2023

Managing Water in a Wet State: Understanding Sources & Working Towards Sustainability

Laura Bowling

Katy Mazer

Keith A. Cherkauer
Purdue University, cherkaue@purdue.edu

Jane Frankenberger

Marty Frisbee

PURDUE UNIVERSITY | Institute for a Sustainable Future

MANAGING WATER IN A WET STATE:

UNDERSTANDING SOURCES & WORKING TOWARDS SUSTAINABILITY

In comparison to many states, Indiana is 'water rich,' with large groundwater reserves in northern counties, as well as rivers and lakes with abundant water for much of the year. Indiana has a history of supporting the water needs of rich agricultural lands as well as robust manufacturing. However, shifts in the amount and timing of precipitation, along with increasing water needs for the population, irrigation, and industry, underline the need to better understand and manage Indiana's water usage. As Indiana's population increases, economic development opportunities expand and the impacts of climate change become more evident, the abundance and resilience of our waters cannot be guaranteed. Understanding Indiana's water resources and careful planning will be key for sustainable water management moving into the future. Researchers at Purdue University have been advancing knowledge about precipitation patterns, climate impacts, water quantity and usage. They provide data that can inform how we prepare for potential shifts in when and how much water is available for key sectors including public use, agriculture, industry, energy production, and domestic use. This document outlines basic concepts to increase understanding of water resources, their use, and challenges to managing water quantity, quality, and availability in the state of Indiana.

OUR WATER RESOURCES

Many of us know about the rivers and lakes nearby in Indiana, such as the White, the Wabash, and the Ohio Rivers, as well as Lakes Monroe, Shafer, Lemon, and Maxinkuckee. As sources of *surface water* they are relatively easy to monitor and we can typically see how precipitation, drought, and withdrawals impact water flow and lake levels over time and across seasons. However, much more water in Indiana is hidden from view as *groundwater* that exists underground in saturated zones. When an underground area can yield a usable quantity of groundwater, it is considered an *aquifer*. In Indiana, most of this groundwater is accessed through wells and pumps. Figure one illustrates typical sources of surface and groundwater.

State and federal agencies estimate that, in a given year, far more surface water is utilized than groundwater. However, for Indiana in 2015, groundwater made up 100% of domestic (home wells) water supply, 54% of public supply, and 65% of agriculture usage.

FIgure 1: Water Sources

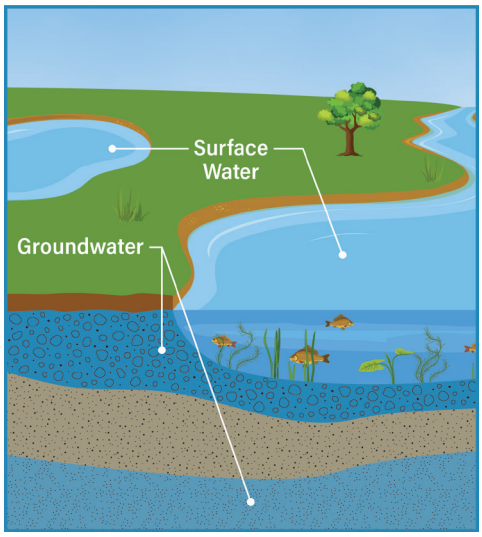
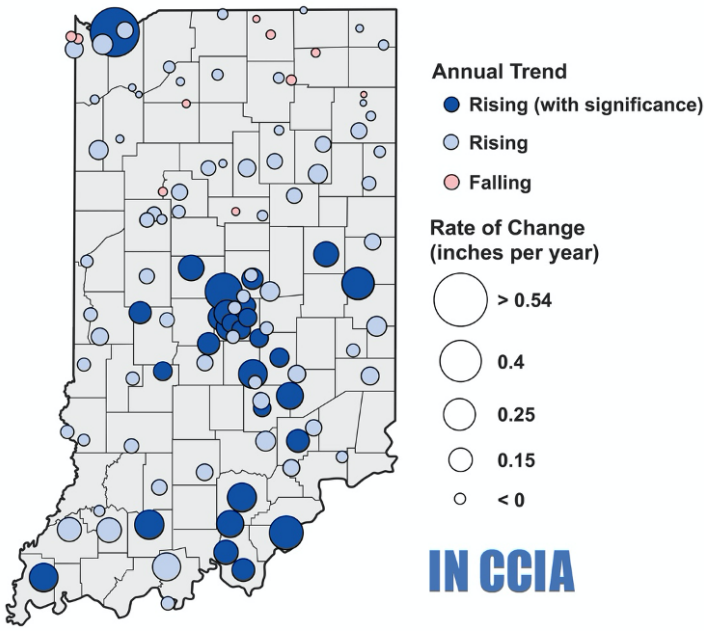


FIgure 2: Indiana Streamflow Trends



FUTURE SURFACE WATER AVAILABILITY

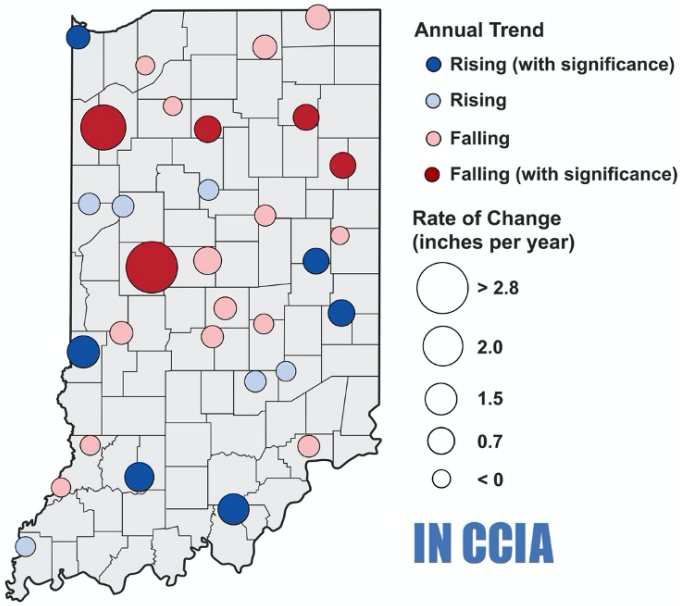
While Indiana is considered a water-rich state, water availability is always changing as it is influenced by rainfall and other climate factors. It is also affected by human impacts such as land use change and loss of areas used to naturally manage water, such as wetlands and forests.

Estimating water availability must take into consideration both surface water and groundwater. In the past 30 years, the water level in Indiana streams has increased overall, largely due to increased rainfall. Figure 2 at left, developed as part of the Indiana Climate Change Impact Assessment (INCCIA) led by the Purdue Climate Change Research Center and the College of Agriculture at Purdue University (2018-2023), illustrates this increase in water as seen through streamflow, the rate at which water is carried through rivers and streams. However, it is important to note that, in comparison to historical averages, water levels have lowered during the driest times of year as weather patterns have shifted.

FUTURE GROUNDWATER AVAILABILITY

Groundwater, which Indiana uses for much of its public, agricultural, and industrial water use, is much harder to quantify because of the complexity of the many aquifer systems in Indiana. Groundwater can be monitored by recording water levels in wells. Groundwater monitoring stations managed by USGS give a snapshot of current conditions, but available data is limited. In fact, many farmers and families who depend on well water only realize the level of accessible water has been depleted when a well goes 'dry.' More data is needed to understand the behavior of our state's aquifers so that we can better monitor how much water they can supply, the quality of the water (i.e., is it clean enough to drink), and how quickly it can typically be recharged. *Recharge* is the process of refilling aquifers as water trickles down or moves through the soil from rain and snow melt, and to a lesser extent, from surface water (rivers, lakes, and wetlands). Groundwater recharges much more slowly than surface water. Figure 3 at right illustrates, given limited abilities to understand this groundwater system in Indiana, trends in groundwater availability. It is important to note that this availability, in addition to groundwater quality, can be gravely impacted by human activity and shifts in utilization over time.

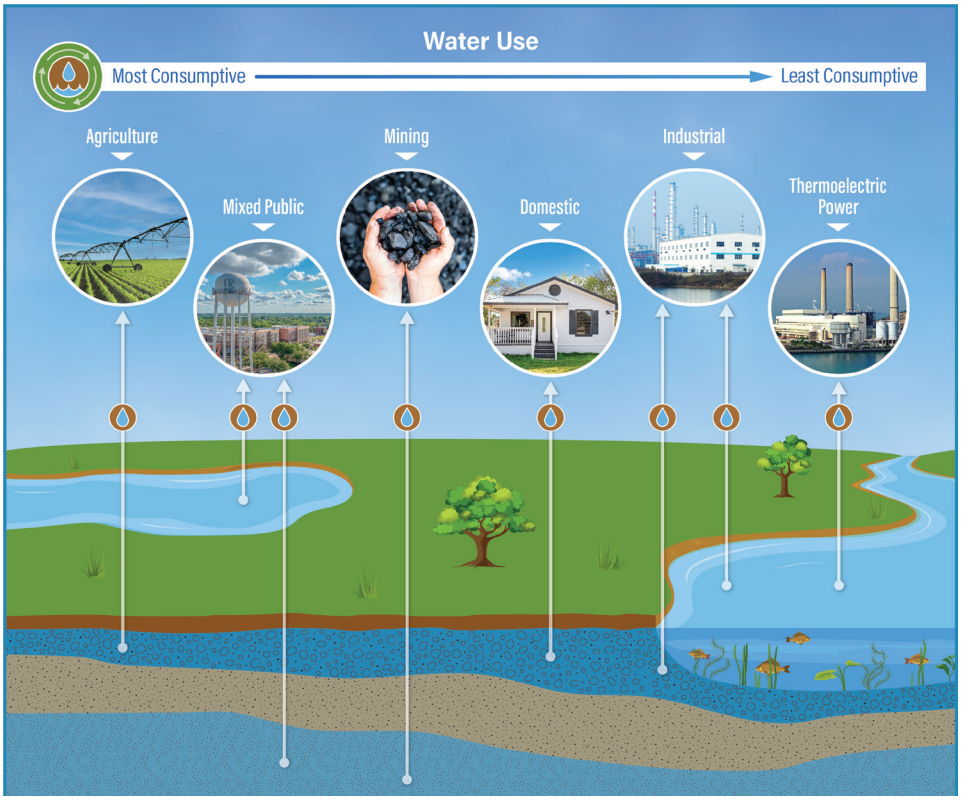
FIgure 3: Indiana Groundwater Trends



HOW WE USE OR CONSUME WATER

Although there is a lot of water in Indiana, it is not evenly distributed and the most water-stressed areas overlap with the most populous areas of the state. For example, while Northern Indiana has relatively large groundwater reserves, Central Indiana typically has access to sufficient surface water, but is more restricted in terms of persistent groundwater reserves. This leads to long-term concerns about our increasing demands for groundwater for human, agricultural and public uses. In addition, as the Indiana economy grows, new industries often have expectations for increased water availability year round. Careful planning is needed to manage both our surface and groundwater needs to ensure that there is sufficient supply for all who need it when they need it.

FIgure 4: Indiana Key Sector Water Consumption Trends

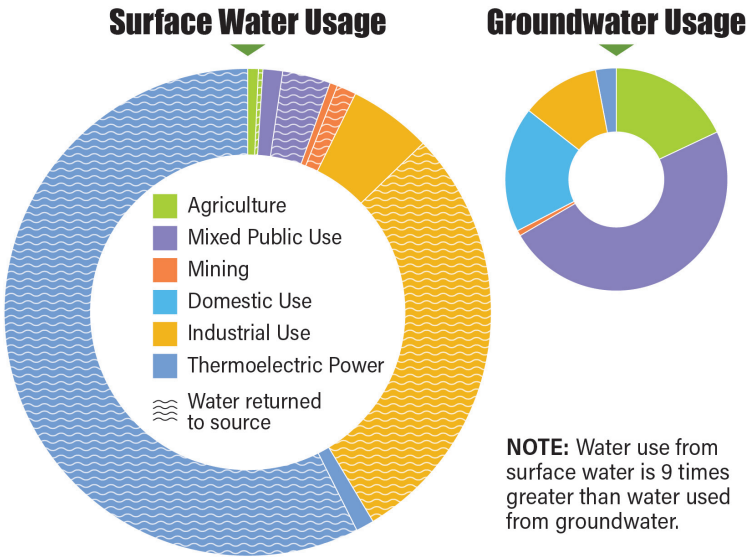


Who uses water and how they use it is also an important factor for water management. In some sectors, like agriculture and domestic use, a large percentage of water is consumed through plant uptake, evaporation, or human intake, known as *consumptive* use. In others, like the thermoelectric power sector, a lot of water is used, but most of it is returned to the source from which it was taken, known as *non-consumptive* use. Figure 4, to the left, illustrates the amount of consumptive use relative to total use for each of the six major sectors, along with identification of the balance water sources (surface vs. groundwater) they typically use.

WATER USAGE BY SECTOR

Figure 5, to the right, shows how much groundwater and surface water each of six major sectors uses in Indiana and how much is returned to the source. The industrial and thermoelectric power sectors use more surface water because water quality is less important. The public and domestic sectors, which depend more on good water quality, use more groundwater. While surface water is used over 9 times more than groundwater, most of the surface water used is returned to the source, i.e., not consumed. However, for groundwater use, even when water is not consumed, it is not directly returned to groundwater sources. Rather, excess water is discharged to surface water. This is one reason that groundwater is recharged much more slowly than surface water. As the population in Indiana grows, so does public water use. Indiana's population has increased by 1.6 million since 1970 and is expected to grow by an additional half million by 2070.

FIgure 5: Comparative usage and Consumption across Sectors



NOTE: Water use from surface water is 9 times greater than water used from groundwater.

HOW CLIMATE CHANGE IMPACTS WATER AVAILABILITY IN INDIANA

Water researchers at Purdue and across the state are hard at work trying to better understand, and prepare for, likely shifts in water availability while they communicate to Hoosiers ways to best manage our water resources. Below are some quick facts and takeaways from their research as summarized in the recently published INCCIA report, "The Future of Indiana's Water Resources" (https://docs.lib.purdue.edu/incciawatertr/).

- Annual precipitation will increase, with this additional rain largely falling in winter and spring. This will likely lead to increased flooding during the spring season.
- Increased annual precipitation will mean more flow in streams every year. This will likely result in fewer multi-year droughts but more short-duration intense water events that may overwhelm water systems.
- More intense storms will increase runoff as well as the probability of flooding. These storms also reduce the opportunity for water to be soaked into the soil and recharge aquifers. Loss of wetlands will likely increase the severity of this impact.
- Increased temperatures will lead to hotter, drier summers that will lead to an increased need for irrigation on agricultural lands due to short-term droughts and lower streamflows.
- Wetter winters will require careful monitoring and management of subsurface drainage to maximize availability for crops.

HOW PURDUE IS WORKING TO ADVANCE THE SCIENCE

Purdue University, as Indiana's Land Grant Institution, has a passion and a duty to help the state and its citizens understand current and future water resource management concerns and potential impacts. In addition to numerous researchers working on water issues in the colleges of agriculture, science, and engineering, Purdue's Institute for a Sustainable Future supports faculty engagement in this area through the Water Challenges research community and the Great Lakes special research Initiative. Our researchers also engage with state and federal agencies as well as non-profits and communities to advance their work. Below is a brief listing of water researchers and support staff who have contributed to this report, and other methods of outreach about Indiana's water use and sustainability concerns. For more information on climate impacts, see the website for the Indiana Climate Change Impacts Assessment (https://ag.purdue.edu/indianaclimate/). Also important to the work on water resource management is the Indiana Water Resources Research Center (https://iwrrc.org/) housed at Purdue.

PURDUE UNIVERSITY | Institute for a Sustainable Future

Burton Morgan
Center for Entrepreneurship
1201 Mitch Daniels Blvd.
West Lafayette, IN 47907
ISF@purdue.edu | @PurdueISF

PURDUE FACULTY IN HYDROLOGY & WATER MANAGEMENT

LAURA BOWLING

Laura Bowling is a professor of hydrology and water resources in the Department of Agronomy and the Director of the Natural Resources and Environmental Science program. Her research program combines first principal understanding of the physical controls on water storage and movement through the environment with field data collection using in-situ and remote sensing, simulation modeling and data informatics to address the sustainability of water resources regionally, nationally and globally. She also evaluates the effectiveness of agricultural conservation practices.

KEITH CHERKAUER

Keith Cherkauer is a Professor of Agricultural and Biological Engineering at and the Director of the Indiana Water Resources Research Center (IWRRC) as well as the co-lead for the Water Challenges research community in the Institute for a Sustainable Future. His research integrates field based observations, remote sensing products and hydrology models to address questions and concerns related to environmental change and to further understanding of land-atmosphere interactions and the hydrologic cycle.

JANE FRANKENBERGER

Jane Frankenberger is a professor of Agricultural and Biological Engineering and leads an integrated extension and research program in watershed management and agricultural drainage to protect water quality. She developed and directs the Indiana Watershed Leadership Academy, and provides water management education to drainage contractors, watershed managers, and the public. Her research has advanced drainage design and management, watershed modeling of agricultural systems, and soil and water conservation strategies, while delivering tools and strategies to stakeholders who can use them to inform decision making.

MARTY FRISBEE

Marty Frisbee is a hydrogeologist and an associate professor in the Department of Earth, Atmospheric and Planetary Sciences. He specializes in quantifying interactions between groundwater and surface water. Much of his research focuses on how the impacts of climate change, land-use and land-cover change, and how other human-induced stresses affect groundwater flow processes and their affect on surface water systems. Frisbee has completed research on how drainage modifications have impacted groundwater recharge and baseflow generation processes in the Wabash River and its tributaries. He is currently working on projects to better understand sources of salinity and chloride legacy effects in the Wabash River.

Katy Mazer, a project manager and research associate in the departments of Agronomy and Agricultural and Biological Engineering, helped develop this white paper. Katy works with faculty and other scientists to increase understanding of Indiana's water resources and develop sustainable water management solutions for Indiana.

This paper is the work of faculty and staff associated with the Water Challenges research community, part of Purdue's Institute for a Sustainable Future. The Water Challenges research community facilitates interdisciplinary research that helps communities solve their water challenges. Within the community, there are several sub-areas of interest including: water management; human dimensions of water; urban water systems; Great Lakes water; ecological restoration; as well as water and energy. Professors Keith Cherkauer (ABE) and Lisa Welp (EAPS) are co-leads for this initiative.
Learn more at: https://research.purdue.edu/isf/research/research-areas/water.php.