Regional Water Study

Abstract and Executive Summary

Wabash Headwaters Region

Jacobs Engineering Group Inc.

Report to Indiana Finance Authority

January 2025

Abstract

This *Wabash Headwaters Region Regional Water Study* (study) presents estimates of historical water use throughout the Wabash Headwaters Region and projects estimates of water demand through 2070 for water using sectors, including public water supply, industry, energy, irrigation, rural livestock production, and self-supplied households. Demand projections were calculated using a regression-based approach to correlate economic, population, and climate factors that influence water use for individual users and within sub-watersheds within the Wabash Headwaters Region study area (study area).

Additionally, a water balance approach was used to calculation potential water historical water availability for the period 2007-2022 considering baseflows (flows from groundwater that flow upward to streams and rivers), reservoir storage and releases, return flows (water returning to the streams and rivers through direct discharges or infiltration), water use and minimal instream flow requirements within the planning region. By considering the return flows in the analysis, the water balance approach accounts for the consumptive use rather than the water demand only. The historical components included in the historical water balance were then adjusted to reflect a reasonable climate scenario and projected demands through 2070.

The results of the historical and future water balance analysis are presented spatially for each of the 10 sub-basins within the planning area as well as for the region. Results are also presented on an annual and seasonal basis to provide information on potential water supply constraints in the future.

Approximately 70% of the groundwater use with the study area is supplied by groundwater sources. The largest users historically have been public water systems (utilities) and industries. This is not expected to materially change in the future. Overall water demand is expected to grow by 9% or million gallons per day (MGD) by 2070. While there is some seasonality in demand patterns, it is not as pronounced as in other regions due to the relatively small irrigation usage as compared with industrial and public water supply uses.

By the Numbers

- The largest historical demands in the Upper Wabash Region are industrial and public water supply (39% and 37%, respectively).
- Approximately 70% of the water supply is obtained from groundwater sources, with the remainder withdrawn from surface water sources.
- The maximum consumptive use observed historically was approximately 26% of groundwater and surface water withdrawals.
- Water demand is expected to increase approximately 9% from 81.8 MGD in 2022 to approximately 89.8 MGD in 2070.
- While groundwater will likely remain the primary water source for the region, a modest shift (5%) from groundwater to surface water use is anticipated.
- Cumulative excess water availability is projected to remain relatively stable, though seasonal variations are anticipated to shift due to climate and hydrological changes.
    - Summer: Decreases expected across most sub-basins (-3% to -20%), except Sub-basins 4 and 9 (increases of 8% and 9%, respectively).
    - Fall changes range from -11% to -32%
    - Winter: Increases expected across most sub-basins (3% to 21%), except Sub-basin 9 (decrease of -6%).
    - Spring increases range from 14% to 39%.

The cumulative excess water availability the study area is expected remain similar to historical conditions with some changes in seasonality due to changes in climate and hydrology. The summer and fall months are projected to exhibit less natural baseflow conditions throughout the study area. Decreases in summer and fall natural baseflow, during already low flow periods, presents the largest potential challenge in balancing water demands when water demands can make up a large percentage of streamflow during these periods. However, with the increase in winter and spring natural baseflow, there may be opportunities to better utilize reservoirs in the study area to help offset reductions in natural baseflow during the summer and fall months.

Executive Summary

The Indiana Finance Authority (IFA) is conducting a series of regional water supply studies to assess 50-year water demand and supply availability throughout the state of Indiana. This report presents an assessment of historical and future water demands and availability within the Wabash Headwaters Region through the year 2070.

The Wabash Headwaters region is in the northern third of Indiana. Because the Wabash Headwaters Region study area (study area) is defined by surface water watershed hydrologic boundaries rather than administrative jurisdictions, the region includes all or most of Blackford, Carrol, Cass, Grant, Huntington, Jay, Miami, Wabash, Wells, and Whitley counties and portions of Adams, Allen, Auglaize (Ohio), Darke (Ohio), Delaware, Fulton, Howard, Kosciusko, Madison, Mercer (Ohio), Noble, Randolph, Tippecanoe, and White counties. Data from upstream portions of the watershed within the state of Ohio were considered in the study.

To facilitate a comprehensive analysis of regional water demand and supply dynamics, the study area was delineated into 10 sub-basins, corresponding to smaller hydrologic areas (Figure ES-1). The Wabash River, which flows southwest into the downstream North Central Region, underscores the importance of inter-regional coordination and data sharing.

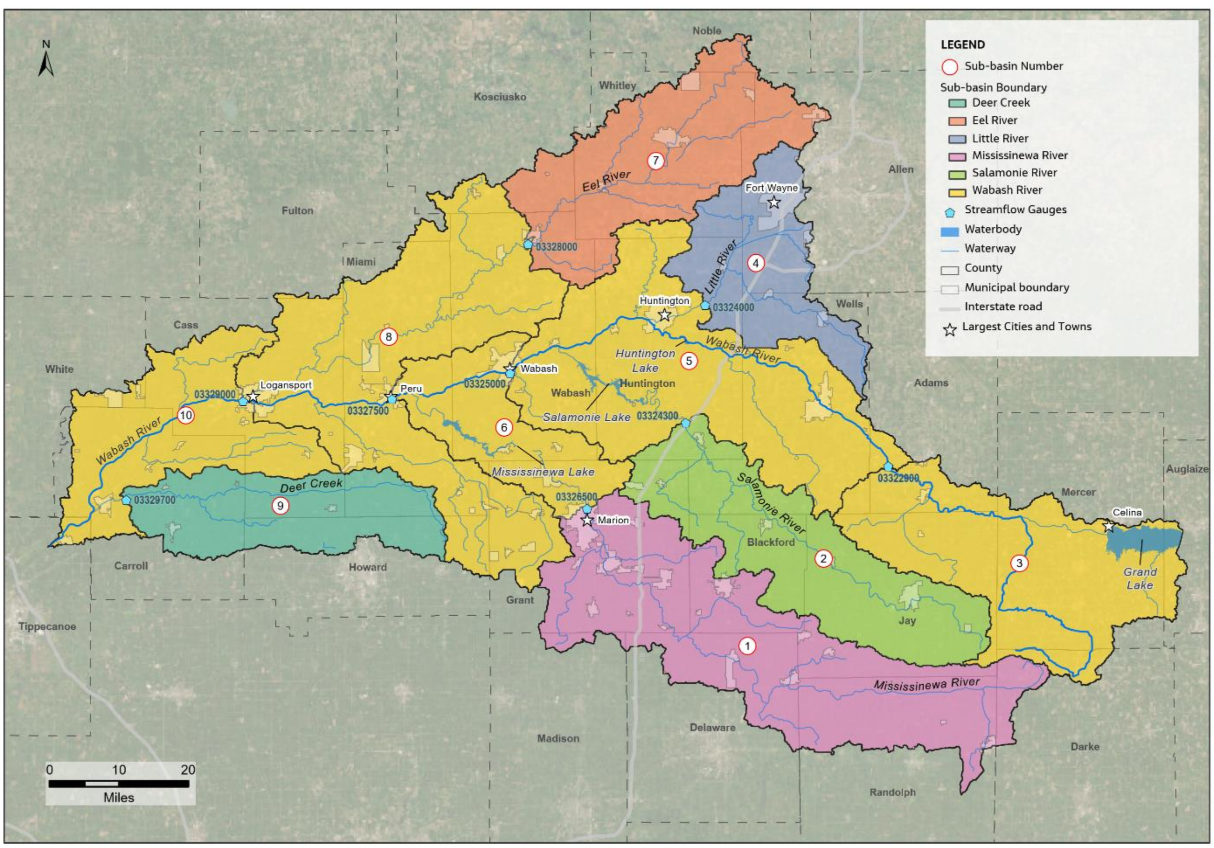


Figure ES-1. Wabash Headwaters Region Study Area and Sub-basins

Study Purpose and Objectives

IFA is undertaking regional water planning studies in 10 hydrologic regions across the state of Indiana to gather and analyze data regarding current and future water demand and supplies pursuant to Senate Enrolled Act 416. This study will analyze historical and projected water demand and supply data through 2070, identify associated risks, and recommend future water planning strategies at regional, sub-basin, county, and statewide levels.

The primary objective of this study is to develop a comprehensive, 50-year water demand and supply forecast extending to 2070. This forecast will serve as a critical tool to support informed planning and decision-making for the region. Objectives include the following:

- Analyze historical and future water demands for the Wabash Headwaters watershed using diverse data sources and stakeholder insights.
- Develop a 50-year water demand forecast considering factors like population, economy, climate, and sector-specific needs (for example, public supply, agriculture, industry, energy, rural, and minimum instream flow requirements to meet ecosystem and habitat needs).
- Assess historical and projected future water supply availability within sub-basins and the entire study area for their capacity to meet demands and instream flows through 2070.
- Analyze and present sub-basin-specific information within the study area.
- Characterize future risks (for example, water supply deficits, water quality concerns) and recommend strategies to address data gaps and mitigate risks.
- Summarize study results in a user-friendly format for water users, planners, and decision makers.

Regional Overview

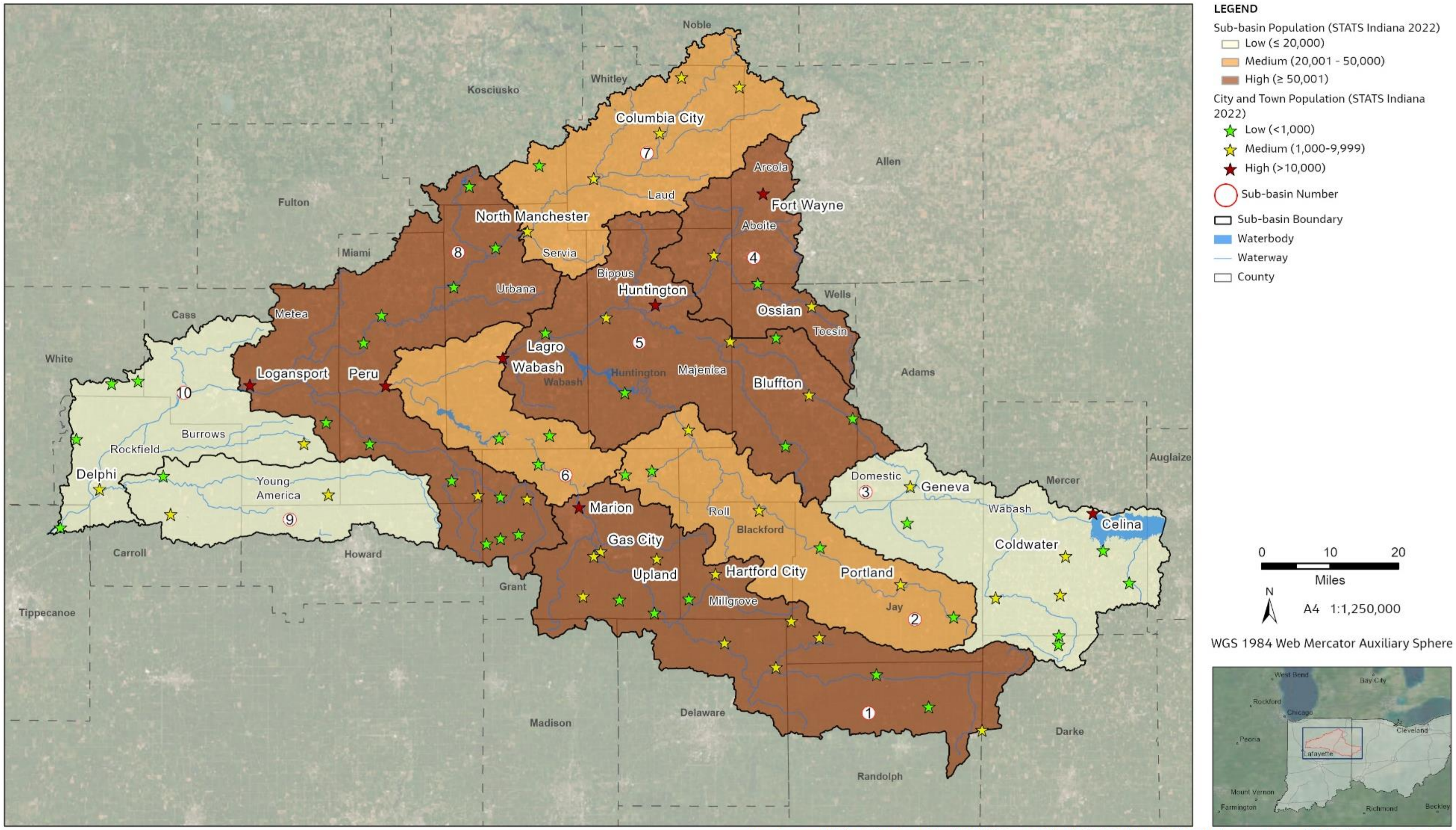
The Wabash Headwaters Region is defined by hydrological boundaries which form drainage basins that contribute flow to surface water (streams, rivers, and reservoirs) and groundwater (aquifers that are sediment or rock formations that lay below the ground surface) within the study area. This approach recognizes how water moves across county and state jurisdictional boundaries and is essential for accurately assessing surface water and groundwater availability to meet human and environmental needs.

The Wabash Headwaters Region Study Area (study area) is composed of five primary hydrological units, identified numerically by the U.S. Geological Survey. This includes the Upper Wabash (05120101), Salamonie (05120102), Mississinewa (05120103), Eel (05120104), and the Middle Wabash-Deer (05120105). While the majority of the Wabash Headwaters Study Area is within the state of Indiana, portions of the Mississinewa and Upper Wabash hydrological units extend into Western Ohio. While this study focuses on the region within the state of Indiana, information about water demand and flows within the state of Ohio that affect water supply within the study area were gathered and analyzed in this study.

Population

In 2022, the Wabash Headwaters Region was home to approximately 323,000 people based on the Census American Community Survey (U.S. Census Bureau, 2022a). The regional distribution of this population is shown on Figure ES-2. Reflective of the rural characteristics of the region, the average population density for the entire study area is approximately 90 people per square mile.

The largest urban center in the study area is the city of Marion, located in Grant County, which accounts for 9.1 percent (%) of the region’s total population. The next largest urban centers are Logansport and Huntington in Cass and Huntington Counties, respectively. The rural and agricultural communities outside the urban centers collectively constitute approximately 56% of the study area’s population



Data Sources: CEC North American Atlas (2024),IN Gov (2024), TIGER (2024), JACOBS (2024); Imagery Sources: ESRI Online Imagery Services
\\ausyd0vs01\GISProj\US_Wabash\Apps\Wabash_Mapping_v3.aprx/EEXM100_Wabash_F002_PopulationDensity_v10 | Date: 6/01/2025

Figure ES-2. Wabash Headwaters Region: City, Town, and Sub-basin Populations

.

Economy

The Wabash Headwaters Region supports a diverse economy, encompassing manufacturing; limestone, clay, sand, and gravel quarrying; biofuel production; agriculture; and livestock operations. The economy within the study area is supported primarily by agriculture and manufacturing, with most employment engaged in agricultural operations (U.S. Census Bureau, 2022). Outside of agriculture, the Wabash Headwaters Region economic drivers also include quarries, manufacturing facilities, retail businesses, and biorefineries.

Climate

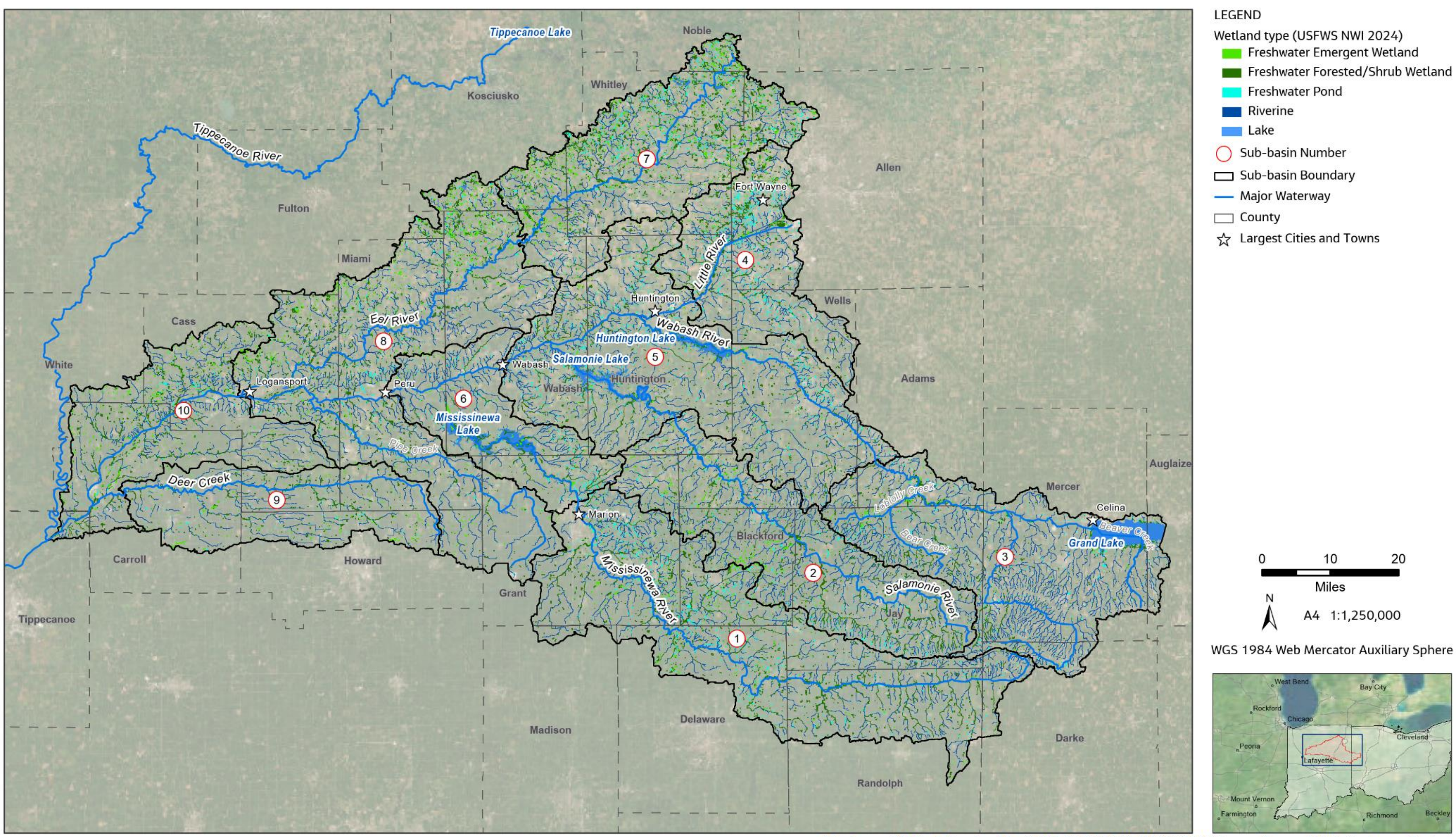
The Wabash Headwaters Region has a humid continental climate characterized by long, warm, wet summers and freezing, snowy, windy winters. With an average annual max temperature of 94.5 degrees Fahrenheit (°F) and an average annual minimal temperature of 10.2°F, the Wabash Headwaters Region experiences a significant temperature fluctuation throughout the year. Based on data from 1985 to 2022, July is the warmest month with average daily highs of 84.0°F and average daily lows of 62.8°F, and January is the coldest with average daily highs of 32.7°F and average daily lows of 17.1°F.

Located in a wet region of the United States, the Wabash Headwaters Region received an average of approximately 42 inches of annual precipitation between 1985 and 2020 (NOAA, 2024). Historical data show gradual increases in average temperatures and increasing precipitation for the entire basin (Widhalm et al., 2018). These trends are expected to increase the area of the floodplains around the Wabash River and its major tributaries.

Water Resources Overview

Groundwater resources are a major source of drinking water in the Wabash Headwaters study area and are used to support energy production and irrigation as well as industrial, commercial, and agricultural operations. Groundwater is obtained from underground aquifer systems, which are formations that contain permeable geologic materials that are saturated with potable water. The productivity of an aquifer depends on the interconnected porosity, the volume of connected voids within the formation, the hydraulic conductivity, the ease by which fluid passes through the formation, and the recharge rate (Fenelon et al., 1994).

Various sand and gravel aquifers are available within unconsolidated deposits, some of which can yield as much as 2,000 gallons per minute (Fenelon et al., 1994). In addition to groundwater, some water users in the study area obtain water through surface intakes from streams and rivers. Figure ES-3 shows the major rivers and reservoirs in the study area.



Data Sources: CEC North American Atlas (2024), TIGER (2024), JACOBS (2024); Imagery Sources: ESRI Online Imagery Services
\\ausyd0vs01\GISProj\US_Wabash\Apps\Wabash_Mapping_v2.aprx/EEXM100_Wabash_F016_Rivers_v05 | Date: 15/11/2024

Figure ES-3. Rivers and Reservoirs in the Wabash Headwaters Region

Historical and Future Water Demands

In 2022, there were 235 unique Significant Water Withdrawal Facilities (SWWFs) operating 467 groundwater wells and 79 surface water intakes within the Wabash Headwaters Region. Significant water withdrawal facility (SWWF) is a water pumping installation or other equipment that can withdraw more than 100,000 gallons of water from the ground, surface, or both in one day. SWWF owners must register with the Indiana Department of Natural Resources (IDNR) and report their annual water use within three months of the end of the year (IDNR, 2024). Figure ES-4 shows the general locations of groundwater wells and surface water intakes throughout the study area. The majority of the SWWFs provide water for public water supply (utilities), agricultural irrigation, manufacturing activities, or mineral withdrawals. In 2022, the highest water demand from SWWFs were public water suppliers and industrial operations. The study area is also home to multiple agricultural operations, several biofuel refineries, and a steel producer.

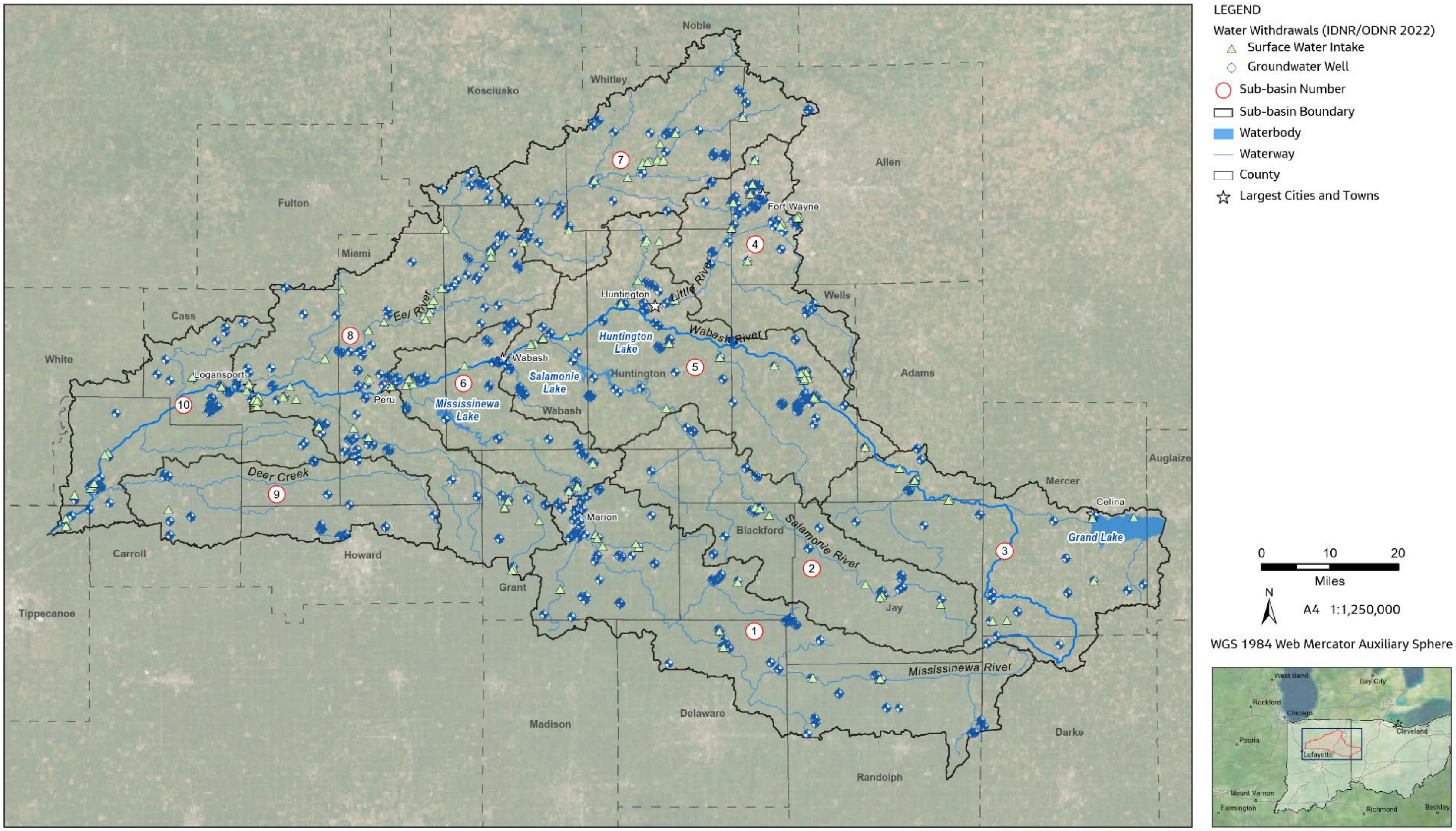
Historical Water Demand

Reported water use was collected from 1985-2022 for various sectors, including public supply, industrial, agricultural, and other uses. The public supply and industrial sectors represent the largest water demand since 1985, despite a slight decrease in recent years. Between these two sectors, the majority of water use is non-consumptive use, meaning that it is returned to the system. Figure ES-5 presents historical water use in the study area. The Wabash Headwaters Region used approximately 29.8 billion gallons of water in 2022 for an average daily use of 81.8 MGD. The largest water demand was in the industrial uses sector, with an average demand of 32.3 MGD, followed by the public water utilities with an average demand of 30.2 MGD in 2022. Figures ES-6 and ES-7 summarize water demand by sector within each sub-basin in 2022.

Future Water Demand

A multiple regression-based approach was used to identify population, climatic, and economic variables that influence water use, and to assess the relative influence of these factors on demand. This approach produced region-wide, sub-basin, and county-forecasts of demand for each sector through 2070. The water demand for the Wabash Headwaters region in the year 2070 is estimated to be 9% greater than the withdrawal observed in 2022. Figure ES-8 shows the most recent (2022) historical water demand by sector and the future (2070) water demand forecast. Energy production and miscellaneous registered facilities are not shown in the pie charts because they represent less than 1% of the total water demands in the region and their demand is not expected to surpass the 1% threshold. In 2070, energy production is expected to use 0.08 MGD and miscellaneous uses are expected to use 0.04 MGD. Industrial demand is expected to have the largest increase in water demand. The self-supplied sector represents residential users with their own well.

Growth in anticipated water demand is driven by explanatory variables like temperature, precipitation, population, inflation adjusted consumer price index, and median household income and increases in future demands for the concentrated animal feeding operation/confined feeding operation, industrial users, and public water utilities. Future climate conditions used for forecasting were adapted from two previous studies (Byun and Hamlet, 2018; Hamlet et al., 2019) that evaluated projected changes in climate and streamflow over the Midwest and Great Lakes Region and the state of Indiana, respectively. Future climate and streamflow datasets were available covering Indiana for a suite of Coupled Model Intercomparison Project Phase 5 Global Circulation Models.



Data Sources: IN Gov (2024), TIGER (2024), JACOBS (2024); Imagery Sources: ESRI Online Imagery Services
\\ausyd0vs01\GISProj\US_Wabash\Apps\Wabash_Mapping_v3.aprx/EEXM100_Wabash_F013_WaterSources_v06 | Date: 28/11/2024

Figure ES-4. Water Withdrawal General Locations by Source in the Wabash Headwaters Regions

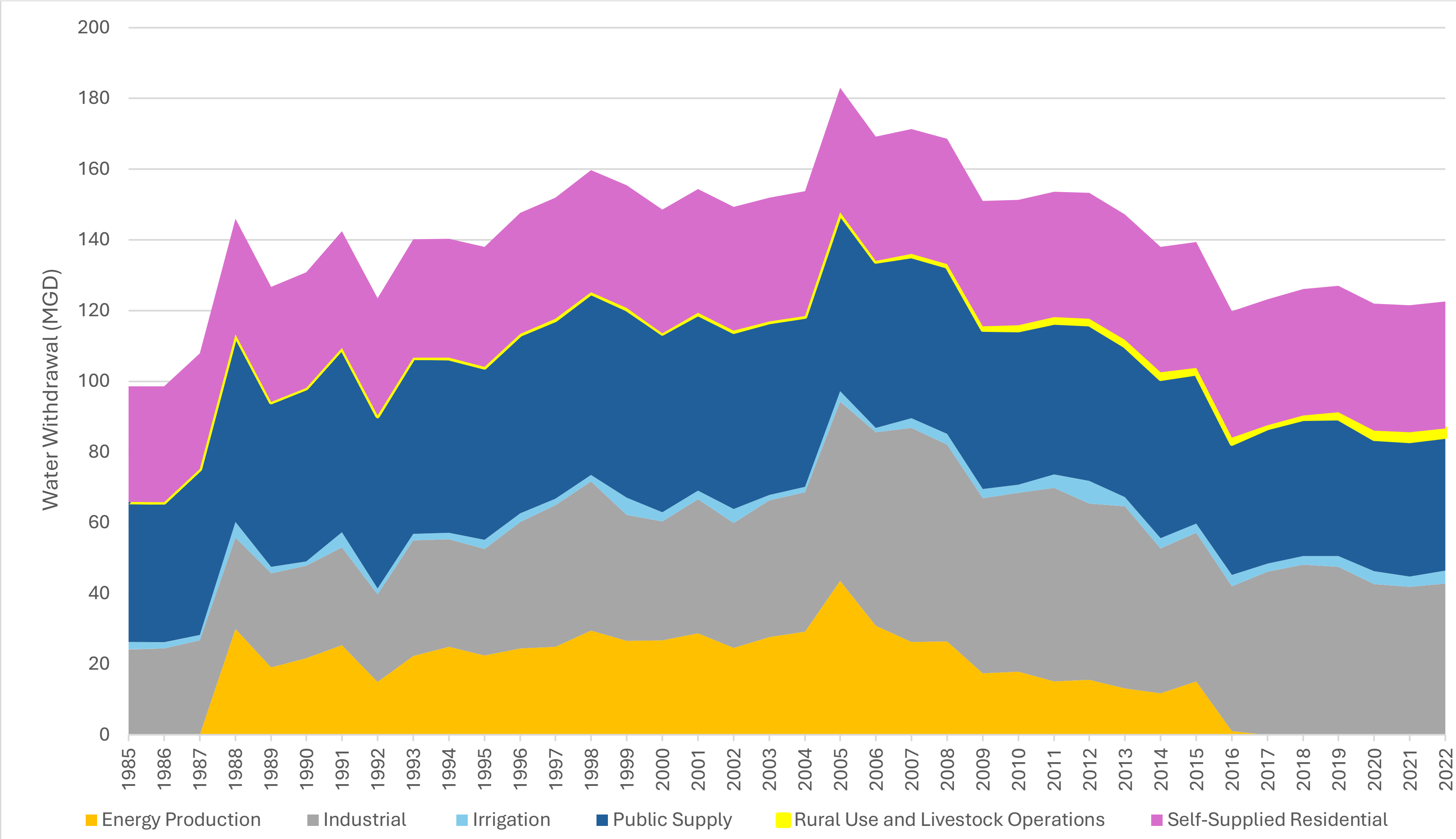


Figure ES-5. Historical Annual Average Daily Withdrawals by Sector, 1985-2022

Note: Miscellaneous registered facilities are not shown because their demand has not exceeded 1% of the total water demands in the region.

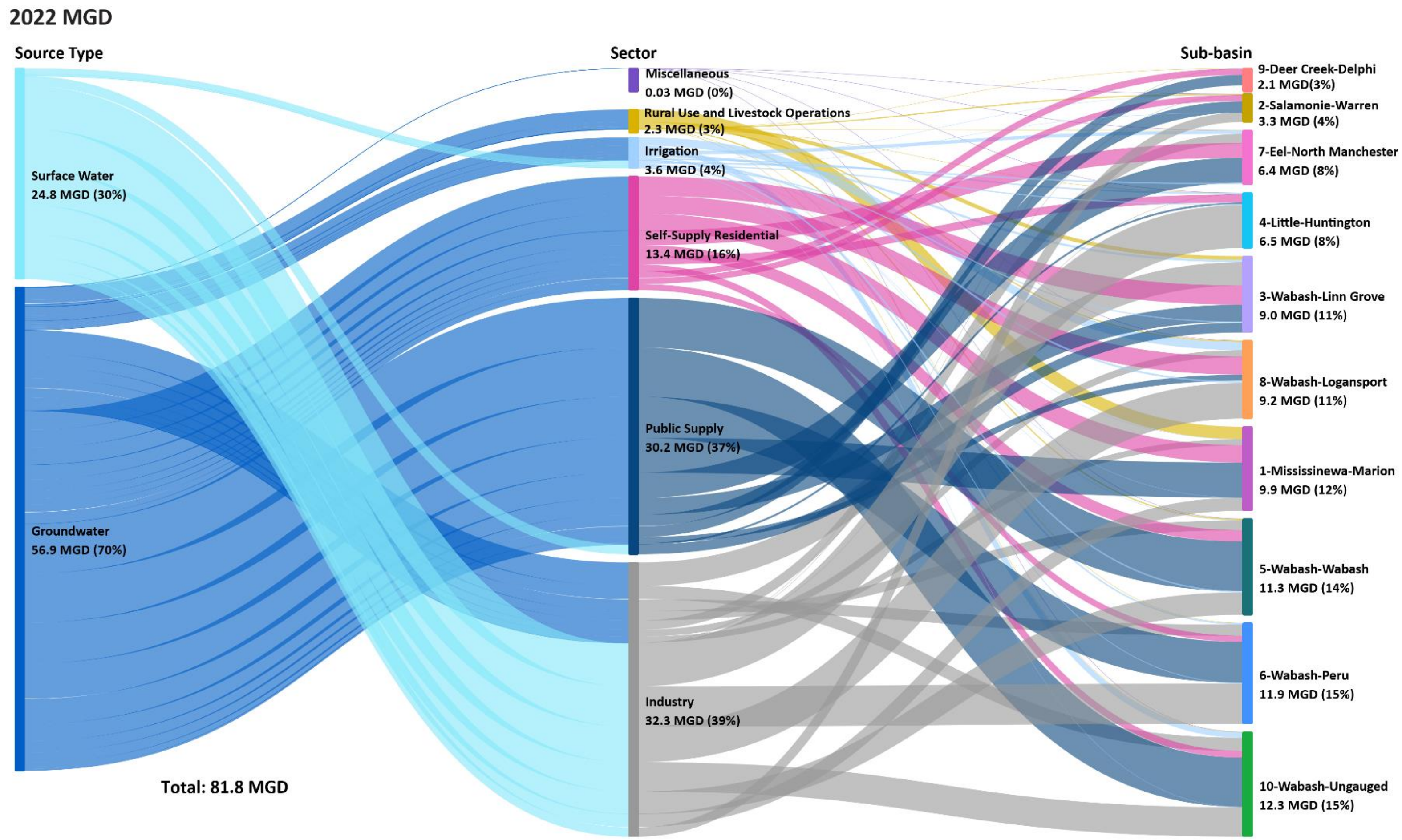
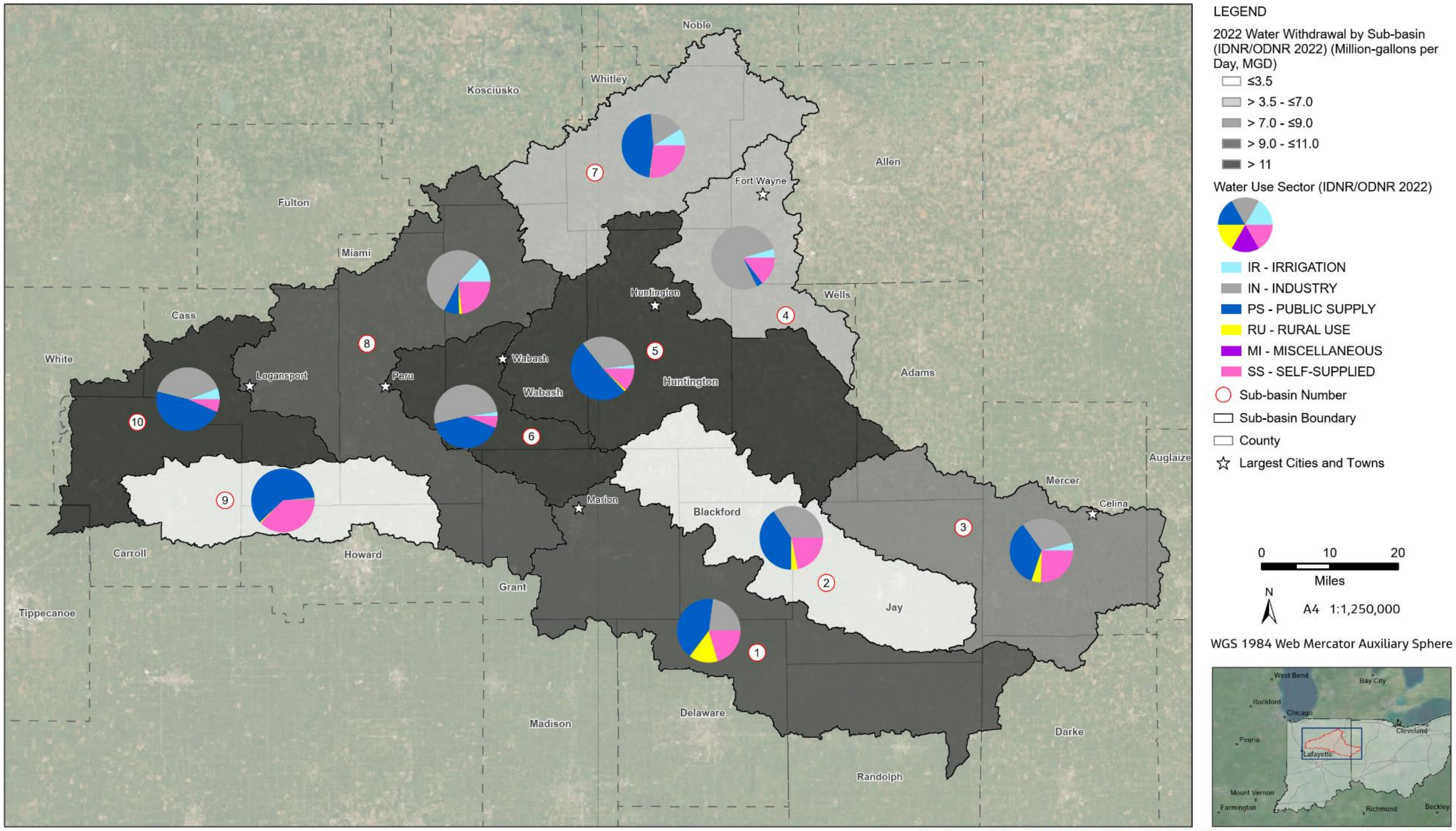


Figure ES-6. Annual Water Use by Sector in Each Sub-basin by Water Source in the Wabash Headwaters Region (2022)



Data Sources: IN Gov (2024), TIGER (2024), JACOBS (2024); Imagery Sources: ESRI Online Imagery Services
\\ausyd0vs01\GISProj\US_Wabash\Apps\Wabash_Mapping_v3.aprx/EEXM100_Wabash_F008_MainWaterUsers_v05 | Date: 9/12/2024

Figure ES-7. Water Use by Sub-basin and Water Use Category in the Wabash Headwaters Region (2022)

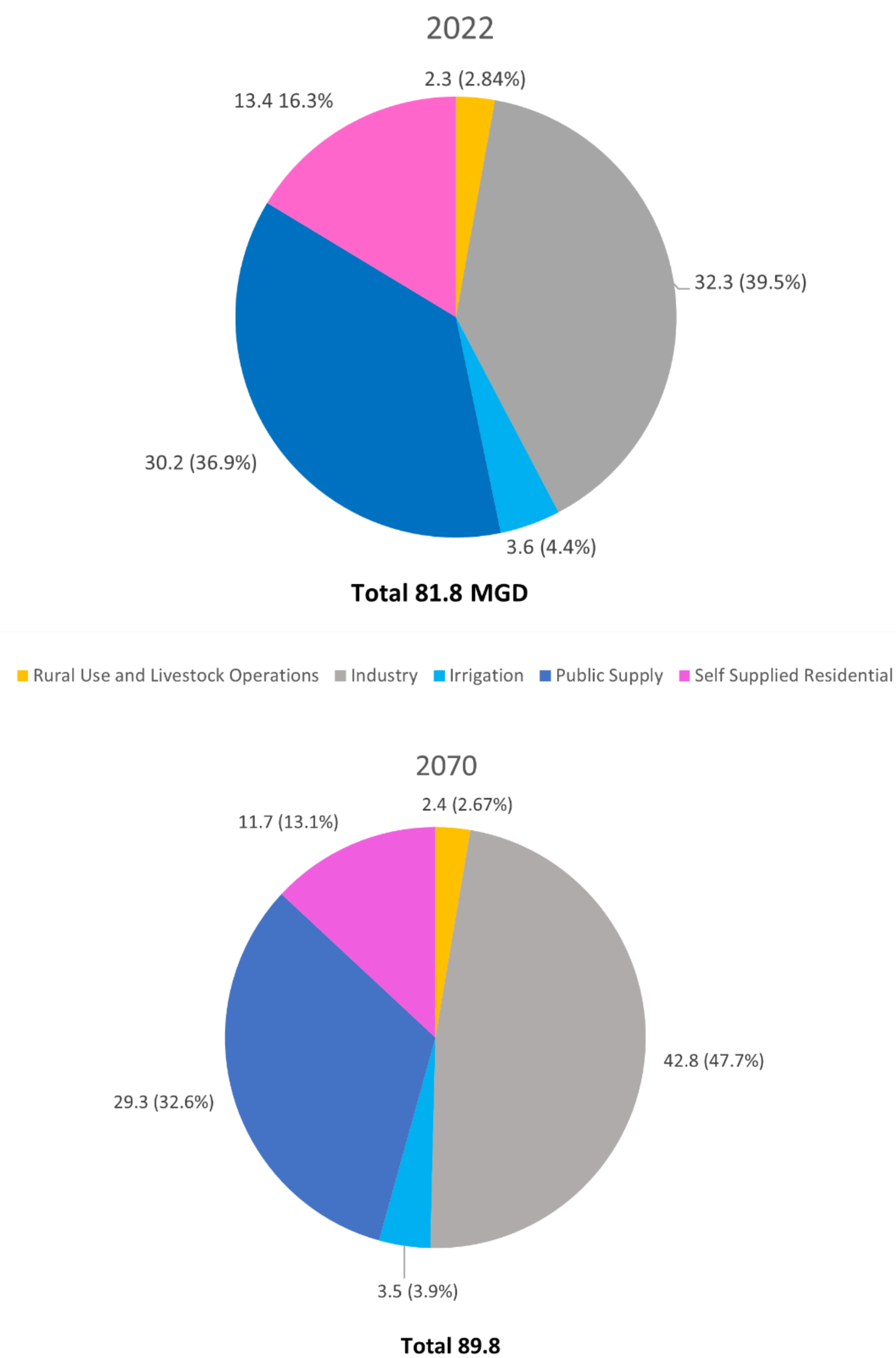


Figure ES-8. Historical (2022, top) and Future (2070, bottom) Water Demands per Sector for the Wabash Headwaters Region

Historical and Future Water Supply Availability

Historical and future water availability in the region was assessed and quantified, building on methodologies developed from previous regional water studies in Indiana (Letsinger and Gustin, 2023; IFA, 2021). The water availability analysis aims to characterize monthly water availability based on local hydrology, stream hydraulics, instream flow requirements, return flows, flood control reservoir operations, and anthropogenic uses of water as defined by the water demand analysis. The water availability analysis is a watershed-based inventory of current (2007 through 2022) and future (2023 through 2070) water availability to support ongoing water resources planning and management efforts in the region. The watersheds used in the analysis correspond to the sub-basins presented on Figure ES-1 and described in Appendix A.

Historical measured data and analytical techniques were used to characterize, quantify, and evaluate components of water availability for each sub-basin in the Wabash Headwaters Region. Three metrics are used for this analysis: water availability, excess water availability, and cumulative excess water availability. The first two metrics are estimated at the sub-basin level and the last term at the sub-basin level but accounting for the effect of upstream sub-basins. The following briefly describes the terminology:

- **Water availability** is characterized as the net baseflow remaining in the stream after net instream flow requirements are met and sub-basin's reservoir operations are accounted for. Water availability accounts for reliable supplies that are available while ensuring that instream flow requirements and flood control factors are prioritized.
- **Excess water availability** is quantified to evaluate the water supply remaining after consumptive use. The consumptive use is considered to acknowledge there is a portion of the surface water and groundwater withdrawals that is returned to the system. The excess water availability provides an evaluation of whether supplies are sufficient to meet water use demands within a sub-basin.
- **Cumulative excess water availability** is quantified to account for regional water availability within the study area and at each sub-basin considering upstream contributions. This metric is especially important for the water supply assessment of the downstream study area, the North Central Indiana region.

Historical Water Supply Availability

Monthly water availability, excess water availability, and cumulative excess water availability were evaluated from January 2007 through December 2022. Table ES-1 presents annual average water availability, excess water availability, and cumulative excess water availability across all sub-basins in the study area. Major influences on water availability include water released from the 3 flood-control reservoirs located within the study area, allocation for minimum instream flow requirements, return flows (non-consumptive water discharged into creeks and rivers), groundwater and surface water withdrawals, and climate factors such as rainfall and temperature.

In general, historical water availability and excess water availability are relatively similar because overall water withdrawals and consumptive use (also known as net return flows) are low compared with study area baseflow conditions and instream flow requirements (Table ES-1). Ultimately, annual historical cumulative excess water availability is positive across all sub-basins. While the Wabash Headwaters Region has opportunities for water use expansion, further evaluation should be considered to characterize "negative water availability" (herein referred to as potential shortages) at the individual sub-basin and seasonal levels. In addition, further analysis on the downstream effect on potential water use expansion to the North Central region needs to be considered.

Table ES-1. Historical Annual Average Water Availability by Sub-basin (1985-2022)

Sub-basin Number and Name	Historical Annual Average		
	Water Availability (MGD)	Excess Water Availability (MGD)	Cumulative Excess Water Availability (MGD)
1 Mississinewa-Marion	151	149	149
2 Salamonie-Warren	72	72	72
3 Wabash-Linn Grove	134	137	137
4 Little-Huntington	53	53	53
5 Wabash-Wabash	116	112	374
6 Wabash-Peru	88	88	610
7 Eel-North Manchester	117	116	116
8 Wabash-Logansport	81	79	805
9 Deer Creek-Delphi	80	79	79
10 Wabash-Ungauged	131	136	1,010

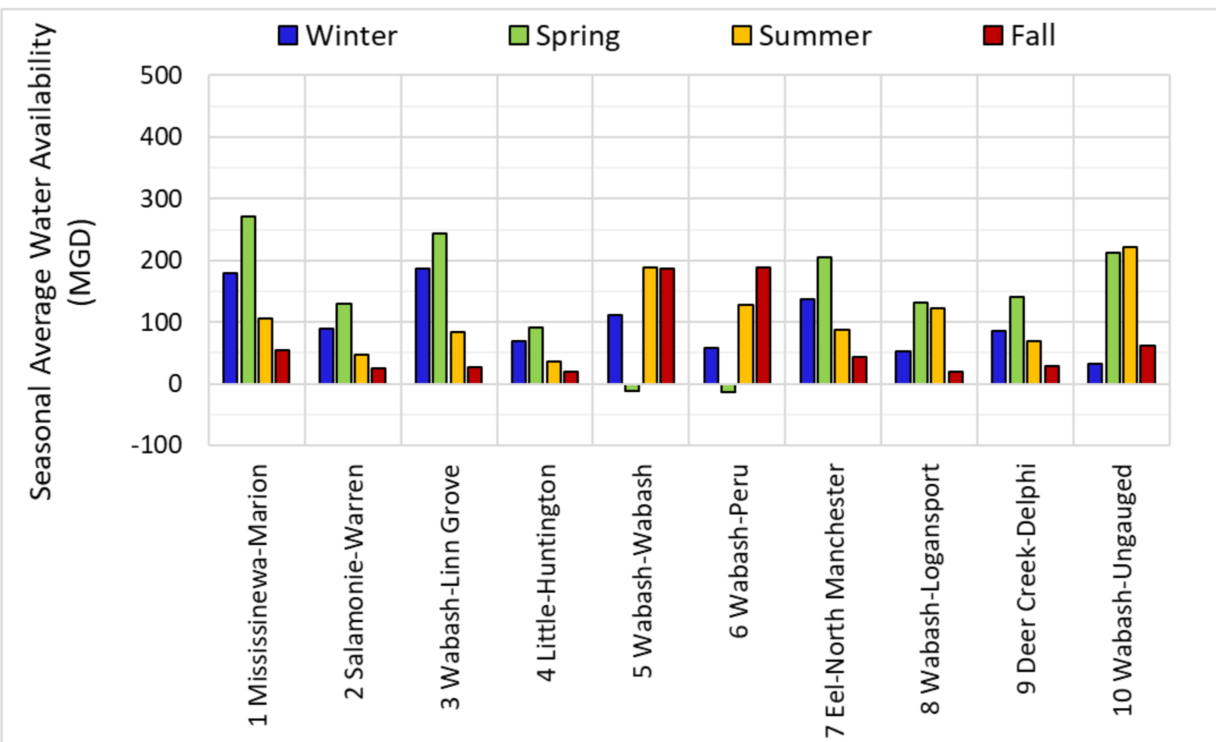


Figure ES-9. Historical Seasonal Average Water Availability by Sub-basin

In addition to annual evaluation of water availability, a seasonal approach to summarizing monthly water availability was employed to characterize seasonal variability in supplies and demands that can have an impact on water availability: winter (December through February), Spring (March through May), Summer (June through August) and Fall (September through November).

Figure ES-9 compares seasonal average water availability for all sub-basins in the study area. All Sub-basins except 5 Wabash – Wabash and 6 Wabash - Peru, have positive seasonal average water availability throughout all four seasons, with more water availability during the winter and spring months and less during summer and fall months.

The following key findings summarize the most relevant insights and observations from the historical availability assessment:

- **The upstream conditions as well as the specific characteristics of the sub-basin influence the water availability results.** In this region, there are two distinct groups:
  - Sub-basins crossed by tributaries to the Wabash River (Sub-basins 1, 2, 4, 7, and 9) and the headwaters of Wabash River (Sub-basin 3). In these sub-basins, cumulative excess water availability is lower as there are no other upstream sub-basins that contribute with additional flow to them and streamflows are smaller.
  - Sub-basins crossed by the Wabash River and with flood control reservoirs influence (Sub-basins 5, 6, 8 and 10). In these sub-basins, cumulative excess water availability is higher and excess water availability seasonal pattern is modified by the reservoirs operations.
- **Water availability, excess water availability, and cumulative excess water availability are all positive on an annual basis.** Positive water availability and excess water availability during the historical period suggests that water demands are generally smaller than the available water supply in all sub-basins throughout the Study Area on an annual basis. Sub-basins' water availability and excess water availability are relatively similar because overall water withdrawals and consumptive use are low compared to groundwater contributions to streamflow (natural baseflow) and minimum instream flow requirements throughout the study area. Cumulative excess water availability is also positive throughout the Study Area (see Sub-basin 10 values), highlighting the interconnection of sub-basins and the availability of water supply as a region.
- **While there may be opportunities for expansion of water use in the Wabash Headwaters Region, further evaluation should be considered to characterize "negative water availability" at the individual sub-basin level, at a seasonal level and downstream effect to North Central Region.** Both positive and negative excess water availability can occur on a seasonal basis within a given year depending on climate and hydrology. Thus, the evaluation of excess water availability is transient and whether water shortage or excess water occurs will depend on seasonal and annual conditions. Also, further analysis on the downstream effect on potential water use expansion to the North Central region needs to be considered.
- **Variability in water availability and excess water availability are generally driven by variability in natural baseflow conditions.** Natural baseflow conditions vary both seasonally and from year to year causing similar variability in water availability and excess water availability. During summer and fall months, and in drier years, when natural baseflow conditions are lower, the balance between supply and demand within the Study Area exhibits a much narrower margin creating negative water availability or water shortages in some sub-basins during some months. This variability is especially relevant in sub-basin crossed by tributary rivers (sub-basins 1,2, 4, 7 and 9) and at the headwaters of Wabash River (sub-basin 3).

- **During summer when river flows are low and water demand is high, the net return flows can represent a significant source of additional instream flows.** For example, in Sub-basin 4 Little-Huntington, the smallest sub-basin in the region, and in Sub-basin 3 Wabash-Linn Grove, the estimated net return flows represent in some months more than 40% of the observed streamflow. A case study for the Wabash River, indicated that during months of reduced flows, the upstream volumetric flow of treated wastewater discharge is approximately equivalent to or greater than the entire volumetric flow of the Wabash River (Wiener et al., 2015).
- **Reservoir operations have a significant influence on seasonal water availability within the sub-basins that contain these reservoirs.** Flood-control reservoirs operated in Sub-basins 5 and 6 have a significant influence on seasonal water availability in these sub-basins due to the storage and release of water to meet reservoir operational criteria. Winter and Spring water availability tend to be lower in Sub-basin 5 and 6, as compared to other sub-basins, due to the reservoirs primarily storing water which negatively influences the water availability balance. Conversely, water stored during the Winter and Spring is generally released during the Summer and Fall months causing the water availability in sub-basins 5 and 6 to be relatively larger than other sub-basins.
- **Reservoir operations increase cumulative excess water availability in Summer and Fall seasons in downstream sub-basins.** Flood-control reservoirs in Sub-basins 5 and 6 sustain summer and fall season flows in downstream sub-basins increasing the cumulative excess water availability in these sub-basins.

Future Water Supply Availability

Forecasts for monthly water availability, excess water availability, and cumulative excess water availability were evaluated from January 2023 through December 2070. Each water availability term was projected into this time frame to account for future changes in demand, changes to inter-annual timing and magnitude of streamflow, and continued operation of the three flood-control reservoirs present in the study area. Assumptions associated with the development of future water availability terms can be found in Appendix A.

The future period developed for water availability assessment contains a prescribed frequency of wet, normal, and dry years. Evaluation of projected water availability, in comparison to historical conditions, was conducted by selecting a 16-year series of future years centered around 2065 that correspond with historical years for the basis of comparison. Figure ES-10 shows the cumulative excess water availability for each sub-basin during the different seasons for Historical and future periods (second column). Also, forecasted changes as a percentage are shown to evaluate the influence of changes in climate, hydrology, and demand on water availability throughout the study area centered on the 2060s period.

In general, winter cumulative excess water availability is projected to increase across all sub-basins, except for Sub-basin 9 Deer Creek-Delphi which exhibits a small decrease in winter cumulative excess water availability. The future water availability variation among seasons is expected to be greater in the future compared to historical conditions, given the projected trend where winter and spring months become wetter and summer and fall become drier. Winter increases in cumulative excess availability range from 3 to 21%. Similarly, spring cumulative excess water availability is projected to increase across all sub-basins ranging from an increase of 14 to 39%. On the other hand, summer decreases in cumulative excess water availability range from -3 to -20%. Fall cumulative excess water availability is projected to decrease across all sub-basins ranging from -11 to -32%.

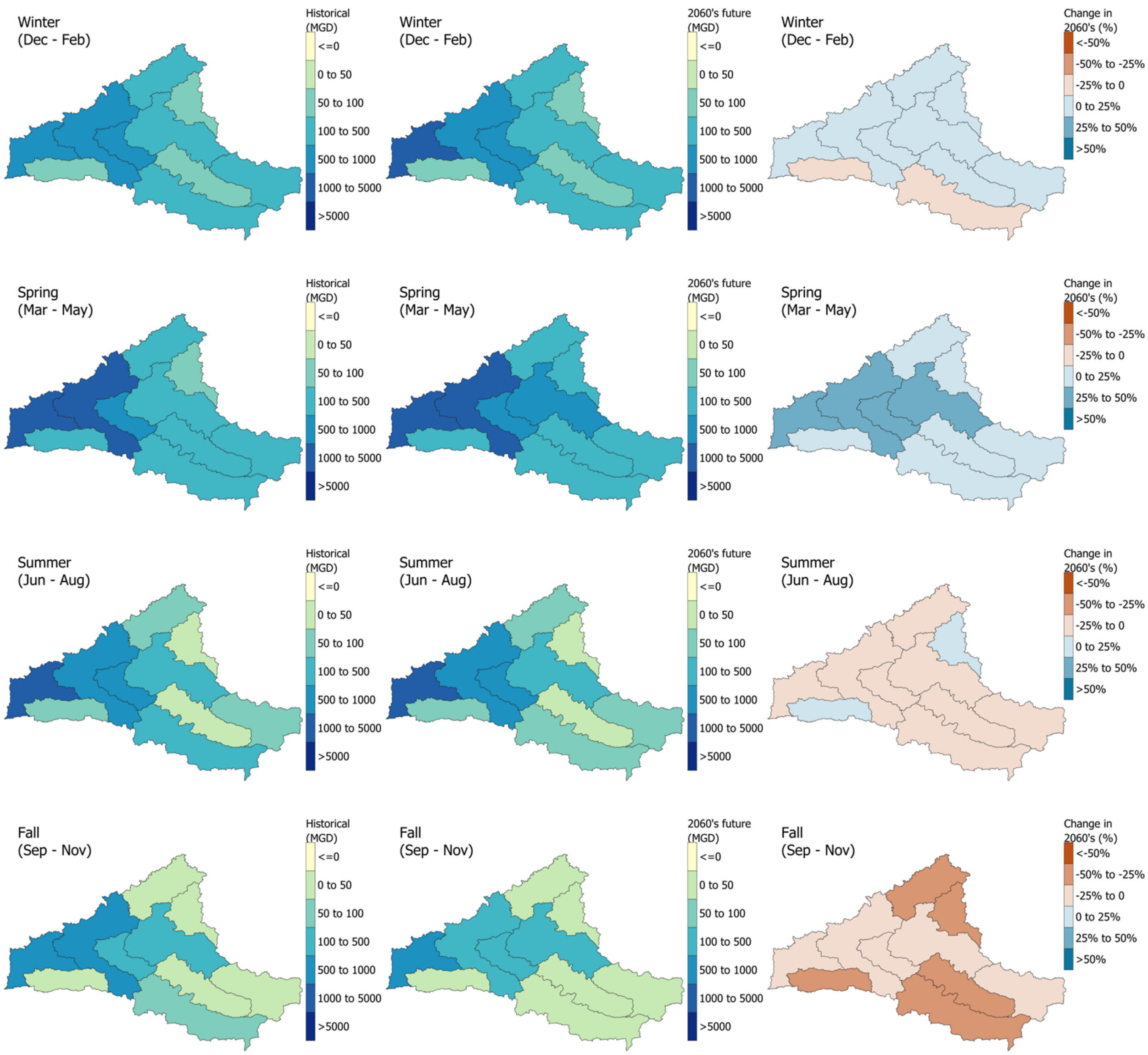


Figure ES-10. Historical and Future Cumulative Excess Water Availability and Future Changes in the Wabash Headwaters Region

Water Quality

According to the 2024 Indiana Integrated Water Monitoring and Assessment Report (IDEM, 2024a), human-generated wastes, such as septic systems and landfills, cause spikes in nitrate levels, and manmade activities and substances, such as underground injection wells, industrial activities, confined feeding operations, oil spills, road salts, and fertilizers, are the main sources of groundwater contamination (IDEM, 2024a). Historically, the Wabash Headwaters Region has experienced some water quality concerns considering the regional economic makeup has a heavy emphasis on the industrial and agricultural sectors. For example, the Upper Mississinewa River previously exceeded the calculated maximum amount of a pollutant that a body of water can receive while still meeting water quality standards (Total Maximum Daily Load (TMDL)) in 2017 addressing *E. coli* and impaired biotic communities (IDEM, 2022). Further the Wabash River in 2006 for *E. coli*, nutrients, impaired biotic communities, DO, and pH. In 2006, the U.S. Environmental Protection Agency-approved TMDL for the Wabash River, which established nitrate + nitrite and phosphorus targets for Indiana and Ohio, though segments of the river still appear on the 303(d) impaired waterbodies list for Indiana (IDEM, 2022). Figure ES-11 shows the assessed surface waterbodies and the respective 303(d) listing categories identified in the 2024 water quality assessment.

Water contamination often starts on land or in surface water bodies and travels through permeable surfaces to reach groundwater sources, making surface water and alluvial aquifers more susceptible to contamination than deeper aquifers. The study area has significant rivers, such as the Wabash and Eel Rivers, that are surrounded by freshwater emergent and forested wetlands (USFWS, 2024), specifically on northern and southern regional borders, increasing contamination impact potential and intensity.

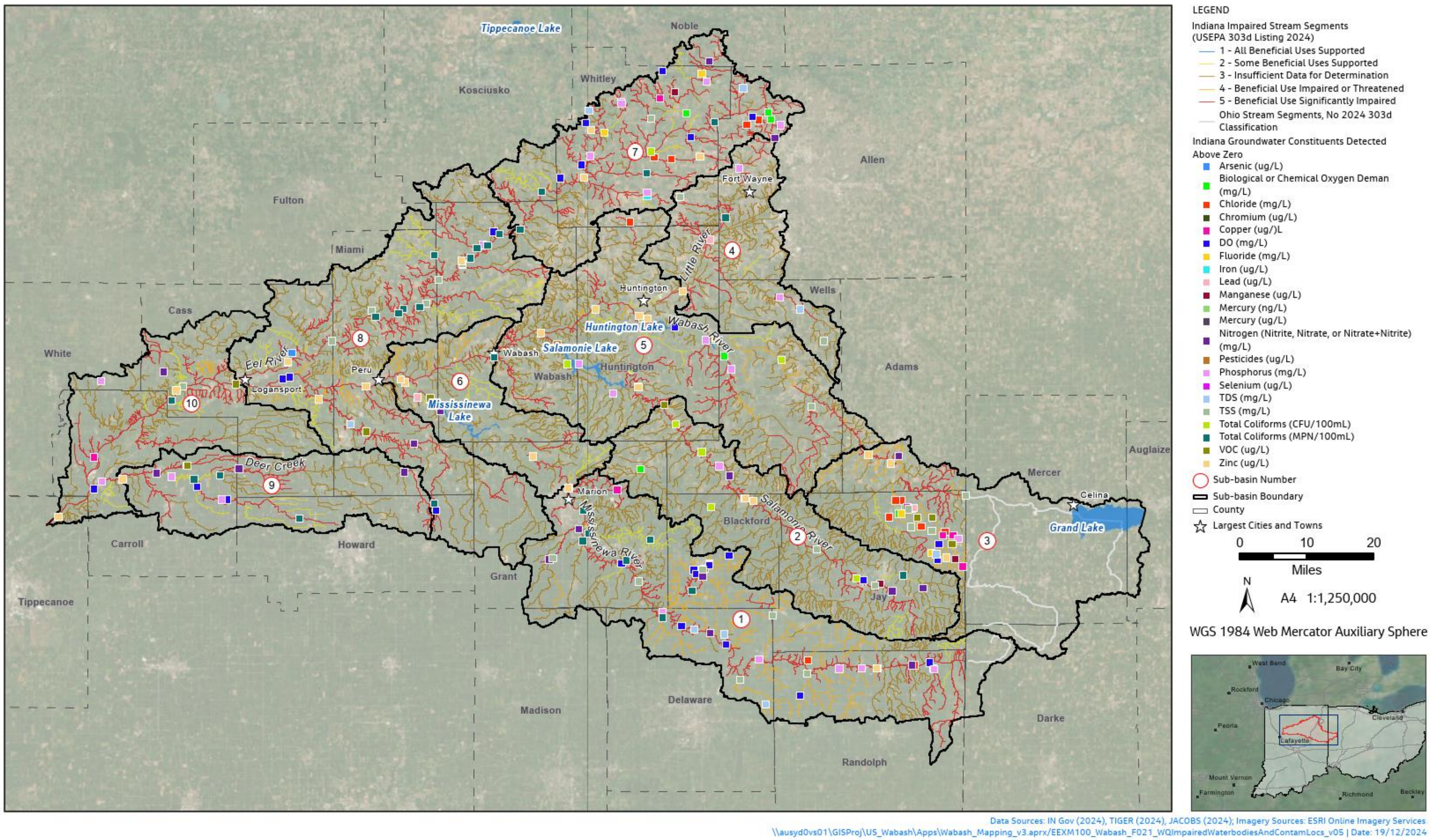


Figure ES-11. Impaired Surface Waterbodies and Detected Groundwater Constituents in the Wabash Headwaters Region

Susceptibility to groundwater contamination is based on the layer thickness and material. Silts, sands, sandy clay, and sand and gravel materials can be vulnerable depending on the overlying materials. Where thick clay deposits or thick till is overlying the aquifer, the permeability is generally lower from the barrier. Hydrogeologic settings with a shallow water table and highly permeable materials generally correspond to higher aquifer recharge and vulnerability to contamination. Hydrogeologic settings such as surficial outwash, surficial alluvium, and natural lakes have a higher susceptibility to contamination because they tend to follow exposed surface water sources, such as the Wabash River, and have little to no surface barrier. Vulnerability may be correlated to aquifer recharge (inches per year), or the total volume of water per unit area infiltrating the aquifer from the land surface, and this was used to characterize the study area for aquifer sensitivity.

Public water utilities have vocalized water quality concerns other than PFAS, such as biological oxygen demand (BOD) loading, as well as elevated iron and manganese concentrations in the surface waterbodies. Generally, these water quality concerns are removed during the drinking water treatment process; however, utilities in Grant County, such as the Town of Converse and Peru Utilities, have noted challenges in treating for elevated levels of iron and manganese in the source water (Preliminary Engineering Reports; Commonwealth, 2023; Wessler, 2019). Other utilities in counties, such as Huntington, Howard, Jay, Wabash, and Wells, have noted higher BOD loading corresponding to groundwater contamination. Huntington and Howard counties have many industrial dischargers where industrial wastewater effluent may have higher BOD loading. Utilities in Wabash and Wells counties have noted that combined sewer overflows and failing septic system impact groundwater contamination and BOD loading. City of Portland in Jay County noted National Pollutant Discharge Elimination System permit violations of BOD loading were responsible for killing fish in the Salamonie River. Therefore, various sources of groundwater contamination could be responsible for water quality concerns across the study area.

Risks, Uncertainties, Opportunities, and Recommendations

Conducing historical analysis and forecasting water demand and supply availability over a 50-year period has inherent risks and uncertainties. In addition, data gaps for which assumptions were made incorporated some degree of uncertainty. While reviewing available data water availability results, opportunities and recommendations were identified to improve the water supply analysis and water supply forecasts aiming to mitigate risks and reduce uncertainties. These identified risks opportunities and recommendations are summarized in this section and discussed in more detail in Section 6. The risks and uncertainties, as well as opportunities and recommendations, are presented in the following categories:

- Overall Risks and Uncertainties
- Water management and planning
- Data and technical considerations

Risks and Uncertainties

Risk and uncertainties identified during the study include the following:

- **Water demand increases resulting from future economic and population changes increasing water demand:** This study used rigorous methods to estimate future demand through 2070; however, various factors could influence actual water use in the future such as significant changes to economic influences that could result in increased water demand in the agricultural and industrial sectors or increases in population that could result in increased demand for public water supply and self-supplied residential users. While not analyzed in this study, increased water use could have implications for additional (or expanded) infrastructure.

- **Seasonal source water supply availability:** While the results of the study analyses indicate no significant negative water supply availability generally throughout the region in annual basis, there is the potential for limitations on surface or ground water availability on a seasonal basis, especially during dry years and sub-basins without upstream sub-basins that contribute with additional flow to them and with smaller streamflow. Also, in smaller sub-basin net return flows during summer when river flows are low and water demand is high, the net return flows can represent a significant source of additional instream flows. Appendix D presents seasonal water availability results by sub-basin. The season water supply availability could represent a regional risk if future demand increase beyond what is forecast in this study, supplies are reduced based changing hydrology or if reservoir operations with the study area change to manage potentially different flooding conditions in the future.
- **Climate change**: Observed temperature and precipitation trends are different over the last few decades as compared with longer-term historical trends. This study used results of a climate change scenario for the State of Indiana (Cherkauer et al., 2021) to forecast potential changes in water demand and supply availability. As presented in Appendix B, other climate futures are possible which could change both future water demands and supply availability.
- **Water quality:** The Wabash Headwaters Region includes many impaired surface water resources (those with water quality below minimum standards). If the water quality trends continue, costs of water treatment could increase and requirements for effluent discharge quality standards could become more stringent. Additionally, there are localized public water systems within the study area that are currently unable to meet drinking water quality standards with their existing treatment plants.

Opportunities and Recommendations

Following are some opportunities and recommendations identified as a result of this study:

- Water demand and water use efficiency:
  - Expand funding and technical assistance for water loss prevention programs to include main replacement, advanced metering, and similar investments, especially for small utilities.
  - Consider local policies and programs to reduce outdoor water use, including lawn watering sprinkler ordinances or incentives for installation of low water using landscapes and irrigation systems.
- Seasonal water availability and storage
  - Consider measures to reduce seasonal consumptive use for outdoor watering within public supply systems and for large irrigation users as an initial first step to reduce seasonal use.
  - Evaluate the potential for aquifer storage and recovery near water demand centers in the event that additional storage is needed in the future.
  - Refinement of net return flows to gain additional insight for potential mitigation measures in small sub-basins for seasonal and drought potential negative excess water availability.

- Existing reservoir operations:
  - Develop a reservoir operations model to perform a comprehensive reservoir water balance to incorporate evaporation, precipitation in the reservoir, and other losses to improve accuracy as well to facilitate analysis impact of climate change and optimization scenarios that affect flooding and the volume, rate, and timing of downstream releases.
  - Assess the condition and design of the existing dams to determine the potential of storing additional water during some seasons or conditions. If the dams can accommodate a potential change of operations, study the potential reallocation of the stored water to meet future downstream demand and instream flow needs.
  - Evaluate variations of operating rules and forecast-informed reservoir operation regimes to determine the potential for meeting the authorized purposes of the reservoirs and downstream needs throughout the Wabash River basin.
- Water quality:
  - Continue water quality monitoring and assessments.
  - Conduct pilot tests of various best management practices that reduce need for application of pesticides and fertilizers and reduce run-off throughout the Wabash River Basin.
  - Consider incentives to encourage landowners to increase their voluntary participation in watershed management and protection plans and programs.
- Climate change and variability:
  - Develop and incorporate high-resolution climate models into future water planning studies with more complete analysis of multiple climate scenarios.
  - Consider adaptation strategies to prepare for potential futures and extreme weather events that could increase demands or affect water supply availability.
  - Conduct detailed studies on potential changes in floodings and potential effects on reservoir operations that could impact water supply availability throughout the Wabash River basin.

Additional technical recommendations regarding data and supply estimation and validation are included in Section 6.