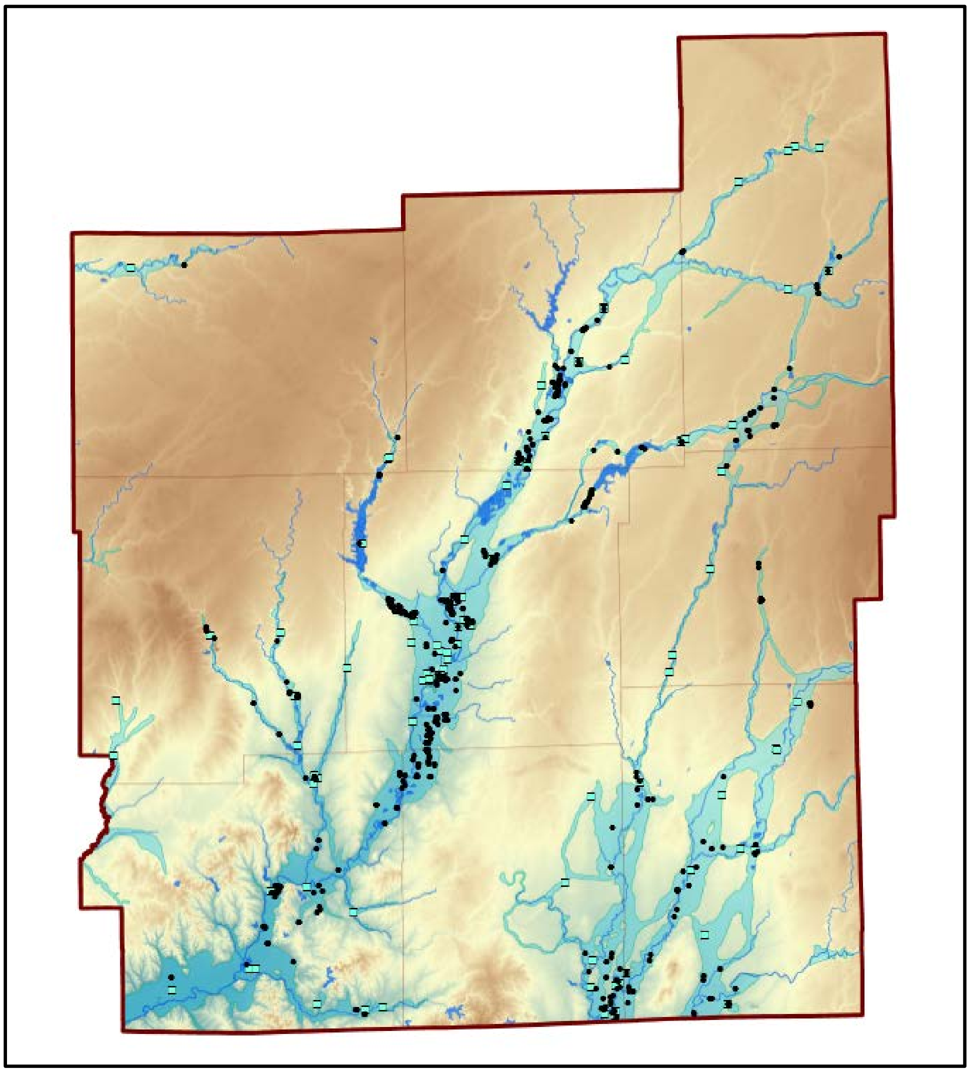
Executive Summary

Central Indiana Water Study

Future Demand, Availability, Options



January 2021

HIGHLIGHTS

This report summarizes the most recent analysis of future water demand and available supplies in the 9-county Central Indiana Planning Region: Boone, Hamilton, Hancock, Hendricks, Johnson, Madison, Marion, Morgan, and Shelby counties. This document describes some of the key findings of two previous reports; the Phase I forecast of future water demand in Central Indiana (total increase of 111 MGD by 2070) and the Phase III analysis of water availability that applies a water budget approach to understand where and when water is available. In addition, this summary identifies options for new supplies and conservation to meet the needs of Central Indiana during periods of high seasonal demands and to manage the potential effects of climate change.

Like most larger cities in the Midwest, the water supplies in Central Indiana are dominated by surface water diversions. In 2018 more than 232 million gallons per day (MGD) were extracted from flowing streams and reservoirs in these nine counties. Most of the source water for Indianapolis' water supply comes from upstream intakes along the West Fork White River and reservoir storage that supplements seasonal low flows. These supplies have historically been stressed by droughts but the addition of strategically located well fields and new storage and transmission infrastructure has increased supplies and overall resilience. In 2018 about 132 MGD was pumped by registered high-capacity wells from regional aquifers. Over the last 25-years most of the water supply growth for municipal water systems in Central Indiana has been from new well fields in the sand and gravel aquifer along the river.

The water-availability analysis conducted for this project used existing data on stream flows, high-capacity water withdrawals, wastewater (National Pollutant Discharge Elimination System, NPDES) discharges, and climate projections to calculate the water budget in Central Indiana during the critical low-flow, high-use quarter of the year (late Summer). While this report identifies actions that will need to be taken in the next decades, new reservoirs and improved collaboration have already improved the area's long-term water security.

Analysis was done to evaluate the effect of water quality on water availability in streams and aquifers in Central Indiana. This effort showed that there needs to be additional investment in tracking long-term trends in groundwater and surface water quality, as well as quantity, in Central Indiana. Focused monitoring (remote digital systems) is recommended to track trends and detect indications of climate change impacts. A framework is presented to use surface water and groundwater models to evaluate development options so utilities and other water users can balance local and regional needs.

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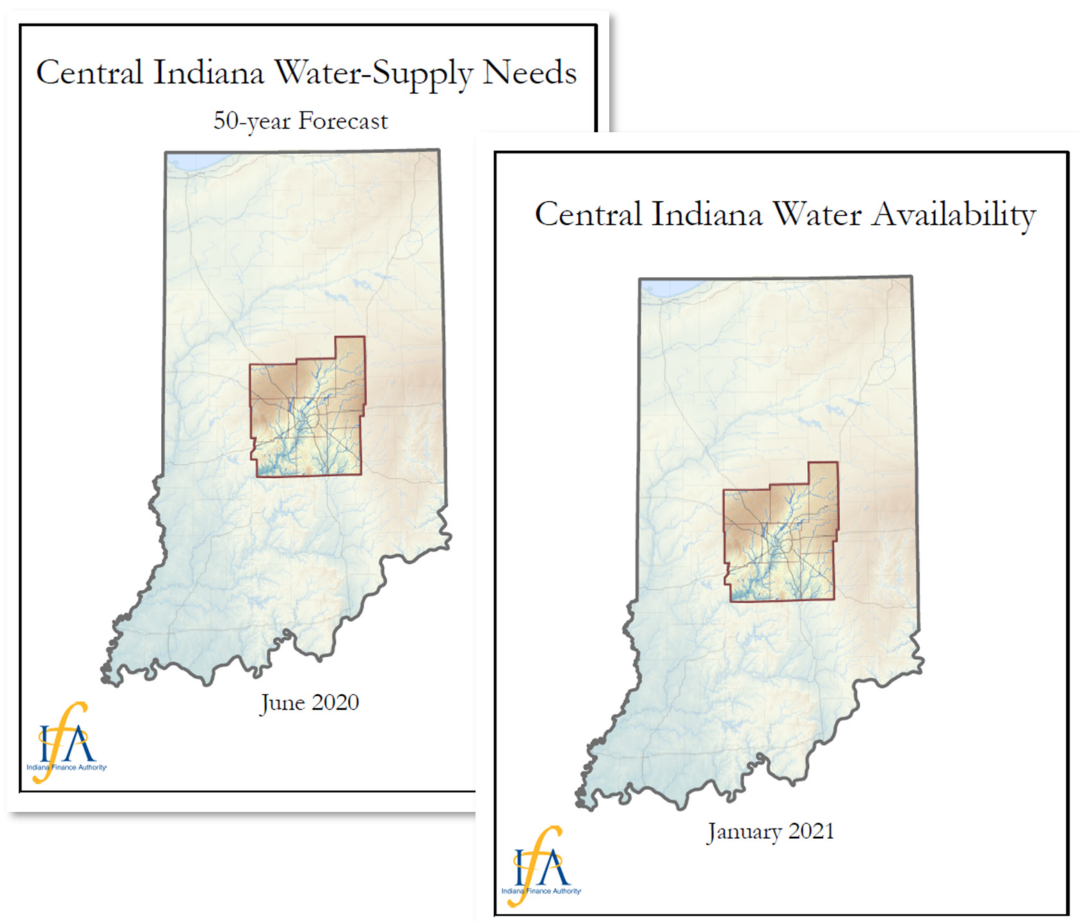
The purpose of this report

This summary report has been prepared to provide a more concise and less technical narrative of the recently completed Phase I Water-Supply Needs study (IFA, 2020) and Phase III Water Availability study (IFA, 2021). Both studies are part of the Central Indiana Water Study project. In addition, this report provides a historical context focusing on the development of water resources in the region, and a discussion of alternatives for increasing water availability in the region.

The Phase I Water-Supply Needs study (IFA, 2020) presents an analysis of current water use in the region and projects water needs to the year 2070. The Phase III Water Availability study (IFA, 2021) analyzes the current and projected future excess water availability in the region that can be relied on to support economic and population growth in the region.

The combined goal of both studies is to identify areas within the region where future demands may exceed available local supplies. The locations with gaps between availability and demand are mapped to suggest how new regional water supplies and conservation could meet future demands. The full technical reports are available on the IFA website (www.in.gov/ifa/).



Water resource development and planning in Central Indiana

Central Indiana has a long history of expanding water supplies to keep pace with economic and population growth. From the 1930s through the 1960s reservoirs were located on major tributaries to secure adequate water for thirsty industries. From the 1980s through 2019, no new reservoirs have been built. Instead, large well fields have been installed to support metropolitan growth. The increases in demand are now a reflection of population shifts towards the urban center and the underlying expansion of commerce. The demands of population growth and economic activity require continuous new water sources and careful management of existing supplies. If the region is to continue to attract new business, it is critical that we understand how to use the resources beneath our feet. Wise management and informed resource development are both needed to support the economy and improve quality of life.

Until the 1940's, new water withdrawals in one town did not affect the water supplies in neighboring communities. In Central Indiana today, however, there are many communities that share sources of supply. As more users withdraw more water, it becomes increasingly critical that areas with excess water supply are distinguished from those that are already producing as much as possible.

A statewide survey of utilities conducted in 2015 included utilities in Central Indiana. Their response was unlike the others in some important ways. The utilities near Indianapolis said that they understood the shared nature of the water supply in a way that was not common in the northern or southern parts of the state. For example:

1. most utilities had working estimates of the yield of their source of supply

2. many systems were concerned about upstream water users

3. staff monitored their sources of supply to track changes over time

These responses suggest that water utilities in Central Indiana understand that there are many commercial, agricultural, and industrial water users who rely on the same resource and compete for that resource during periods of drought. The survey also indicated that the utilities wanted to engage more to fully understand their long-term needs.

Existing surface water storage and diversion systems reflect the water supply development and planning that has occurred over the last century. The timeline presented below describes the events and features of the system that provide context for the water supply planning discussion that is occurring today.

TIMELINE

PAST CENTURY OF CENTRAL INDIANA WATER

Pre-WWII: Dust Bowl droughts of the 1930s and 40s

Period of **rapid population growth and industrialization** with repeated droughts. Several well fields were constructed, and Geist Reservoir was built to expand supply near Indianapolis.

1940 – 1980: Post War industrial development

New **reservoirs were added to keep up with the growth** in automobile and heavy manufacturing. Morse reservoir was built in the 1950s and Eagle Creek was built by the U.S. Army Corps of Engineers in the 1960s. New wells were added in the industrial center of the city.

1980 – 2000: Industrial peak production in the 1980's

Drought (1988) and water shortage renew interest in groundwater as an alternate supply. Initiation of the water Shortage Task Force. Indianapolis experiences **slower growth and new competition** for water. Water Resources Management Act of 1983 calls for Basin Studies program (1987 – 2002).

2000 – 2010: New ownership of the largest water utility

Indianapolis Water Company is acquired – twice. **Fiscal austerity** reduces water-resource monitoring investments; DNR Basin Studies program is terminated for lack of funding. The Water Shortage Task Force begins meeting again.

2010 – 2020: New ownership and drought of 2012

Suburban growth brings increased groundwater use and new utility ownership in 2011 followed by the drought of 2012. The **state reconsiders water supply planning** and management by beginning a series of data collection efforts to inform new policy.

(HistoricIndianapolis.com, 2017)

(HistoricIndianapolis.com, 2017)

TIMELINE

PAST DECADE OF CENTRAL INDIANA WATER

2011

Water Resources Legislative study committee heard testimony that suggests the state is unprepared for drought. Indianapolis sells water utility.

2012

Intense summer drought causes central Indiana utilities to ask for reductions in use. Sources of water supply and regional infrastructure pushed to their limits.

2013

Water Resources Legislative study committee asks Indiana Utility Regulatory Commission to assess water utility planning to use existing data to consider source of supply planning.

2014

Indiana State Chamber of Commerce publishes statewide water investigation that shows water needs in Central Indiana growing relative to supplies.

2015

Indiana Finance Authority directed to survey utilities for best planning practices. Some utilities unable to invest in infrastructure and more concerned about their source water supplies.

2016

IFA conducts another survey of all community water utilities (a total of 532 systems). Utilities need $17B more in the next 20 years for infrastructure.

2017

IFA conducts another investigation of the feasibility of a regional water system that could move new water from a source of supply along the Ohio River to Southeastern Indiana.

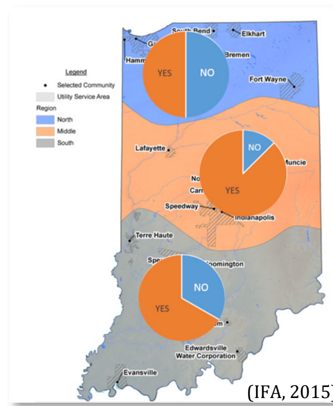
2018

Citizens Energy Group, the utility that supplies drinking water to Indianapolis and sections of all 9 counties in the region, develops innovative storage to expand supplies by up to 30 MGD.

2019

IFA selects the nine-county area of Central Indiana region to be investigated for water supply planning.

(Scheer, 2019)



(IFA, 2015)

Central Indiana Water Studies are based on publicly available data

Data from various state and federal agencies were used in completing the Phase I and Phase III studies. Agencies that maintain data critical to the water-use and water-budget analyses all informed different parts of the studies:

- Indiana Department of Natural Resources (IDNR), Division of Water: annual water withdrawal data
- U.S. Environmental Protection Agency (USEPA): NPDES discharge database
- U.S. Geological Survey (USGS): streamflow, low flow statistics
- Indiana Department of Environmental Management (IDEM): water-quality
- Indiana Geological and Water Survey (IGWS): aquifer geometry, recharge, and mapping
- Indiana University (IU) Business Research Center: demographic projections

Many of the agencies that provided the critical data are also collaborators. Monthly working group meetings were hosted by the Indiana Finance Authority, with representatives from many state and federal agencies and consultants acting as project partners. The purpose of the inter-agency meetings was to provide updates on each project phase, to coordinate efforts between phases, and to review and discuss methods and results. Agencies and consultants regularly represented in the working-group meetings include the following:

State and Federal agencies

- Indiana Finance Authority (IFA)
- Indiana Geological and Water Survey (IGWS)
- Indiana University (IU)
- U.S. Geological Survey (USGS)
- Indiana DNR, Division of Water (IDNR)
- Indiana DEM, Office of Water Quality (IDEM)

Private entities:

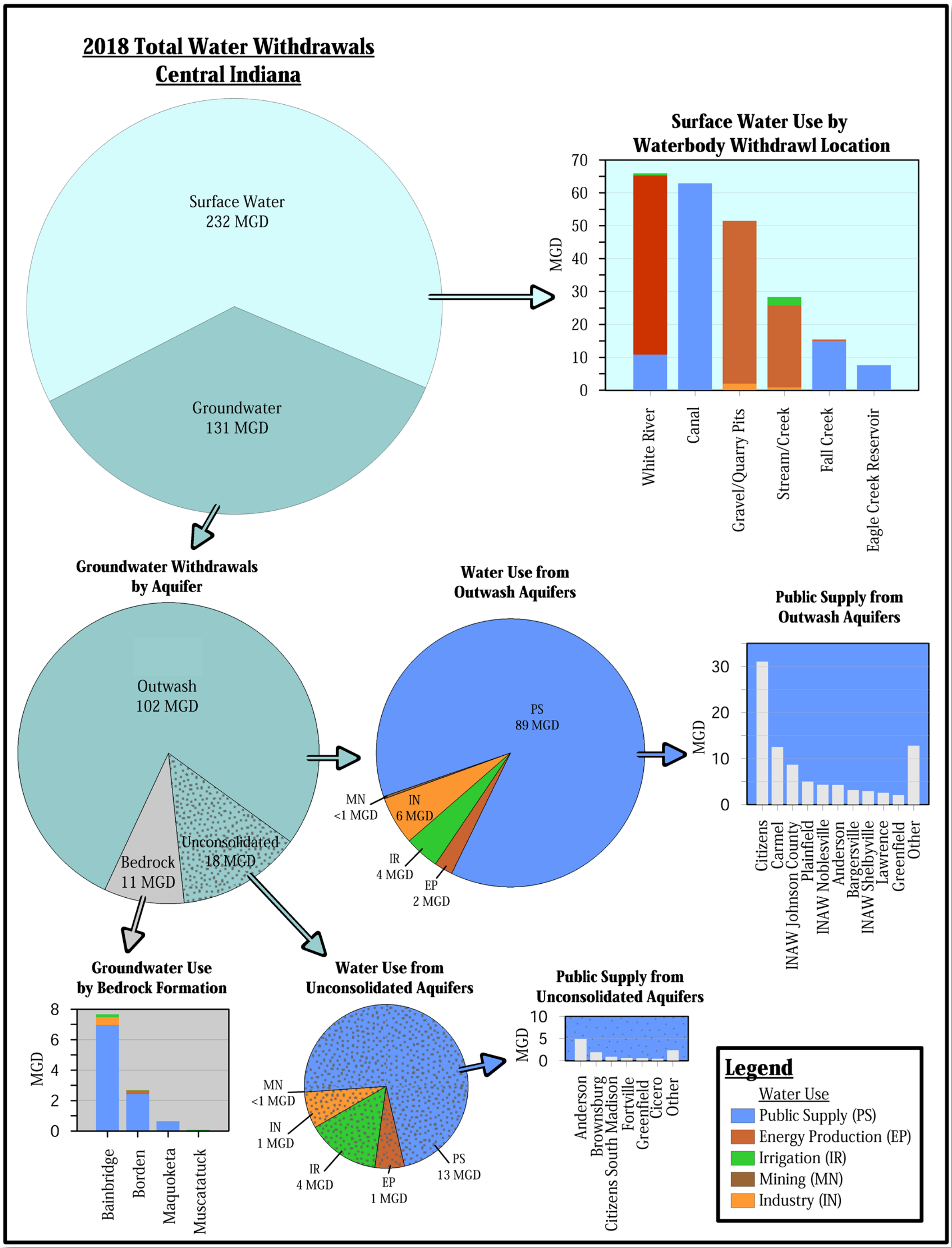
- INTERA Geosciences and Engineering Solutions
- Empower Results

PROJECT PARTNERS

Regional water supplies have various sources

The Phase I Report (IFA, 2020) summarizes how water use is currently distributed between water-use sectors, how the water use is distributed geographically, and how those demands are distributed among water sources. Water-use sectors include Public Supply, Energy Production, Irrigation, Mining, and Industry. Water-supply sources include direct surface water withdrawals and pumping from groundwater wells completed in outwash, unconsolidated, or bedrock aquifers. The figure below illustrates how 2018 water withdrawals were distributed among sectors and sources.

Sources of water for registered high-capacity water users in the 9-county Central Indiana Planning Region in 2018.

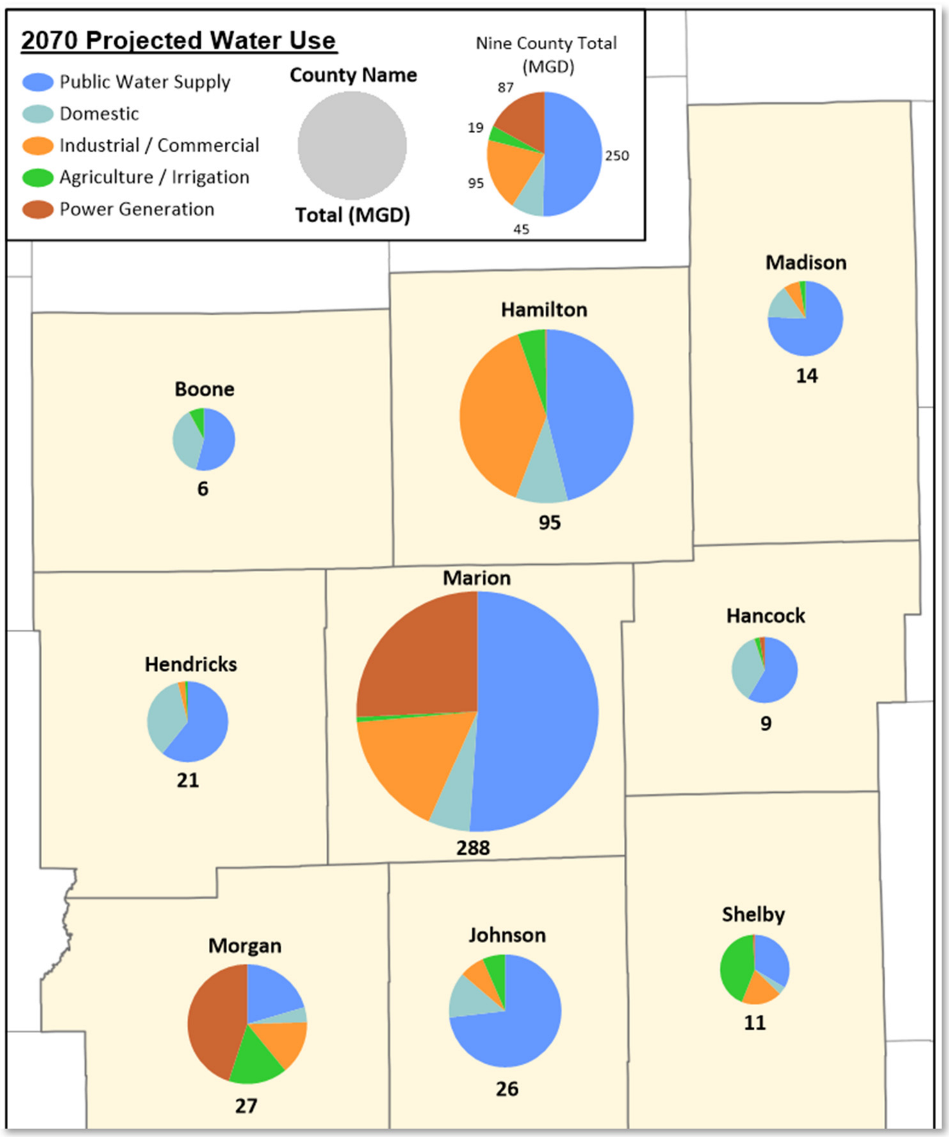


Average water demand expected to increase by 111 MGD

A key finding of the Phase I report (IFA, 2020) is that, on average, by 2070 the region will use an additional 111 million gallons per day (MGD). Of this total, almost half of the increase (~50 MGD) will be needed to supply drinking water systems. However, most of the increase in water use will be from the seasonal increase in demand that occurs in the growing season. So, while the lowest water use seasons for utilities may only slowly increase, future water demand is assumed to continue to create higher peak demands, especially in areas that use automatic lawn irrigation.

Population growth is expected to be greatest on the north side of Indianapolis. In addition, unlike other areas within Central Indiana, the north side of Indianapolis is expecting an increase in the gravel mining industry, which will require additional water to meet their needs. The ability to satisfy these increases in demand can only be interpreted after considering expected growth and regional water resources.

Average Annual Forecast Demand from 385 MGD today to 495 MGD in 2070.

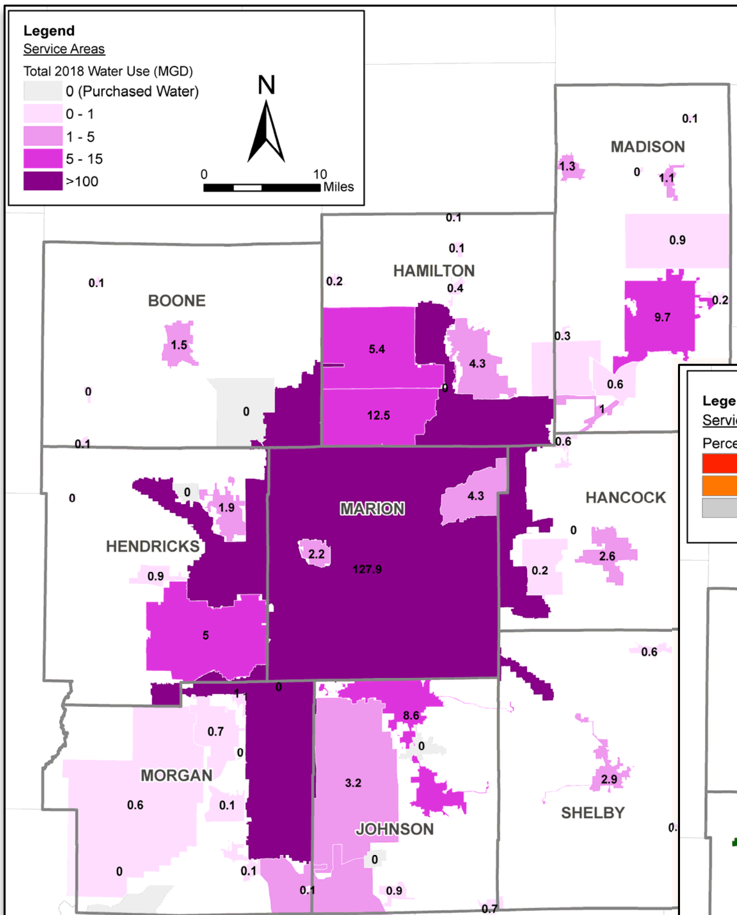


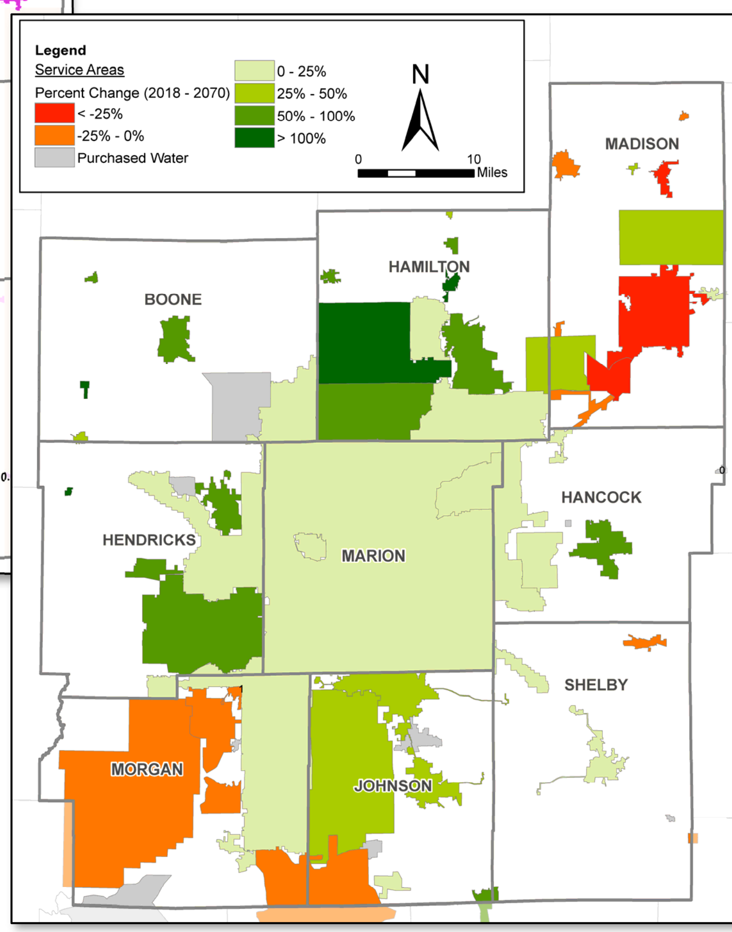
Growth in Marion and Hamilton Counties

Public water supplies accounted for half of the total water withdrawals in Central Indiana in 2018, and growth in the public supply sector is projected to continue that trend through 2070.

Withdrawals in Marion and Hamilton Counties account for 76% of the total current public water supply in Central Indiana. This proportion of the total supply is projected to remain the same through 2070, with increases of about 20 MGD required for each county. This reflects projections of nearly 100% growth in public water supplies in Hamilton County and 20% growth in Marion County by 2070.

Water withdrawals for public supply by service area: 2018 (left), and projected percent change in water withdrawals by 2070 (below).





Regional Water Availability Key Findings

Water availability is based on a water-budget analysis

From a water-supply perspective, regional water availability is a product of the natural hydrology of the local watershed, current regional water use, and existing regional infrastructure. Hydrological characteristics and the installed infrastructure combine to determine water availability. In Central Indiana, we have records to quantify the following characteristics:

1. *Landscape hydrology* – the way that stream flows increase and decrease in response to precipitation through the dry and wet periods of the year

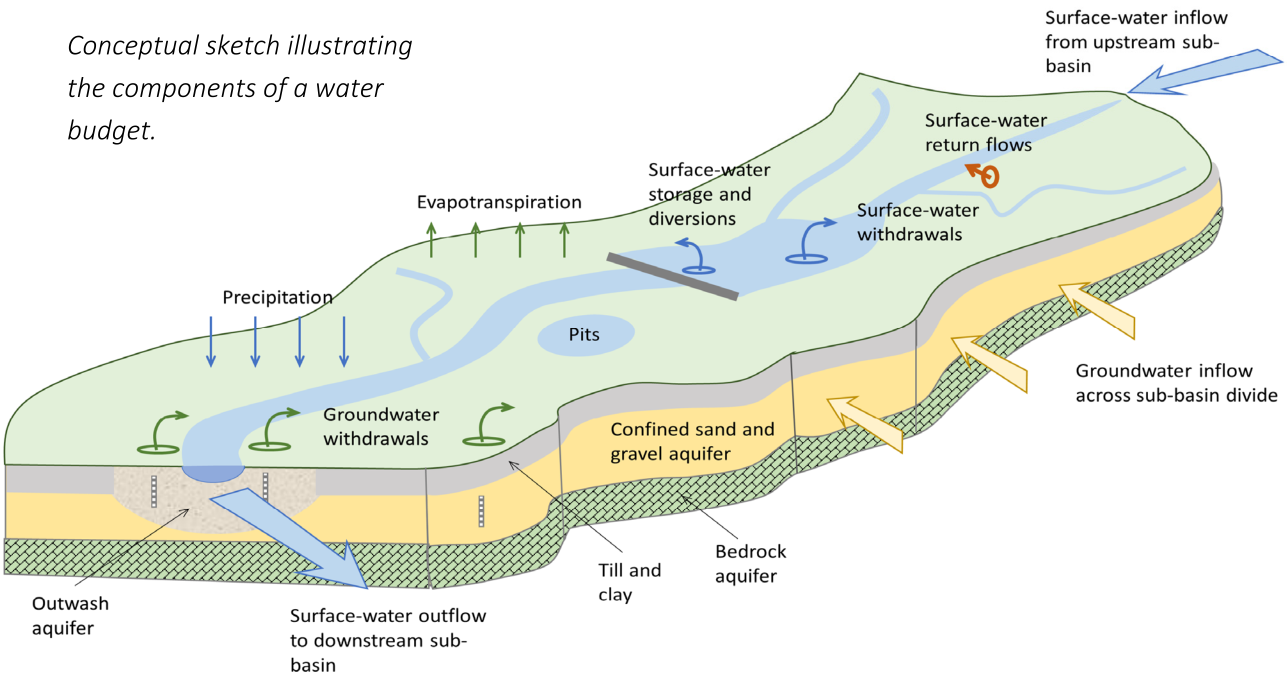
2. *Reservoir storage* - stored volumes, operations, and locations of regional reservoirs that are used to supplement stream flows

3. *Withdrawals* - high-capacity withdrawal intakes, including stream diversions and pumping centers that remove water from the stream or adjacent aquifers

4. *Return flows* - treated effluent discharged back into the streams, which supplements downstream water availability

A water budget is an accounting of water flowing into and out of a given region. The Central Indiana Planning Region and surrounding areas were divided geographically into sub-basins, and water budgets were developed for each sub-basin. The water-budget analysis forms the basis for determining water availability.

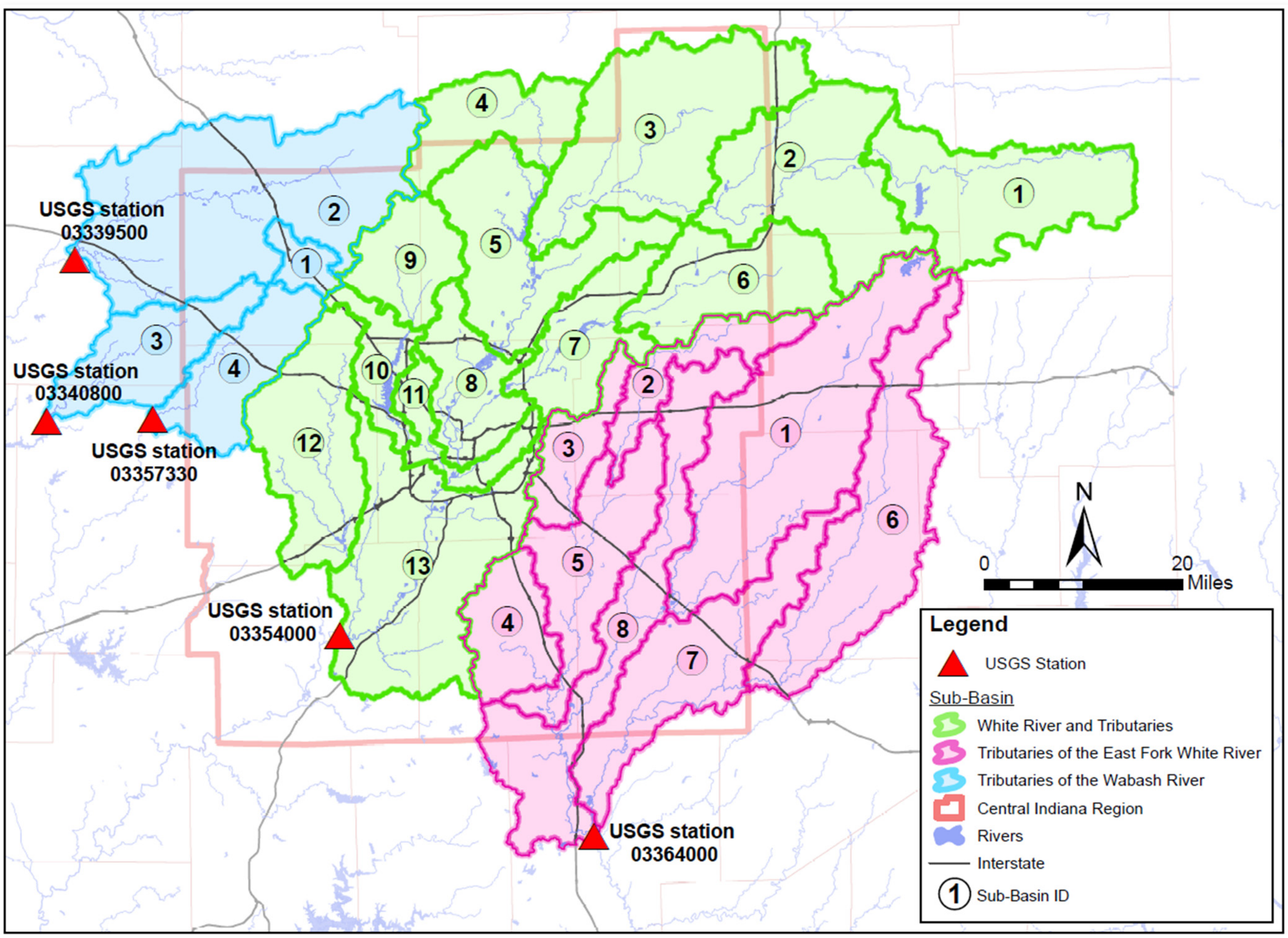
Conceptual sketch illustrating the components of a water budget.



Water budgets were computed for sub-basins defined by USGS stream gages

The 9-county planning area was divided into sub-basins that drain a fraction of the landscape in three different river basins: the Wabash River (blue) receives water from Boone and northwestern Hendricks County, the East Fork White River (pink) drains the southeastern and east-central area, including all of Shelby and some of Hancock and Johnson Counties. The West Fork White River (green) drains the northeastern and central counties in the region. Each of the three major drainage systems are further divided into sub-basins. The sizes and locations of these sub-basins reflect the drainage areas of the existing stream gages, which are the locations of available streamflow data used for these studies.

A water budget was developed for each sub-basin based on data spanning the period 2007 to 2017, which was the period of data availability for the suite of variable needed for the analysis. The water budgets were used to assess the geographic distribution of water availability over that period.



Sub-basin boundaries used to compute water budgets and water availability.

Defining hydrologic terms

To evaluate the water availability in the 9-county planning region, several concepts were developed that made use of existing data. Before the method and data used to estimate water availability can be explained, a few hydrological terms need to be defined:

Natural baseflow: discharge from aquifers to streams

Baseflow is commonly understood to be the contribution of groundwater to a stream. The water exchange in stream/aquifer interactions can go both directions. Streams can have gaining (groundwater contribution to the stream) or losing (water loss from the stream bed to recharge groundwater) reaches. In water-budget calculations, the sign of this term can be positive (gaining reach) or negative (losing reach) and can be influenced by outside factors such as near-stream well pumping. Natural baseflow is an estimate of the groundwater discharge contribution to a stream reach without considering anthropogenic interventions such as water withdrawals or wastewater-return flows.

Minimum instream flow: a lower limit on streamflow that is used as a drought-response threshold

Much of the stream/aquifer system flowing through Central Indiana also serves as the natural infrastructure for the municipal water supply system.

Indiana does not have any regulated limit on low streamflow. In this study, the $Q_{7,10}$ low flow (the average low flow that can be expected for a 7-day period, once each decade) was examined as a *placeholder* to consider the effect on water availability. Most NPDES discharges are permitted based on a $Q_{7,10}$ low flow for dilution.

Reservoir storage: water stored in reservoirs to supplement streamflow

Reservoir storage is important from a water-supply perspective because water can be diverted into storage when there is excess, and then released when needed to satisfy downstream demands. The three large reservoirs in the region were all built to supplement flows for the drinking-water supply or provide flood control. The rivers and streams transport for reservoir-storage releases to downstream intakes. In some areas, reservoir releases are designed to replace the groundwater captured by high-capacity well fields.

The analysis not only accounts for what was released in the past, but also includes the effects of new (in-progress) infrastructure that will increase availability in some parts of Central Indiana. While most of the outlying communities use groundwater exclusively because it is easier to develop and less expensive to treat, Citizens Energy Group (Citizens) has added the new Citizens Reservoir to increase the resilience of their system.

Defining the measures of water availability

In each sub-basin, water availability is the sum of these elements: natural baseflow, storage, and instream-flow requirements

Water availability = natural baseflow – instream flow + reservoir storage

Although this definition of water availability is hydrologically meaningful, it fails to account for the anthropogenic changes within a sub-basin, such as water withdrawals and return flows that are discharged back into the river. Throughout Central Indiana there are intakes located upstream and return flows from that same use located downstream. It is not unusual for a diversion to occur in one sub-basin and the return flow to be added back some distance downstream – even in another sub-basin. The amount of water any sub-basin can produce is limited by these withdrawals and return flows within the sub-basin. Excess water availability is the net water remaining in a sub-basin after all water uses are accounted for.

***Excess* water availability** = water availability – withdrawals + return flows

Each sub-basin below the headwaters also receives water from the upstream sub-basins. The cumulative excess availability is the sum of the excess water availability in all upstream sub-basins. The calculation of cumulative excess water availability uses available stream-flow records, information in NDPES permits, and water-use data, and incorporates whether each sub-basin is a gaining or losing reach.

***Cumulative* excess water availability** = the sum of all upstream excess water availability

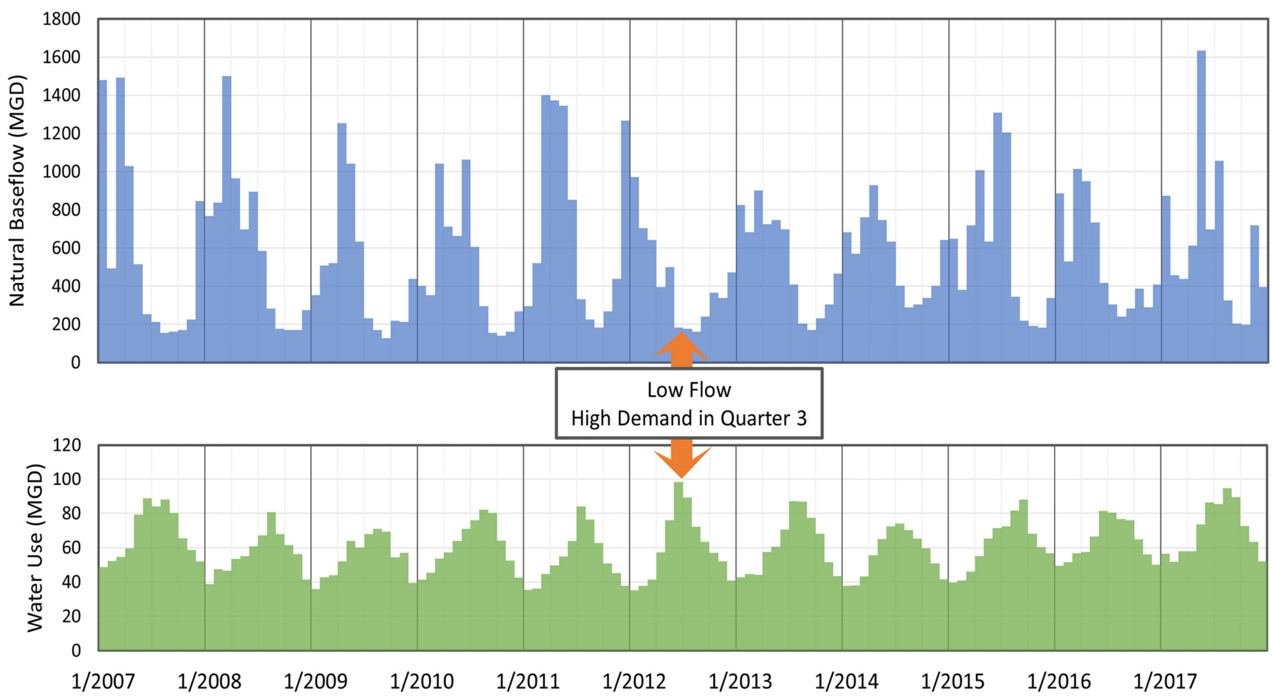
Using this definition of cumulative excess water availability and following the West Fork White River from upstream northeast of Indianapolis to downstream south of Indianapolis, more water is available above and below Indianapolis than at the city center. North of Indianapolis, withdrawals are relatively small, so the system behaves like a natural hydrological system. As the river flows into Hamilton County there is a large surface-water intake as well as more than 40 MGD of groundwater capacity. Effectively, water users within the Indianapolis sub-basin are using the water before it is treated and returned to the river downstream at the Belmont Advanced Wastewater Treatment Plant south of Indianapolis

Water availability and water use vary seasonally and annually

Natural baseflow, the largest continuous component of water availability, has a strong seasonal variation. During the Spring, the natural baseflow in a stream may be five times greater than during the summer or fall. This leads to large variations in water availability throughout a calendar year.

Water demand also has a seasonal variation, with the greatest demands occurring in the Summer. These seasonal variations produce a critical period for water supplies when availability is low and demand is high. In Central Indiana, this critical period occurs most often in the late Summer. The third quarter of the calendar year (Quarter 3; July, August, and September) is the critical period for water availability.

In addition to seasonal variations, the natural streamflow values vary from year to year, with both wet years and dry years appearing in the records, as well as years of low and high annual demand. For the period of record (2007-2017), the minimum availability occurred under drought conditions in 2012 for most of the sub-basins in Central Indiana. Consequently, 2012 is used as a basis for reporting availability for both current and future conditions.



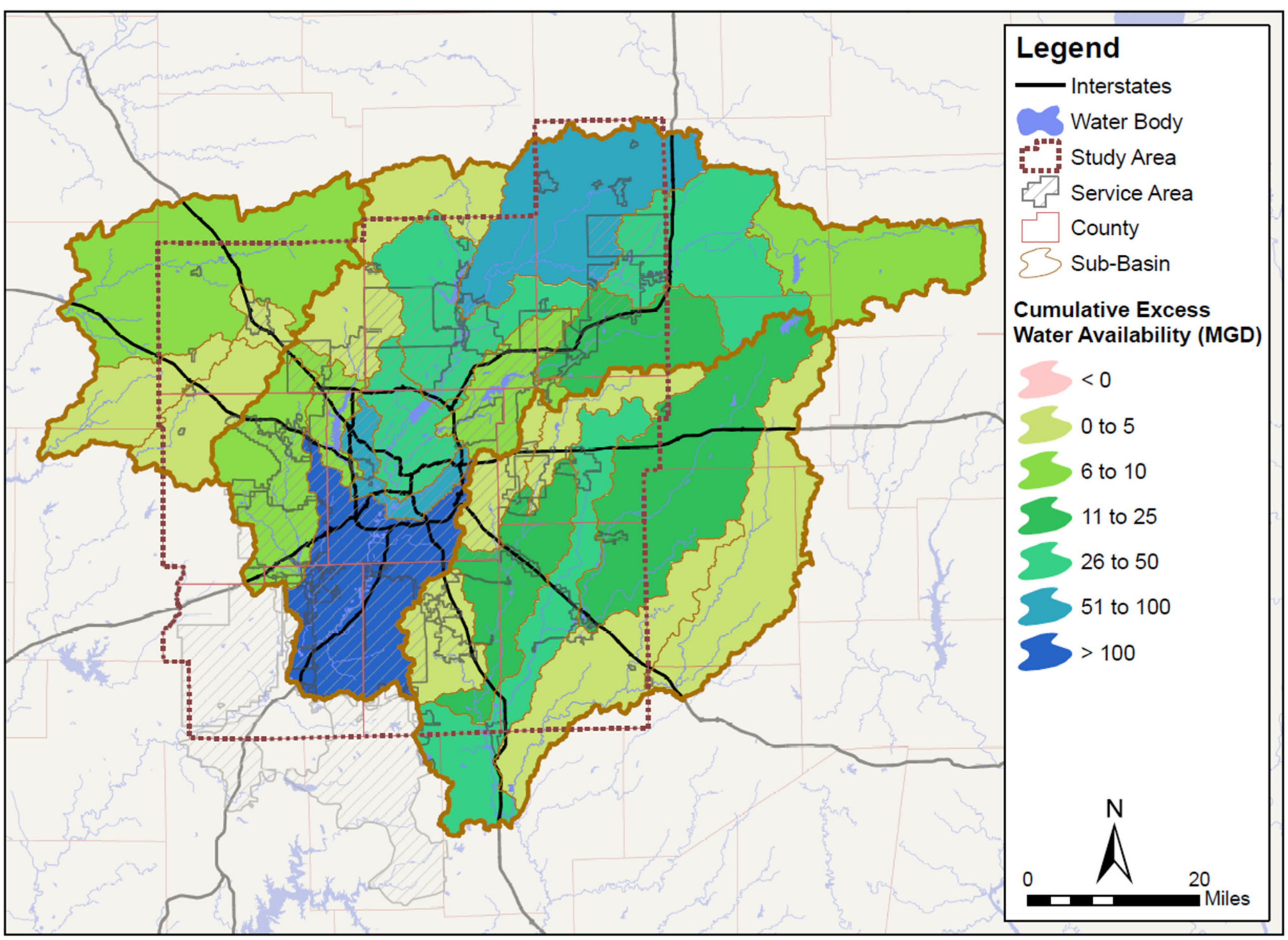
Natural baseflow and water use vary seasonally and annually. Quarter 3 (July, August, September) of the calendar year is generally a critical period when baseflow is low and demand is high.

Water availability varies geographically

Mapping water availability for the driest 3-months of the annual record shows that there is more water available downstream of the city, reflecting the added flows from the Belmont Advanced Wastewater Treatment Plant.

Results show that an expansion of the water supply system up to 50 MGD could be possible along the White River corridor. To the northwest and southeast, outside of the White River drainage system, water availability is very limited and expanding existing supplies will be difficult.

While some sub-basins in Central Indiana were found to have annual water deficits, as a whole, the region has *cumulative* excess water availability for the period of record, 2007-2017. This highlights the fact that informal transfers (*e.g.*, downstream channel flow) of excess water between sub-basins is an important feature of the regional water-supply system as it exists today. The water supply for both Hamilton and Marion Counties depends, in part, on utilizing excess water availability in upstream sub-basins.

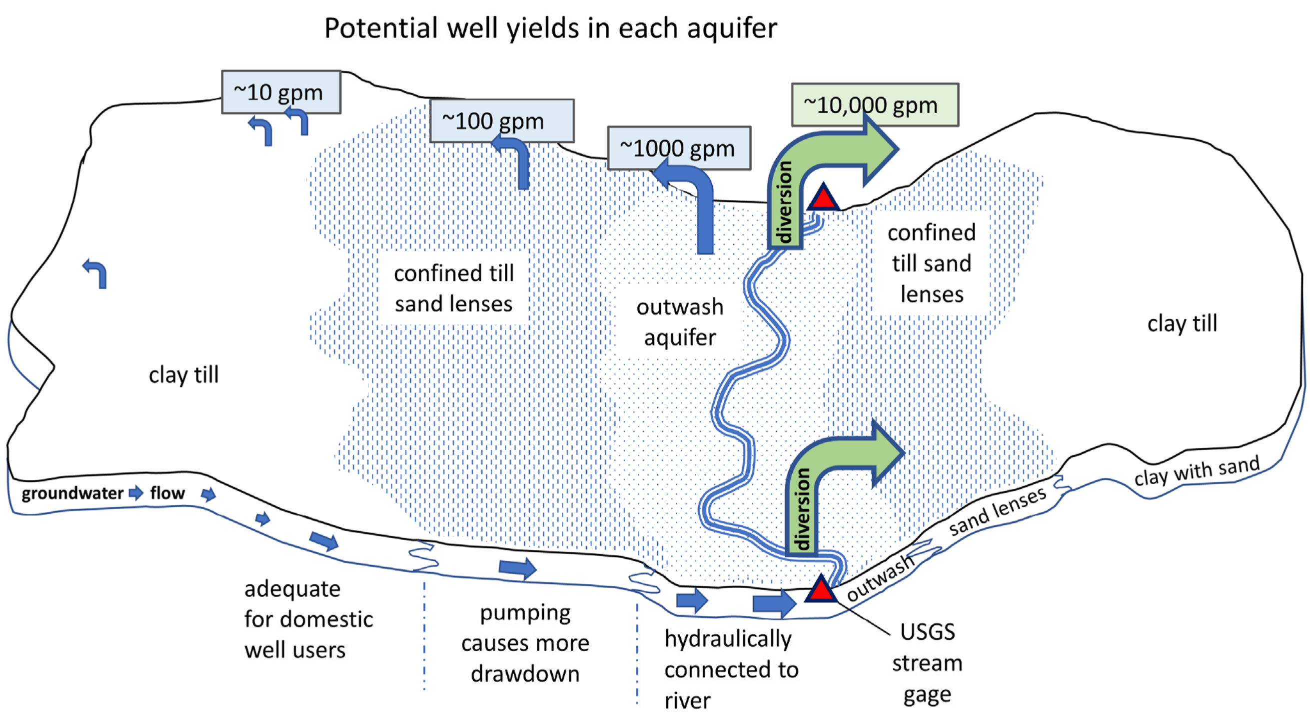


Minimum (2007-2017) Cumulative Excess Water Availability during the Quarter 3 of the calendar year (i.e., July, August, September) for sub-basins in the region. Availability is high upstream of the intakes north of Indianapolis and high downstream of the Belmont Advanced Wastewater Treatment Plant (See Phase III Report for details).

Available water may not be accessible water

The cumulative excess water availability is mapped as a single representative value for each sub-basin. The actual conditions within a sub-basin, however, may restrict where available water can be accessed and extracted.

The geologic history of Central Indiana explains the distribution of aquifers, with ancient bedrock units (e.g., sandstone or limestone aquifers) lying below more recent sediments (i.e., unconsolidated aquifers) emplaced by glaciers or glacial rivers. In each sub-basin, the ability to sustainably extract new supplies of water is limited by aquifer properties and local perennial stream flows (closely related to natural baseflow). The largest withdrawals in Central Indiana are direct surface-water diversions extracted from major rivers. The highest capacity wells pump from the very permeable sand-and-gravel glacial outwash aquifer adjacent to rivers. Withdrawals from the outwash deposits either intercept water on its way to the river or capture river water through the sediments. Access to groundwater from the thin sand lenses confined in glacial till is limited to pumping rates that may only be suitable for domestic supplies. These low-productivity regions typically lie along the ridges and watershed divides, farthest from the streams.



Water accessibility varies within a sub-basin: water is most accessible along the river corridor that includes glacial outwash deposits and becomes less accessible as you move from the river.

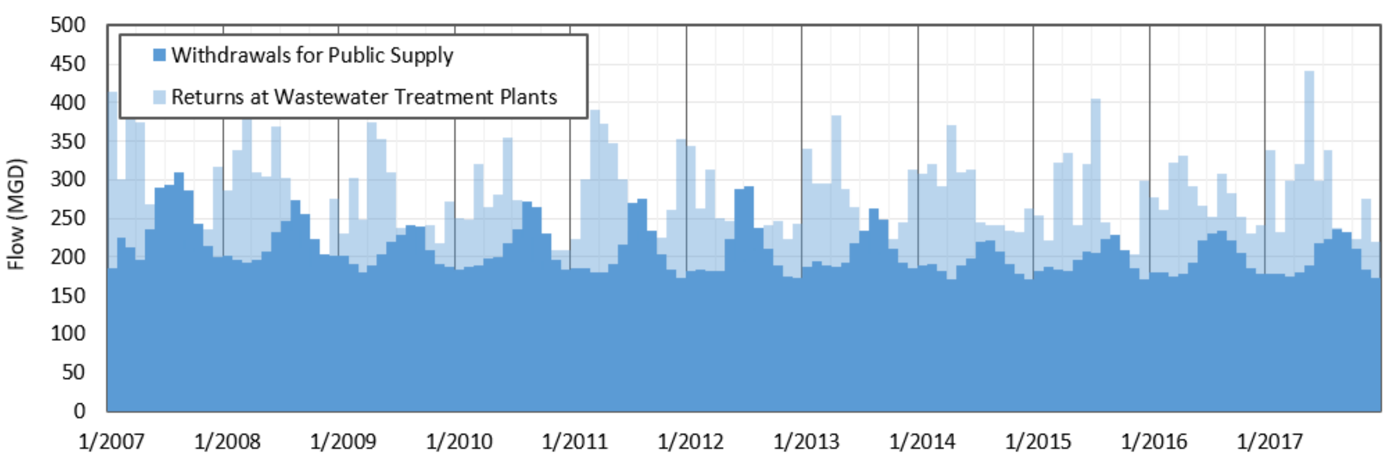
Current and future water supplies depend on unplanned water reuse

Water reuse is the process of reclaiming wastewater and converting it for use for beneficial purposes. Unplanned water reuse describes a situation in which a source of water is, at least sometimes, substantially composed of previously used water. The most common example of unplanned, but managed, water reuse that applies to Central Indiana occurs when communities draw their water supplies from rivers that receive treated wastewater discharges from upstream communities. During the driest part of the year (Summer), treated wastewater and groundwater discharge (natural baseflow) are the largest components of streamflow.

In this case, downstream water supplies depend on treated upstream effluent. We rely on instream biological processes, UV sunlight, and the ecosystem within the water-exchange zone near the riverbed, to further improve water quality for the next user. The quality improvements in wastewater discharge, along with the technology of advanced drinking water treatment processes, make surface waters more resilient as sources of supply.

The USEPA does not require or restrict any type of water reuse. Generally, states maintain primary regulatory authority (i.e., primacy) in allocating and developing water resources. Although Indiana does not, some states have established programs to specifically address reuse, and some have incorporated water reuse into their existing programs.

Treated wastewater discharge is a critical regional asset from a water-availability perspective. In Central Indiana, some of the fastest growing communities depend on their upstream neighbors to discharge reliably clean and consistent flows to the stream.



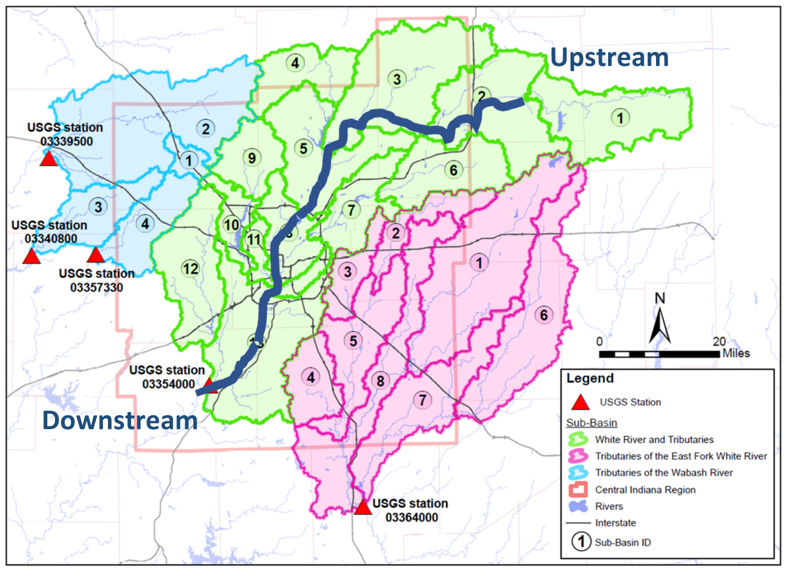
Treated wastewater discharge is a regional asset, critical to maintaining water supplies.

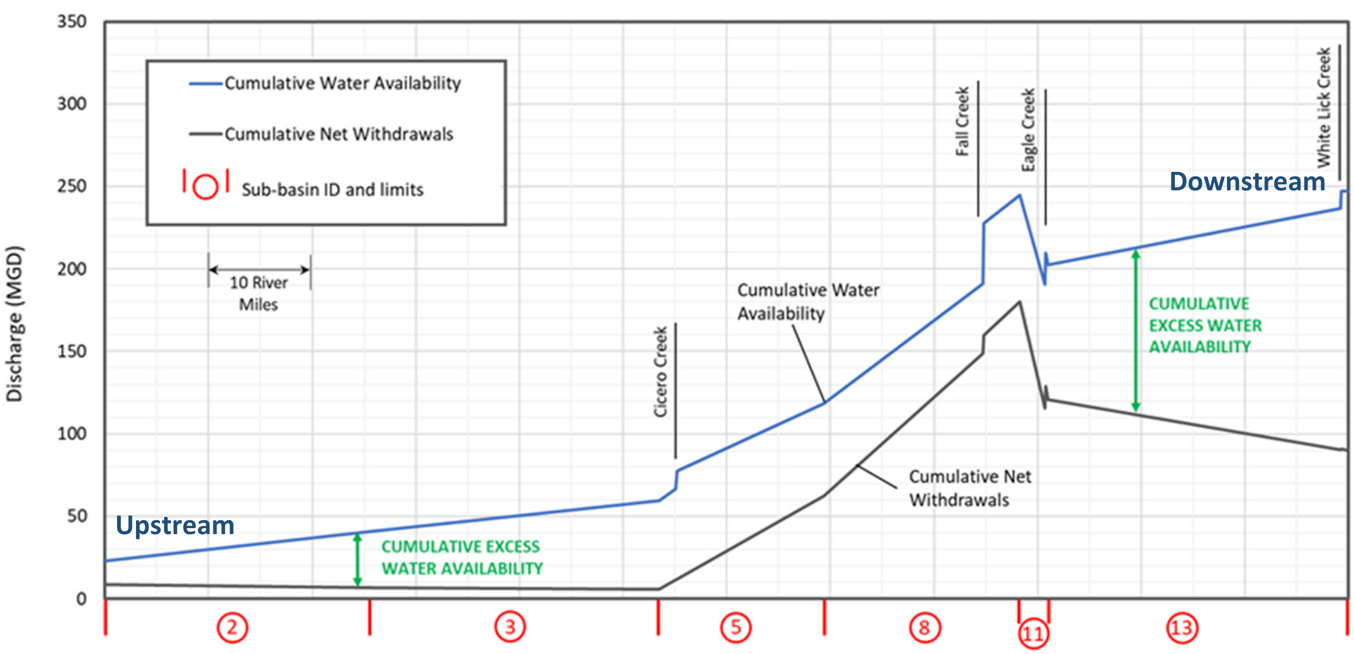
Water availability increases from upstream to downstream in the West Fork White River Basin

The gap between availability and net withdrawals (withdrawals minus return flows) shows approximately 50 MGD of cumulative excess water availability in the basins upstream and more than 130 MGD in the basins downstream of Indianapolis.

In Marion County and upstream, regional supplies are being efficiently expanded with repurposed aggregate quarries to supplement low flows. Additional storage, new well fields, and more efficient conveyance structures upstream will supply the water needed for local growth. Development of water supplies downstream could be one option for a sustainable, long-term future source of supply.

Below: Availability and net withdrawals. The plot follows the centerline of the White River from upstream to downstream, as illustrated on the map to the right.



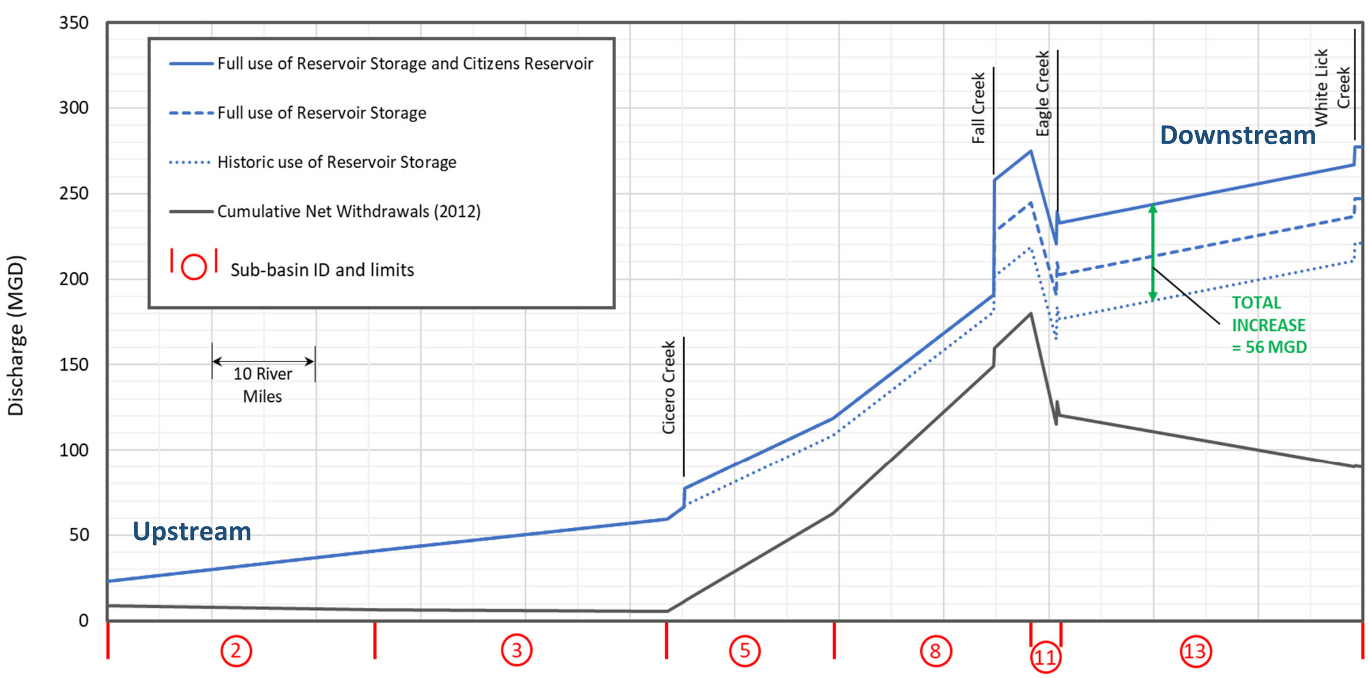


Utilities increased future water availability through capital improvements

Many Central Indiana utilities have taken steps to address water supply and demand issues. Changes made by Citizens, the largest utility, have a large impact on the regional supply. Since acquiring the Indianapolis water supply utility in 2011, Citizens has conducted infrastructure improvement projects to expand water accessibility and availability in their service areas and provide a more resilient water supply.

Projects in Indianapolis include the new 30th Street surface-water intake which makes it possible to divert water from the White River to the Central Canal during low flows. In addition, a new intake was constructed near 16th Street that allows water to be transferred from Fall Creek to the Central Canal. These improvements have increased water availability by making it possible for Citizens to capture water released from their reservoirs, allowing more regular use of reservoir storage in the future.

In 2019, Citizens began converting a former limestone quarry adjacent to Geist Reservoir into a water-storage reservoir, named Citizens Reservoir. The quarry lies at the northern, upstream end of Geist Reservoir, and was formerly owned and operated by Irving Materials Inc. When full, the reservoir will hold up to three billion gallons of stored water. The reservoir will be operated solely for purposes of water storage with no public access for development or recreation. The reservoir is planned to be operational in 2021.



Impacts of Citizens infrastructure improvements on cumulative water availability relative to cumulative net withdrawals. The plot follows the centerline of the White River from upstream to downstream.

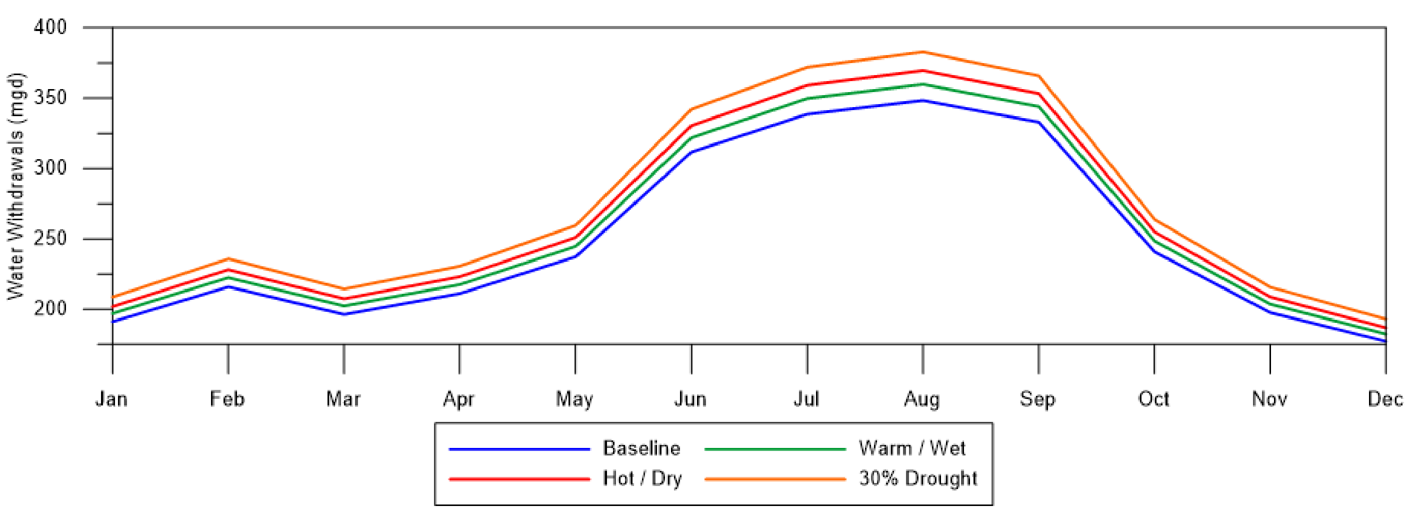
Climate change will impact water availability – monitoring is necessary

Observations of temperature, precipitation, and streamflow in Indiana over the last 100 years show increasing annual averages, with increasing rates of change over the last 20 years (Widhalm et al, 2018). These observations are consistent with trends in temperature and precipitation predicted by global climate models and are commonly attributed to climate change. Climate change will impact excess water supplies in Central Indiana in two ways: first, through changed demand patterns, and second, through changed streamflow.

Impacts on demand for public water supply are included in the projections of the Phase I Study (IFA, 2020). EPA guidance for utilities (US EPA, 2018) was used to define three future demand scenarios based on future climate projections. The climate scenarios, listed in order of increasing demands include warm/wet, hot/dry, and 30% drought conditions.

Predicting the impacts of climate change on streamflow and baseflow is a more difficult problem. Results from independent researchers attempting to predict climate-driven changes to streamflow in Indiana have been inconsistent: a study conducted at Indiana University (Dierauer and Zhu, 2020) predicts that the critical Summer streamflow will decrease by 40% of long-term averages (1971-2000) by 2100; a study by the US Army Corps of Engineers (Drum et. al, 2017) indicates a likely increase in July, August, and September streamflow of 30% of the long-term average. USGS streamflow records from the last decade indicate that streamflow and baseflow have increased in response to changing climate.

It remains unclear whether utilities should plan for decreasing water availability or increasing availability due to climate change impacts in Central Indiana. Recent decades have seen increasing streamflow, baseflow and water availability in the region. The use of natural baseflows calculated for the 2007-2017 period in estimates of future water availability assumes that the observed increases in that period relative to long-term averages, continue into the future.

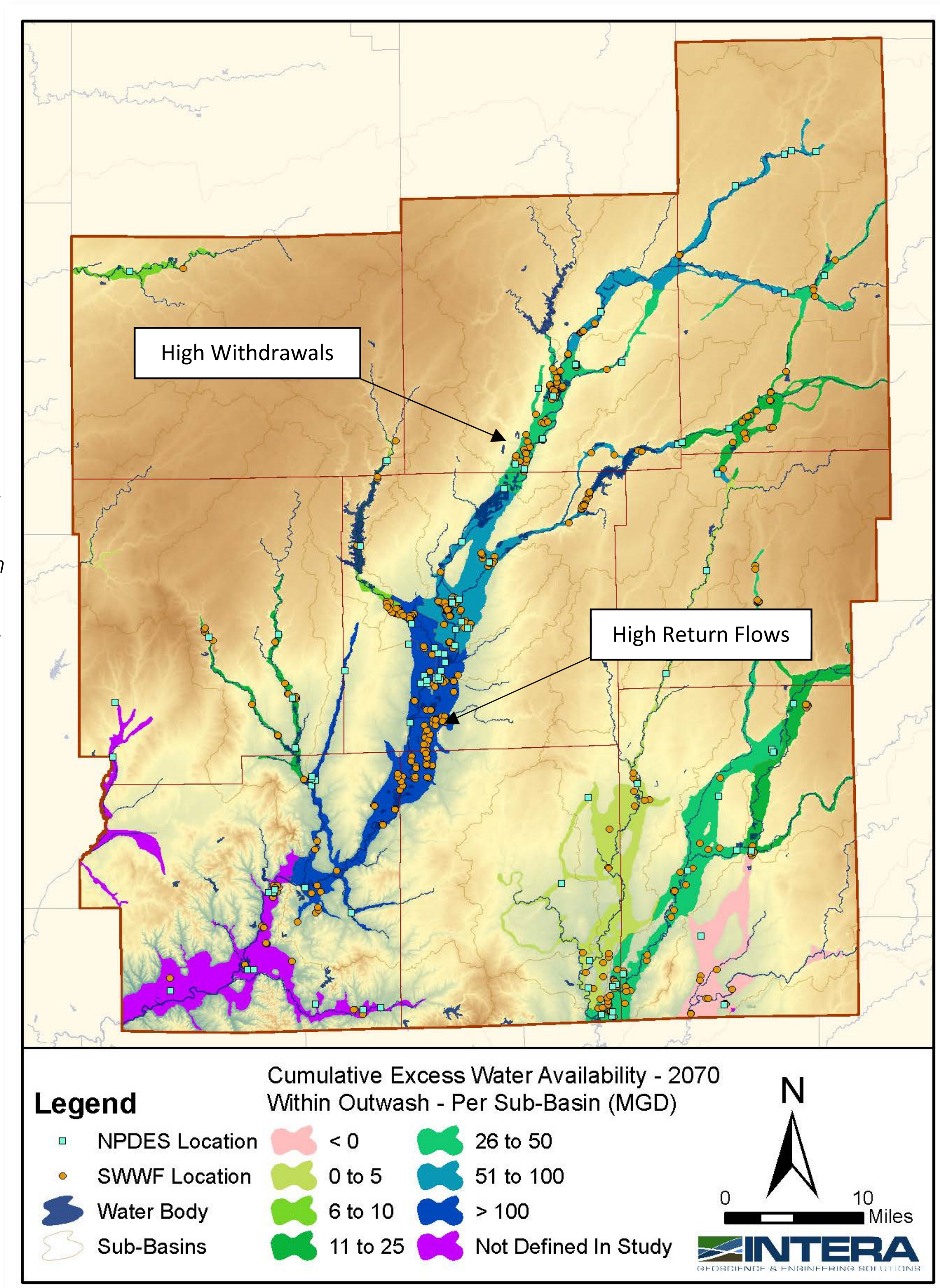


Projected impacts of climate change on water demand in 2070: Baseline and 3 model scenarios.

Future growth maintains similar patterns to availability today – less water north, more water south

Results of the water-availability model, including average projected 2070 water withdrawals and returns, are illustrated in the map below. In the White River and Tributaries of the Wabash River drainage systems, projected water availability remains positive in all sub-basins. Small negative cumulative values are projected in south-central Shelby County in the East Fork White River drainage system.

Minimum Quarter 3 cumulative excess water availability for the 2070 baseline scenario, shown in the outwash where water is most accessible.

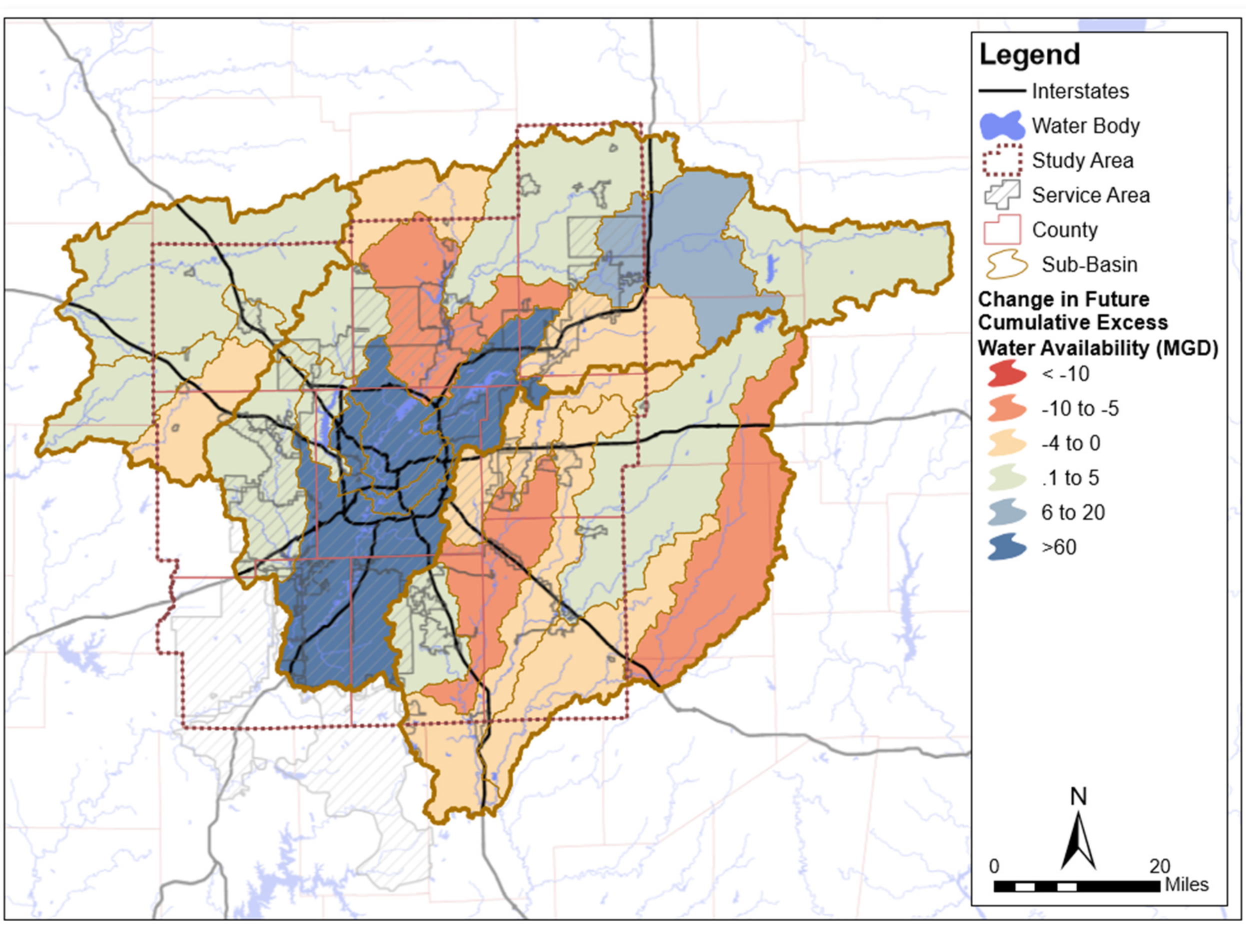


Water availability changes between now and 2070

The changes in water availability from current conditions range from -5 to +5 MGD in most sub-basins. In the West Fork White River drainage system, larger projected decreases in availability occur in Hamilton and Marion Counties, primarily due to increased withdrawals for public supply. In Hamilton County, the increased demand is not offset by returns from wastewater treatment plants, so there is projected to be a local increase in the deficit.

On the flip side, water-availability increases are projected in the Fall Creek watershed downstream of Geist Reservoir, as well as to the south of Indianapolis. The projected availability increase in the Fall Creek watershed is due to the operation of the new Citizens Reservoir, while the increase south of Indianapolis is due to increasing return-flow discharges at the Belmont Advanced Wastewater Treatment Plant.

Changes in the other major drainage systems are projected to be small, except for the south- central portion of Shelby County in the East Fork White River drainage system, which is a result of anticipated increased withdrawals in the Irrigation and Agriculture Sector.



Change in sub-basin water availability in the 2070 baseline scenario. The total change accounts for projected growth, increases in water availability from Citizens improvements, and increases in wastewater treatment plant return flows. This scenario does not account for climate change impacts.

Regional water quality is not pristine and may locally limit availability

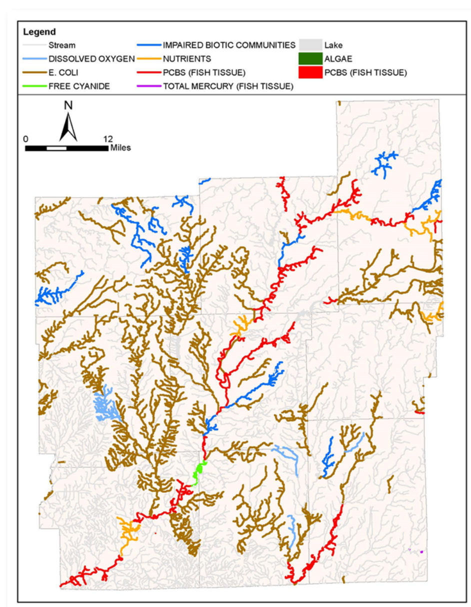
Water quality in the White River Basin is typical for the industrial Midwest with local pods of legacy contaminants in urban groundwater and high sediment runoff into streams from municipalities.

Ambient, or background, groundwater quality in Central Indiana is well-characterized by the ongoing statewide monitoring activities conducted by the Groundwater Section of IDEM. In an analysis based on IDEM data, the ambient groundwater quality does not limit the potential sources for groundwater supply for a large water utility. Although several constituents occur at levels greater than the maximum contaminant level, most can be removed by standard treatment to provide a potable water supply.

Groundwater contamination from historical pollutant releases poses a larger threat to groundwater supply, accessibility, and availability in Central Indiana than ambient conditions. A potential-contaminant source inventory was conducted to assess this concern. The inventory suggests that impacts to groundwater availability are primarily of concern in Marion County, where many potential (where an event occurred) and actual (measured pollutants) contamination sources exist. The potential-contaminant sources alone account for over 11% of the surface area of the outwash deposits in Marion County, which are the primary source of groundwater supply in the county. Substantially more area is covered by known contaminant plumes, but those areas remain largely unmapped on a regional scale.

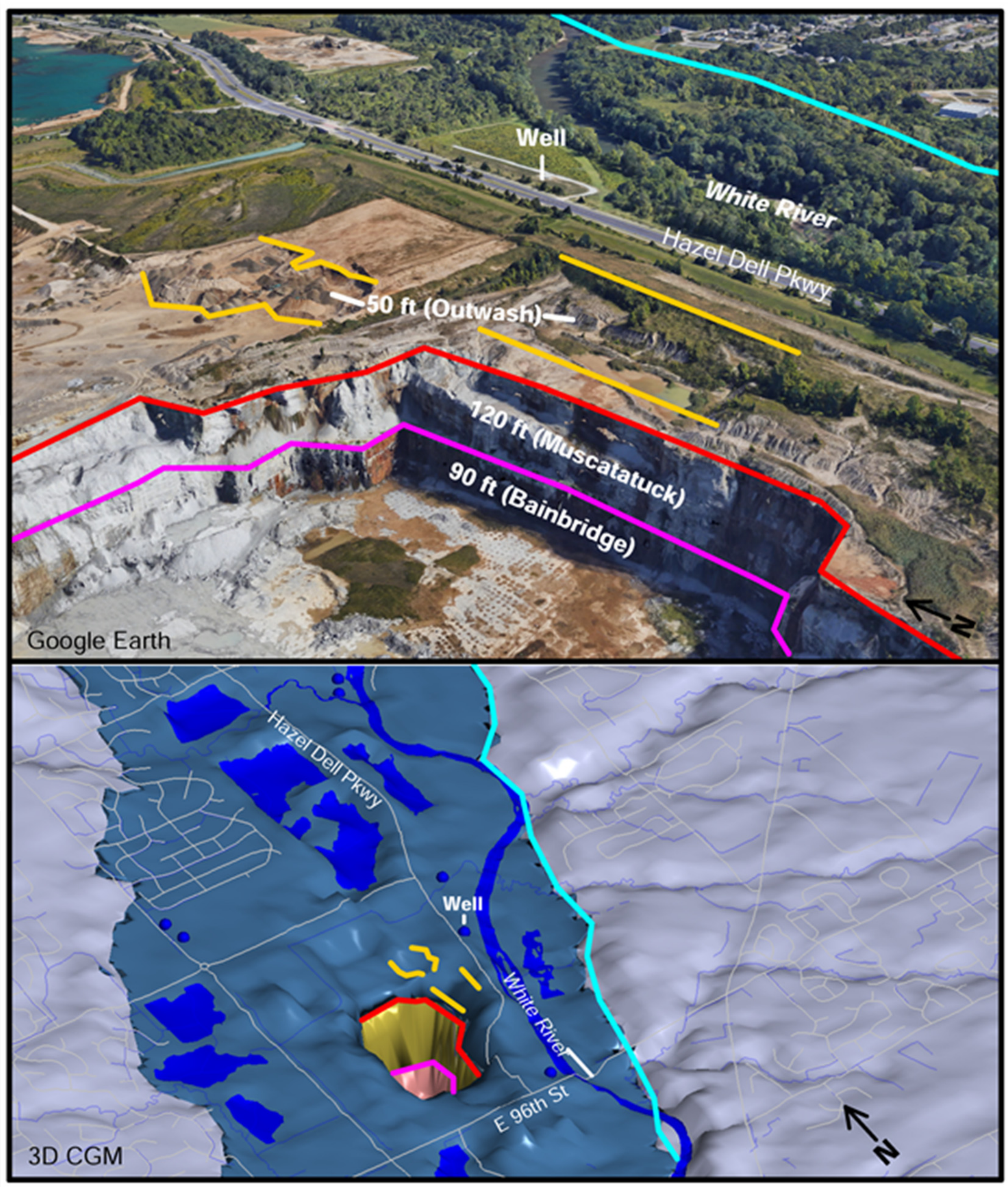
The current state of surface water quality in the region is summarized in the federal 303(d) listing of impaired waterways, which shows most major rivers and streams in the region to be impaired by a large range in chemical, bacterial, and biological parameters. Surface water quality in the past has been impacted by combined sewer overflows; conditions in Marion County will improve significantly with the operation of the deep tunnel interceptor.

Water-quality impaired surface waters in Central Indiana.



There are signs of local groundwater-supply shortages in Hamilton County

In Hamilton County, both public supply and industrial uses of groundwater are changing. More municipal wells are being located near the river to amplify groundwater recharge and minimize impacts on other groundwater users. Industrial use in Hamilton County is dominated by water handling and dewatering related to aggregate and gravel quarries along River Road in Carmel. These quarries have begun using nearly 10 MGD that is stored in the linked network of surface gravel pits in reclaimed quarry ponds. Some of these gravel pits are have hydraulic connection with the local outwash aquifer, so they act as imperfect infiltration drains to the local shallow aquifer. The operational withdrawals in the quarries, however, lower water levels in the overlying water-supply aquifer, reducing yields in nearby municipal wells.



Quarry activity and dewatering of the outwash aquifer that is the source of water for many high-capacity wells in the region. In some conditions, industrial and water-supply uses appear to conflict.

Regional water-supply options

Estimates of future need for all water users in communities east and west of Indianapolis, including the needs of self-supplied residential wells, are likely to be satisfied by local groundwater resources. In the center of the planning region, Marion County's growth may benefit from new high-capacity supplies downstream along the West Fork White River in Johnson and Morgan Counties. In this area the groundwater resources are entirely sustainable. However, the sub-basin water budgets on the north side of the planning region, especially in Boone and Hamilton Counties, may exceed available local supplies between now and 2070. Estimated water needs from the Phase I Demand Forecast suggest that there will be significant growth on the north side of Indianapolis as well as to the suburban counties to the south. At the same time, it is expected that withdrawals from subsurface mine dewatering will increase as the mined area expands. More underground excavations are statistically more likely to encounter fractures and other secondary porosity that can drain water from overlying saturated unconsolidated sand and gravel units.

Given the projected increased seasonal demands and the available resources, there are a variety of water-supply options that could close the gap between existing resources and future demand. They can be grouped into two categories: 1) alternatives to increase water availability, and 2) an alternative to decrease demand.

Alternative Descriptions, Capabilities, and Cost Estimates

The discussion in this section is neither exhaustive nor descriptive of any specific water-supply system discussed in this report. The information is offered as a generalized discussion of potential alternatives and anecdotal experiences. Therefore, none of the information presented should be construed as a recommendation that can be directly applied to any system's situation.

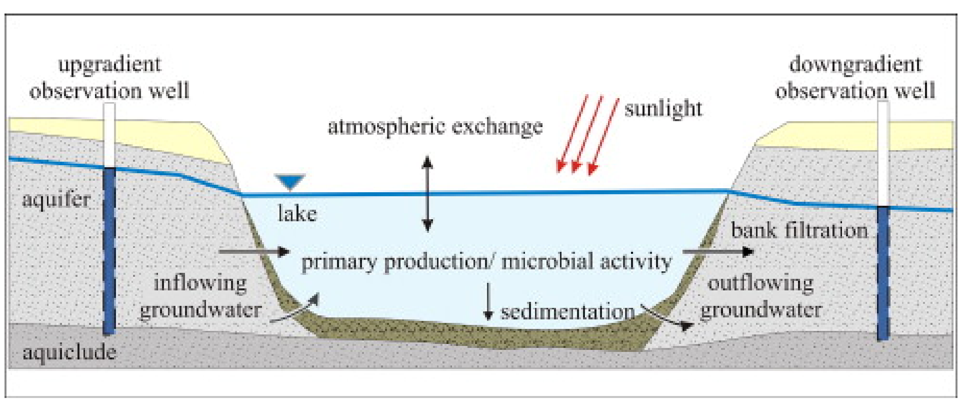
Cost information provided in this section is extracted from isolated regional projects and is empirical; it is not descriptive of any or all specific water-supply alternatives and/or future application of alternatives relative to Central Indiana referenced in this report. As such, any cost estimates provided are representative of order-of-magnitude costs for various types of water-supply projects.

Increasing water availability – Local surface-water storage

For the center of the state, creating additional water storage is the most traditional method of increasing source-water resources. Central Indiana has a set of reservoirs to capture and store a proportion of the annual runoff from within their respective watersheds. Additional seasonal runoff could be captured in reservoirs by adding new storage volume or by making additional use of existing quarries or mines to create new local storage. Storage can be added to existing reservoirs by dredging sediment to increase the water volume. Because dredging to increase reservoir volume can be expensive and new single-purpose storage is cheaper, re-purposing existing rock quarries is one of the most economical methods to increase regional water availability. The cost and complexity of utilizing reservoirs varies based on scale of the project and likely impacts.

The different factors that could affect cost include procurement of state and federal permits, mitigation of impacts to natural resources and surrounding land uses, property acquisition requirements, location, reservoir volume and depth, dam and spillway construction, and contractor market conditions. Similar factors affect cost when considering dredging. However, dredging could potentially release large amounts of suspended solids and other pollutants to the reservoir water column and would likely require a reconfiguration of the water-withdrawal system, which might make sense in the right circumstances.

Expanding surface-water withdrawals for public supplies may not be possible where other water users reduce aquifer yields in Hamilton County. Data are needed to understand any conflict between mine dewatering and water-supply development so that solutions can be found. Currently the mine-water management system – discharging the water into mine lakes before they flow to neighboring streams – could be the beginnings of a collaborative solution. With a few changes in design of the mine lakes and the discharge, these lakes could become an infiltration system to supplement increased groundwater extraction. To engineer a solution, additional data need to be collected to understand how the lakes could be optimized for recharging the shallow aquifer. The figure below illustrates some of the physical mechanisms that influence water supplies near a mine lake.



Conceptual cross section of a mine lake (from Muellegger et al., 2013).

Increasing water availability – Development of reservoirs in quarries

Historically, reservoir storage has been developed in Central Indiana to supplement low flows during drought conditions and increase water availability. However, because there is higher population density and more legal restrictions that address these projects today, the task of building a dam across a valley has become much more complex. These complications mean that building a large reservoir can be so expensive and contentious that it is hard to prioritize as a new water-supply option. Without federal funding, the cost for the planning and development is beyond the reach of most utilities. The regulatory, economic, and political difficulty of developing a traditional reservoir, along with the delays and uncertainty that come with legal challenges, make this option a less attractive water-supply alternative.

Another approach to develop surface-water storage is to reuse existing rock quarries as reservoirs. In the last several years, Citizens developed a new 30 MGD reservoir in a 230 ft-deep limestone aggregate quarry adjacent to Geist Reservoir solely dedicated to water-supply use. This approach holds promise, with many advantages over traditional reservoir construction. The fact that it has such a small footprint to produce large supplies is part of the reason it is so much less expensive than building a dam to fill another valley with water. This new use of the existing quarry could be applied to other locations in Central Indiana. The yield of this reservoir will also be more reliable than other storage because it is dedicated to water supply. It is a simple approach to solving a complex problem. This new utility infrastructure also points out that aggregate mining is not necessarily incompatible with water-supply development. The new reservoir holds almost half of the volume of Geist Reservoir, more than 3 billion gallons of water, that can be used to produce additional sustainable supplies for the community.

Indianapolis' next reservoir a drought '~insurance policy'

AP By JOHN RUSSELL

Posted 11/24/2019 7:00 AM

FORTVILLE, Ind. -- It's not much to see yet-just a deep, empty pit with rocky walls and a few puddles on the bottom. But in a year or so, the 230-foot-deep former limestone quarry in Fortville will be outfitted with pumps, pipes and tunnels, and filled with 3 billion gallons of water, making it the newest reservoir in central Indiana.

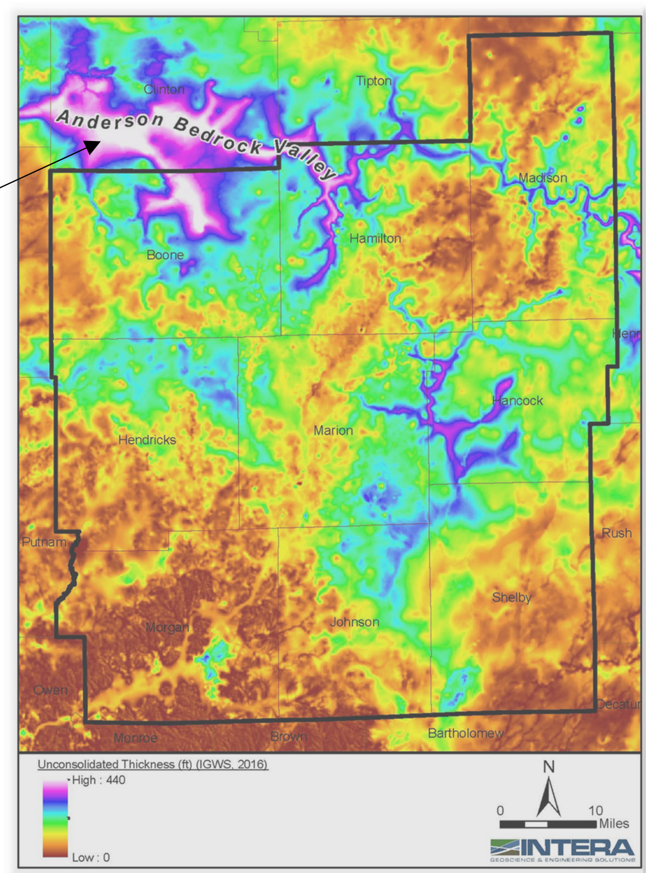
Indianapolis-based Citizens Energy is constructing the reservoir as a backup water supply during droughts or periods of high water consumption. When completed, the 88-acre project, called Citizens Reservoir, will be able to pump up to 30 million gallons a day of captured rainwater into nearby Geist Reservoir. From there, the water will flow over a dam into Fall Creek and Citizens' water-treatment plants in Indianapolis.

(Daily Herald, 2019)

Increasing water availability – New well field in buried valley aquifer

Just north of the planning region boundary (north of Boone County) there is a relatively unexplored aquifer that could supply several million gallons per day (gpd) from a properly designed well field. This regional supply, depending on hydraulic properties of the valley fill, could be used to satisfy near-term growth and then expand infrastructure with demand. This bedrock-valley aquifer is defined by a pre-glacial drainage of the ancestral Teays River just north of the Wabash River. In Clinton County municipal wells in the 300-400 ft deep buried valley aquifer can produce more than 1200 gallons per minute (gpm). While the sustainable yield of this groundwater resource is not yet known, the difficulty of collecting the necessary data to understand the hydraulic characteristics of the system is relatively low. Exploration and testing would be required to consider the regional value of the Anderson Valley Aquifer.

If the Anderson Valley Aquifer system could be developed as a water-supply alternative, it would be very practical from a fiscal, technical, and political perspective. Increases in pumping would occur incrementally. A new well field in this aquifer would be the most straightforward way to expand supply to meet the rapidly growing demand for water in Boone and Hamilton Counties. Although the yield is likely to be limited to 10-20 MGD, this "add-on" alternative is less complex and less expensive than many other regional supply options.



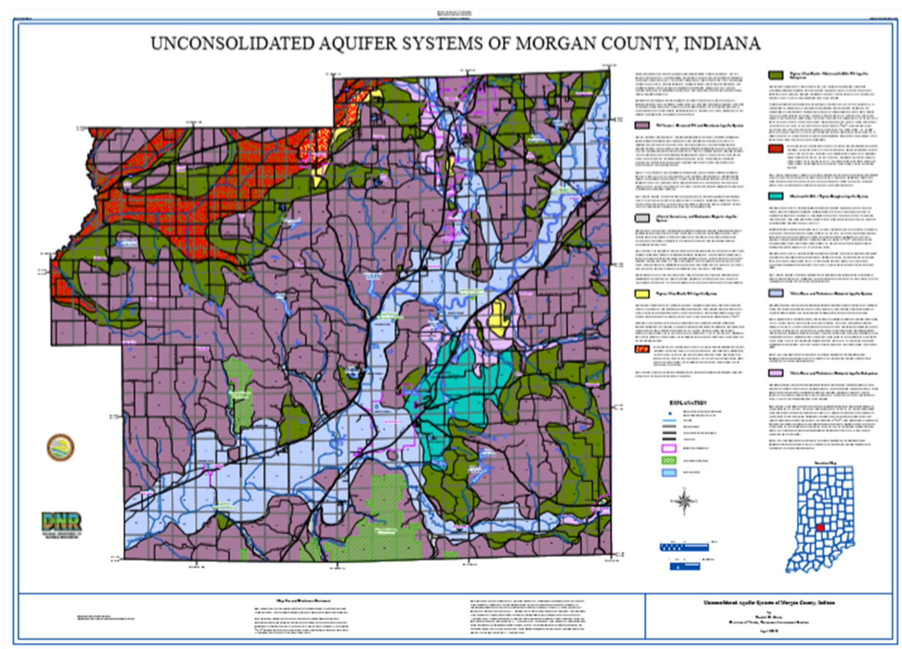
Thick deposits fill the untested Anderson Valley Aquifer in Clinton County.

Increasing water availability – Strategic development of the regional outwash aquifer

In contrast to development of new untested aquifer systems is the potential of expanding the use of the regional outwash aquifer. In general, it is difficult to quantify the added capacity and sustainable yield that could be seasonally derived from additional new uses of the outwash aquifer. The outwash aquifer is a heterogeneous sand and gravel aquifer that is, in some places, divided into an upper and lower aquifer separated by leaking confining units that vary in thickness throughout the region. The potential groundwater yield varies spatially; modeling of specific scenarios using both regional and local groundwater models was required to develop the estimates for the water-availability analysis in the Phase III report.

One important factor to consider in the use of the outwash aquifer is its rapid recharge from annual precipitation. Because there is no continuous clay-confining unit associated with this aquifer, recharge is relatively fast when compared to the deeper bedrock aquifers. While limited by recharge rates, the near-river outwash aquifer can be a sustainable source if managed properly.

The forecasted increasing demands on the south side of Indianapolis could be sustainably met with new groundwater extraction along the West Fork White River in Morgan County. Growth in Shelby County could be supplied by existing sources, but additional growth in irrigation needs to be monitored to avoid conflicts. On the south side of the planning region, the outwash deposits are not as abundant near the southern limit of the most recent glacial sediments and have multiple competing uses. The shallow sand-and-gravel outwash aquifer developed by most of the municipal systems is also used by gravel mining operations for wash water and is pumped by farmers for irrigation. In this area, high yields are attainable in properly designed riverbank-filtration (RBF) well fields. Water supplies in outwash would only need to avoid pre-existing contamination to be able to increase availability.



Map of the prolific West Fork White River outwash aquifer (light blue). With the addition of metropolitan wastewater return flows, the White River Basin has ample water supplies, even at low flow.

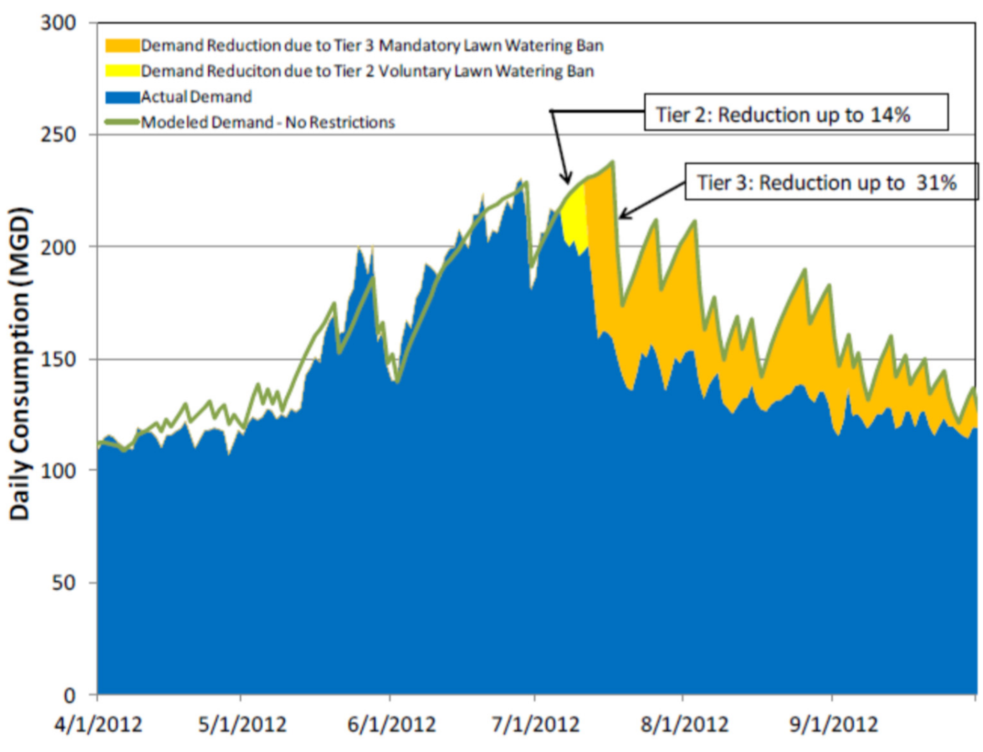
Alternative for decreasing demand – Water conservation

Both sides of the water demand-supply system can be adjusted. Increases in demand in the Summer can potentially be mitigated by voluntary conservation. It is difficult to predict how much demand reduction is achievable without having some historical data from implemented conservation efforts, but we do have some insights about the effect of water conservation during the 2012 drought.

Citizens has documented the impacts of voluntary and mandatory conservation to manage demand in 2012 (CEG, 2013). With a tiered drought response action plan already in place before the drought, the utility was able to effectively manage demand (primarily lawn watering) through their public response to water-shortage triggers. The demand reductions achieved in 2012 were as high as 31%. Peak seasonal demands can successfully be managed with outward-facing communications and public cooperation. This approach is inexpensive and effective and should be a part of any regional supply plan.

Water conservation measures are used throughout the region to encourage people to change behaviors and habits to reduce water use. Water conservation also includes any beneficial reduction in water losses or waste. Water-conservation programs are aimed toward water consumers and can involve technical or financial means and public-education programs. Utilities have worked hard to imbue a conservation ethic in residents, industries, and businesses. Future demand projections show that there is a role for conservation as a component of everyday water use and as a demand-management tool during drought conditions.

Graph taken from Citizen's Drought Management Plan. Shows demand reduction over 30% from voluntary and mandatory lawn watering bans during the drought (CEG,2013).



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