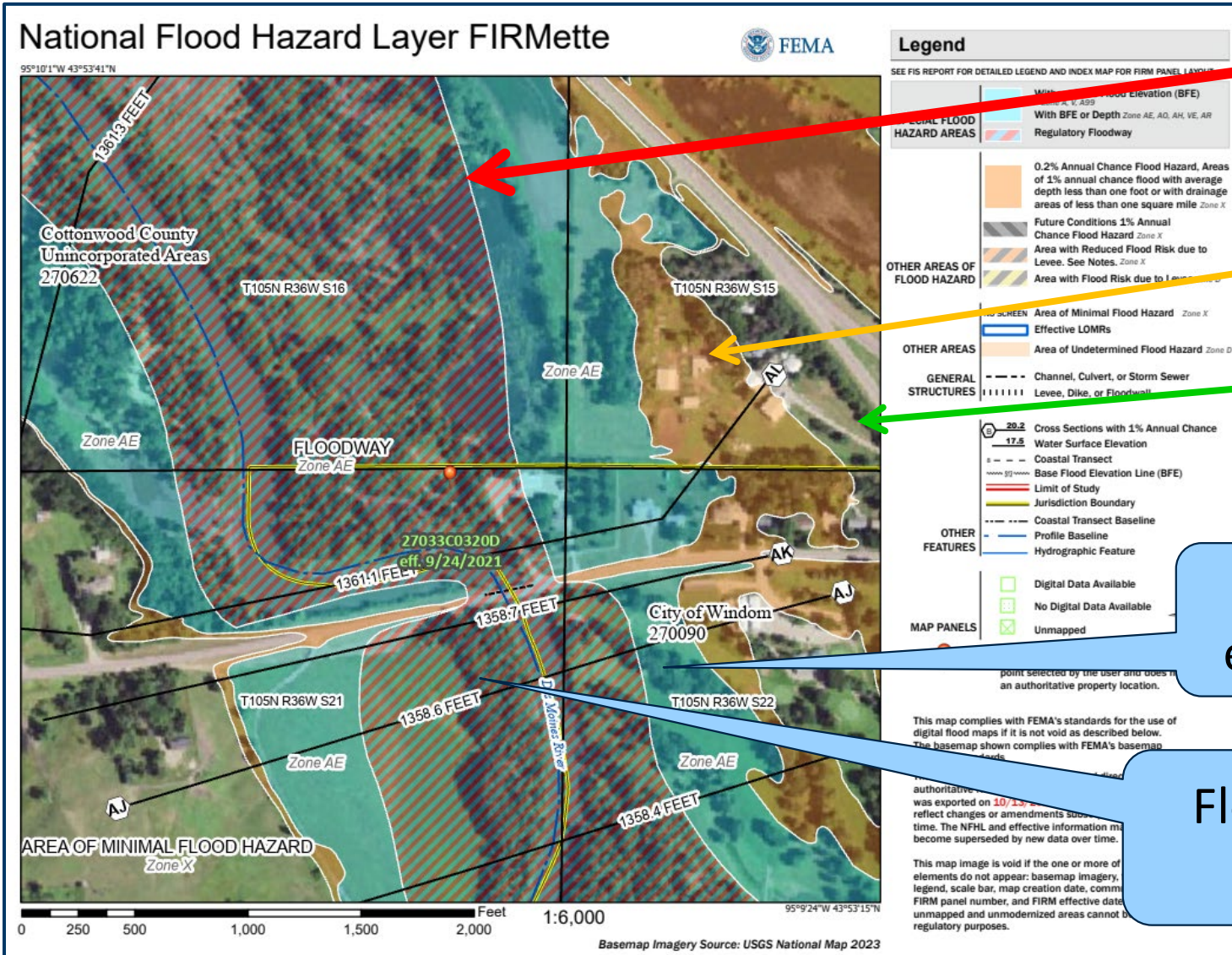


FLOOD FRINGE
FLOODWAY
FLOOD FRINGE

R-1 Residential	
C-1 Commercial	
R-1 (FF) Residential Flood Fringe	
C-1 (FF) Commercial Flood Fringe	
FW Floodway	

- Very restrictive in floodway:**
- No new buildings
 - No expansion so existing buildings
 - Hydraulic analysis for any grading/filling

FEMA Map with Special Flood Hazard Area (SFHA)



High Flood Risk (must require flood insurance and regulate)

Medium Flood Risk

Low Flood Risk

Flood Fringe (blue overlay) – elevation/flood proofing standards

Floodway (red & blue hatched area) – very restrictive zoning

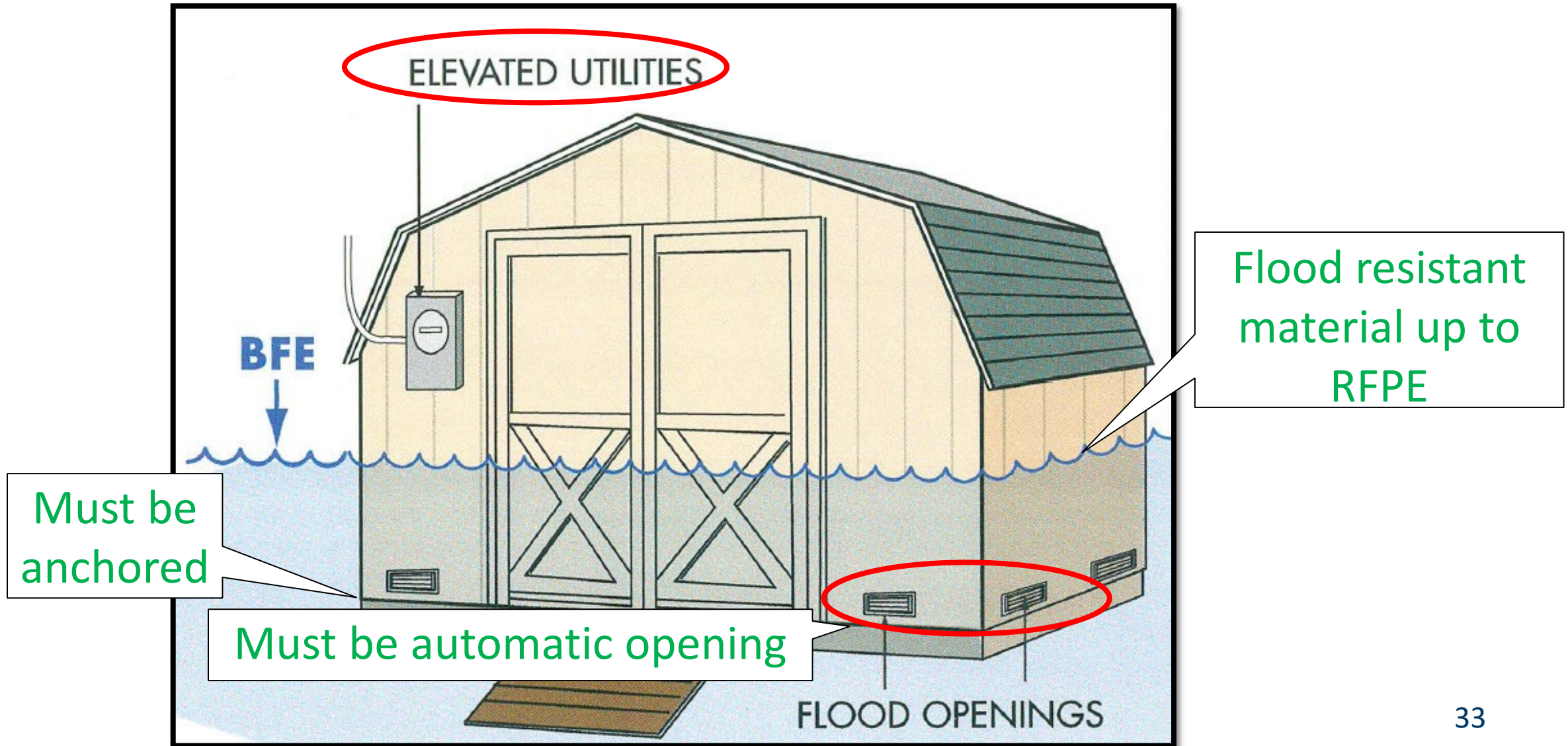
Minimum Elevation Requirements in Flood Fringe

- Structures elevated on fill
- Structures can be elevated on pilings, piers, or perimeter walls (for residential, a CUP is required)*

* In older versions of DNR's state model floodplain ordinance, a CUP is required for non-residential also.

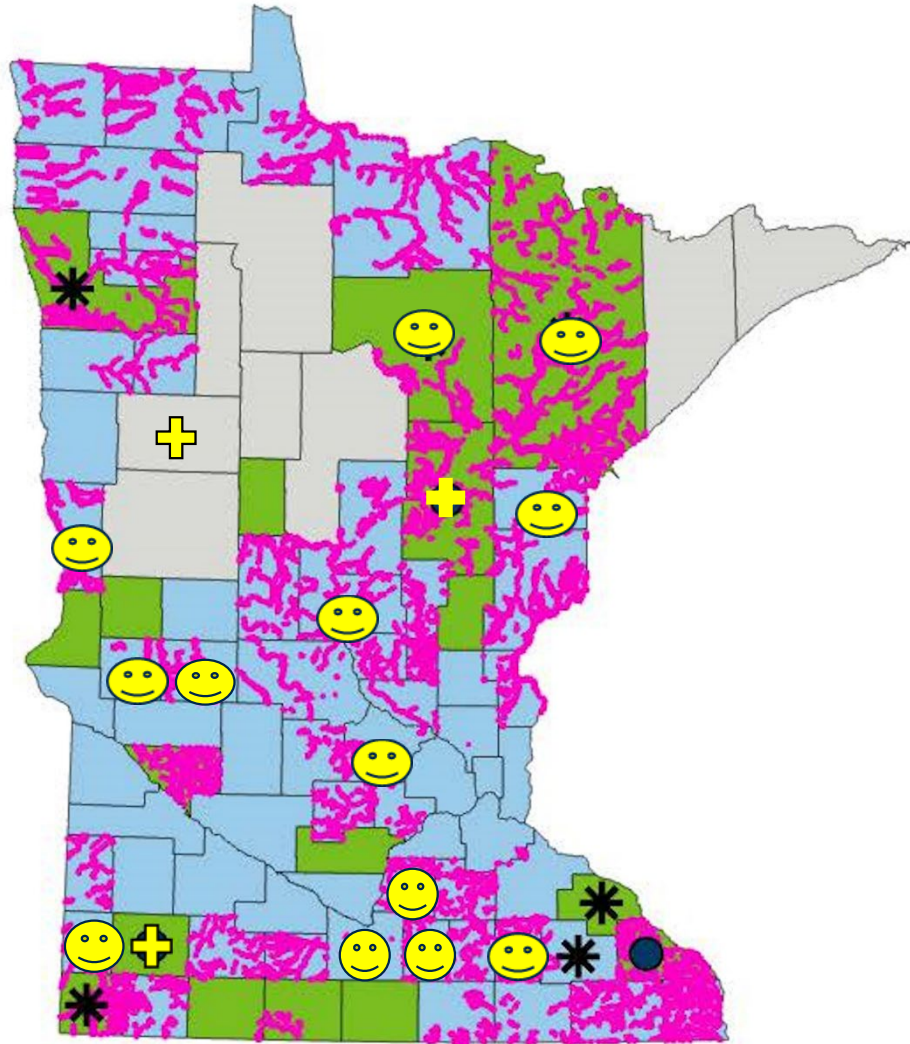


Accessory Structures less than 576 SF & Used only For Parking and/or Storage



Mapping Updates Flood Insurance Rate Maps (FIRMs)

Updates of this map on DNR's [Find Flood Maps page](#)



😊 New DFIRM in Dec. 2023 to March 2025

□ DFIRM Counties

□ Paper Map Counties

□ Unmapped Counties

— Estimated 1% Base Flood Elevations

✱ Preliminary DFIRMs Available

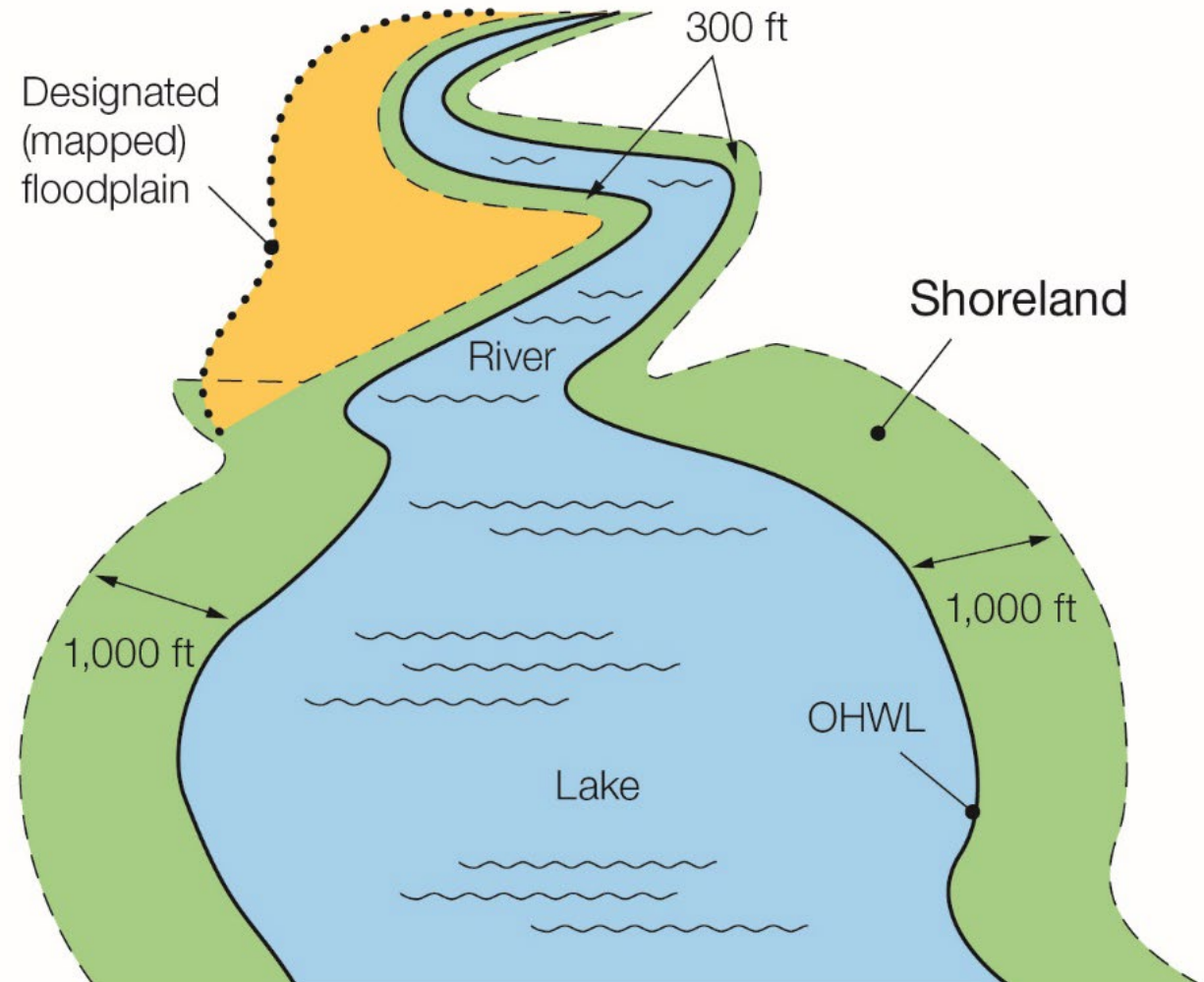
● Countywide Modernization

+ Funded through Preliminary
New Maps

Within Shoreland Districts (also adopted in 1969) Also Have Minimum Lowest Floor Requirements

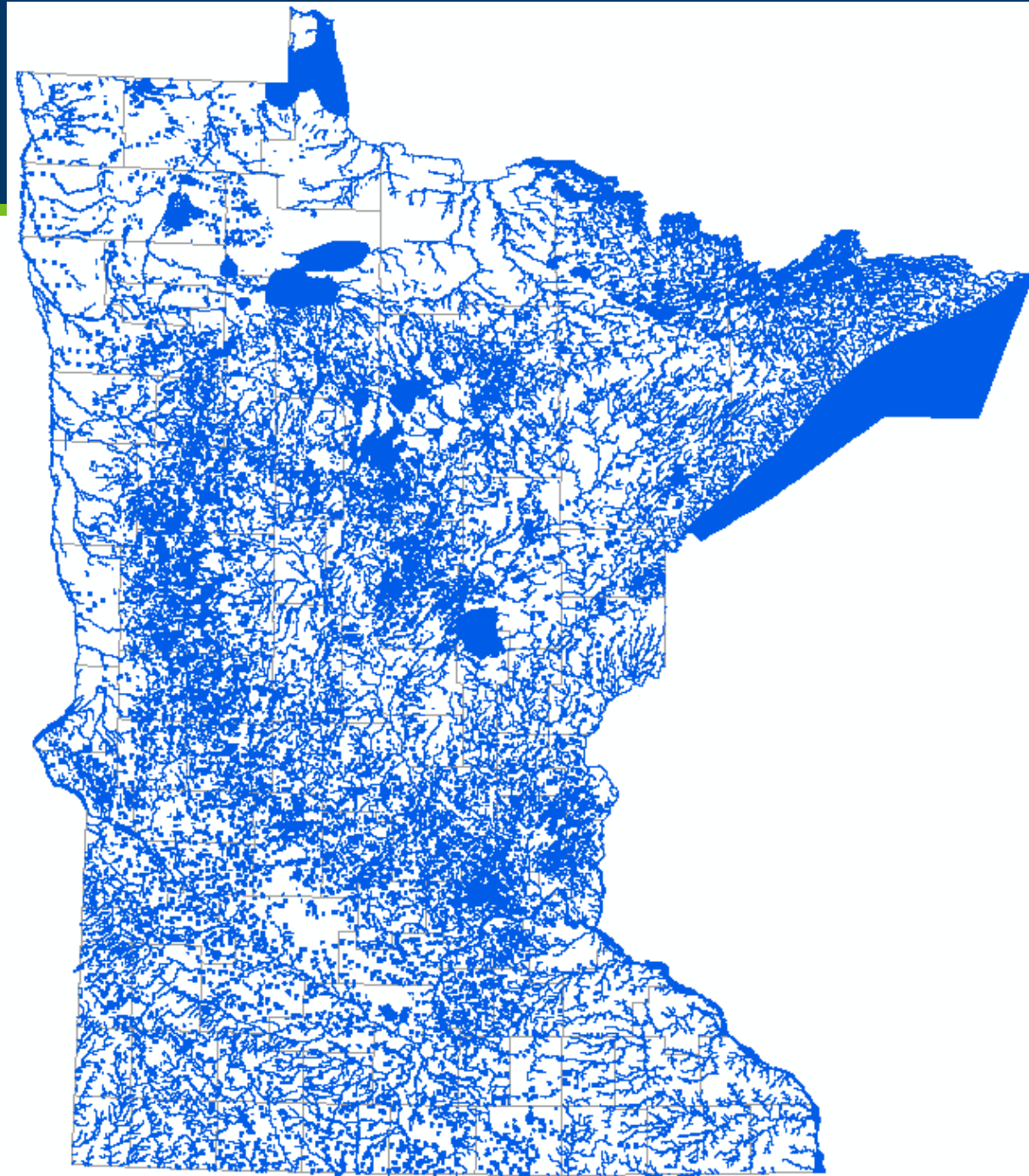
- 1000 feet from OHWL for lakes
- 300 feet from OHWL for rivers/streams or floodplain boundary, whichever is greater

Boundaries of District



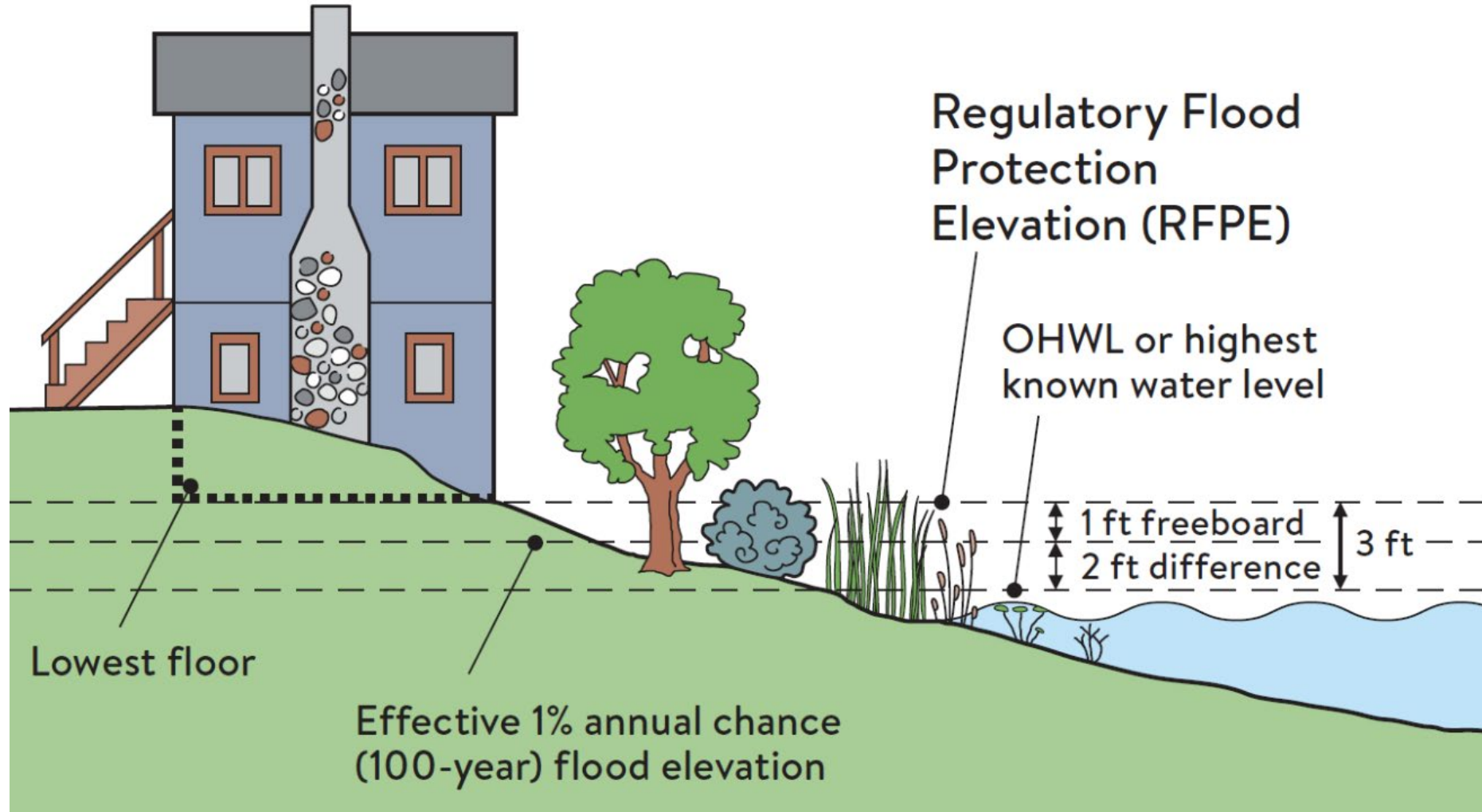
Public Waters with Shoreland

- Lakes:
 - ✓ ≥ 25 acres in counties
 - ✓ ≥ 10 acres in cities
- Lakes includes “Type 3, 4, & 5” wetlands
- Watercourses draining > 2 square miles



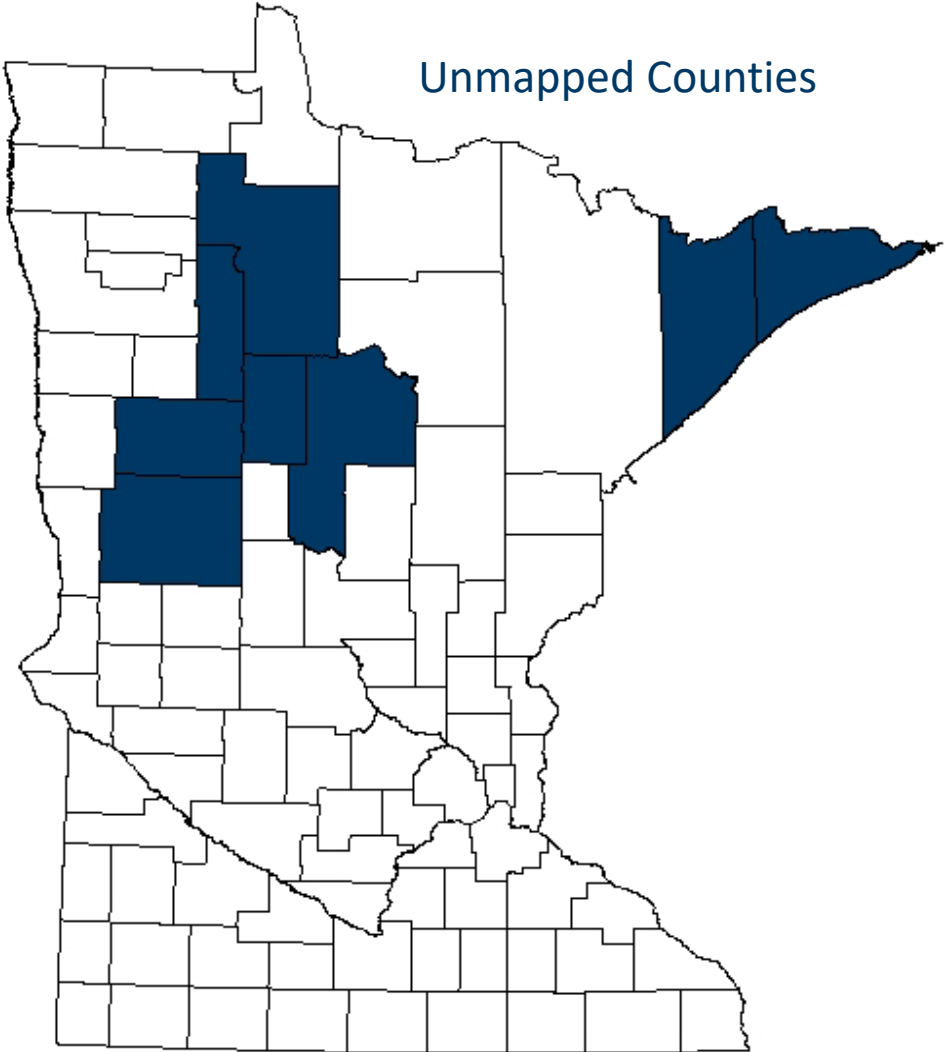
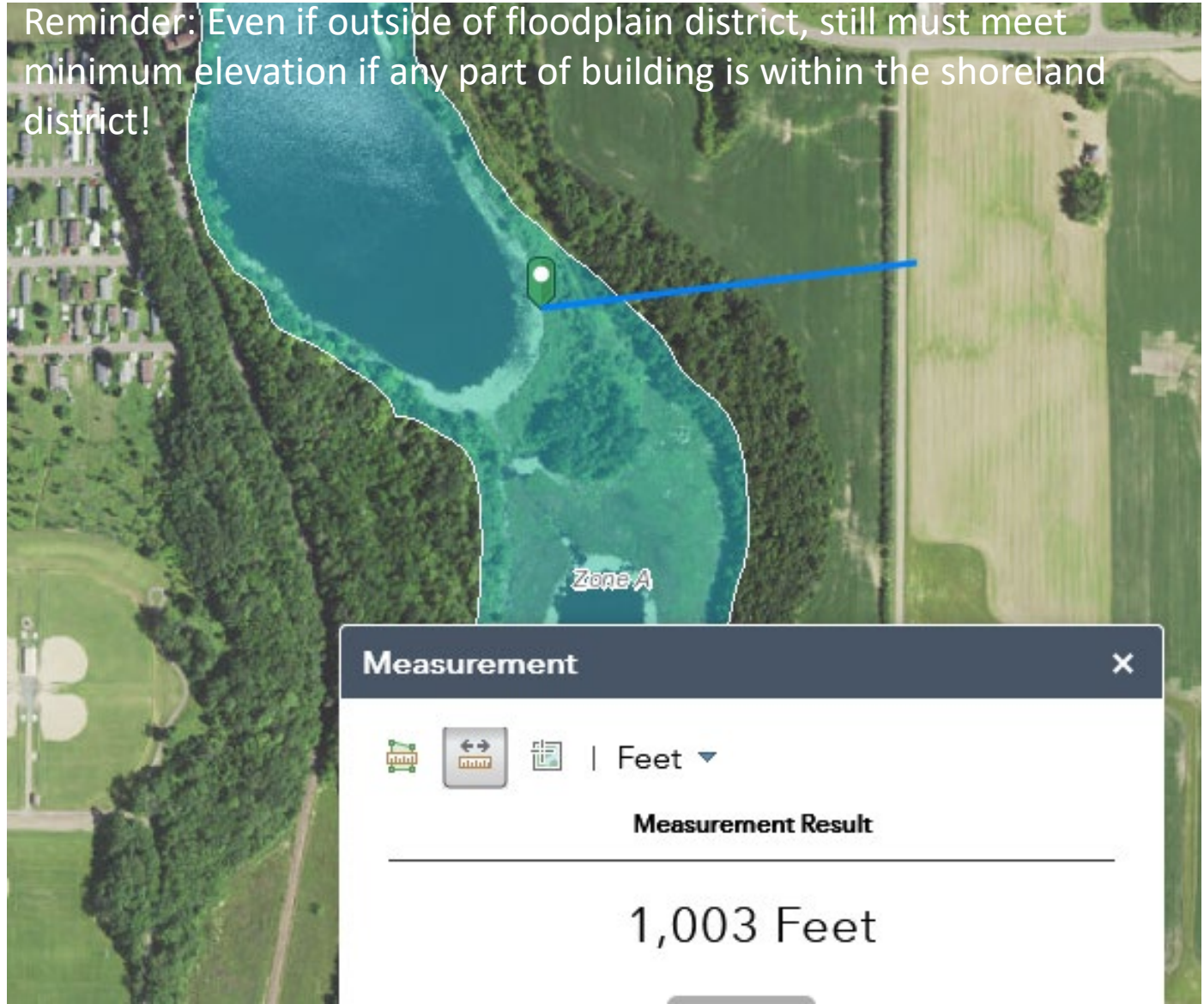
Minimum Elevation Standard

- Applies within whole Shoreland District, whether in or out of mapped floodplain
- If no BFE determined, use highest of OHWL or HKWL plus 3 feet for lowest floor



Minimum Elevation Standard2

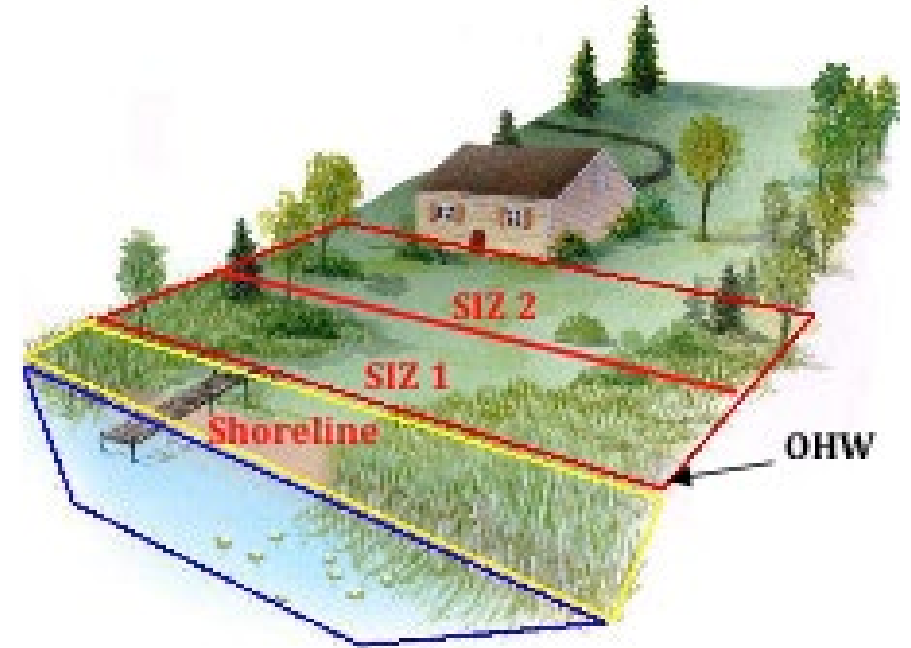
Reminder: Even if outside of floodplain district, still must meet minimum elevation if any part of building is within the shoreland district!



Example Shoreland Regulatory Requirements



Lot size

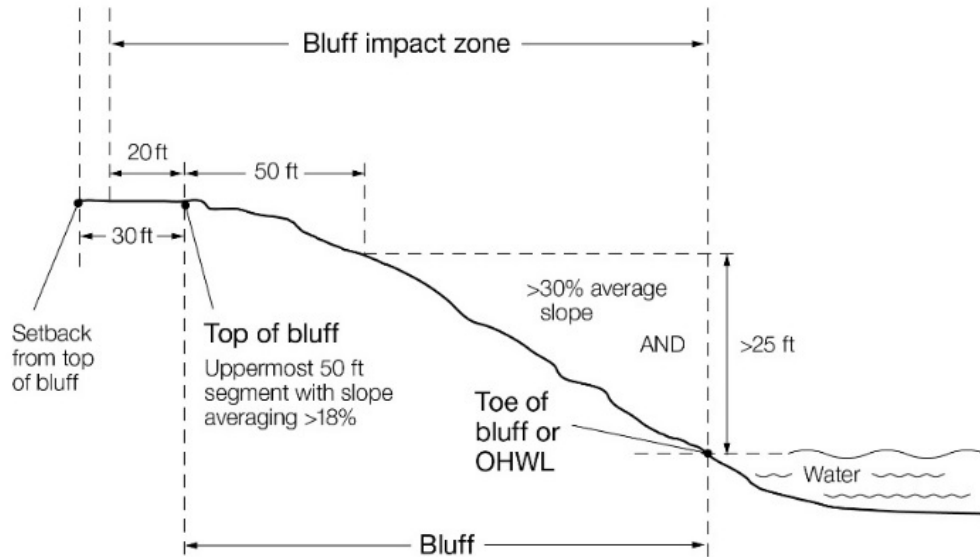


Structure & septic setbacks from OHWL;
Limits in Shore Impact Zone (SIZ)



Vegetation management,
Aesthetics/screening

Example Shoreland Regulatory Requirements2



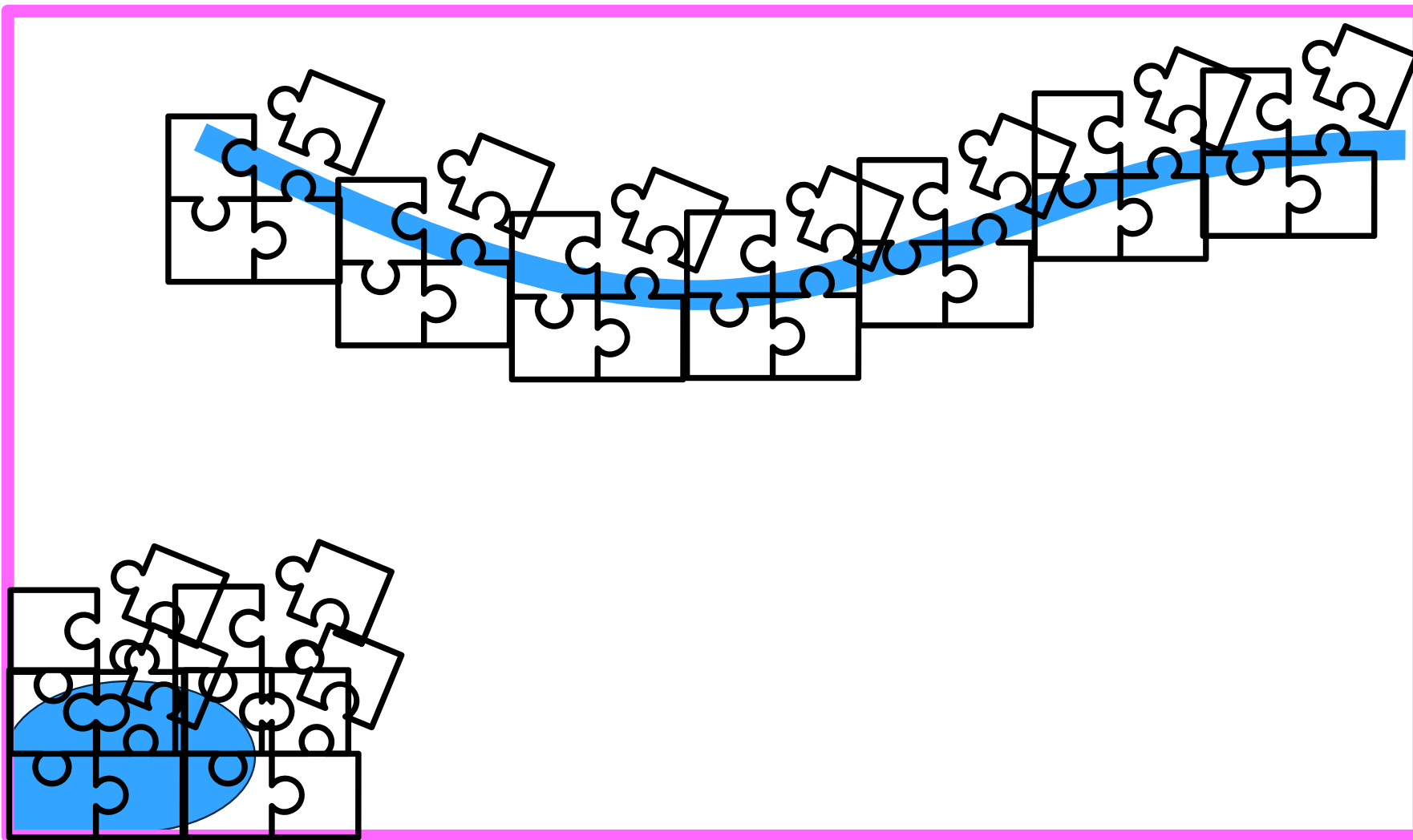
Impervious Surface Limits

Bluff protections: Why?

- Risk to property
- Erosion & sedimentation
- Loss of natural scenic beauty through visible placement of structures



State Laws Are Only Part of the Puzzle to Help Walter



Community
boundary

Other Natural Benefits / Balancing

- Less loss of shoreline and erosion (less spent on expensive repairs)
- Flooding (public safety; costs to repair/replace)
- Water quality (tied to higher property values)
- Habitat



What Can Communities Do?

Use variety of tools:

- Higher regulations
- Watershed level planning & prioritizing
- Risk communication
- Updated policies for community actions
- Educate on options / Encourage / cost-share



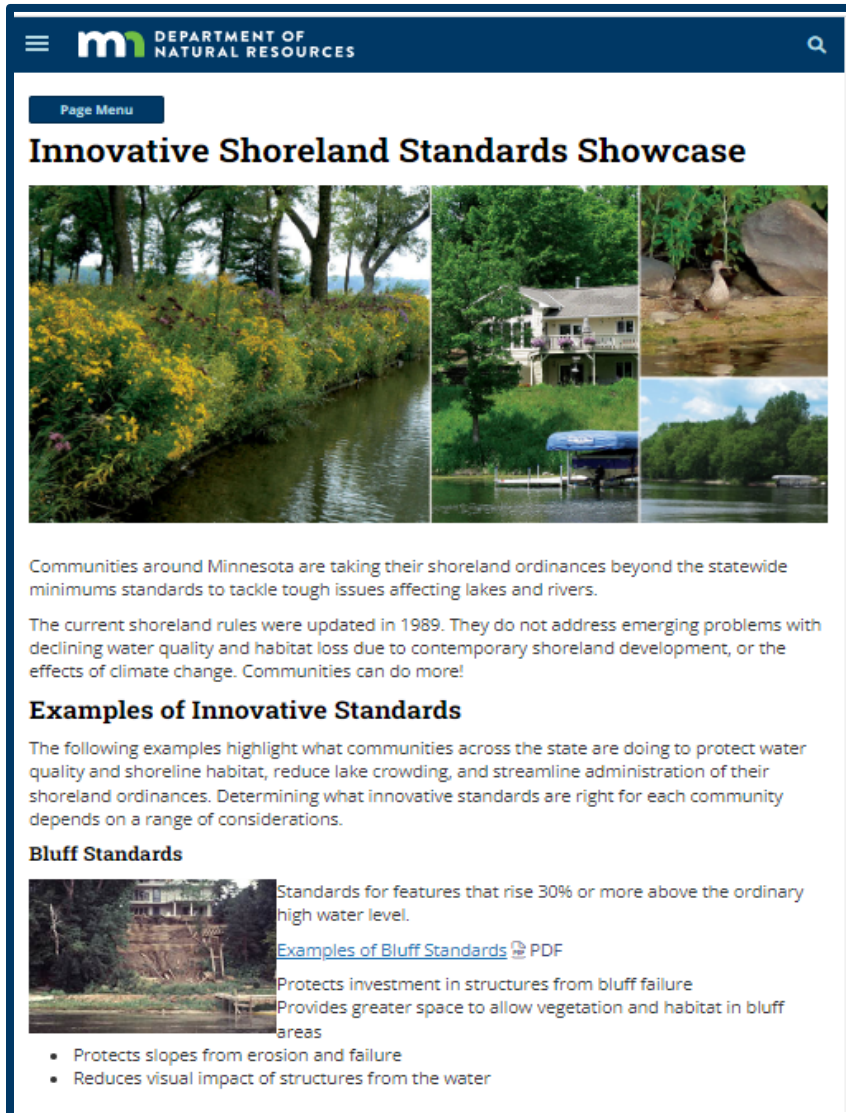
Examples of Higher Standards in MN Model Floodplain Ordinance

In [MN model floodplain ordinance](#) with **blue bold** & note it's optional:

- Critical Facilities outside of .2% (or higher freeboard)
- Dry land access: no more than 2' below RFPE (0.5-1' below BFE)
- Cumulative substantial improvement determination (since ordinance adopted) – could specify other time period (i.e., 10 years)
- Substantial damage based on Increased Cost of Compliance (ICC) Rep Loss language

Most communities adopt these. Many fewer adopted when separate language was provided to insert.

See Innovative Shoreland Standards Showcase




The screenshot shows the Minnesota Department of Natural Resources website. At the top left is the logo with the letter 'm' and the text 'DEPARTMENT OF NATURAL RESOURCES'. A search icon is at the top right. Below the header is a 'Page Menu' button. The main heading is 'Innovative Shoreland Standards Showcase'. Below this is a collage of five images: a river with yellow flowers, a house on a hill, a rocky shore with a turtle, a boat on a lake, and a forested shoreline. Below the images is a paragraph of text, followed by a section titled 'Examples of Innovative Standards' with another paragraph. The 'Bluff Standards' section includes a small image of a bluff, a description, a PDF link, and a list of bullet points.

DEPARTMENT OF NATURAL RESOURCES

Page Menu

Innovative Shoreland Standards Showcase




Communities around Minnesota are taking their shoreland ordinances beyond the statewide minimum standards to tackle tough issues affecting lakes and rivers.

The current shoreland rules were updated in 1989. They do not address emerging problems with declining water quality and habitat loss due to contemporary shoreland development, or the effects of climate change. Communities can do more!

Examples of Innovative Standards

The following examples highlight what communities across the state are doing to protect water quality and shoreline habitat, reduce lake crowding, and streamline administration of their shoreland ordinances. Determining what innovative standards are right for each community depends on a range of considerations.

Bluff Standards



Standards for features that rise 30% or more above the ordinary high water level.

[Examples of Bluff Standards](#) PDF

Protects investment in structures from bluff failure
Provides greater space to allow vegetation and habitat in bluff areas

- Protects slopes from erosion and failure
- Reduces visual impact of structures from the water

[Innovative Shoreland Standards Link](#)

- See groupings of higher standard ideas
- Includes language from different community ordinances
- Floodplain page like this is coming

See Innovative Shoreland Standards Showcase3

Land Alteration Standards



Standards that guide land disturbance and grading activities in sensitive areas.

[Examples of Land Alteration Standards \(PDF\)](#)

- Prevents sedimentation and flow of nutrients into surface waters
- Reduces risk of slope and bluff failure
- Retains vegetation

Vegetation Management Standards



Standards that promote the protection and restoration of near-shore vegetation for habitat, water quality and aesthetic purposes.

[Examples of Vegetation Management Standards \(PDF\)](#)

- Slows runoff into waterbodies, encouraging groundwater recharge
- Infiltrates runoff and filters nutrients and pollution
- Provides habitat
- Enhances natural lakeshore character
- Anchors the soil, reducing erosion

Plymouth Minimum Elevations & Riparian Buffers

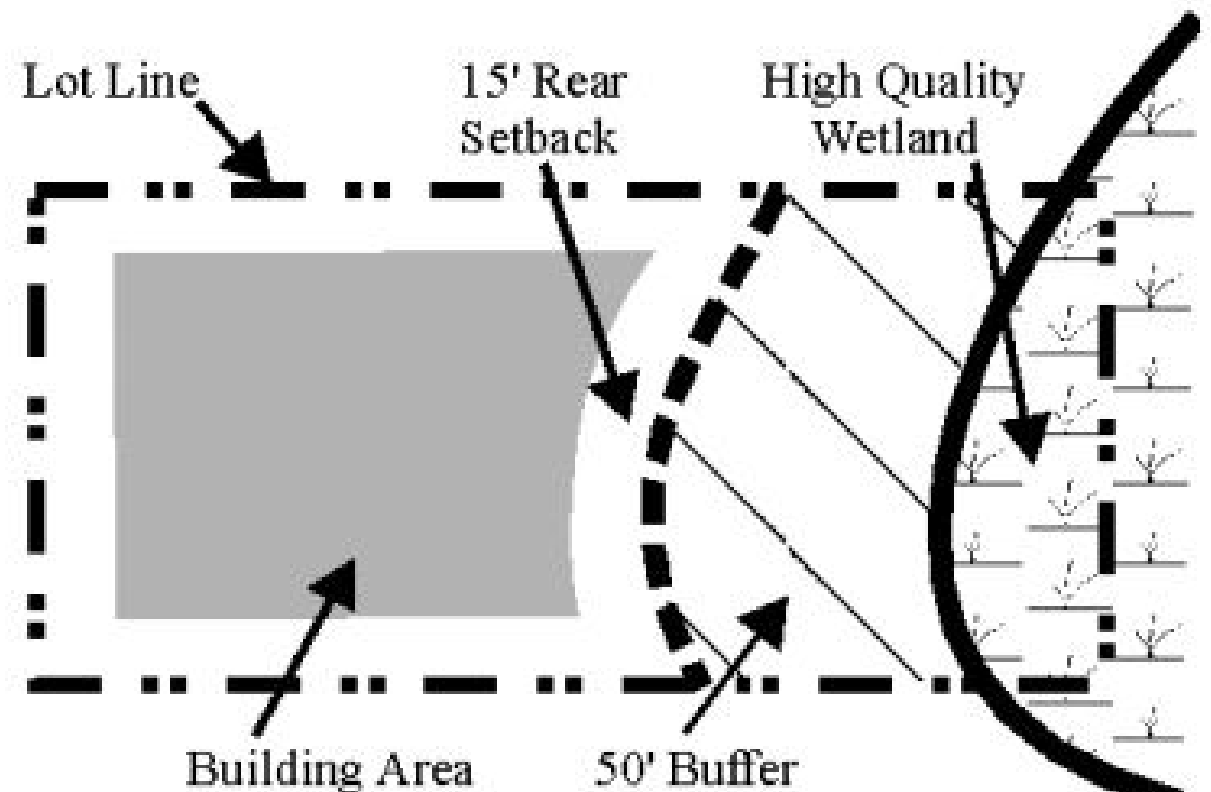
- Lowest floor 2 ft above 1% annual flood elevation
 - ✓ Applies city-wide
 - ✓ City stormwater management plan with 1% annual chance flood elevations in every sub-watershed
- Wetland riparian buffers and setbacks
- Adopted early 1990s

Plymouth Wetland Riparian Buffers

- Classified Wetlands
- Riparian buffers and setbacks
- Monument requirement



Example of Buffer and Setback Applied to a High Quality Wetland



Water Detention On-site Example



Community Ponding Basin



Defendable in Court?

- Consistent treatment: not “arbitrary and capricious”
- Applicable: Addresses local concerns/issues
- Defendable: Based on data/science; quantifiable

Remember – communities are most likely to lose in court because they did NOT enforce their floodplain-related regulations (especially if someone is impacted)!

