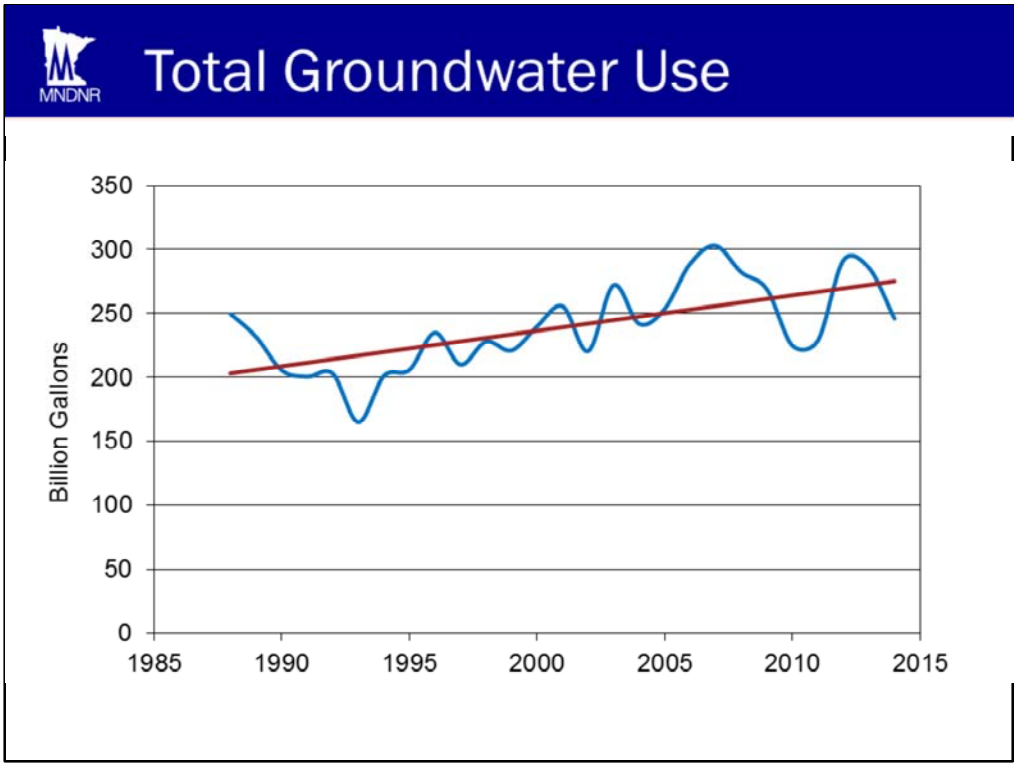
The DNR is charged with managing waters resources to assure an adequate and sustainable supply for multiple uses.

Minnesota Laws 2015, chapter 4, article 4, directed the Department of Natural Resources (DNR) to consult with interested stakeholders and develop recommendations for statutory or rule definitions and thresholds for negative impacts to surface waters.

Overview

- Understanding our use of groundwater
- Stakeholder Input
- Statutory requirements
- Recommendations
  - Definitions
  - Statute changes
- Approach to thresholds
  - Methods
  - Application to permitting

We recognize much of this audience is already familiar with basics of water use in Minnesota, so will focus on the motivation for this report and its principal recommendations. We'll spend about half our time digging into the details of the thresholds



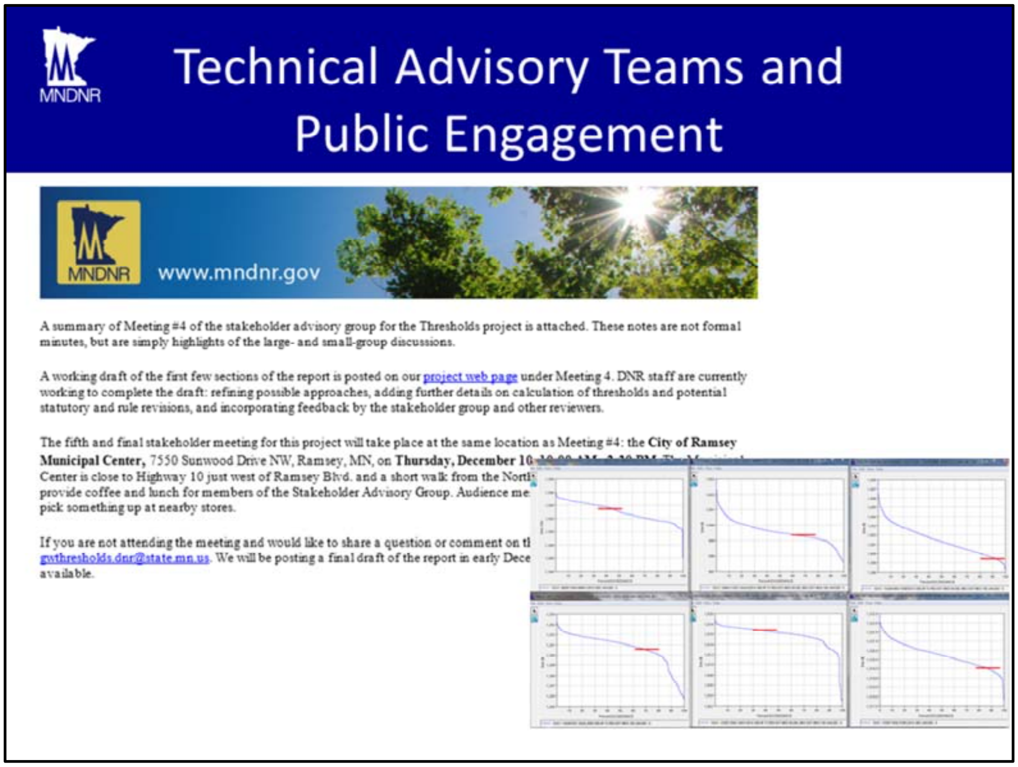
On average we are using about 75 billion gallons more groundwater per year than we were 25 years ago, growing at about 2.8 billion gallons per year.

Our water use fluctuates from year to year depending on the amount of summertime precipitation, which also illustrates that a large fraction of the water we use is for irrigation (including residential lawns, golf courses, crop and non-crop irrigation).

Note that this chart shows <u>reported</u> use. So private domestic wells are not included.

(About a third of the GW use is for irrigation (ag, golf courses, institutional); just over half is for public water supply, and about 1/3 of that we estimate is for domestic irrigation, and the remainder is split among industrial, power generation, and other uses.

The report was required based on legislation in the 2015 special session, with a six-month time frame. Our stakeholder group was highly engaged in the process. Four meetings were originally scheduled; one more was added by request and meetings were increased in length to 4 ½ hours. Meetings included robust large and small-group discussions of proposed definitions and thresholds. Many comments and questions of stakeholders are reflected in the final report.

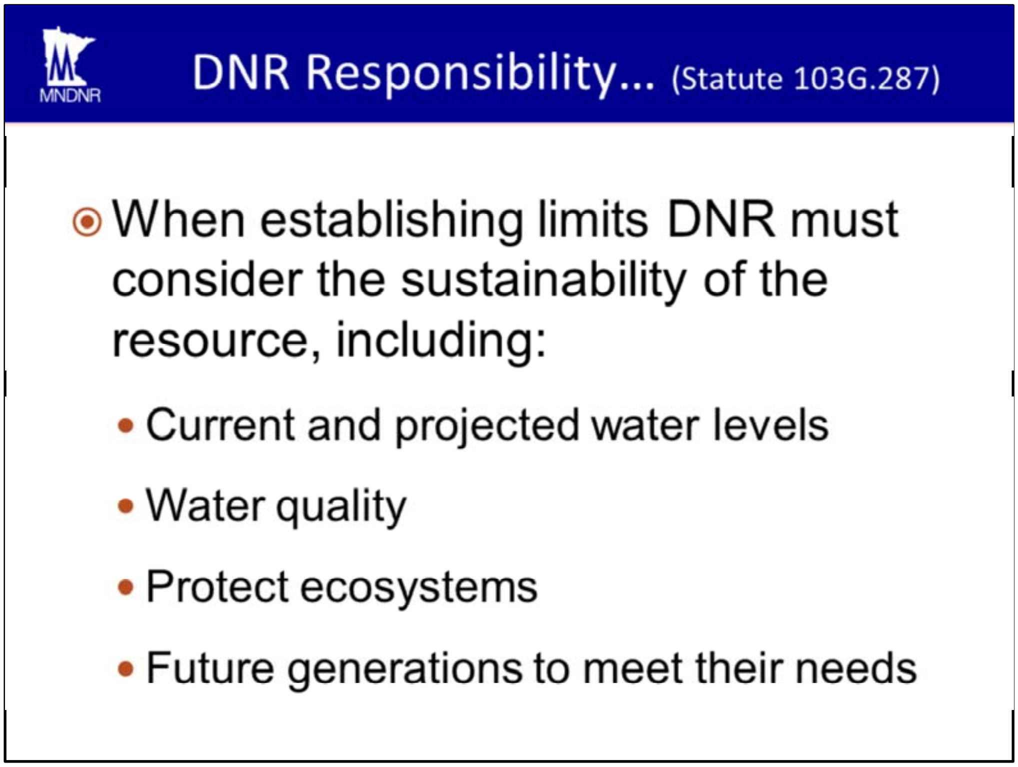


The technical teams included DNR, MPCA, BWSR, MDA staff, university researchers and consultants. We formed an internal policy advisory team that focused on water permitting, statute and rule changes and implementation issues. Each team met twice; some scheduled additional consultations with technical experts, i.e., on lake dynamics. While the stakeholders group dug into both the technical and policy details, while the technical teams focused on scientific research, often conducting project-specific research. For example, the charts at lower right show exceedance curves for 6 lakes compared to their runout elevations – among the 38 indicator lakes analyzed for multiple factors that contribute to water budgets.

Among the groups we frequently checked in with: the Clean Water Council, Clean Water Fund Interagency Team. Presentations were made to Legislative Water Commission, Clean Water Council, MN Association of Watershed Districts, Water Resources Conference, Irrigators Association of MN, MN Ag Water Resources Center, etc., and additional presentations are planned.

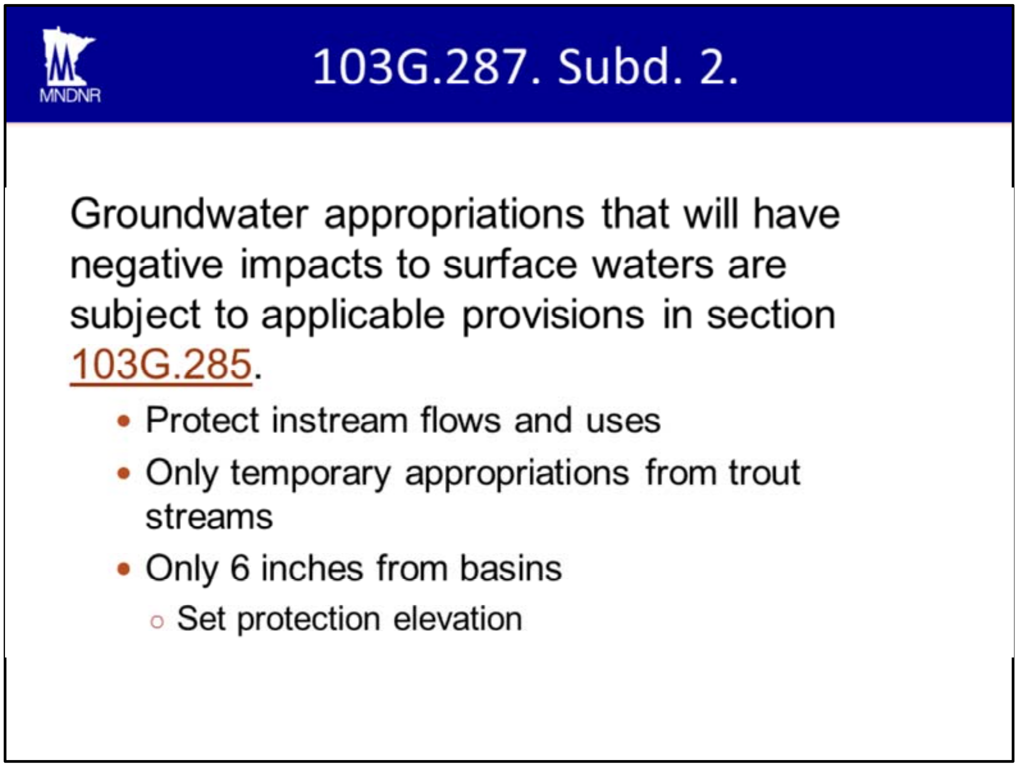
Website and GovDelivery

(±400 subscribers, 9



Just to set the stage: The DNR manages water supplies through our permitting program, generally above the thresholds of 10,000 GPD or 1 million GPY. A permit is for a limited amount of water. When we issue a permit, we need to consider the sustainability of that resource, as outlined in this statute.

Permits do not establish a permanent right to water.



The operative phrase is “will have negative impacts” but that has been difficult to demonstrate. How much monitoring and modeling of the GW system is needed to demonstrate a likely negative impact. And if negative impacts appear likely, the directions in 103G.285 are designed for surface water withdrawals, not directly applicable to groundwater withdrawals. So there was a lot of discussion at the Legislature in the last session about how to measure negative impacts. Should a numerical limit be established, like 20% of streamflow? That led to the legislation directing us to research these issues and prepare this report.

Recommendations

Definitions

Negative Impacts to Surface Waters
– in relation to water appropriations, a change in hydrology sufficient to cause ecosystem harm or alter riparian uses long-term

103G.287, sustainability standard, states that a proposed GW use must not “harm ecosystems” – that is the next term we think it’s important to define. “Riparian uses” – we need to recognize uses by the public and riparian landowners such as water access, navigation, boating, swimming, etc.

Recommendations

Definitions

Ecosystem harm – in relation to water appropriations, to change the biological community and ecology in a manner that results in a less desirable and degraded condition

The terms "less desirable" and "degraded" refer to the diminished ability of the water body to support indigenous plant and animal species and communities that would otherwise be present, as well as desirable introduced species such as gamefish. Keep in mind that most of our water bodies have already been altered – outlet control structures on lakes, dams on streams, etc. What we want to avoid is an alteration that converts a high quality trout stream into a poor quality trout stream, or a wetland into a lower quality wetland. It's ultimately the DNR's responsibility to make that determination.

Recommendations

Definitions

Sustainable diversion limit – a maximum amount of water that can be removed directly or indirectly from a surface water body in a defined geographic area on an annual basis without causing a negative impact to the surface water body.

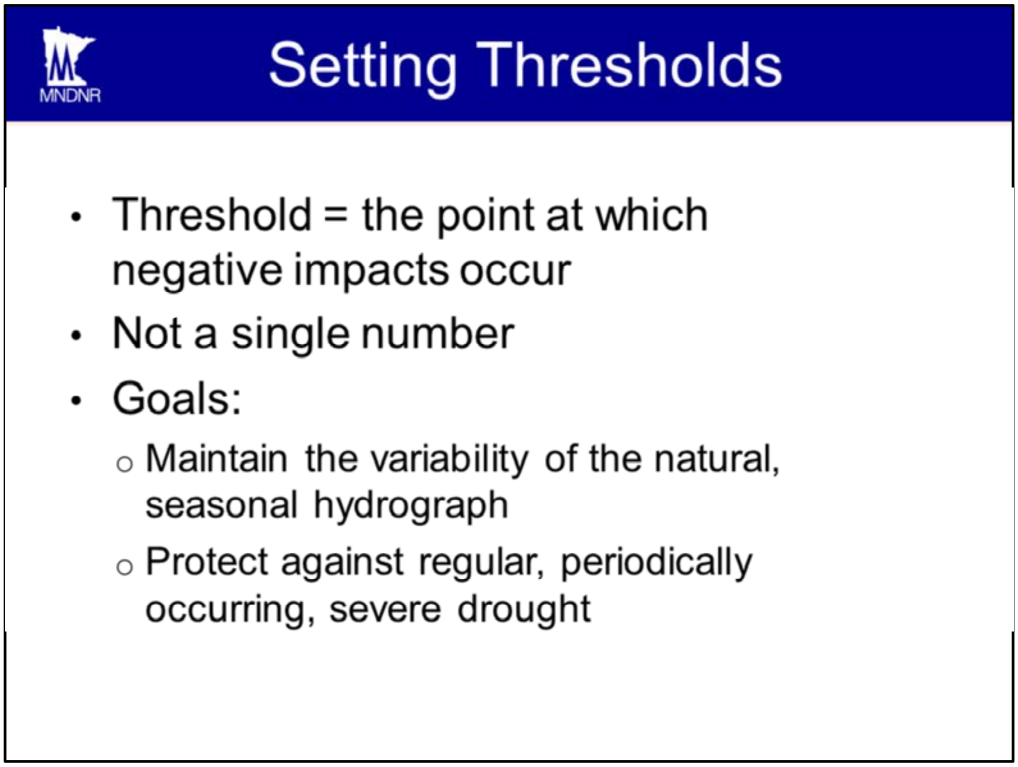
The term “diversion” rather than “withdrawal” is used to describe the collective, cumulative withdrawal of groundwater as it affects a surface water body. “Withdrawal,” when applied to groundwater, generally refers to a limit established in an individual appropriation permit, not to the cumulative effects of multiple withdrawals. The next series of slides explore this concept as it applies to the three types of surface water bodies.

Recommendations

Statutes

Combine surface water appropriations (103G.285) and groundwater appropriations (103G.287) into a new **“Water Appropriations”** section

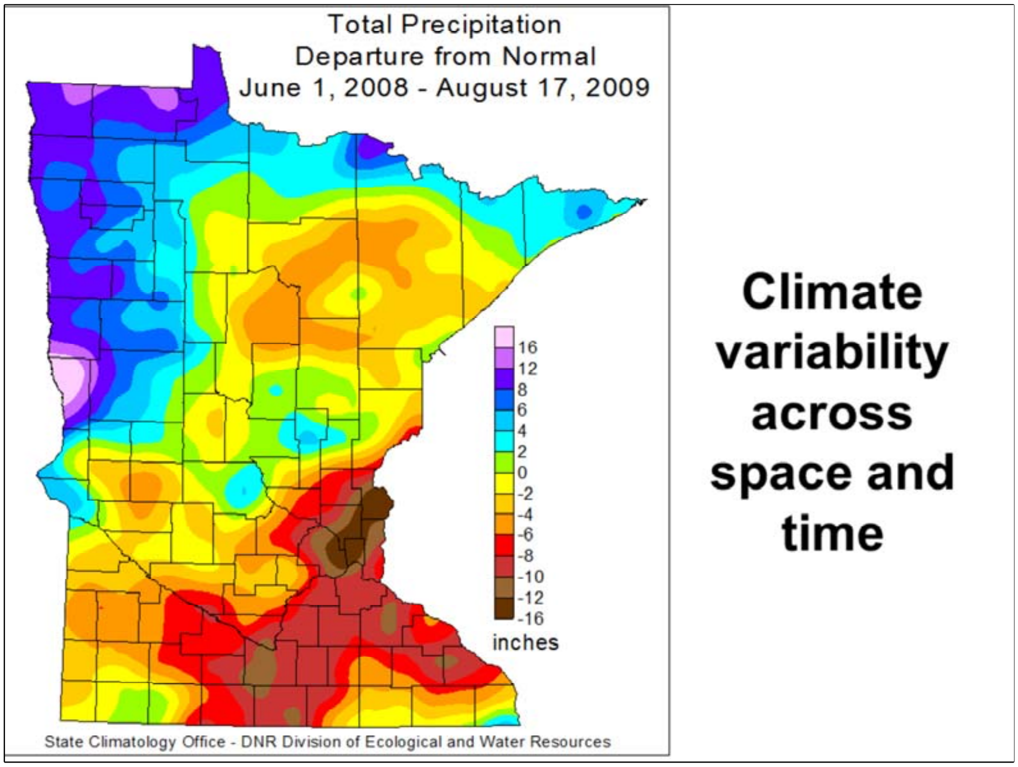
The intent is to avoid the circularity of this ‘negative impacts’ determination in the current statutes and better recognize the interrelated, interdependent nature of surface and groundwater resources. We will be working with agency partners and stakeholders to develop statutory language to propose.



Thresholds can be estimated but it isn’t feasible to establish a single threshold for streams or lakes that would apply statewide given the number of variables involved – i.e., which species, or which riparian uses are negatively impacted. The diversity of Minnesota’s surface water and groundwater resources, land use, and climatic factors would make a single number misleading and inappropriate for many locations and conditions.

We recognize that droughts occur under ‘natural’ conditions. Our use of water is highest during periods when water levels are low, and can add stress to already stressed resources. Our challenge is to determine at what point we need to establish limits to avoid altering the ecosystem or long-term riparian uses such as boating.

In the following slides we discuss specific approaches to establishing thresholds for streams, lakes and wetlands

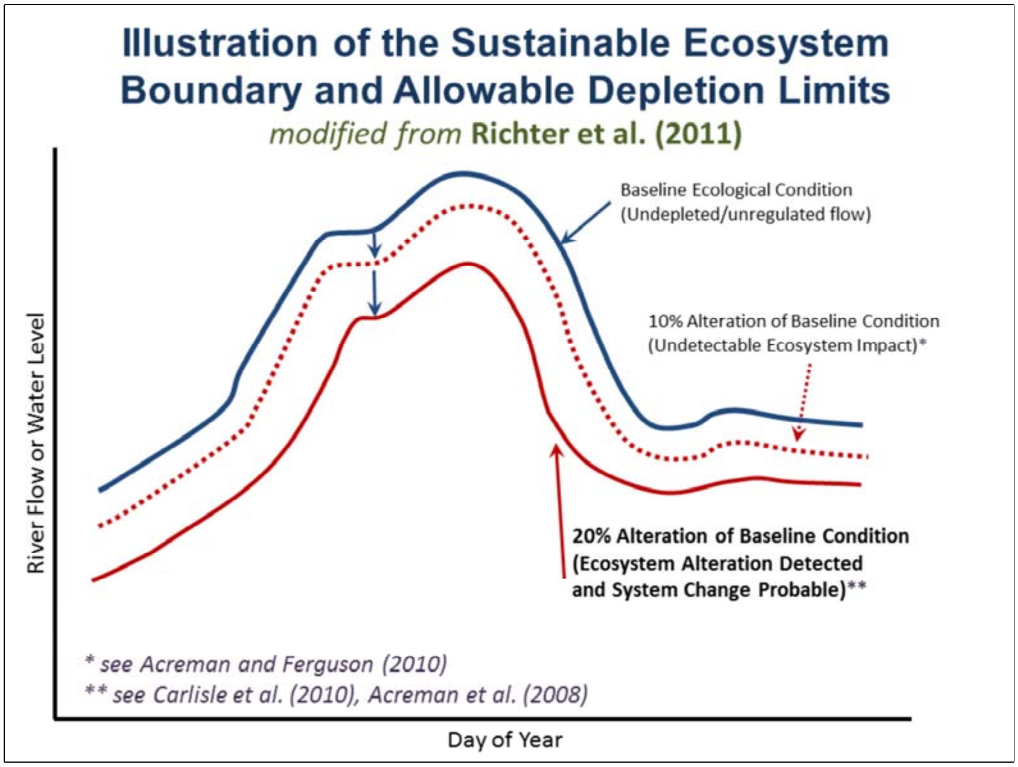


The next three slides illustrate the context and some of the science behind these recommendations.

Precipitation patterns in Minnesota often change abruptly within a given year or season. Weeks of wet weather can be followed by extended periods of dry conditions. Periods of anomalously wet or dry weather can have significant impact on the landscape and water levels. Here's an example of a climate scenario depicting a high degree of variation over space as well as demonstrating conditions that were relatively rare in the historical database. For the 15-month period ending in August of 2009, precipitation totals in the northeast metro were 12 to 16 degrees below the historical average. This occurred during a period of time when locations as close as St. Cloud received above-average precipitation. By mid-August, the U.S. Drought Monitor depicted the east metro as undergoing "Extreme Drought" (the red coloring). The Extreme Drought designation is considered to be a one-in-twenty year occurrence. This climate feature extended well into northwest Wisconsin and is part of the White Bear Lake lake level story.

Southeastern Minnesota Trout Stream

A trout stream is an example of a highly groundwater-dependent ecosystem.



The DNR's research and a review of scientific literature indicate that a 20% change in hydrologic regime (measured as the August median base flow) will negatively affect the ecosystem, while a change less than 10% is not likely to be detectable. Setting a <u>diversion limit</u> of no more than <u>10% of the August median base flow</u> will preserve the seasonal variability of the natural hydrology and maintain geomorphology, water quality, connectivity, and biology of the system the vast majority of the time. This relatively conservative approach would provide predictability for water users under all but the most extreme drought conditions. This approach is also suitable for highly groundwater-dependent ecosystems such as trout streams.

The DNR recommends a 10% limit in most circumstances, but we also recognize a diversion limit of up to 15% may be appropriate in some areas where water uses are less dependent on a consistent supply. A higher diversion limit would require more intensive monitoring and management.

Lake level patterns in MN
which lake types are most vulnerable?

	Shallow Lakes	Deep Lakes
Frequent Surface Outflow	Moderate	Lowest
Infrequent Surface Outflow	Highest	High

The DNR recommends an approach that establishes sustainable diversion limits for two categories of lakes:

<u>Lakes connected to stream systems that outflow most of the time</u>. For these lakes, the outflowing stream's diversion limit would be applied to the lake and a separate protection elevation for the lake would not be necessary.

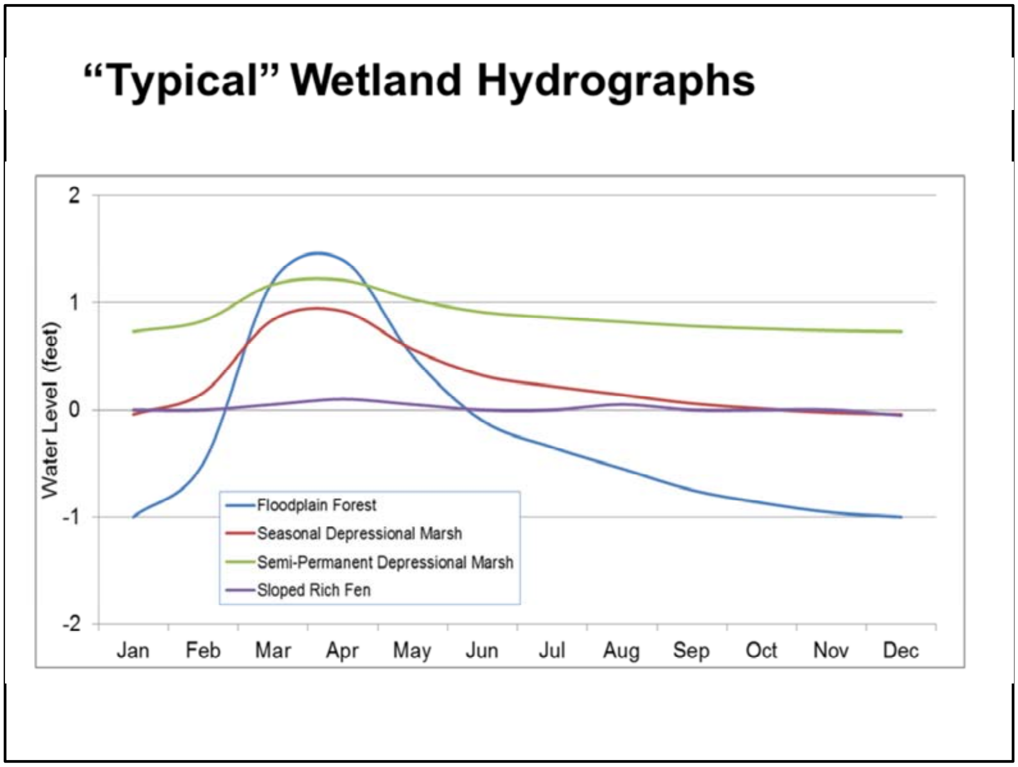
<u>Lakes with infrequent surface outflow</u>. For these lakes, protection elevations specific to the lake could be established based on key considerations related to hydrology, ecology, and riparian uses. Water levels at and above the protection elevation are expected to maintain the characteristic hydrology, ecology, and riparian uses of the lake most of the time. Water levels below the protection elevation put one or more of the water body's resources or uses at risk. The protection elevation is used to establish the sustainable diversion limit.

Important to note that broad and gently-sloped nearshore areas are not limited to shallow lakes, they can occur on deep lakes as well. Both nearshore aquatic habitat and surface water recreational use can be impacted as water levels change.

Different types of wetlands have distinct and characteristic seasonal water levels that maintain their characteristic plant and animal communities. Most wetland types in Minnesota depend to some extent on groundwater for at least some part of the growing season. Some wetland types, such as fens, are highly connected to and dependent on groundwater, while others, such as floodplain forests (the lower photo), are more directly influenced by surface-water.

As yet there is no systematic method for evaluating potential negative impacts on wetlands due to groundwater appropriations. A suggested approach is development of target hydrographs: ranges of acceptable water levels throughout the year for the various wetland types, extending from “normal” levels to infrequent or rare low levels that stress the characteristic plant and animal communities. The target hydrograph is used as a guide for developing allowable appropriation amounts throughout the growing season to maintain the characteristic hydrologic regime.

Impacts to wetlands are also regulated under other authorities, primarily the Minnesota Wetland Conservation Act and the Public Waters Permit Program. The DNR’s goal under this approach would be to avoid wetland drainage that would trigger regulation under those programs.

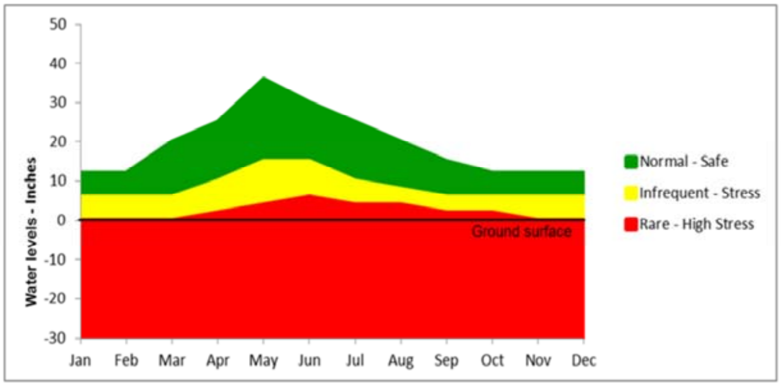


Different wetland types display fairly characteristic annual hydrology patterns. Note that the fen shows relatively little water level variation across the year, evidence of its heavy dependence on groundwater.

In regulating groundwater (or surface water) appropriations, the goal is to maintain the basic hydrologic regime for the particular wetland type, including long-term wet/dry cycling where appropriate, thereby helping to ensure that the wetland will maintain its characteristic plant community, wildlife habitat, and associated functions.

The flatter the hydrograph the more vulnerable.

Example of a Target Hydrograph



The hydrograph illustrates ranges of water levels for a particular wetland type, extending from normal – frequently occurring – conditions to rare, but still naturally occurring water levels that create stress on the wetland plant community. Different wetland types have relatively distinctive hydrologic regimes, as shown in the previous slide.

Once the target hydrograph has been derived for a particular wetland type or group of types, the width of the Normal-Safe zone can be used as a guide for developing allowable appropriation amounts. A diversion limit based on some proportion of the width of the Normal-Safe zone (i.e., the range of water levels within the zone) at the critical part of the growing season (August, most likely), is likely to ensure that the characteristic hydrologic regime is maintained.

Challenge

Translate sustainability thresholds
- Streams
- Lakes
- Wetlands

→

Volume allowed for withdrawal
- Individually
- Cumulatively

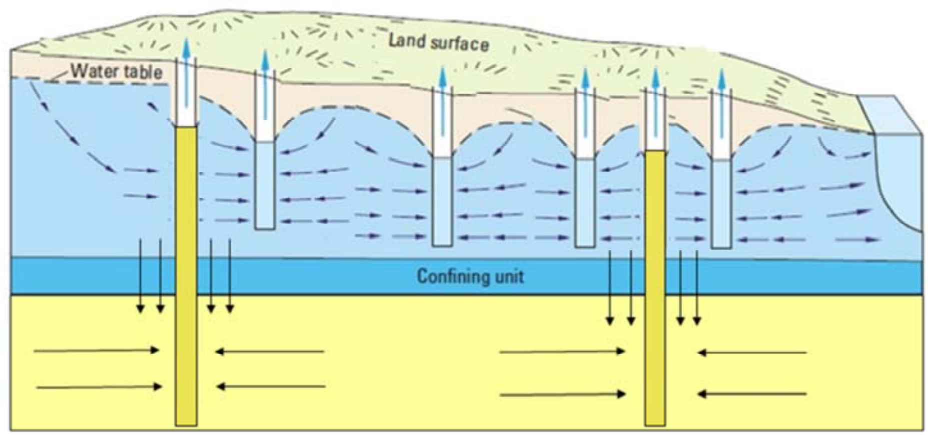
=

"sustainable diversion limit"

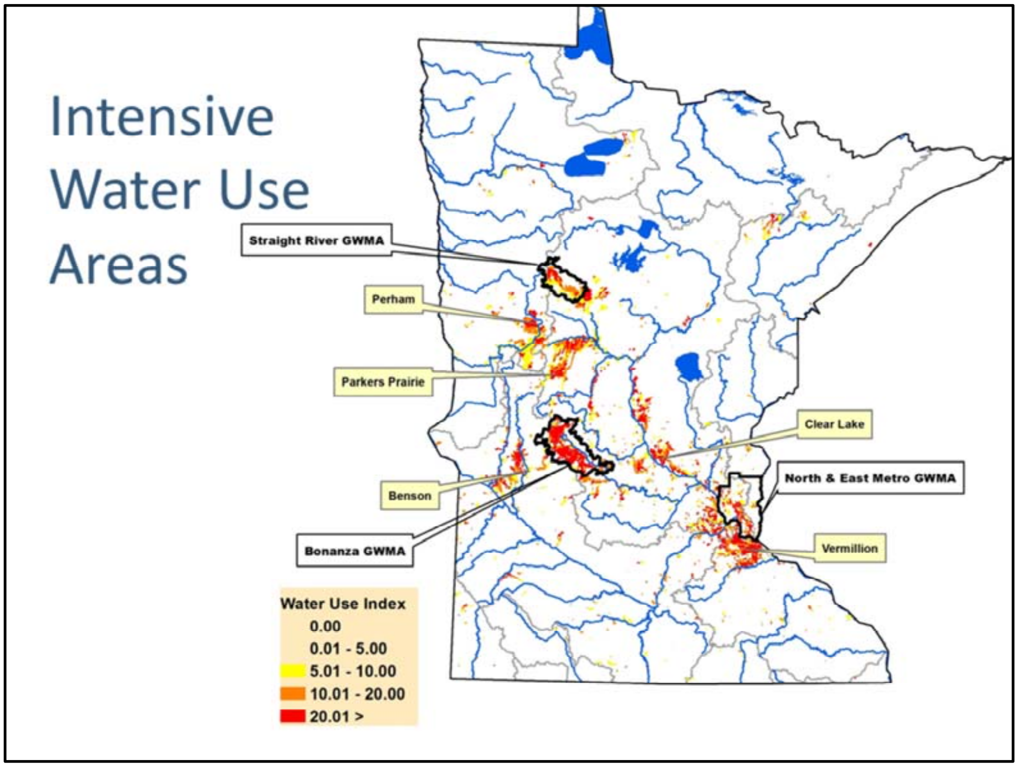
Methodology

- Quantifiable
- Reasonably quick
- Technically and scientifically sound
- Accounts for cumulative GW use
- Predictive
- Adaptive

The DNR strives to ensure that permitting decisions are quantifiable, technically and scientifically sound, and as timely as is compatible with sound decision making. As new information becomes available through groundwater and surface water monitoring, the DNR's intent would be to periodically evaluate diversion limits and adjust water appropriation permits accordingly.

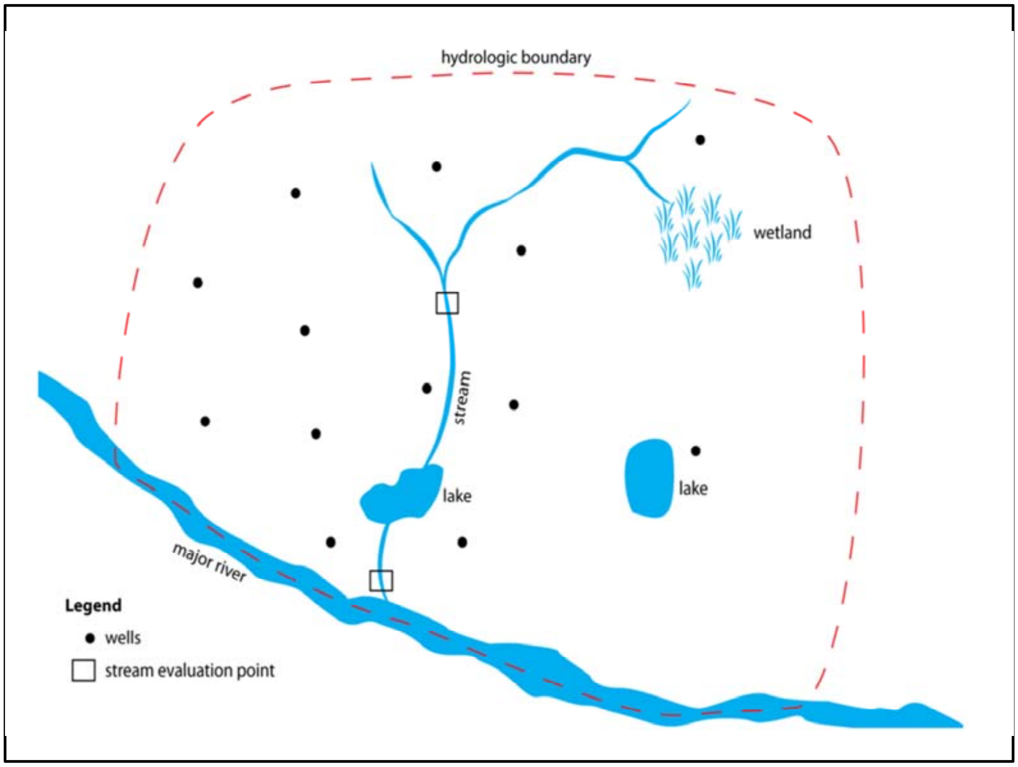


This conceptual diagram illustrates a more realistic example of the complexity associated with multiple appropriations from different locations and depths. The challenge then is to determine the hydrologic effect on the adjacent or nearby surface water. It's important to keep in mind that geologic material, the extent and character of confining units, the distance, and the duration of pumping all play a role in determining the hydrologic effect on connected surface waters.



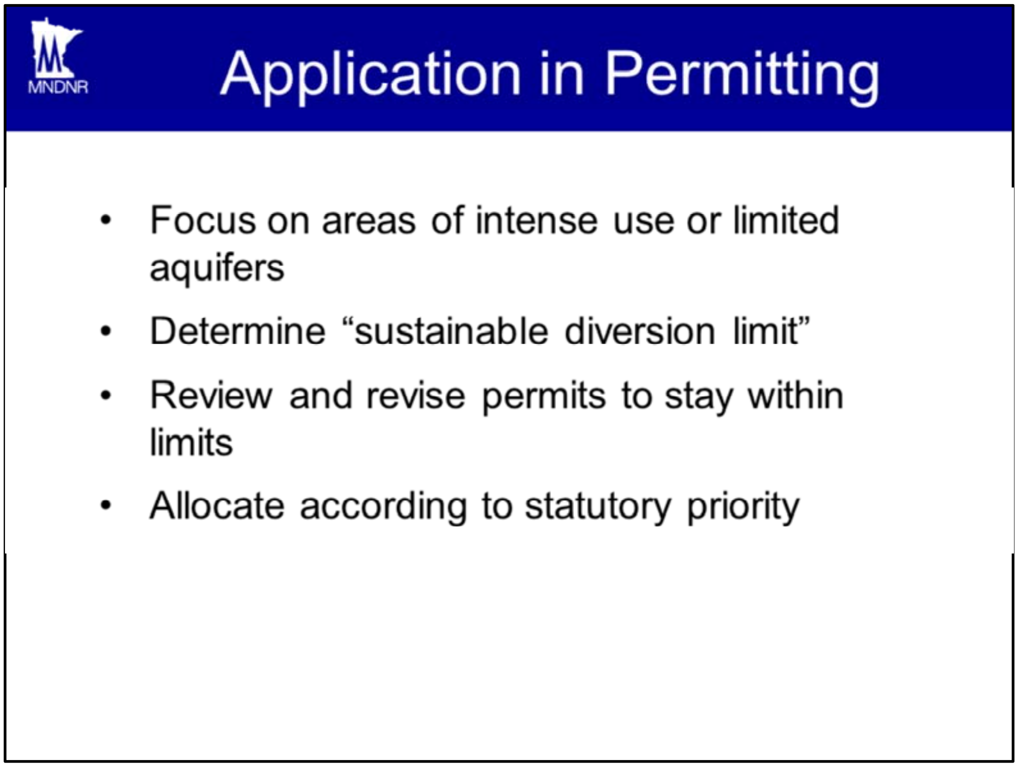
This map shows the relative intensity of water use. The darker the color the more intense the consumption of water in that watershed area. The result can be significant reduction in stream flows, lower water levels in lakes and wetlands. The map is not intended say there is a problem, but it does help us anticipate where problems are more likely to occur. Note that the three Groundwater Management Areas are located in these intensive use areas

Available Water = Mean Annual Flow
Mean Annual Flow is a hydrologic indicator and influences ecological resources. Mean Annual Flow is estimated using: stream gage data (90 gages), current and lagged annual precipitation, current and lagged average temperature, geographic coordinates, year, and drainage area.
Water Use - Cumulative (from upstream catchments) reported use based on water use permits (does not include private wells)
Mean Annual Flow - Index is average for years 2007-2011
Data available from 1989-2011
Source: Watershed Health Assessment Framework



This example has been helpful in illustrating the issues involved in managing water allocations within a hypothetical hydrologic area. It shows a number of wells in proximity to the various types of surface water bodies discussed in this report. Typically:

- Effects on streamflow from the wells close to the stream will be greater than effects from the wells further away.
- Effects on streamflow in the upper reaches of the stream will usually be proportionally greater than effects in the lower reaches, since the base flow in upper reaches is lower.
- The diversion limit for the lake connected to the stream would generally be that of the stream.
- The diversion limit for the isolated lake would be based on its water level records, key resources, existing appropriations and riparian uses, all of which contribute to a water budget that is used to establish a protection elevation.
- The water regime for the wetland may also affect the flow of the tributary stream.
- The wells in the illustration may serve multiple use categories, such as irrigation, municipal, golf course, and industrial users. Each falls into a different ‘priority’ class according to statute (§ 103G.261). If the amount of water available for use is less than the amount of water requested for appropriations, these priorities must be considered in the final allocation plan.

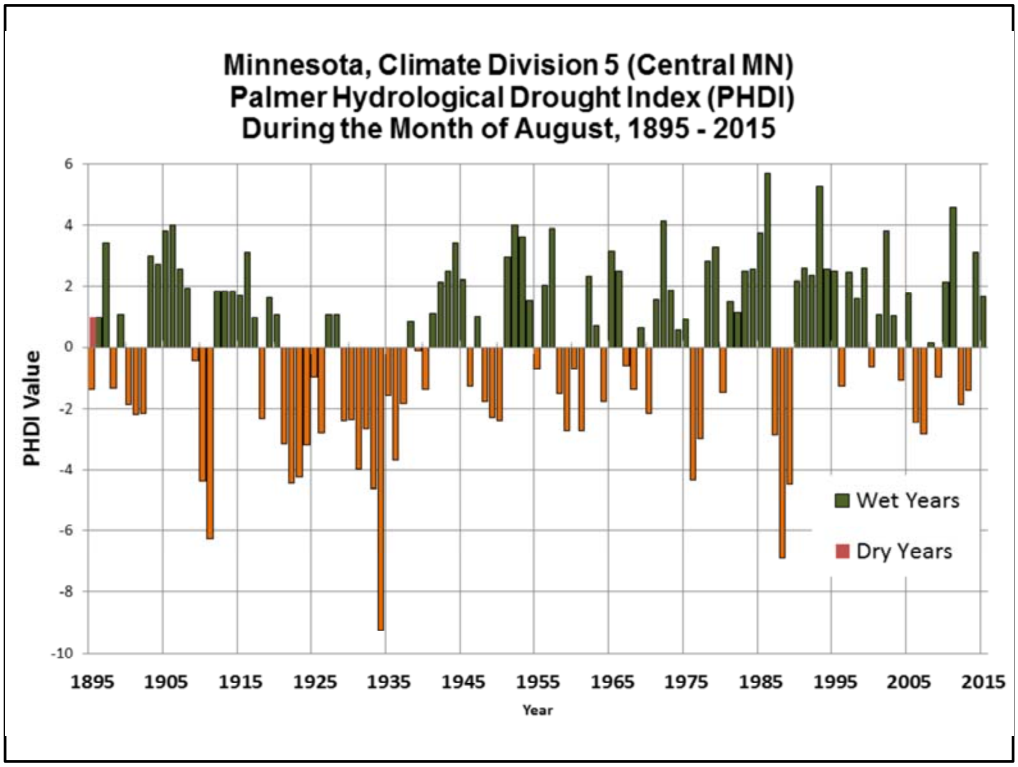


Based on the recommendations in this report and our existing groundwater management responsibilities, the DNR would set thresholds for specific surface water resources and conduct groundwater modeling in those (limited) areas where surface water features are considered to be at risk due to intensive use of groundwater, or combined surface and groundwater use.

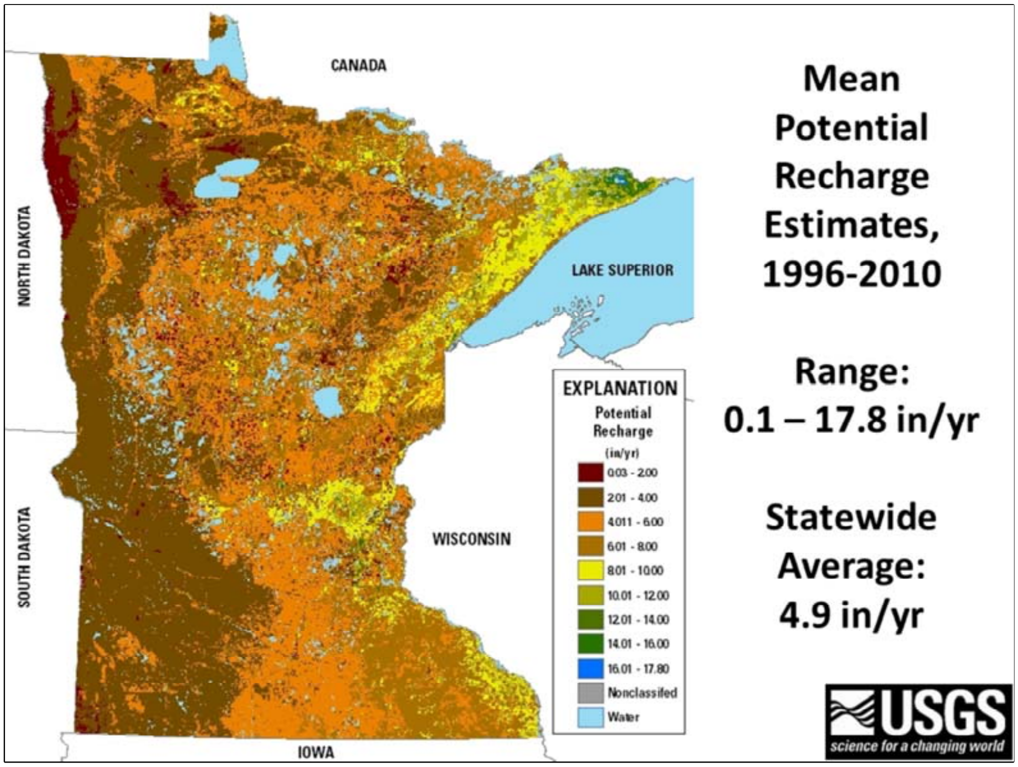
The essential elements of this approach are already being piloted in the three Groundwater Management Areas (GWMAs) that are currently completing their planning phases.

Conclusions

1. “Urgency room”
2. Water management policies conceptually sound
3. Statutes could be improved
4. Strong scientific basis for setting protected flows and protection elevations
5. DNR will focus on areas of intense use



An extra slide, if needed for discussion:
The variability of Minnesota's climate and geography mean that rainfall is not always available in the quantities we need at the times when it is most needed. Increasing demands on both surface water and groundwater supplies can cause negative impacts to the ecosystems and riparian uses of streams, lakes, and wetlands. While water levels fluctuate naturally throughout the year, water appropriations can significantly reduce stream flows and push lake and wetland levels lower, more frequently putting fish, wildlife, plant communities and riparian uses at risk.



An extra slide, if needed for discussion:

Final mean potential recharges estimates for the period of 1996-2010. This is the final calibrated grid of potential recharge, based on the methods just described and detailed in the final report.

Average recharge for the entire state is 4.9 inches per year over this period. The range in recharge is from almost zero (0.1 inches per year) up to close to 18 inches per year (17.9 inches per year). Although a few places have high values greater than 14 inches per year, this is rare and the majority of recharge in the state is below 8 inches per year.

To explain the map a little further, a couple of key areas: (1) western Minnesota has low recharge, in particular northwestern Minnesota along the North Dakota border in the Red River valley; (2) northeastern and southeastern Minnesota have the highest recharge rates; (2) another area of the state with higher potential recharge easy to distinguish is the Anoka Sand Plain, a pocket of yellow (8-10 inches per year of potential recharge) in east Central Minnesota.