

The Water Underground

Stretching Supplies

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Executive summary

It's almost impossible to walk past a spewing faucet without stopping and trying to turn it off. We can't bear to see the waste... The first step is seeing it. And then refusing to go back to not seeing it.

— Seth Godin

It is easy for Minnesotans to pat ourselves on the back while shaking our heads at the short-sighted depletion of aquifers that plague various regions of the world. Groundwater supplies that could have lasted centuries have been drained. As these areas are forced — there is no better word than this — to grapple with enormous costs and disruption, we ought to remember that if not for far-sighted capital investments in the Mississippi River reservoirs, Minneapolis-St. Paul water systems, and clever policy work, we would not be as well-positioned as we are with our long-term water supply.

Yet patting ourselves on the back isn't warranted, since most of these investments in protecting our water supplies were made a generation ago or more. The work of far-sighted individuals has resulted in a long-term water supply that looks pretty attractive to industries looking to relocate. How can the current generation grow industry and ensure we maintain a long-term groundwater supply? That is the question this report aims to answer.

Communities in arid areas have demonstrably reduced water use but it takes time and an all-hands-on-deck attitude to change social

norms. We can start with practices that have worked elsewhere and have not yet become established in Minnesota. In this report we recommend ways to stretch our supplies until changes in behaviors become the new norm.

We do this in three chapters.

1. We briefly review a few of the proven municipal strategies for **using less** water. Water suppliers generally have the technical knowledge of how to do this; political will and community outreach capacity appear to be the limiting factors. We need strategies to overcome these. This is a job for cities.
2. Then we explore how water we pump up from an aquifer can be **used multiple times** before it is discharged to a river. State agencies have been doing their part by (slowly) wrestling with relaxing constraints to this practice and should kick out a report this June.
3. Lastly, we examine **enhanced recharge** techniques that can speed the natural recharge of aquifers. Barely talked about in Minnesota to date, state review of constraints and scientific findings should be put on the clock by the legislature so the 2019 legislature can start doing their part to stretch supplies.



EXECUTIVE DIRECTOR

Introduction

How much groundwater is really down there? You can't see it, weigh it, or easily calculate its volume. Yet most Minnesotans have faith that if we need water we can drill a well and find enough.

Ask a Minnesota well driller and you'll get a different perspective: drill the well *first* and then build the house. They know that finding adequate water isn't a given and may tell you about an ethanol plant in western Minnesota dubbed "the golf course." The water-intensive plant was built first; 18 dry holes later they finally found the water required to run it.

Minnesotans should not assume that groundwater will always be there, where and when we need it. Groundwater is unevenly distributed across the state and when you consider how long it takes water to get into the ground, in many areas it is not renewable within a human lifetime.

Some planners in water-challenged parts of the country think that groundwater should only be used as a last resort — when and where surface water is not available. Others see a practical need to use some groundwater because surface water won't always be available in dry years. Few see any sense in unnecessarily depleting groundwater reserves. Although there are only certain regions of Minnesota where alarm bells are currently sounding, it is time to take steps to make our groundwater use more sustainable throughout the state.

This report is the second in a three-part series on Minnesota groundwater. In our first report, *The Water Underground, Reframing the Local Groundwater Picture*, we described three groundwater-supply scenarios playing out in communities across the state: *steady*, *declining*, or *deficient*. In it we found public water suppliers, industry, and irrigators have the conservation tools to address declining and deficient scenarios but may not feel the urgency to do so. The role of state agencies is to continue

to provide information on the status of groundwater because they have the best understanding of regional trends. They can do this not only through the existing permitting program, but also by expanding that program to monitor groundwater usage and sharing that information with communities. Local authorities are still best positioned to implement conservation practices but need to understand how their usage patterns fit into the bigger picture of regional groundwater sustainability.

This report recommends three approaches to build groundwater resilience by stretching local supplies:

1) **reduce** groundwater use, 2) **reuse** groundwater before discarding it, and 3) **recharge** groundwater and have strong wellhead protection measures in place. We think of these as sequential steps to address groundwater deficits with the easiest strategies being implemented first while the harder ones are realized with greater patience and in areas with the greatest need.

The final report in this Freshwater Society groundwater series will address the intersection of agricultural practices and our groundwater future. Look for that report later this year.

Our current hydrologic cycle has been altered at every step. We install drainage, pump from long-term storage, and even change evaporation by altering plant cover. For the most part, water flows when and where we want.

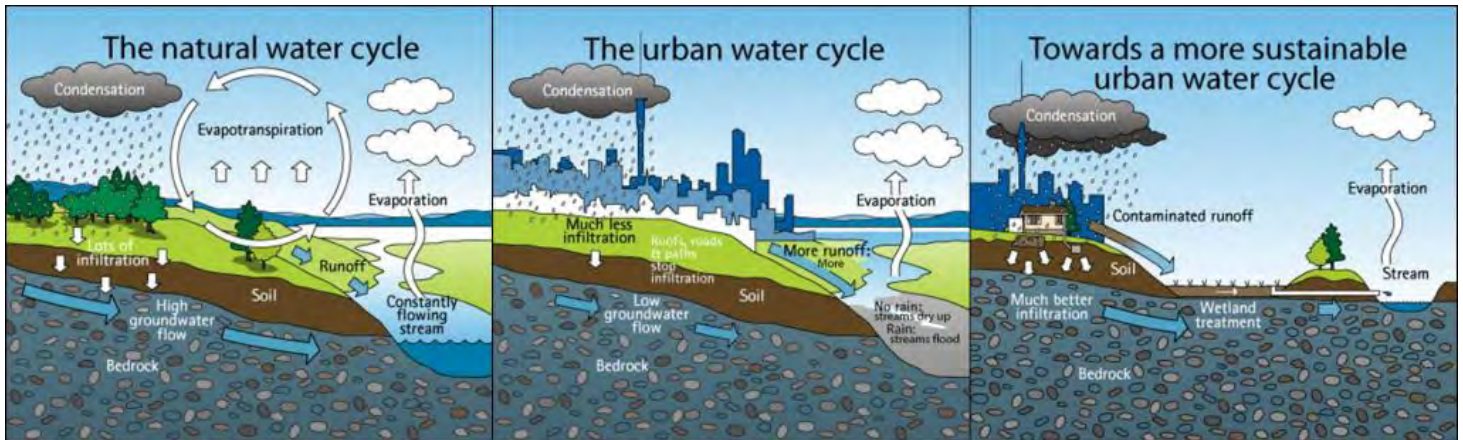


Image source: <http://www.sswm.info/sites/default/files/toolbox/AUCKLAND%202010%20UrbanWaterCycle.jpg>

Altered hydrologic cycle

Do you remember your Earth Science class? Every discussion of water resources predictably started with a discussion of the hydrologic cycle. We need a wake-up call to see how altered that cycle has become.

An experienced educator knows that before a student can learn, they need to identify misconceptions and disrupt them.

Misconceptions such as 1) all rivers flow south, 2) lakes sit on the surface like water in a bowl, and 3) the water underground flows in rivers are barriers to new learning. More complex concepts can only be built on a strong foundation of knowledge. Weeding out the misconceptions is an often-overlooked but important first step.

We need to overcome some widely held misconceptions about the water we use in order to build incentives to reduce, reuse, and replenish groundwater. Many Minnesotans believe that groundwater is everywhere and that groundwater is an infinitely renewable resource (if they think about groundwater at all). Yet if you

focus on a specific place, there may not be enough groundwater to support a city, a farm, or even a home. Even if you do find adequate water, it may not be replenished in your lifetime. So then the question is, are you harvesting a renewable resource or are you exploiting a diminishing resource?

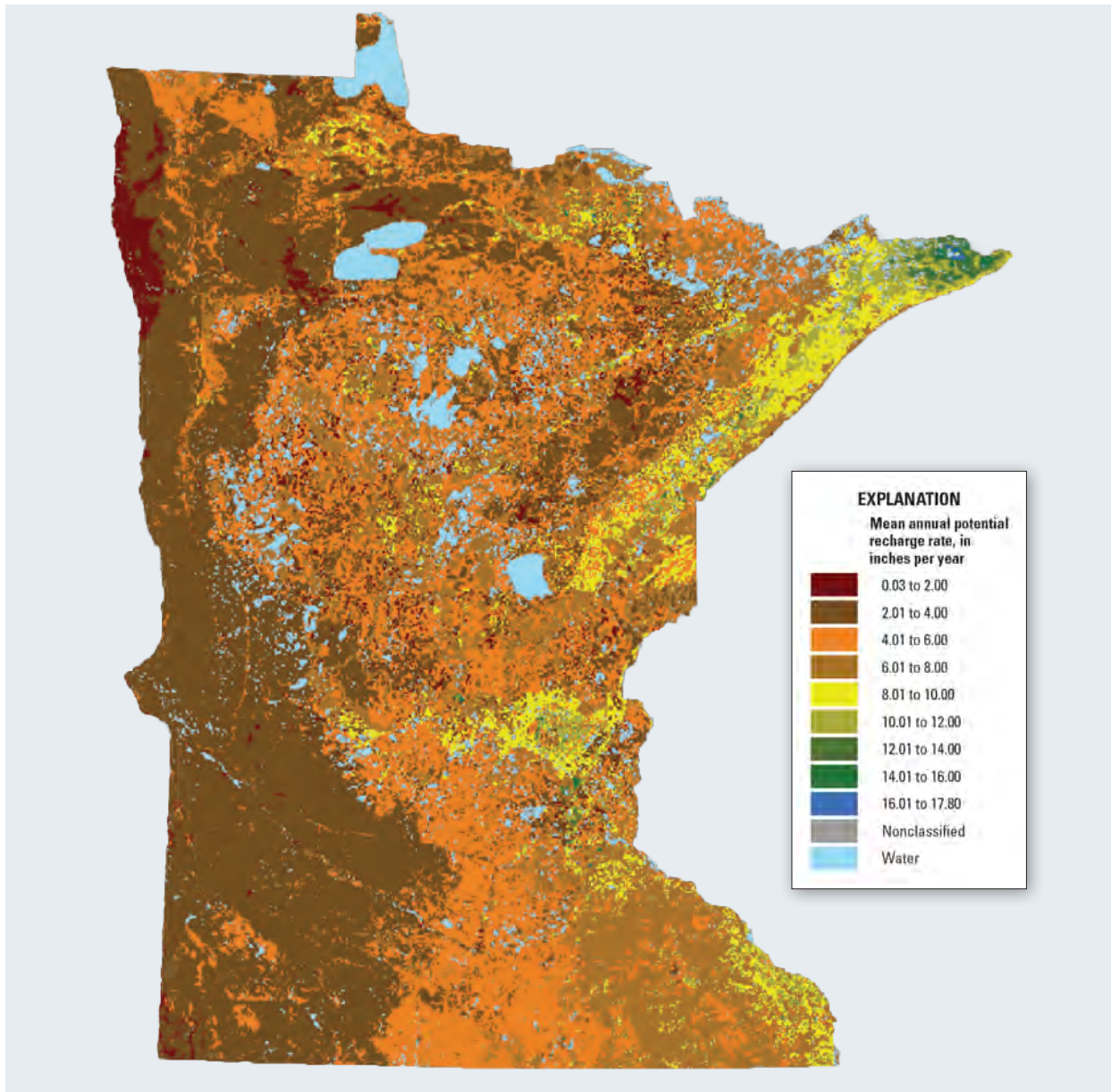
Yes, there is a hydrologic cycle that we can count on to distill, filter, store, convey, and generally recycle the finite amount of freshwater on the planet. However, we have introduced quite a few shortcuts into this system. Scientists are still figuring out what all the alterations to the hydrologic cycle mean globally, but locally it has changed things a lot — even our weather patterns. Shortcuts include:

- ◆ pumping groundwater from deep storage and discharging it to surface water;
- ◆ intercepting rain and stormwater to reduce localized flooding;
- ◆ preventing water from soaking into the ground in farm fields by installing tile drainage; and
- ◆ upsetting the normal return of water to the atmosphere by significantly changing plant cover.

Groundwater is simply old rainwater so we have to wait on rain, or snow melt, to refill the underground tank. How quickly does that happen? The U.S. Geological Survey has recently published a soil-water-balance model that uses land cover,

soil texture, and meteorological data to calculate how much water is available to potentially recharge Minnesota aquifers each year. Most of the state has 2-8" of possible recharge per year. After it soaks in, it begins a slow journey.

Potential groundwater recharge for Minnesota using Soil-Water-Balance Model, 1995-2010



Source: <https://pubs.usgs.gov/sir/2015/5038/pdf/sir2015-5038.pdf>

This map shows how much water is available to recharge aquifers. It is not only dependent on the amount of precipitation but also land cover, soil texture, and the timing and intensity of precipitation. All areas show a positive water balance but the trend from dryness in the west to wetter conditions in the east is clear.

You could be drinking rain that your great grandparents witnessed or snow that fell when the first Minnesotans were sharpening spear points and following caribou herds to the ice sheet jammed against the basalt cliffs of Lake Superior. Or, the groundwater you are drinking could be almost as young as the rain that falls from the sky. If you can't taste the difference, why does it matter?

Scientists estimate the age of groundwater during monitoring, mapping, and modeling to gauge the travel time of water from the surface to the aquifer. The widely varying ages of groundwater means that different aquifers can sustain different withdrawal rates.

It took over 20,000 years for some of our groundwater to accumulate drop by drop.



hydrology.nl/iahpublications/201-groundwatercartoons.html



PHOTO: Gabriel Kocha, CC BY 2.0

There are tradeoffs when using either young or vintage sources. Among the many important considerations that water suppliers must balance are how fast the water is being consumed and replenished.

◆ Young water

In the southwestern part of the state there is a drinking-water treatment plant where the temperature of the water goes up overnight during a summer thunderstorm. The wells that plant is drawing water from are tapping into very young water that infiltrates into the aquifer in just a few hours — almost like putting a straw in a puddle. Communities with water sources like these have tapped into the shallowest groundwater sources (unconfined, surficial aquifers), probably because they have no other options. If it stops raining, they may face shortages. If something happens at the surface — an accidental or intentional release of chemicals — they are vulnerable. Common contaminants entering surficial aquifers include anything we spread on the ground: road salt, fertilizers, pesticides, fungicides, pathogens in animal waste, and additives to animal feed that are spread with manure.

Areas where there are thin soils over fractured bedrock also contain young water. Water travels much faster through bedrock containing fractures (called *secondary porosity*). Beware of the local spring! It may just be a short cut in the local groundwater system through which surface water bypasses the natural filtration available in the smaller pores in sediment and rock.

◆ Vintage water

Deeper, more protected aquifers recharge much more slowly. It can take centuries for precipitation to seep through the pore spaces of sediment and rock to the deepest layers. Some groundwater in Minnesota still retains the isotopic signature of glacial meltwater and may not be recharged until there is another glaciation, if at all, because it required the extra pressure from a thick slab of melting ice to drive water deep into the ground. Want to wait around for that to happen? If not, then we should view any extraction of these vintage waters with a glacial-melt signature the same way as we do mining a non-renewable resource. It will not be replenished for generations to come.

The longer water has been moving through sediment and rock, the more time it has to dissolve minerals and pick up potential undesirables such as sodium, iron, calcium carbonate, sulfur, manganese, magnesium, boron, arsenic, and radium. If concentrations of these substances become high enough they can become health concerns, or simply a nuisance to plumbing systems. So although vintage water is better protected from the things we do on the surface, it may still require treatment to remove deleterious substances it has picked up.

Challenges of groundwater distribution

The boundaries of aquifers do not line up with community boundaries or even those of surface watersheds. For example, 18 counties in southeastern Minnesota share the same bedrock aquifers. From a community perspective, one town may receive permission from the Department of Natural Resources (DNR) to drill a new well. But from an aquifer perspective, that new well will most likely take water from the same aquifer that the old one did, and the same one that all of the neighboring communities use —like two straws (or 18 or 50!) in the same glass.

Drill a well deep enough anywhere in southeastern Minnesota and you will hit a rock layer that most likely has adequate water supply (light blue area in the southeast corner of map on following page).

The upper layers of these bedrock aquifers are increasingly contaminated, most commonly with nitrate pollution.

This is a result of land-use practices and the natural way water easily moves through the bedrock layers, some of which are riddled with fractures and even gigantic caverns that allow water to move quickly with little to no filtration. Communities in this region commonly have had to drill deeper to find low-nitrate water and then blend it with high-nitrate water to create a mixture that meets drinking water standards.

The bedrock in southwestern Minnesota does not host usable aquifers because the sediment is too fine-grained. It may also contribute nuisance or harmful elements like manganese or arsenic to the water. So these are not first-choice aquifers because of quality and quantity issues.

The patchwork quilt of colors in the rest of Minnesota's bedrock map depicts granite, gneiss, basalt, and other crystalline rocks that are generally very dense and do not have pore spaces to hold water. Instead, water is held in minuscule fractures, which results in low-yielding wells. Communities in these areas may struggle to find usable groundwater and water-intensive industries may not be able to depend on the water resources. In some of these



places, you have to rely on harder-to-predict and much smaller glacial-sediment aquifers or use surface-water sources.

This glacial sediment buries the bedrock in most of Minnesota. There are places, though, with extensive sandplains at the surface; this is both a blessing and a curse. Surficial sands are readily recharged by precipitation but quick to dry out during drought, so crops grown on them are typically irrigated. Sandy fields are easier to plant and harvest from but readily leach nitrogen and other chemicals into the shallow groundwater. These large sandplains are the first to exhibit issues with quantity and quality so most of them have been designated groundwater management areas by DNR.

Finding a buried glacial aquifer is often like prospecting for gold. Many off-and-on glaciations over the last two and a half million years deposited sand and gravel layers in extremely complex configurations. Well drillers, some on their third generation in the business, may have developed an intuitive, place-specific sense of where to drill based on decades of trial and error. One third-generation well-drilling family in southwestern Minnesota is still looking for good water to wash their muddy drilling clothes. In their spare time, they deepen the family well in the front yard thinking that the perfect laundry water is down there somewhere. In the meantime, they continue to learn more about the scattered glacial aquifers of southwestern Minnesota.

There is no cheap or easy exploration tool — just keep drilling and hope to hit a thick layer of soft, wet sand that covers a large enough area. Buried glacial aquifers are usually not large enough to support a large community system but can be adequate for a home well. Large parts of southwestern and south-central Minnesota rely on rural water systems to pipe water tens of miles to them because they can't or won't use the water beneath their homes, either out of preference or necessity. Some have even resorted to importing Missouri River water across state lines.

Where groundwater is not available, some Minnesotans are lucky to have lakes and year-

round streams from which to draw drinking water. However, these are commonly last-resort choices for small towns because they require more expensive treatment plants and water availability may fluctuate seasonally.

Given this uneven distribution of available groundwater across the state, each region has to come up with its own set of solutions. We present measures that can be put into place now while policy makers, agencies, and communities work to equitably achieve a long-term, sustainable-use plan. We break our recommendations into three chapters: **Reduce**, **Reuse**, and **Recharge**.



Image credit here

Groundwater is readily available in the bedrock aquifers depicted as blue-colored map units in the southeastern 18 counties. High-quality bedrock aquifers are less abundant to non-existent elsewhere in the state.

Aileen Lively, spouse of Minnesota Geological Survey staff member Rich Lively, created this batik appliqué quilt based on the 2011 bedrock geology map. It contains over 80 separate colors, all 87 county outlines, and an inset showing the distribution of Cretaceous rocks.

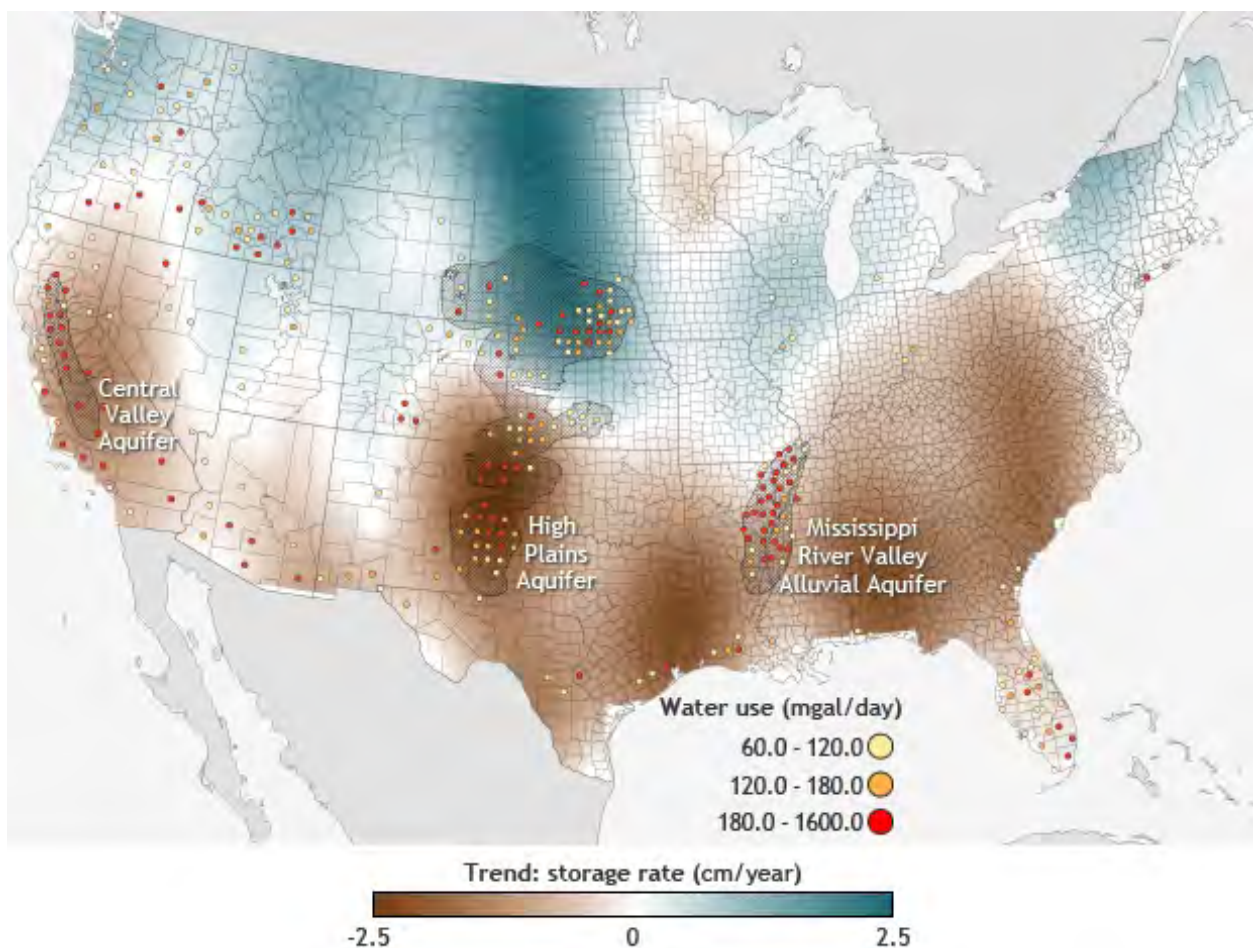
Reduce

Water is part of our state identity; we like water so much that in 2008 we voted to tax ourselves in order to protect it. Yet we seem to lack a deeper understanding of where our water comes from and what our water future holds. Maybe that is why Minnesota is experiencing declining levels of groundwater in some areas. Are we splurging when it comes to groundwater use?

The trends are clear — our groundwater is in decline and getting dirtier.

We could keep spending money to get a perfect understanding or we could move ahead now with our “pretty good” numbers. State agencies and communities generally agree that in order to avoid difficult and likely unpopular regulatory oversight, we must begin now to reduce groundwater usage. Fortunately many municipalities have already begun this work and can serve as examples.

Minnesota is the only state in the upper Midwest shown as having a groundwater deficit on this map. This may be because of changing climate, irrigation, or a combination of both.



From “Water in the Balance,” Famiglietti and Rodell, Science, 2013. Overlay of county-level water use data from USGS. Composite figure from Climate.gov, October 15, 2014. Freshwater Society hosted Jay Famiglietti as part of the Moos Lecture Series. Watch the archived lecture: <http://mediasite.uvs.umn.edu/Mediasite/Viewer/?peid=aa3b0de52531420e82a8d2d2d2b780ea>

Status update on groundwater reserves

The map on the previous page shows in brown the areas of the country that are losing groundwater. This broad but accurate picture is based on subtle changes in the earth's gravitational field. When groundwater is depleted, whether by pumping or reduced recharge from decreased precipitation, the area loses mass and therefore has a weaker gravitational force.

We've heard about the problems in the central valley of California and Texas.

They would view our groundwater deficit as a self-inflicted wound because we have options: large rivers with dependable flow, a Great Lake, and more than 10,000 smaller lakes.

Instead, we keep pumping old water from deep underground. Over-pumping not only impacts communities and their industries, but also the rivers and lakes that depend on stable groundwater levels for the slow seepage that sustains them.

For the other renewable natural resources we use, like trees, pheasant and walleye, we have an estimate of how much there is and how much of that we can safely or economically harvest. Our first priority therefore should be to determine the state's water balance:

water in - water out + ? = water stored

How much is in the bank and how quickly can we spend it before the next paycheck arrives? Do we want to be living paycheck to paycheck or should we have a little extra liquid stashed away for a non-rainy day?

The Metropolitan Council recently created regional groundwater flow models for the metro area (Metro Model 2 and 3), with input from many stakeholders and groundwater professionals. The models use geology, monitoring, water-use, and recharge data to project sustainable groundwater use for the metropolitan area. This helps us predict future scenarios and safe levels of

groundwater withdrawal. DNR does localized modeling for the rest of the state and uses ecological criteria to determine when pumping negatively impacts aquifers and surface waters connected to them. Both modeling and ecological impact assessment have some wiggle room because of the inherent uncertainties and assumptions in the methods. This can allow room for politics and beliefs to instill doubt that can unduly influence the decision-making process.

The DNR's observation wells currently only record static water levels. Smart networks, also known as IOT (Internet of Things) Technology, enable transmission and visualization of continuous data. If this new technology were required in all permitted pumping wells in the state, valuable data about changes in aquifers and their basic properties such as water storage and flow could be extracted. The DNR could use these data to create a centralized database with water-level and flow-rate information and simplify enforcement of permits.

Real-time reporting on changes in water levels can motivate cities with facts to help them identify and implement water- and energy-saving measures that will slow down their consumption of groundwater and help plan for new water infrastructure.



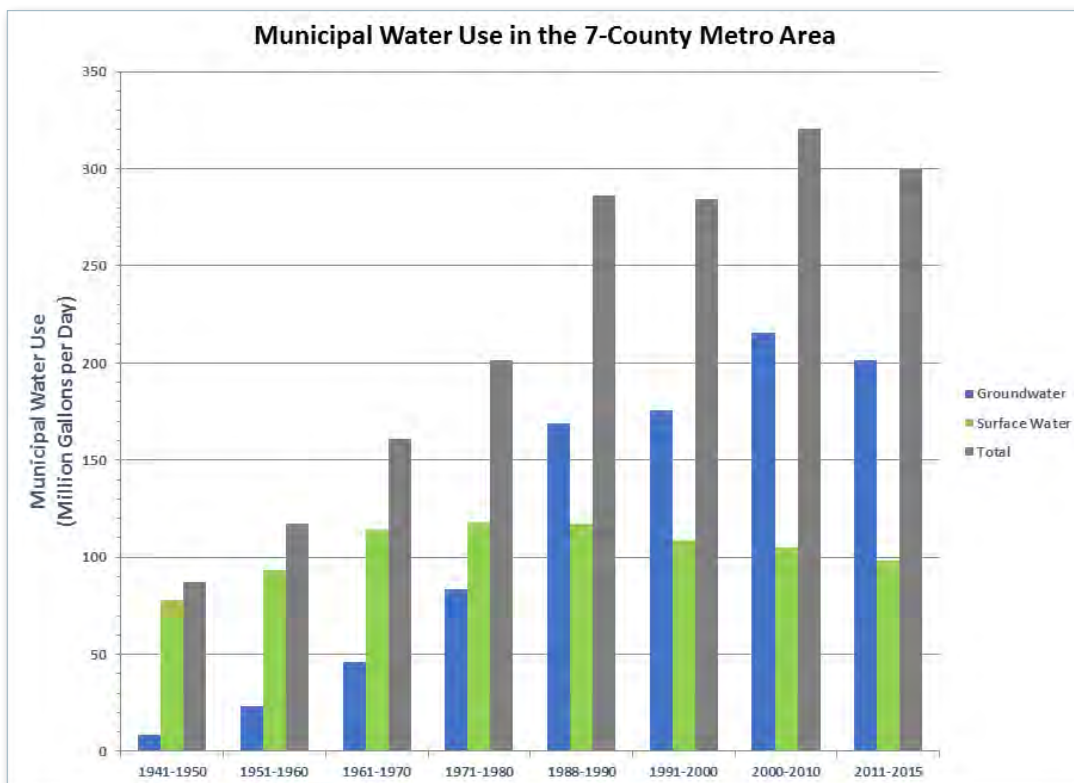
PHOTO: Summit Environments, Inc.

Current groundwater use

The water we choose to consume first is groundwater. In the metro, although total water use has not risen, groundwater use has. As population expands, dependence on groundwater grows. Municipal use is the second and fastest-growing water demand in the metropolitan area (power generation is the first) and the largest use for groundwater. Statewide, our surface water use has begun to decline or, if you include once-through power plant cooling, is flat. However, total statewide groundwater use has

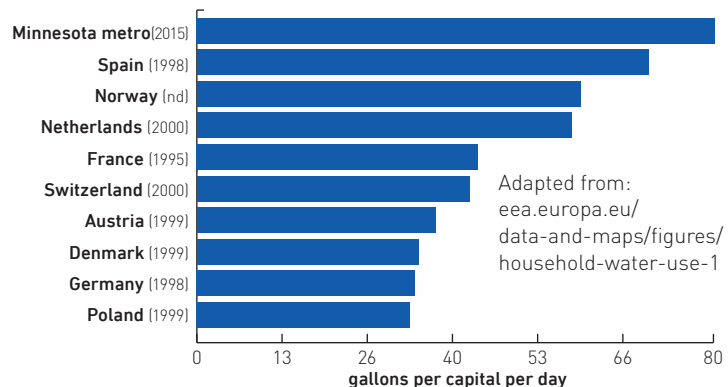
increased through 2000. Even in areas that have a lot of recharge, we must determine if we are taking water faster than it is being replaced.

In the last decade or so, the average metropolitan Minnesotan used about 80 gallons of water per day. That is close to the 75 gallons per day goal for residential use recommended by the DNR for sustainability. However, the amount of water used per person for residential outdoor water use has not declined.



Source: Master Water Supply Plan, December 2015, Metropolitan Council

To put this into a broader, global context, this goal exceeds the current average domestic use of every major European country and in most cases is approximately three times what these countries are using.



Communities collaborate with the DNR to develop their water conservation plans. In the 7-county metropolitan area, they also receive help from the Metropolitan Council. This cross-border planning is essential because, as we acknowledged earlier, a lot of cities are sticking their straws in the same cup. Cities and the urban fringe must plan together, and rural communities need to understand their large sphere of influence.

The Metropolitan Council offers technical guidance and online resources for conservation practices. They estimate that the region might sustainably withdraw 400-500 million gallons of groundwater per day. However, even with lower withdrawals, there may be local impacts to sensitive features such as shallow wells or trout streams. Based on water use reports from DNR permits, the metropolitan area currently pumps

255 to 338 million gallons of groundwater per day, with an additional 11 million gallons per day pumped from residential wells within the 7-county metro as estimated by the U.S. Geological Survey (see Table 2). Remember though, that these aquifers extend to all of southeastern Minnesota.

Regionally, we are closing in on maximum estimated groundwater withdrawal rates and in some areas and for some aquifers, are exceeding sustainable rates.

Additionally, as the metro area expands we are paving over critical recharge areas.

So, why aren't the brakes being applied? We think they should be.

TABLE 2. Summary of water supply sources in the Twin Cities metro area, including key management considerations; estimated amount of water sustainably available from sources in areas where infrastructure currently exists; or, in the case of stormwater, has current support for implementation and number of municipal water supply systems currently supplied by each source.

Source & Management Considerations	Estimated sustainable amount available	Municipal supply systems currently using this source
Quaternary Aquifer <ul style="list-style-type: none"> • Challenging to identify most productive sand and gravel layers • First aquifer to experience changes in recharge quantity and quality • Most likely of all aquifers connected to surface water • Treatment needs for naturally and manmade contamination varies across region • Response to recharge may change with climate and land use 	About 70-90 MGD	24
Prairie du Chien-Jordan Aquifer <ul style="list-style-type: none"> • Not available to some growing communities • As the most heavily used aquifer in parts of the region, greater likelihood of water-use conflict • Connected to some protected surface waters • Treatment needs for naturally and manmade contamination varies across region • Response to recharge may change with climate and land use 	About 280-330 MGD	83
Tunnel City-Wonewoc Aquifer <ul style="list-style-type: none"> • Productivity varies greatly across the region and is highest where it is fractured or weathered • Connected to some protected surface waters • Treatment needs for naturally and manmade contamination varies across region • Low recharge rate in parts of region; response to recharge may change with climate and land use 	About 70-90 MGD	30
Mt. Simon-Hinckley Aquifer <ul style="list-style-type: none"> • Use of this aquifer is restricted by Minnesota law • Very slow recharge rate; response to recharge may change with climate and land use 	About 10 MGD	35

Adapted from: Master Water Supply Plan, December 2015, Metropolitan Council

Shouldn't we say "slow down!" to suburban communities where the monthly volume of water used triples or more during summer months, primarily to water lawns? This adds up to about 1/4 to 1/3 the total annual volume pumped. If citizens were presented with these facts and they were reinforced with billing practices, most would probably find ways to pump less water from 400 feet underground to water their lawns.

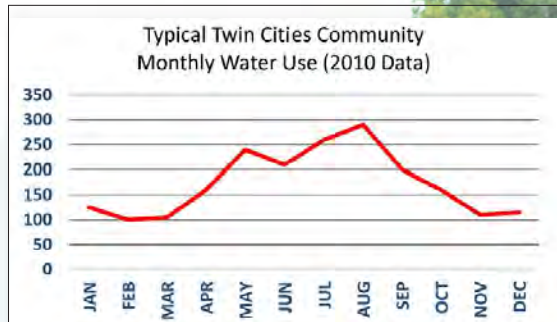
But they haven't gotten the message because most metro lawn-waterers only pay about \$30/month for the privilege of a steady stream of water for all uses, including green grass. In 1988, an estimated 60-80% of domestic irrigation water used in the metro was groundwater — about 40% of all groundwater used. The Metropolitan Council is currently conducting an efficiency survey of home irrigation systems. Many automatically water the lawn whether it needs it or not. Would we set up a schedule to automatically flush a toilet? Run a dishwasher? Why do we do this with our lawns?



The price of drinking water in much of Minnesota is very low and this doesn't motivate reductions in use. The city may also lack motivation because the operating budget of a water plant is tied to how much water is consumed. It is usually less expensive to withdraw new groundwater than it is to treat it for reuse.

Sadly, water that is not accounted for (non-revenue water) makes up more than 10% of total water use — or rather misuse. It is simply lost through big pipe ruptures and small persistent leaks. Accurate water accounting and leak detection are good investments to ensure that the water we extract and treat ends up getting used rather than just dribbling away.

Seasonal municipal water use in a typical metro area community, 2010. Winter use is 100 million gallons per month. This increases threefold by August as lawns and gardens are watered.



Source: Master Water Supply Plan, December 2015, Metropolitan Council.

PHOTO: PCA/Flickr

Reduce recommendations

We are at a critical threshold in some key parts of the state and the trend of groundwater usage must change. Whether action comes from the state, community, or individual, we must keep groundwater levels from declining further. Our April 2016 report recommended that the state “continue to fill gaps in monitoring, modeling, research, and communication necessary to support local groundwater management.” Those goals may be even more achievable than we thought a year ago.

Cities are usually in control of municipal water supplies and for the most part already know what to do. A municipality can begin to make reductions if they know what to target:

- ◆ monitor water levels and flow rates in all of their wells in real time
- ◆ understand and include an analysis of water-level trends in their annual water-use report
- ◆ communicate these water-level trends to customers to show the need for management
- ◆ educate their customers on conservation methods and efficient-use practices recommended by the American Water Works Association, the Metropolitan Council, and other sources with proven methods
- ◆ provide incentives to change consumption habits such as varying rates to reward conservation
- ◆ fund distribution system maintenance and replacement to reduce system water losses
- ◆ set the cost of water to reflect the full cost of pumping, delivery, treatment, maintenance, system improvements, reuse, and education
- ◆ diversify water supply

The state can, through its rule making and statutorily-empowered agencies, provide tools for greater awareness:

- ◆ expand the monitoring well network as recommended in our April 2016 report
- ◆ modify water appropriation permit conditions to require emerging transducer and cellular-network monitoring technology to reduce the cost of water-level sensing and make the data easier to access, visualize, and use in real time
- ◆ require cities to discuss water quantity in their annual water-use reports
- ◆ compile easy-to-read, multi-decade trends for every aquifer and municipal well field, to help cities analyze water-level trends

- ◆ seek legislative approval to increase DNR permit fees immediately to reflect all costs of groundwater management activities
- ◆ audit water-usage reports, and identify unpermitted withdrawals and bring them into compliance
- ◆ adjust permitted appropriations to reflect actual use
- ◆ require phasing-in of water conservation best management practices for permitted wells in declining aquifers
- ◆ support Minnesota Technical Assistance Program (MnTAP) efforts, sector-specific training, and water-efficiency technical assistance to largest water users

Individual, commercial, institutional, and industrial water users can also take steps to reduce water use:

- ◆ monitor water usage
- ◆ fix leaks
- ◆ use manual irrigation systems and water lawns only when needed or upgrade to smart irrigation systems
- ◆ install low-flow and water-saving fixtures and appliances. The U.S. EPA's WaterSense program is a resource (<https://www3.epa.gov/watersense/>)
- ◆ frequent water-efficient businesses and become a water-conscientious consumer
- ◆ replace treated drinking water with captured rainwater for outdoor uses
- ◆ conduct water-system audits and implement cost-effective water efficiency improvement projects
- ◆ educate youth about the importance of a water conservation ethic
- ◆ become involved in water stewardship activities, events, and organizations
- ◆ plant native landscapes

Woodbury offers freebies to cut down on water usage

Woodbury's campaign to cut down on water waste by irrigation is moving to homeowners.

The city is partnering with the Minnesota Technical Assistance Program (MnTAP) on a pilot program to see how well smart controllers might work in single-family homes. Officials are offering dozens of free Rachio IRO controllers to single-family homeowners in Woodbury who now use clock-based water controllers. Certain system requirements must be met in order to be eligible. The controllers will be given out on a first-come, first-serve basis while they last. Woodbury has made water conservation a major priority out of concerns that state regulators may not let the city continue to drill more wells as it grows. It already has worked on irrigation devices with commercial users.

By David Peterson

Excerpted from an article in the Star Tribune, June 24, 2016

Reuse

The second strategy to reduce our demand on groundwater supplies is through reusing the centuries-old groundwater that we've already pumped from an aquifer. Do we really want to go to all that effort to find, extract, and treat it and then use the water only once before sending it down the nearest river to Iowa? It is like money down the drain. We need to regard used water as a resource, not a waste to discard. Water reuse has the potential to both reduce demand on water resources and to improve stormwater management.

An interagency workgroup in Minnesota defines reuse as: the capture and use of stormwater, wastewater, and subsurface water to meet water demands for intentional and beneficial uses such as flushing, irrigation, cooling, washing, industrial processes, and drinking. When the state passed the Minnesota Groundwater



Protection Act of 1989 and its amendment in 1990, its overarching goal was to assure an adequate water supply and prevent further degradation of groundwater, at a time when the federal government was not taking action.

If the state has supported sustainable water use, and more explicitly water reuse, why has it not become an accepted practice? It's complicated.



Different agencies are responsible for different parts of the water cycle. As rain falls it may become stormwater (MPCA) and directed to a pond (DNR, waters of the state); if this water is to irrigate a ballfield, it may come in contact with humans (MDH); if it is used to flush toilets in a building it must be plumbed according to code and safe for human contact (MDH and DLI).

Agencies and their water roles

The state separated the regulation of drinking water and wastewater and gave agencies specialized water-governing roles to protect resources. This structure doesn't necessarily align with reuse purposes as we try to bring those two streams back together.

What seems like a simple stormwater reuse project can trigger a response from multiple agencies.

The interagency workgroup is trying to make reuse easier by simplifying the permitting process but the separate silos and roles are proving difficult to reconfigure.

As seen in the table on the next page, the regulation of reuse is nuanced because of differences in water source, end use, and stage in the reuse treatment train. When playing by existing interpretations of the rules on the books, reuse gets complicated fast. There is no clear path to follow even though there are a lot of rules. The absence of an accepted practice makes every proposed reuse case a "one-off", which results in a kind of prohibition. Most people give up before they even start.

The responsibilities of the agencies as outlined in the table are currently required by law. To reap the full benefits of reuse, laws have to change. Fortunately, one goal of the interagency workgroup is to make reuse easier and accepted

as mainstream practice. This will only happen after reuse has a clear regulatory pathway and is safe, sustainable, and affordable. The affordability will come when all of the benefits of reuse are quantified and water is valued in such a way as to make reuse economically feasible.

The interagency effort began in 2016 and recommendations for developing best practices and regulatory and non-regulatory approaches for reuse in Minnesota will be completed by summer 2017.

Currently, there appears to be no plan to change the agencies' primary roles, but rather to better align their responsibilities for more coordinated through-flow of permits. However, stakeholders have requested a shift in thinking from "How can we control this?" to "What can we undo to unleash this?" Without a clear lead agency or project manager, the efforts of this team could end up moth-balled or not fully realized.

We think the executive branch should identify and fund a project manager and lead agency dedicated to this complex effort. They would field inquiries, act as a hub for sharing technology, and shepherd permits through the process until a well-worn path is created. They could also take a leadership role in the nascent Minnesota Chapter of the Water Reuse Association, act as a clearinghouse of reuse information, and work towards consistent federal standards. Ultimately, as with the building code, the goal should be for local jurisdictions to manage oversight.



PHOTO: Alistair Young, CC BY 2.0

Roles of Regulators at Different Points of a Reuse System

	Source	Capture/Storage	Treatment	Distribution	End Use
Rainwater	<i>Not explicitly regulated</i>	DLI regulates the drainage or collection from roofs and catchment systems.	MDH has broad authority over drinking water quality and public health but nothing specific about evaluating the safety of reuse systems. DLI has water quality treatment requirements for rainwater.	DLI regulates use within buildings and drainage systems. DNR regulates if volumes collected/used >10,000 gallons per day or one million gallons per year (some residential exceptions).	MDH regulates injection wells, has controls on infiltration in vulnerable DWSMAs , ERAs , and some WHPAs . DLI requires backflow preventers to prevent cross-contamination with potable water sources.
Graywater	DLI administers plumbing code, which governs the design and installation of graywater systems as well as plumbing licensing requirements; all graywater systems require a variance. County or City issues permits for volumes < 10,000 gal/day.	MPCA regulates disposal of graywater as a component of wastewater, including specific technical requirements for septic tanks, pumps, dispersal in trenches, seepage beds, mounds, at-grade systems. DLI mandates that public sewer and water be used if available, requiring a variance for graywater projects.	<i>Lack of standardized treatment, though DLI can set treatment requirements through variance.</i>	MDH requires graywater disposal to be certain distances from wells. DLI requires graywater and backup systems to be separated through plumbing code for piping, make-up water, backflow provisions, cross connections, testing requirements, and setbacks.	MDH is involved only if the end use is potable, as drinking water standards would apply. DLI would require a variance for uses in buildings. MPCA regulates discharge to surface waters and land discharge (including irrigation), issues guidance on reuse.
Stormwater	<i>Not explicitly regulated</i>	MPCA provides guidance in capture and storage of stormwater in the Stormwater Manual.	MDH is evaluating for the safety of common stormwater reuse installations.	DLI regulates use within buildings (and has broad authority to regulate stormwater conveyance systems, but does not regulate irrigation systems unless combined with indoor use). DNR regulates if volumes collected/used >10,000 gallons per day or one million gallons per year (some residential exceptions).	MDH regulates injection wells and infiltration in vulnerable DWSMAs , ERAs , and certain WHPAs . DLI requires backflow preventers and compliance with MDH well code to prevent cross-contamination. Stormwater use within buildings requires a variance. MPCA issues permits for stormwater discharge and infiltration.
Wastewater	MPCA regulates municipal and industrial sources of wastewater. County or City issues permits for volumes < 10,000 gal/day. DLI would require a variance for all wastewater systems.	MPCA regulates the disposal of wastewater including specific technical requirements for septic tanks, pumps and dispersal in trenches, seepage beds, mounds, or at-grade systems. DLI mandates that public sewer and water be used if available, requiring a variance for wastewater projects.	<i>Lack of standardized treatment, though DLI can set treatment requirements through variance.</i>	MDH requires wastewater disposal to be certain distances from wells. MPCA regulates municipal and industrial disposal to surface waters, subsurface, and land. Metropolitan Council permits any discharge to the metro system (many large cities/sanitary districts also have this authority). DLI regulates wastewater piping within buildings and property lines.	MPCA regulates discharge to surface waters and land discharge (including irrigation), issues guidance on reuse. MDH applies drinking water standards to potable end uses; a variance would be needed for aquifer injection. DLI requires a variance for use in buildings, and upholds MPCA design requirements. USEPA involved in aquifer injection.

DLI Department of Labor and Industry; **DNR** Department of Natural Resources; **MDH** Minnesota Department of Health; **MPCA** Minnesota Pollution Control Agency; **USEPA** U.S. Environmental Protection Agency; **DWSMA** Drinking Water Source Management Areas; **ERA** Emergency Response Areas; **WHP** Wellhead Protection Areas. Table from *Water Reuse Workshop Proceedings Report*, Freshwater Society, 2016.

Matching standards to source and use

Water reuse is best categorized by the water source and how it will be reused. Sources are numerous but can be broadly grouped into:

- ◆ rainwater
- ◆ subsurface water (e.g. from shallow groundwater removed for building projects and mining),
- ◆ stormwater, and
- ◆ wastewater, which can be further subdivided into industrial wastewater and domestic wastewater, a subset of which is graywater (laundry, sinks, showers, and tubs).

Uses include potable and non-potable indoor use, irrigation (crop vs. non-crop), and industrial uses such as for washing. The easiest reuse efforts involve harvesting lightly used water and using it for non-crop irrigation. We believe that a tiered approach to permitting reuse is the most straightforward way to proceed.

Stormwater: a good place to start?

It seems straightforward and helpful to save stormwater and use it for irrigation. Stormwater is defined as rainwater that has hit the ground — rainwater only touches the roof.

- ◆ a one-acre parking lot generates over 27,000 gallons of runoff during a 1" rainfall
- ◆ an average of six 1" rainfall events occur annually
- ◆ approximately 246,000 acres of impervious area exist in the metropolitan area

Therefore, stormwater may yield approximately 100 million gallons per rainy day in the metropolitan area (Chapter 4 Master Water Supply Plan, Met. Council, 2015), about *a third of the water currently used*. Annually, about 750,000 gallons of runoff per impervious acre are generated, or about 18 billion gallons. Obviously, this water would have to be cost-effectively stored to yield a benefit. In addition to the large volume it would contribute to augment water supply, capturing stormwater for reuse can also improve surface water quality and reduce flooding and associated erosion. The MPCA has authority over stormwater and has developed some guidelines for its reuse.

However, the regulatory path to using stormwater can be meandering.

- ◆ Anything dirtier than rainwater still requires a variance every time someone proposes to use it indoors or connect it to a plumbing system.
- ◆ A stormwater pond *may* be interpreted by the DNR to fall under the statutory definition of "Waters of the State", those public waters that the DNR has authority to regulate.
- ◆ However, the MPCA has authority over stormwater and *does not* classify constructed stormwater ponds as "Waters of the State".
- ◆ If the DNR interpretation holds, it means that use of stormwater from a pond may require an appropriation permit and annual volume reporting to the DNR if volumes exceed the appropriation permitting thresholds.
- ◆ If stormwater infiltrates the ground it cannot, by law, further degrade groundwater. This rule has also been interpreted by the MPCA to mean that stormwater should also not move or dilute any existing areas of known contamination.
- ◆ Stormwater used for any purpose with the potential for human contact — for example to irrigate a ballfield or a commodity crop, flush toilets, or for industrial purposes — may be subject to MDH recommendations to minimize human health risk though the agency currently only has an advisory role.
- ◆ Stormwater that flows through a pipe indoors may require DLI oversight because the plumbing code controls all indoor water use. A long-awaited update to the plumbing code in January 2016 now allows for harvested rainwater to be used for some indoor uses, but other sources are still not permitted.

Having no clear regulatory pathway is almost as bad as having an onerous one.

For someone outside the agencies, even knowing where to start, which agency to approach first, and which has the final say, is unclear. We can simplify the current regulatory framework by treating low-risk sources and reuse applications differently. Rainwater and stormwater can be treated differently than graywater and wastewater.

Reclaimed wastewater, a steady stream

Although the region currently has just enough water to meet demand, for anticipated growth we have to consider using water from all sources: not just rain and stormwater. The Metropolitan Council is exploring this approach. A 2007 report describes recycling treated wastewater for industrial water use.¹

Hopefully we will overcome the “ick factor” and add reclaimed wastewater to the reserve that we are tapping. Only then will we be able to meet our growing demand year round. As stated earlier, we are pretty much at peak groundwater use now and need to find supplemental sources of water.

Wastewater is produced continuously and provides opportunities for reuse everywhere there is a treatment plant (or a toilet). In the metropolitan area, where we use about 300 million gallons of groundwater per day, there are eight wastewater plants with an average flow of 250 million gallons per day. We currently lack a distribution network for reclaimed water. That’s why the decentralized ‘district’ systems appear most promising for getting used water to where it is needed. If we reuse this water, we can allow for growth while balancing our groundwater budget.

San Francisco is exploring onsite treatment and non-potable reuse of wastewater. The small town of Wichita Falls, Texas was forced out of necessity to reuse their wastewater for drinking water, and headlines were constructed to sensationalize rather than ease concerns. We are not there yet, in need or acceptance. However, you don’t have to *drink* reused wastewater to gain the groundwater savings. Reclaimed water could be sold to supplement or replace treated groundwater that is used in water-intensive industries, to flush toilets, and certainly to irrigate our lawns and golf courses. Wastewater can be treated to a level of purity equivalent to distilled water, where needed.



Texas town forced to drink toilet water

In News by Brian Abrams / May 8, 2014; <http://www.deathandtaxesmag.com/220536/texas-town-forced-to-drink-toilet-water/>



Reclaimed water portion of the waste water treatment plant in Mankato, Minn. Photo: Jackson Forderer/MPR

¹ <https://www.leg.state.mn.us/docs/2007/other/070575.pdf>

Energy-saving motivations for reuse

It takes a lot of energy to move water – first from the ground to the treatment plant and then from the plant to homes. The drinking water treatment plant in Minneapolis uses more energy than any other city-owned building and accounts for 50 percent of the electricity and natural gas used in city buildings. This is a bit more than the 30-40 percent average for U.S. cities.² Some cities in Minnesota are saving energy by pumping and treating groundwater during off-peak hours.

Wells lose efficiency over time as minerals fill the pore spaces of the aquifer near the well and clog the well screen. It is difficult to detect this slow decline in pumping efficiency but the gradual increase in energy required and the time it takes the water level to recover after pumping add up to real costs.

Wells that don't recover quickly can continue to be pumped but the decrease in water level means more energy is required to raise the water to the surface. It is more economical to switch to a different well before the drawdown is too great.

Smart networks exist that allow people to use their phones to view GIS-enabled constellation information in the sky and traffic conditions on the ground, and now that same level of

integration has become cost-effective for groundwater level data. Post-processing of water-level data in hundreds of wells allows municipalities to 1) better visualize how their groundwater use impacts the aquifer in the short and long term; 2) optimize individual well efficiency to lower operating costs; and 3) reduce the effects of aquifer drawdown on surface water features.

Ideally a city would pump, treat, and transport less water overall for ultimate savings. But reusing already-pumped water and doing that near where wastewater is discharged can also save energy. You can also extract heat and energy from water moving through a wastewater treatment plant.

We need to change our mindset and begin to look at wastewater as a resource.

European countries are way ahead of us in this area of integrated water management. We can look to places like Denmark and Germany for how to proceed in siting water-intensive industries next to wastewater treatment plants, for example.



PHOTO: imgur.com

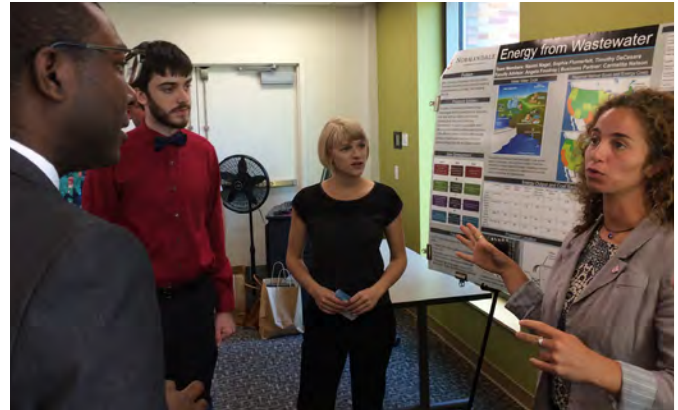
² <http://humphreyreview.umn.edu/water-reuse-minnesota-greywater>

Reuse workshop findings

Policy barriers are one of the primary reasons more reuse projects aren't installed in the state, according to findings presented in the *Water Reuse Workshop Proceedings Report*, which summarizes a meeting co-hosted by Freshwater Society and Capitol Region Watershed District on May 2, 2016 (July 2016). A lack of clear standards or a process for permitting creates a complicated and circuitous planning process, and increases cost and frustration. The table below summarizes the barriers that participants identified for two types of water that are most commonly considered for reuse: rainwater and wastewater.

Some early adopters of reuse were featured at the Water Reuse Workshop. See the Freshwater Society July 2016 report for summaries of how they braved the policy obstacle course and made reuse happen.

rainwater	1. Cost is high, and potable water is inexpensive
	2. Lack of state or national policies/guidelines for oversight and management of decentralized non-potable water systems
	3. Lack of water quality/performance standards for decentralized water systems
	4. Water appropriations permits and reporting processes are discouraging
	5. Not enough public health or risk data
wastewater	1. Cost is high, and potable water is inexpensive
	2. Treatment requirements are not in line with use
	3. High chlorides in treated wastewater is a challenge for industrial reuse
	4. Lack of state or national policies/guidelines for oversight and management of decentralized non-potable water systems
	5. Lack of water quality data on alternate water sources



Normandale students, from right, Sophia Flumerfelt, Naomi Nagel and Tim DeCesare discussed their award-winning project with Garrison McMurtrey of U. S. Sen. Amy Klobuchar's office.

Normandale students take national honors for innovative renewable energy proposal

Normandale Community College students say their proposal for renewable energy could save about \$400 million a year nationwide.

Wastewater treatment plants in the United States discharge 365 billion gallons of water a day, and according to a group of young science wizards from Normandale Community College in Bloomington, nobody ever thought of doing something useful with it.

Until they came along, that is.

The Normandale students just returned from the national Community College Innovation Challenge, where they tied for second place among 10 teams previously selected as national finalists.

Normandale's entry was simple in theory: Install hydrokinetic turbines to generate renewable energy from the discharge at treatment plants.

Yet as they researched the topic, the students didn't discover a single example of the technology's use in more than 16,500 U.S. treatment plants.

The students — Tim DeCesare, Sophia Flumerfelt and Naomi Nagel — estimated that their idea could save about \$400 million a year nationwide and pay for itself after two years of operation. A city the size of Moorhead, Minn., could install a turbine for about \$300,000, the students calculated.

By John Reinan

Excerpted from an article in the Star Tribune, August 17, 2016

Reuse recommendations

The message is clear. We cannot survive on groundwater alone and because not all communities have the Mississippi River running through them, the state must promote the use of additional water sources, including reused water. We can increase capacity by reusing rain, storm, and even wastewater to balance the water budget in certain areas of the state. We should encourage the separation of graywater from wastewater since graywater requires less treatment and has fewer psychological hurdles to overcome. Integrated water management is the ultimate goal. Where risk and complications are low, we may simply need to unleash the process and let the bottled-up technology that has been tested in other parts of the country and world be employed.

Strategies to address current barriers to reuse are included in Freshwater Society's *Water Reuse Workshop Proceedings Report*. We expand on those by emphasizing specific recommendations, some of which have been identified by the interagency reuse workgroup.

More importantly, Freshwater Society would like to reframe the conversation and encourage the state to view groundwater use and reuse through an integrated water-management lens. We envision policies that link the management of stormwater, drinking water, wastewater, surface water, and groundwater. The question is not simply how much water a community uses, but how much of that is virgin groundwater. Communities that reuse water should be encouraged and rewarded. Communities that do not reuse water should be incentivized to do so.

Water is a resource that can be safely managed through its extraction, use, treatment, and reuse. Fully appreciating the economic, environmental, and social benefits of reusing water will help with the sales pitch. To that end we recommend that, after the interagency workgroup report is processed and approved by the agency commissioners, the state should:

- ◆ Quantify the full environmental and economic benefits of reuse on regional aquifer levels by calculating:
 - the cost of supplying water
 - the value of discarded water, and
 - the environmental benefits of steady groundwater levels(DNR, Environmental Quality Board)
- ◆ Review the effectiveness of financial incentives on promoting efficient use and reuse (DNR, Metropolitan Council)
- ◆ Assess acceptable risk of different types of reuse projects and develop tiered treatment standards to apply to the varied sources and end uses (MPCA, MDH)
- ◆ Adopt the chapter on Alternate Water Sources for Nonpotable Applications of the Uniform Plumbing Code to allow graywater reuse (DLI)
- ◆ Require integration of data from permitted wells to:
 - better optimize well-field efficiency
 - produce energy savings
 - provide data on aquifer characteristics and trends (DNR)
- ◆ Streamline regulations and nominate a lead agency to:
 - actively promote reuse
 - create policies and measures that integrate all aspects of water management
 - remove redundancies in state oversight
 - establish a simplified process for designing, permitting, and installing reuse systems
- ◆ Update codes to:
 - clear regulatory hurdles at the city and county levels
 - incentivize water reuse in the early stages of planning and provide financing

Recharge

If we succeed in reducing our groundwater dependence, some of the ideas in this final chapter won't need to be implemented. However, that seems unlikely in the near term, so we'll explore the concept of replenishing aquifers that have been severely impacted by overuse or contamination.

Plans to protect the recharge areas for municipal well fields (wellhead protection areas) could be expanded by protecting all recharge areas, not just those associated with a nearby well. This fits under the definition of "managed recharge"—identifying and protecting those areas where natural recharge is already occurring. It may also mean pre-treating the water before it recharges. This also addresses non-point source pollution, which goes unregulated in current law.

Where continued pumping of groundwater will result in a level from which it will take centuries to recover, sustainable exploitation of an aquifer may require not only that the main recharge areas are protected, but that in some cases recharge is artificially enhanced. This means intentionally directing water to suitable aquifers for subsequent recovery or to achieve environmental benefits.

A well-managed process ensures adequate protection of human health and the environment.

Some will argue that we currently do not (and may never) have aquifers that reach this critical state. However, other regions of the country and world have been replenishing aquifers for decades. Shouldn't we at least consider the possibility?

Storage of water in an aquifer rather than a surface reservoir conserves land area and takes advantage of natural filtration and breakdown of contaminants. California has been doing this in a safe and reliable way for more than 50 years. This is, in fact, standard practice in places where there is:

- ◆ limited surface water
- ◆ frequent drought
- ◆ land subsidence or salt water intrusion from groundwater withdrawal
- ◆ abundant surface water during flooding with space available in aquifers to store it
- ◆ a dense and growing urban population that cannot be supported on groundwater alone.

Minnesota only fits into the last two categories. Before we proceed we need to understand what has and hasn't worked around the world, adjust for conditions specific to Minnesota, and become comfortable with the idea of recharge if it becomes necessary in Minnesota.



PHOTO: Minnesota River Basin Data Center

What would motivate a Minnesotan?

Barring significant changes in precipitation patterns, it may be hard to motivate Minnesotans to actively recharge their groundwater. In fact, some find it downright scary to even consider pumping water into the ground. However, fear is not a reason to disregard this tool; it is a reason to proceed in a cautious manner.

Parts of the state are already showing signs of imbalance and unsustainable groundwater use. The metropolitan area, which has the best groundwater reserve in the state, is already pumping near peak rates. Water planners must begin to look for supplemental sources. In some locations, aquifer replenishment may be one of the solutions to ensure long-term availability of water.

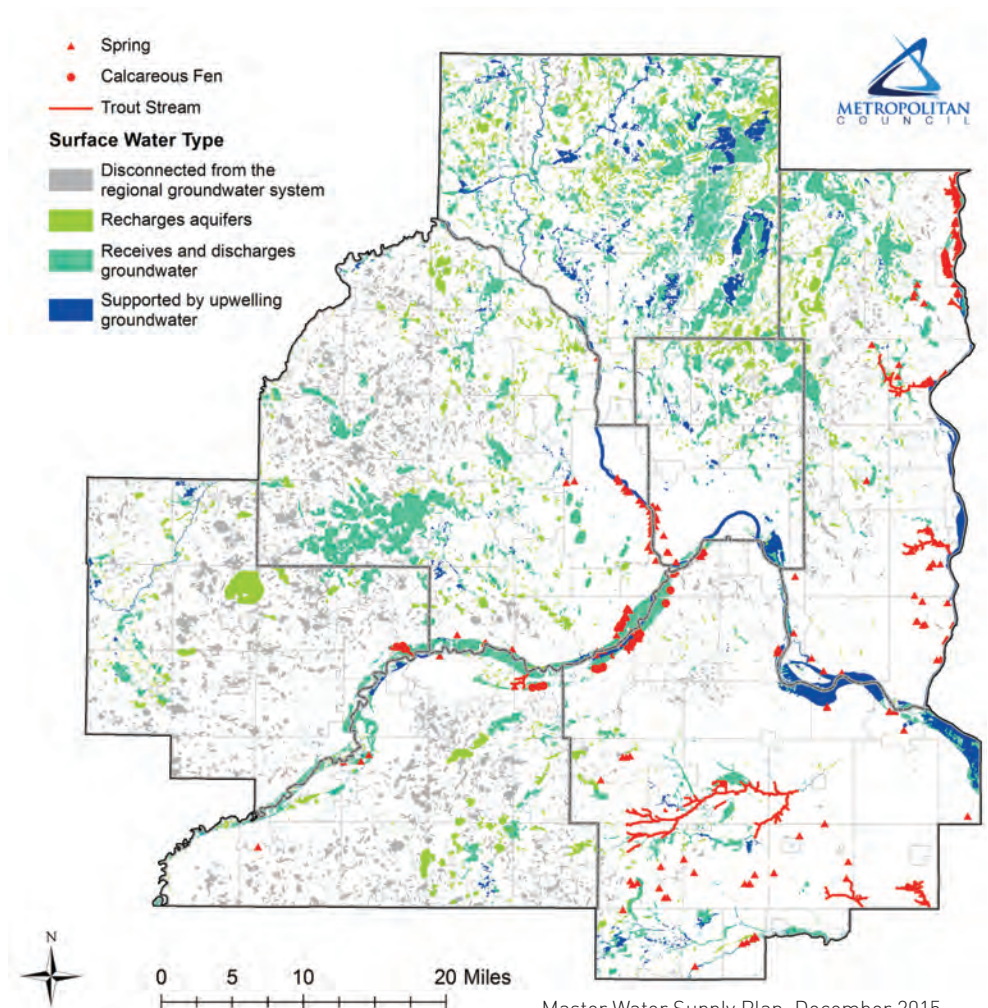
Low groundwater levels can affect surface water resources. There is a misconception that lakes are separate from the groundwater beneath them. In fact, they are commonly the expression of the groundwater level in the aquifer closest to the surface. Evaluating the tradeoffs between users of aquifers and the difficult-to-quantify environmental benefits of stable lakes, wetlands, and fens is fraught with conflict and can tear communities apart. Recent low levels of White Bear Lake got the attention of those used to launching boats and swimming on the shore of that lake.

White Bear Lake is not unique; about half of the surface water features in the metropolitan area are connected to the regional groundwater flow system (Metropolitan Council, 2010).



Caroline Yang for MPR News <http://www.mprnews.org/story/2015/09/03/white-bear-lake>

Docks on White Bear Lake have gotten shorter than they were when water levels were at their lowest in early 2013.



Master Water Supply Plan, December 2015, Metropolitan Council

But outside of a crushing drought impacting a favorite lake, what would motivate a Minnesotan to consider the managed recharge of an aquifer? Possible scenarios include situations where:

- ◆ overpumping has reduced aquifer levels, affecting the ability of existing wells to penetrate the aquifer and requiring new, deeper wells
- ◆ unplanned and undesirable recharge is already occurring, degrading groundwater quality and posing risk to humans and the environment
- ◆ pollution or natural contamination issues could be offset by injecting treated water to deflect the contaminated water plume

Drawdown in aquifers in a metropolitan area that depresses water levels can significantly increase energy costs to pump water to the surface. The cost to pump water from just a little bit deeper may be the motivating factor to recharge aquifers.

Currently, most of the metropolitan area pumps from the Prairie du Chien-Jordan aquifer and many monitoring wells in this aquifer show a declining trend.

In the Metropolitan Council's updated Water Supply Plan (2015), the projected drawdown of this aquifer is tens of feet if the demand for water in 2040 continues to be met by current (2015) sources.

Decades ago there was a significant drawdown of water levels in the Jordan Sandstone aquifer

A high-volume pumping depresses the water surface in the vicinity of the well. This can lead to problems with nearby wells and water features that rely on groundwater.

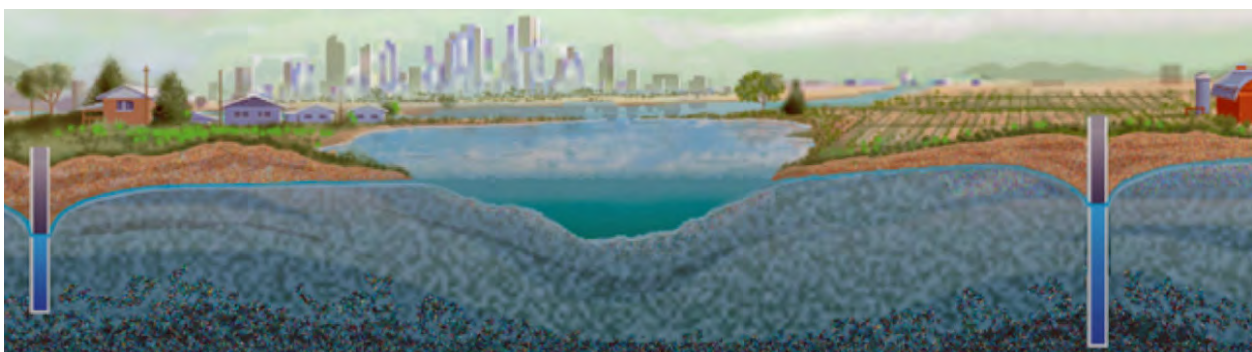


Image from The Groundwater Foundation website; <http://www.groundwater.org/get-informed/basics/glossary.html>

underlying the Twin Cities. This led to the unpopular but wise decision to discontinue some pumping practices, such as once-through cooling systems that pumped up deep groundwater to cool buildings and discharged it to surface water. Starting in 1989, this was controlled through permitting before it was outlawed in 2015. It also led to a groundwater recharge experiment conducted in 1971, described on the next page.

Better managing aquifer recharge not only improves supply, but it can improve the quality of groundwater in two ways:

- ◆ replenishing polluted aquifers and diluting natural or introduced contaminants and
- ◆ changing the hydraulic gradient to keep contaminants from entering a pumping zone.

We need to review the non-degradation standard for groundwater — enforced by the MPCA — and find ways to view stormwater infiltration as beneficial because it dilutes or redirects contaminants.

As the Minnesota Department of Agriculture Township testing program expands, nitrates and pesticides are increasingly being found across the agricultural portion of Minnesota in multiple aquifers. Their mere presence makes it clear that unplanned aquifer recharge is happening on a broad scale. We currently have no federal regulatory tools to address this non-point source pollution. A state plan to recharge aquifers in these areas with pre-treated water could improve water quality.

Examples of managed aquifer recharge in Minnesota

Each aquifer is unique and local examples can show how recharge should be handled. There are a few cases of bedrock aquifer recharge in Minnesota and some communities in the metropolitan area are already recharging near-surface aquifers with treated wastewater.

Jordan Sandstone Recharge Study, USGS

Jordan Sandstone hosts a deep, bedrock aquifer that is widely used in southeastern Minnesota. It suffered a significant decrease in water levels when it was first being used. In the six-year period between 1965 and 1971 – the beginning of significant groundwater pumping in the Minneapolis-St. Paul metropolitan area – the static water level in the Jordan Sandstone was drawn down by as much as 90 feet.

The USGS investigated the practice of injecting water as an option that would involve less work than developing a surface-water supply for the metropolitan area. They conducted an aquifer-recharge feasibility study in the fall and winter of 1971 in which they injected municipally-treated water into the Prairie du Chien Group rock layers and monitored its infiltration into the underlying Jordan Sandstone.

The USGS concluded:

“Water that is free of sediment and bacteria that is of the same general chemical type as used in this study could be injected into the fractured limestone and dolomite with few apparent geochemical problems.”

Admittedly, we know a lot more about chemicals of emerging concern and we are just beginning to understand the vast microbial communities present in groundwater. By comparison, authors of the USGS report in the early 1970s were proud to say: *“All calculations were made on a programmable desk calculator.”*



Aquifer levels rebounded from the lows of the early 1970s without injecting surface water into the aquifers. However, their conclusion that injection to recharge the Jordan Sandstone in the metropolitan area was feasible still has merit because they demonstrated that it is physically possible to do so. Today we might take a more informed approach to pre-treatment and monitoring but interestingly, their other recommendations were identical to ours in the first two chapters of this report: reduce the use of groundwater and recycle or reuse it.

Surficial recharge case study, East Bethel, Anoka County

East Bethel is a small town on the Anoka Sandplain west of Lino Lakes that had been served by septic systems and wells. When it came time to upgrade to a regional treatment system, surface discharge of effluent was not considered a viable option because of a high regional water table and numerous wetlands. Instead, a wastewater

reclamation plant and new water treatment plant were designed in tandem as the area's first integrated water reuse system, completed in 2013. Wastewater was treated and then piped to two subsurface disposal sites or reused for purposes such as golf course irrigation.

Mt. Simon water storage for Albertville, Hanover, St. Michael, and Frankfort

Having enough treated water to meet peak demand has recently prompted a metropolitan area in Minnesota to store water in a confined bedrock aquifer. This was a less expensive alternative to building a new treatment plant. The cities of Albertville, Hanover, St. Michael, and Frankfort kept their water treatment plant sized to treat average, rather than peak demand by storing treated, iron- and manganese-free water in a confined aquifer

until needed. They drilled a 504' deep well into Mt. Simon aquifer and injected treated water, which displaced the native groundwater horizontally.

A side benefit of the project is that it "reduced concerns about an abandoned landfill that has a groundwater contaminant plume migrating to the area of the new well field."



<https://mountsimonaquifer.wordpress.com/hi-i-am-the-mt-simon-aquifer/>

Shakopee Mdwakanton Sioux aquifer recharge study

To preserve groundwater availability, the Shakopee Mdwakanton Sioux Community developed a pilot project to establish a protocol for injecting treated wastewater into a buried glacial gravel layer that lies above the principal bedrock aquifer, the Jordan Sandstone. This protocol has not yet been implemented but still can be, because the community is a sovereign nation unrestricted by Minnesota rules.



The pilot project included tertiary treatment through a combination of reverse osmosis, ultra violet light, and ozone treatments followed by laboratory analysis for emerging contaminants. Lab results show that

all tested parameters can be completely removed or reduced below detection levels.

"The recycling of treated wastewater, especially the possibility of direct or indirect unrestricted end-use, has brought two scientific uncertainties or problems into sharp focus. One uncertainty is the fate of the large number of natural (e.g., hormones) and synthetic chemicals, such as pharmaceuticals and personal care products (PPCPs), flame-retardants, and preservatives affecting both human and environmental receptors via a variety of mechanisms including endocrine disruption, cytotoxicity, and increased antibiotic resistance."³

³ Ole Olmanson, 2011, <https://ngwa.confex.com/ngwa/2011gws/webprogram/Paper7695.html>

Recharge recommendations

We can easily take first steps towards better managing our aquifers. Approaches can be separated into two categories: 1) managing recharge to protect groundwater quality and 2) actively recharging groundwater to replenish a depleted aquifer, or manage a contaminant plume. The Metropolitan Council has recently taken the first steps in identifying promising recharge and stormwater capture areas in the metropolitan area with the goal of protecting them.⁴ We recommend the following:

1) Work with managed aquifer recharge:

- ◆ Secure additional funding to protect and set aside land located in Wellhead Protection Areas and Drinking Water Supply Management Areas
- ◆ Direct the Minnesota Geological Survey and the Department of Natural Resources to define other geologically promising recharge areas
- ◆ Prioritize Clean Water Funds to promote enhanced infiltration practices in all of these areas to:
 - allow stormwater to recharge shallow aquifers and monitor impacts
 - incentivize natural biofiltration systems
 - promote perennial and organic vegetation instead of conventional row-crop agriculture to minimize chemical use
- ◆ Leverage federal programs to allow and fund recharge easements
- ◆ Study existing, long-term recharge examples

2) Investigate active aquifer recharge:

- ◆ Measure the transport and fate of micropollutants and other chemicals of emerging concern like human and animal pharmaceuticals and personal care products in aquifers
- ◆ Pursue authority from the EPA to oversee injection wells
- ◆ Monitor microbial activity in shallow aquifers to assess the ability of groundwater to break down pollutants

Replenishing aquifers through managed recharge should make sense both environmentally and economically. However, water is seldom exchanged in a free market and to this end we also encourage the state to fund studies on the economics of managed aquifer recharge that evaluate benefits from:

- ◆ reduced pumping costs
- ◆ avoidance of new wells

- ◆ restored wetlands and trout streams
- ◆ improved water quality
- ◆ savings in stormwater and wastewater treatment

Ultimately, the goal of Freshwater Society is for the state to be in a strategic and economic position of strength to manage recharge when and if it becomes necessary.

⁴ [https://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Studies-Projects-Workgroups-\(1\)/Ongoing-Studies-Projects/Regional-Feasibility-Assessments.aspx](https://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Studies-Projects-Workgroups-(1)/Ongoing-Studies-Projects/Regional-Feasibility-Assessments.aspx)

Summary

Our recommendations to **reduce** groundwater use can be implemented immediately by individuals and in the short term by communities. Conservation practices are not only important in homes but also in institutions and businesses. The state can help municipalities better quantify and visualize their usage patterns by providing aquifer-trend reports and can assist with financing to help cities replace aging infrastructure to minimize leaks.

Reuse steps take more planning but we also need to change the mindset around them. If we view water as a resource, not a waste product, we will shift towards a model where we want to use it again and again. Our society can easily make a shift and move the source for domestic irrigation water from groundwater to stormwater. It will take more planning to integrate wastewater treatment plants with water-intensive uses. A clear lead agency can be established to promote, simplify, and assist with reuse efforts.

Recharge can begin with introducing the concept and framing current practices, such as wellhead protection, as managed recharge. This will help the public to more easily accept active recharge if it becomes necessary. In the meantime, the state can identify and protect areas where managed recharge makes geologic sense and encourage pretreatment (biological) of stormwater in these areas. It can fund studies of existing cases of enhanced recharge in Minnesota to assess risk, and draw on the approaches of other states and countries with similar conditions.

We can create a sustainable groundwater future in Minnesota by using all of the tools in our toolbox.



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