

*Preserving*

# Water Quantity Report

2024 Report



**THE MIAMI  
CONSERVANCY  
DISTRICT**

## Abstract

*The Miami Conservancy District (MCD) continuously monitors water quantity in the Great Miami River Watershed to assess long-term trends in precipitation, runoff, and groundwater levels. This report presents hydrologic data for 2024, analyzing water inflows and outflows across an area of over 3,630 square miles. The findings indicate that while annual precipitation measured 41.91 inches—near the 30-year average—runoff was lower than historical norms. The MCD flood protection system stored high water 21 times, aligning with historical averages. Groundwater levels remained stable, with most index wells ending the year at higher levels than they began. Long-term trends show increasing precipitation and runoff, while groundwater levels have remained steady due to declining water withdrawals. These insights are essential for regional water management, flood mitigation, and infrastructure planning, reinforcing the importance of continued monitoring and adaptive resource management.*

## Executive Summary

To track changes in water availability in the Great Miami River Watershed, MCD records precipitation, runoff, and groundwater levels, estimating water inflows and outflows for an area exceeding 3,630 square miles.

- The average annual precipitation recorded in 2024 was 41.91 inches, slightly below the 30-year average (1991–2020) but consistent with the long-term upward trend in precipitation.
- Runoff for 2024 was measured at 12.39 inches, which was 3.85 inches below the 30-year average, reflecting variability in surface water flow despite increasing long-term trends.
- The MCD flood protection system stored high water 21 times in 2024, aligning with the historical average but without surpassing the top 10 largest storage events.
- Groundwater levels at most index wells ended the year higher than at the beginning, demonstrating stability in the buried valley aquifer system despite fluctuations in precipitation and runoff.
- Long-term trends indicate that while precipitation, runoff, and streamflow are increasing, groundwater levels remain stable, reflecting both climatic variability and reduced water withdrawals.

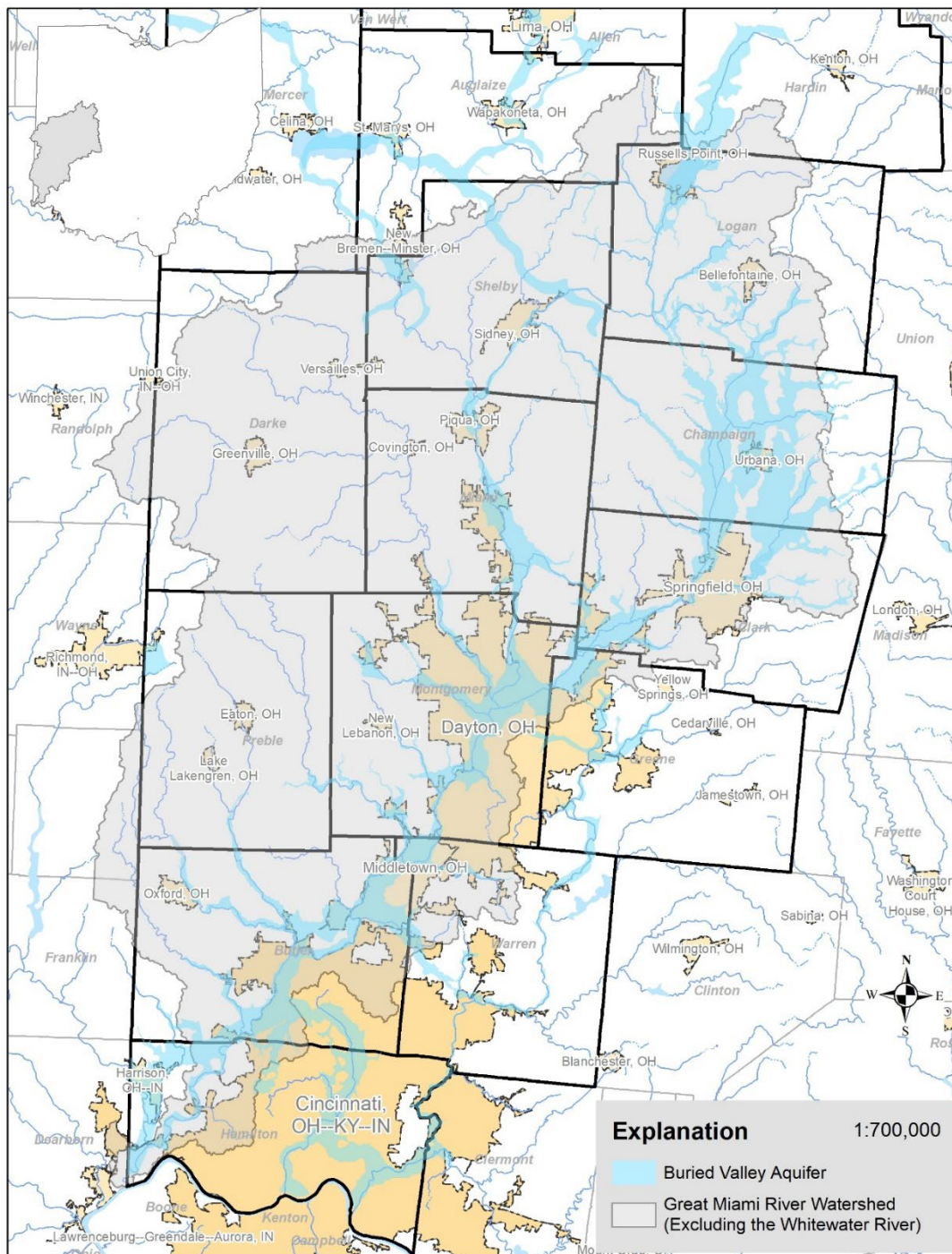
These findings underscore the importance of continued monitoring and management to ensure sustainable water use and flood protection for the region. MCD remains committed to providing data-driven insights that support regional resilience and resource planning.

## Background

The Miami Conservancy District is a conservancy district - a political subdivision of the State of Ohio. Miami Conservancy District works as a regional government agency throughout the

Great Miami River Watershed (see figure 1). Formed in 1915, Miami Conservancy District provides flood protection, water stewardship, and recreation.

*Figure 1 – Map of the Great Miami River Watershed, Ohio.*



To track natural water resource conditions, Miami Conservancy District operates automated and observer precipitation stations as well as extensive stream gaging and observation well networks to record precipitation, streamflow, and groundwater levels.

Miami Conservancy District operates the stream gaging network with the U.S. Geological Survey (USGS) under a cooperative agreement that has been in place since 1931.

Partnering with a variety of federal, state, and local governments, Miami Conservancy District conducts surface water and groundwater quality and quantity studies.

## Tracking Water Quantity

The Miami Conservancy District tracks changes in water availability - including precipitation, runoff, and groundwater level data through partnerships with USGS and a network of citizen observers.

Water data from these partnerships provide estimates of water inflows and outflows for the Great Miami River Watershed upstream of the Hamilton stream gaging station (the most downstream gage), an area of more than 3,630 square miles.

These data also allow for comparisons between current hydrologic measurements and historical measurements to evaluate trends in water quantity entering and leaving the watershed, as well as trends in aquifer storage.

The trends can be useful for planning related to water supply, flood protection, construction, agriculture, commerce, and industry.

## Water Cycle

- All water coming into the Great Miami River Watershed arrives as precipitation.
- Precipitation falls on the surface of the Great Miami River Watershed as rain, snow, or ice.
- Some of the precipitation flows by gravity toward streams and rivers and becomes surface runoff which eventually reaches the Great Miami River (see figure 2).

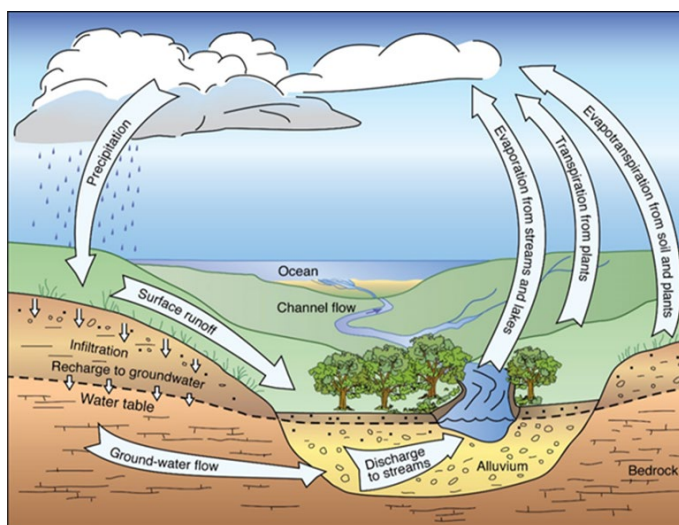


Figure 2 – Movement of water through the water cycle.

- Some of the precipitation infiltrates the ground and percolates through the soil until it reaches the water table. This water provides groundwater recharge to the aquifers and helps sustain the abundant water resources in the Great Miami River Watershed.
- Water in the aquifer either remains underground and in storage for an extended period or stays close to the ground surface and seeps into nearby streams or rivers as base flow.

As a result, many streams and rivers in the Great Miami River Watershed can sustain flow, even during periods of prolonged drought, because the underlying buried valley aquifer provides base flow to the streams and rivers.

## Observing Precipitation

To track precipitation amounts, Miami Conservancy District maintains a network of 42 stations staffed by citizen observers who record daily precipitation amounts (see figure 3). The observers make daily measurements of precipitation collected in standard National Weather Service rain and snow gages (see figure 4) and send the readings to Miami Conservancy District via mail or electronic submittal. Miami Conservancy District uses the data to calculate annual precipitation for the watershed by averaging annual precipitation totals measured at each of the stations.

## Annual Precipitation & Trends

The average annual precipitation recorded by Miami Conservancy District during 2024 was 41.91 inches.

Monthly precipitation in the Great Miami River Watershed was above average during January, April, July, September, November, and December (see Figure 5). April recorded the highest monthly precipitation total in 2024 at 5.82 inches. Below average precipitation occurred in February, March, May, June, August, and October. October recorded the lowest precipitation total in 2024 at 0.34 inches.

The highest annual total precipitation amount of 53.95 inches was recorded at Miami Conservancy District's Eaton observer station, while the lowest amount of 36.27 inches was recorded at the Lockington Dam observer station.

The year 2024 started out with the entire Great Miami River Watershed under moderate drought conditions. Abnormally dry conditions persisted in northern areas of the watershed throughout January, February, and into early March. The region was free of drought for most of March and throughout April and May. Abnormally dry conditions returned to the Great Miami River Watershed in mid-June and quickly intensified into moderate drought conditions



*Figure 4 – A typical National Weather Service rain gage.*

in portions of the watershed by the end of June. Drought conditions eased somewhat in late July through August because of above normal precipitation in both months. However, the drought intensified once again in September as conditions dried out and most of the watershed experienced moderate to extreme drought conditions. Drought conditions peaked near the end of September when most of the watershed was in severe to extreme drought (see Figure 6). Most of the watershed remained in some form of drought until mid-November and abnormally dry conditions persisted in northern areas of the watershed until late December.

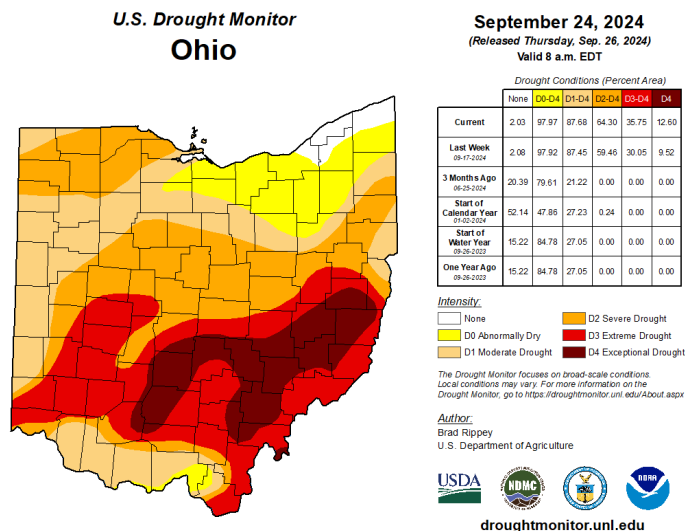


Figure 6 – U.S. Drought Monitor map of Ohio for September 24, 2024.

While the year 2024 recorded near normal precipitation, the average annual precipitation is still trending upward (see Figure 7). Average annual precipitation for the 30-year timespan of 1951 – 1980 was 37.29 inches. For the 30-year timespan of 1991 – 2020 average annual precipitation climbed to 41.92 inches showing an increase of 4.63 inches over 40 years.

## Measuring Streamflow

Miami Conservancy District, in cooperation with USGS, maintains a network of 24 stream gages equipped with telemetry (see Figure 8). Each stream gage transmits data to the USGS National Water Information System (NWIS). A streamgage records the water level or stage of the river or stream at the gage location. NWIS estimates discharge for a given water level through a rating which is a mathematical relationship between water level and discharge. USGS derives this mathematical relationship from field measurements of discharge across a range of water levels. The stream gage network allows Miami Conservancy District to estimate annual runoff for the Great Miami River Watershed and track storage events at each of the five Miami Conservancy District flood protection dams.

## Estimated Runoff & Trends

Nearly all the water leaving the Great Miami River Watershed exits through the processes of evapotranspiration and runoff. Miami Conservancy District does not measure

evapotranspiration directly but does measure runoff. Runoff includes all the water that flows across the land and enters streams, as well as water discharged from aquifers into streams.

Miami Conservancy District estimates annual runoff amounts by the following process:

- Determine the average daily flow ( $\text{ft}^3/\text{sec}$ ) for the Great Miami River at Hamilton gage for a particular month;
- determine the monthly flow volume of water ( $\text{ft}^3$ ) by multiplying the average daily flow ( $\text{ft}^3/\text{sec}$ ) for the month times the number of days in that month using a conversion factor to convert days into seconds;
- divide the monthly volume of water ( $\text{ft}^3$ ) by the entire watershed area ( $3,630 \text{ mi}^2$ ) upstream of the gage using a conversion factor to determine water depth in inches;
- sum the water depths for each month of the year to get total annual runoff in inches.

Estimated runoff for the Great Miami River in 2024 was 12.39 inches. This amount is 3.82 inches less than the 30-year (1991 to 2020) average for the watershed.

Runoff was significantly above average in the month of April. Runoff was below average for all the other months in 2024 (see Figure 9).

Like precipitation, the 30-year average annual runoff is trending upward (see Figure 10). The average annual runoff for the 30-year timespan of 1951 - 1980 was 12.23 inches. For the 30-year timespan of 1991 - 2020 average annual runoff climbed to 16.22 inches showing an increase of 3.99 inches over 40 years.

## Flood Storage Events

The five Miami Conservancy District dams have a combined peak storage capacity of 841,000 acre-feet, or about 274 billion gallons of water (see Figure 11).

During times of high precipitation and runoff, the dams reduce downstream flows on the Stillwater, Great Miami, and Mad rivers and on Loramie and Twin creeks. This allows the channels and levees downstream to safely accommodate the river flow. The dams accomplish this by temporarily storing floodwater over the land behind the dams.

A storage event occurs when the pool elevation behind the dam reaches a minimum stage at which the conduits begin to reduce the flow of water downstream of the dam (see Table 1). The storage event continues until the pool elevation drops below that minimum stage. Miami Conservancy District records storage events at each of the dams separately. If all five dams are in storage at the same time, Miami Conservancy District records five storage events.

Construction of the five flood protection dams in the Miami Conservancy District flood protection system was completed by 1922. Since that time, Miami Conservancy District has recorded each of the storage events that have occurred.

Miami Conservancy District recorded a total of 21 storage events during 2024. The average number of annual storage events for the five retention basins, over the entire life of the dams, is 21. None of the storage events that occurred in 2024 were large enough to exceed Miami Conservancy District's top 10 storage event ranking.

Of the 21 storage events that occurred in 2024, 2 events occurred during January, 4 events occurred in March, 9 events occurred in April, and 6 events in December (see Figure 12).

The total number of storage events per decade has increased in recent decades (see Figure 13). Miami Conservancy District recorded 175 storage events during the decade of the 1980s. Since that time Miami Conservancy District recorded 242, 273, and 324 storage events respectively during the decades of the 1990s, 2000s, and 2010s.

## Groundwater Levels in the Buried Valley Aquifer System

Miami Conservancy District maintains a network of 103 observation wells in the Great Miami River Watershed. Of these wells, 62 are installed in the buried valley aquifer system.

The Ohio Department of Natural Resources (ODNR) Division of Water Resources also supports a network of observation wells in the Great Miami River Watershed system which includes 26 wells.

To track groundwater levels, 12 observation wells (8 Miami Conservancy District and 4 ODNR) were selected as index wells for the buried valley aquifer system between the mouth of the Great Miami River and as far north as Miami County (see Figure 14). An index well is installed in a representative part of the surrounding buried valley aquifer system that can allow for measuring and interpreting hydrologic responses at local scales. Data trends in index wells provide a strong indication of buried valley aquifer responses to changes in human water use as well as shifts in local climate.

The depths of each of the index wells are displayed on Table 2. All the index wells are equipped with vented or non-vented pressure transducers for logging groundwater levels and telemetry. The pressure transducers measure the depth-to-water below ground surface every hour and send the data to NWIS allowing the data to be accessed in near real-time.

Groundwater levels measured at 10 of the 12 index wells in 2024 ended the year at higher levels than at the beginning of the year (see Figure 15). The exceptions were BU-32 and MT-6 where groundwater levels declined by 0.58 feet and 11.77 feet respectively. Average groundwater

levels for 2024 were lower in 10 of the 12 wells when compared with 2023 averages. The lowest groundwater levels (greatest depths to groundwater) tended to occur in September or November. Highest groundwater levels occurred in April or May.

It should be noted groundwater levels at MT-6 fell below the bottom of the well from July 21 through November 22. MT-6 is in an area of Dayton with a high density of open loop geothermal systems that pump groundwater for cooling buildings. This area experiences large declines in groundwater levels during the summer cooling season.

Average annual groundwater levels have been relatively stable at most index wells over the long-term showing an even balance between groundwater recharge and groundwater discharge (see Figure 16). The exceptions are BU-32, MT-6, and MT-49 where average annual groundwater levels have been declining in recent years. Average annual groundwater levels in MT-6 have declined by nearly 15 feet since 1990. Average annual groundwater levels at BU-32 and MT-49 have declined by 9 feet and 6 feet respectively. Recent drought cycles combined with increases in groundwater pumping are the likely causes of these downward trends.

## Water Use in the Great Miami River Watershed

Through its water withdrawal facilities registration program, ODNR tracks water use in the Great Miami River Watershed. The Ohio Revised Code requires any owner of a facility, or combination of facilities, with the capacity to withdraw water at a quantity greater than 100,000 gallons per day (GPD) to register such facilities with the Ohio Department of Natural Resources (ODNR) Division of Water. Facilities that withdraw less than 100,000 GPD are not required to register, therefore estimates of water use in this report do not capture water withdrawals from smaller facilities. It's possible that water withdrawals from clusters of small water withdrawal facilities could be significant in certain areas of the watershed. Water use information for 2024 was not available at the time of this report and so 2023 water use information is reported instead. Given recent water use trends, it's likely the differences between 2023 and 2024 water use data are negligible.

In 2023, surface water withdrawals from the Great Miami River Watershed averaged 29 million gallons of water per day. Groundwater withdrawals averaged 260 million gallons of water per day. Groundwater withdrawals make up 90 percent of total water use in the Great Miami River Watershed. Total groundwater withdrawn during 2023 was approximately 95 billion gallons of water. Most of this water was returned to the Great Miami River and its tributaries by discharge from water reclamation facilities.

Water withdrawn by public water suppliers accounted for 76 percent of total groundwater use (see Figure 17). The remaining groundwater withdrawals included industry, miscellaneous (mainly for open loop geothermal systems), mineral extraction, and agricultural irrigation.

Water use trends in the Great Miami River Watershed show total water withdrawals peaked during the decade of the 2000s at around 600 million gallons of water per day (see Figure 18). Since that time, total water withdrawals have declined to approximately 289 million gallons of water per day. Surface water withdrawals declined more than groundwater.

Surface water withdrawals peaked at 261 million gallons of water per day in 2005 and declined to 29 million gallons of water per day in 2023. About 74 percent of this decrease occurred because of the closure of four power-generating stations which used surface water for cooling. Groundwater withdrawals peaked in 2002 at 330 million gallons of water per day. In 2023, groundwater use was down to 260 million gallons of water per day.

## Conclusions

The analysis of water quantity data for 2024 confirms that the Great Miami River Watershed continues to experience long-term increases in precipitation and runoff, while groundwater levels remain stable. Despite annual variability, the overall trends suggest a resilient hydrologic system supported by effective water management practices. The MCD flood protection system functioned as designed, preventing significant flood damage by storing high water 21 times throughout the year. Groundwater stability, despite increased precipitation, highlights the impact of reduced withdrawals and sustainable water use practices.

These findings emphasize the need for ongoing monitoring, adaptive management, and regional collaboration to ensure water availability, flood protection, and ecological balance in the face of climate variability. MCD remains dedicated to leveraging scientific data and strategic planning to support informed decision-making and long-term sustainability in the Great Miami River Watershed.

## Acknowledgements

This report compiles and summarizes Miami Conservancy District data along with information supplied by the United States Geological Survey (USGS) and the Ohio Department of Natural Resources (ODNR).

- **Streamflow, Runoff, and Groundwater Level Data - USGS**, *Ohio Kentucky and Indiana Water Science Center*
- **Groundwater Level and Water Use Data - ODNR**, *Division of Water Resources*

## Tables and Figures

*Table 1 – River stage at which storage begins at the Miami Conservancy District dams.*

| Dam         | Stage Where Storage Begins (ft.) |
|-------------|----------------------------------|
| Germantown  | 12                               |
| Englewood   | 11.6                             |
| Lockington  | 12                               |
| Taylorville | 15                               |
| Huffman     | 11                               |

*Table 2 – Depths of the index wells used in this report.*

| Index Well | Well Depth (ft.) |
|------------|------------------|
| BU-32      | 234              |
| BU-70      | 54               |
| BU-179     | 43               |
| BU-282     | 74               |
| CL-11      | 180              |
| H-1        | 124              |
| MI-3A      | 130              |
| MI-43      | 140              |
| MT-6       | 60               |
| MT-49      | 220              |
| MT-73      | 95               |
| W-10       | 51               |

Figure 3 – Map showing locations of Miami Conservancy District precipitation observer stations.

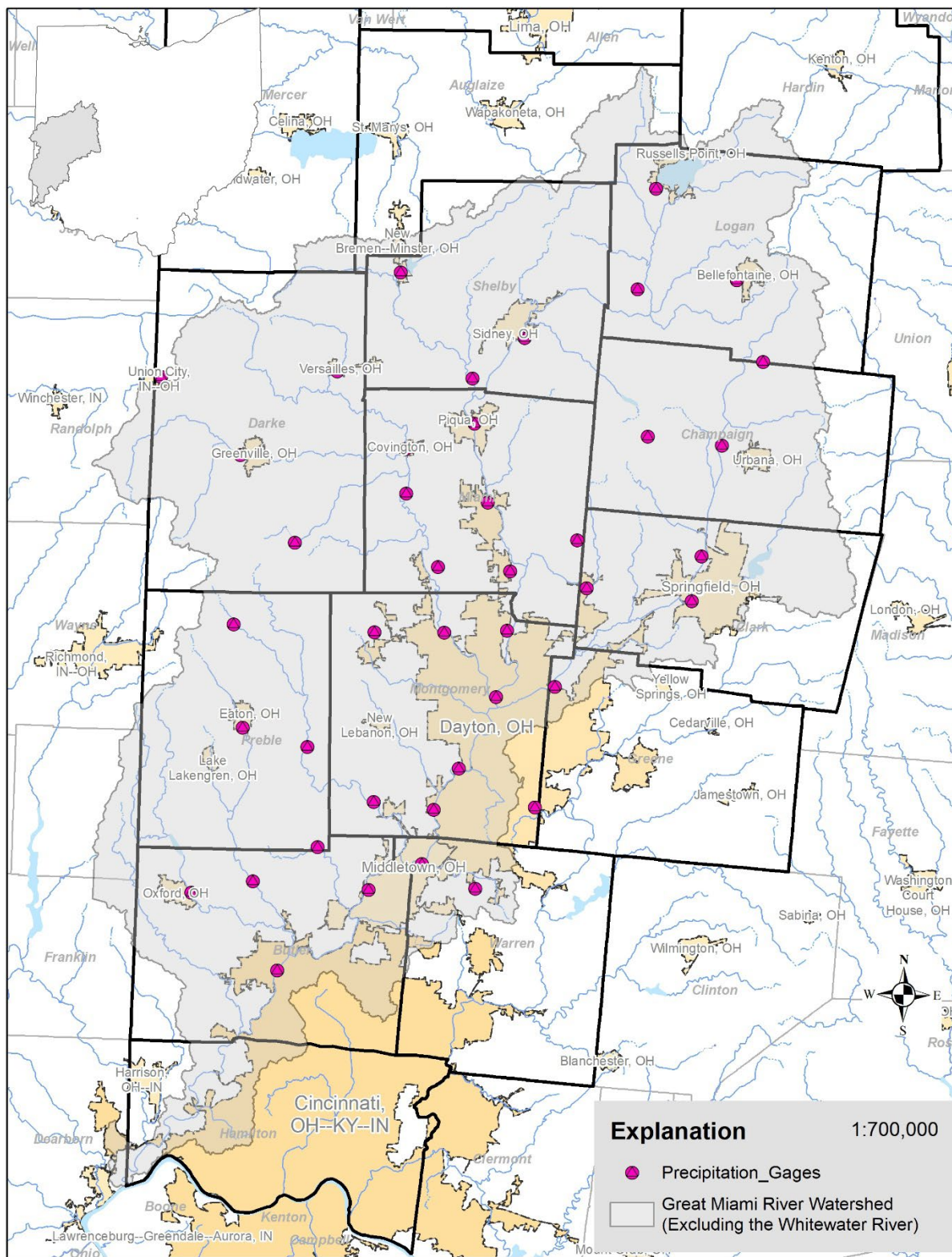


Figure 5 – Monthly precipitation compared to 30-year average for the Great Miami River Watershed.

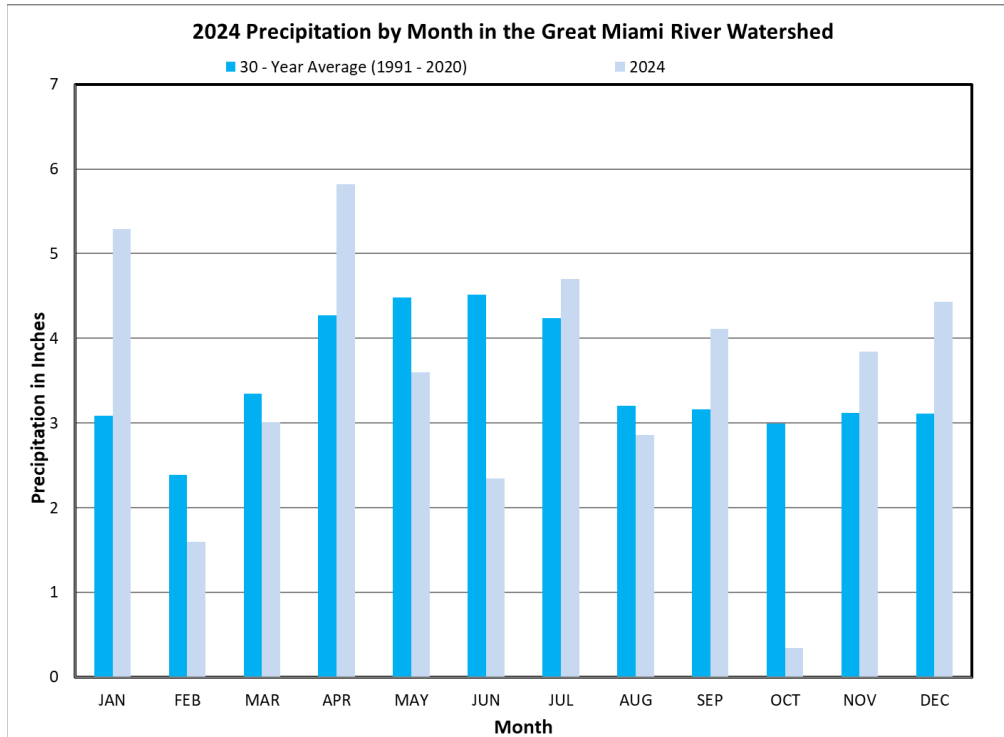


Figure 7 – Moving 30-year mean annual precipitation for the Great Miami River Watershed.

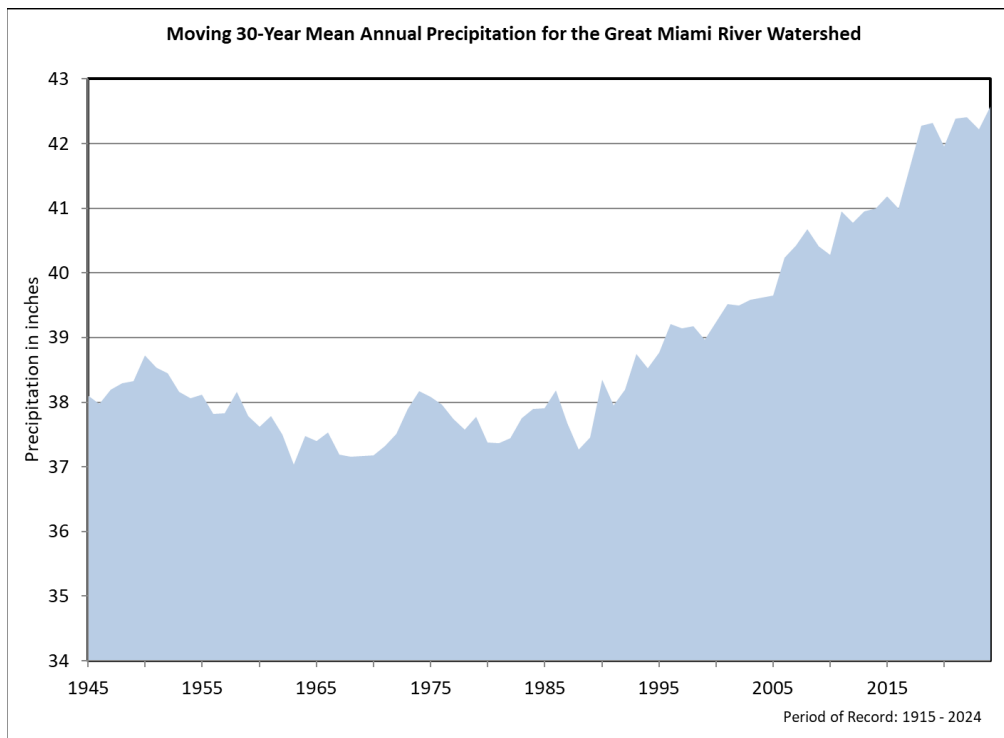


Figure 8 – Map showing locations of MCD-USGS cooperative streamgages.

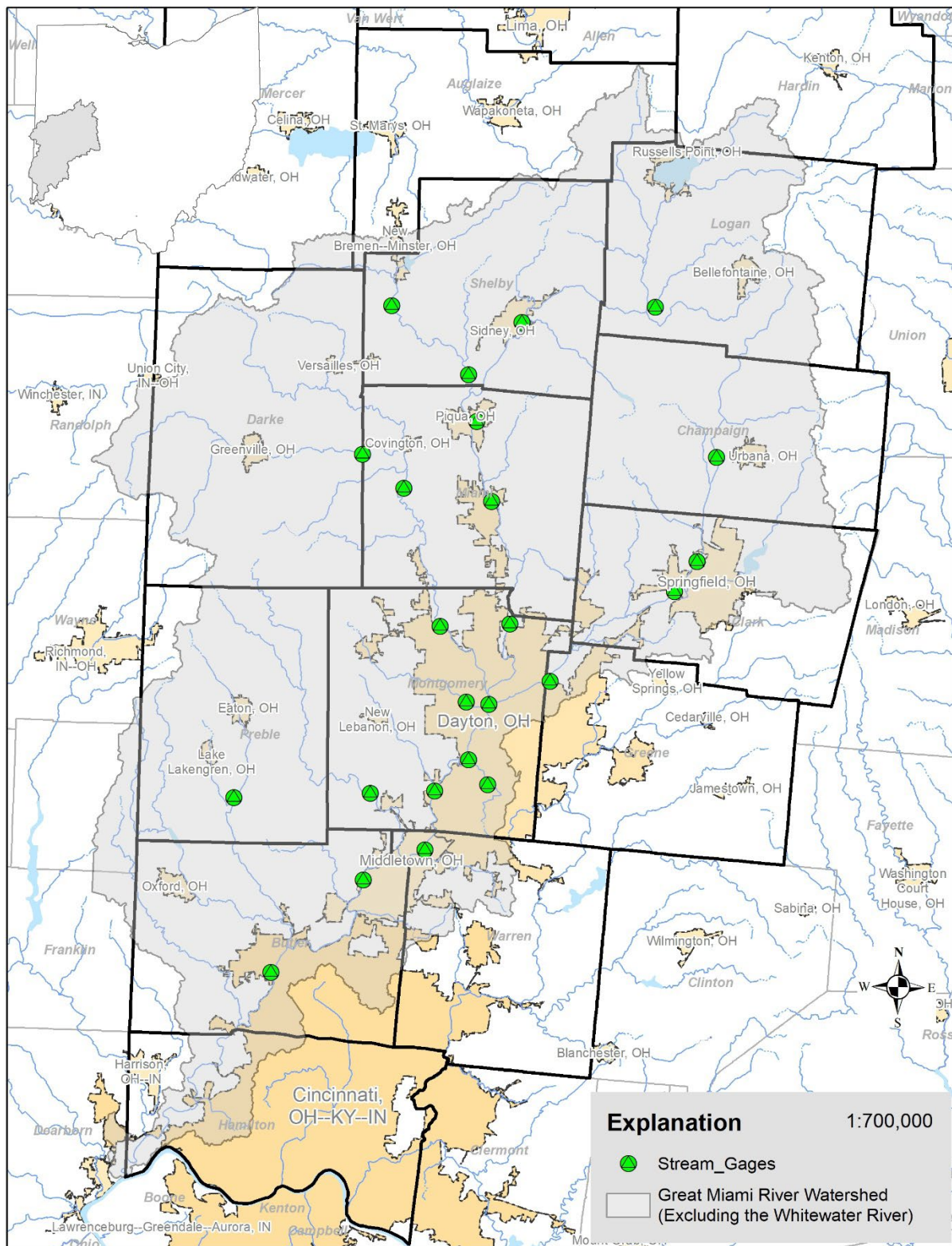


Figure 9 – Monthly runoff compared with 30-year averages for the Great Miami River Watershed.

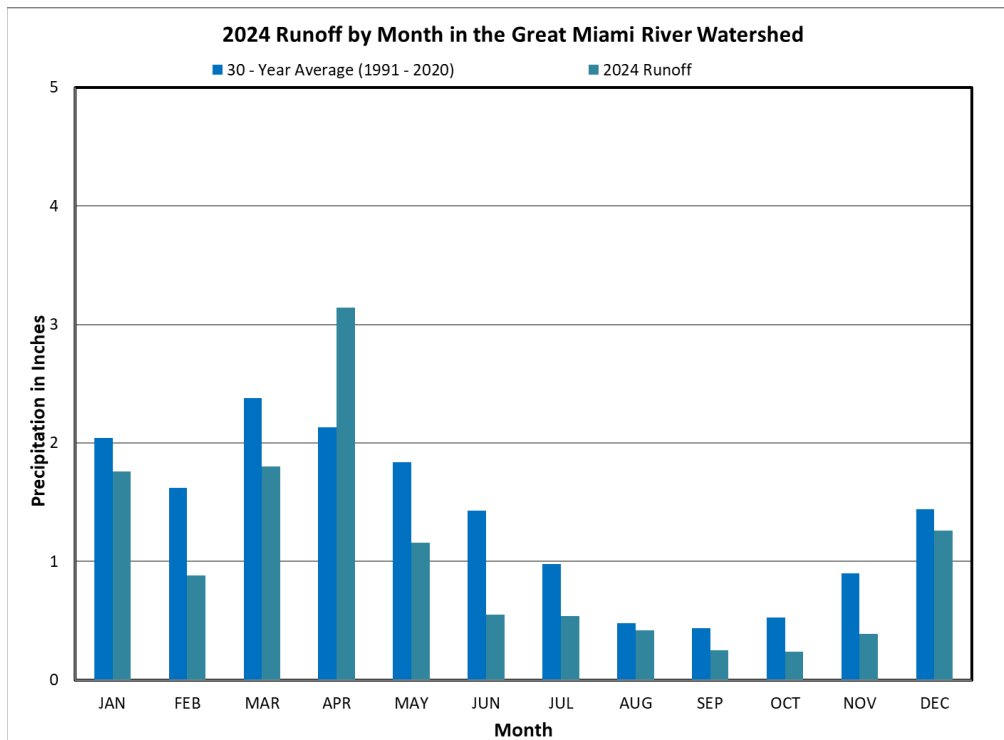


Figure 10 – Moving 30-year mean annual runoff for the Great Miami River Watershed.

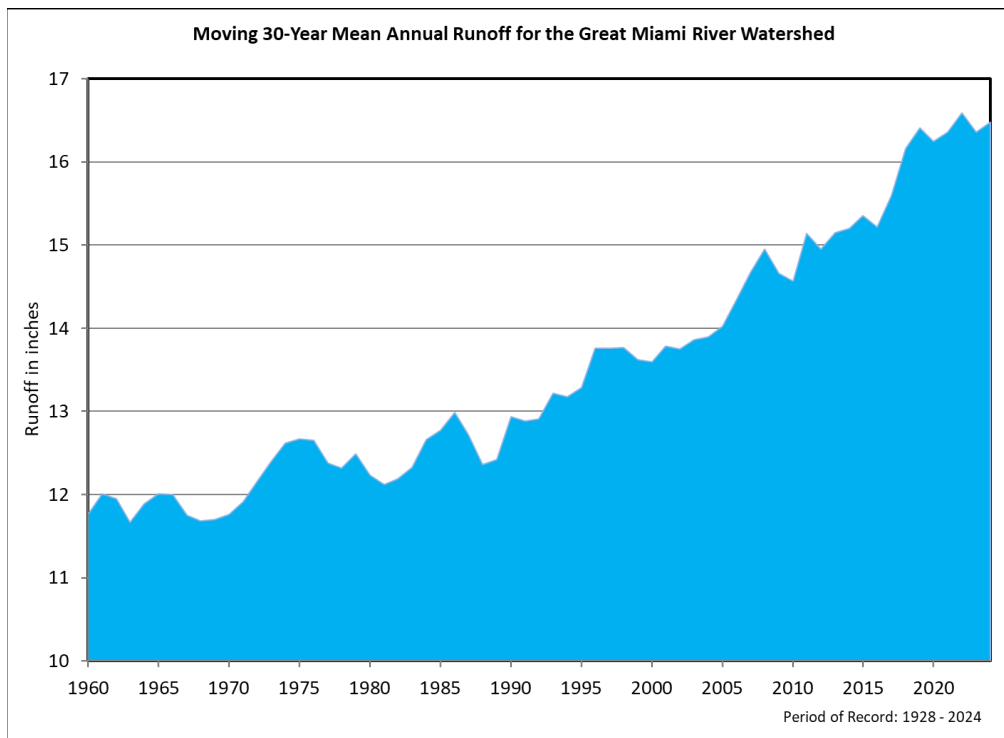


Figure 11- Map showing locations of Miami Conservancy District flood protection dams, storage basins, and levees.

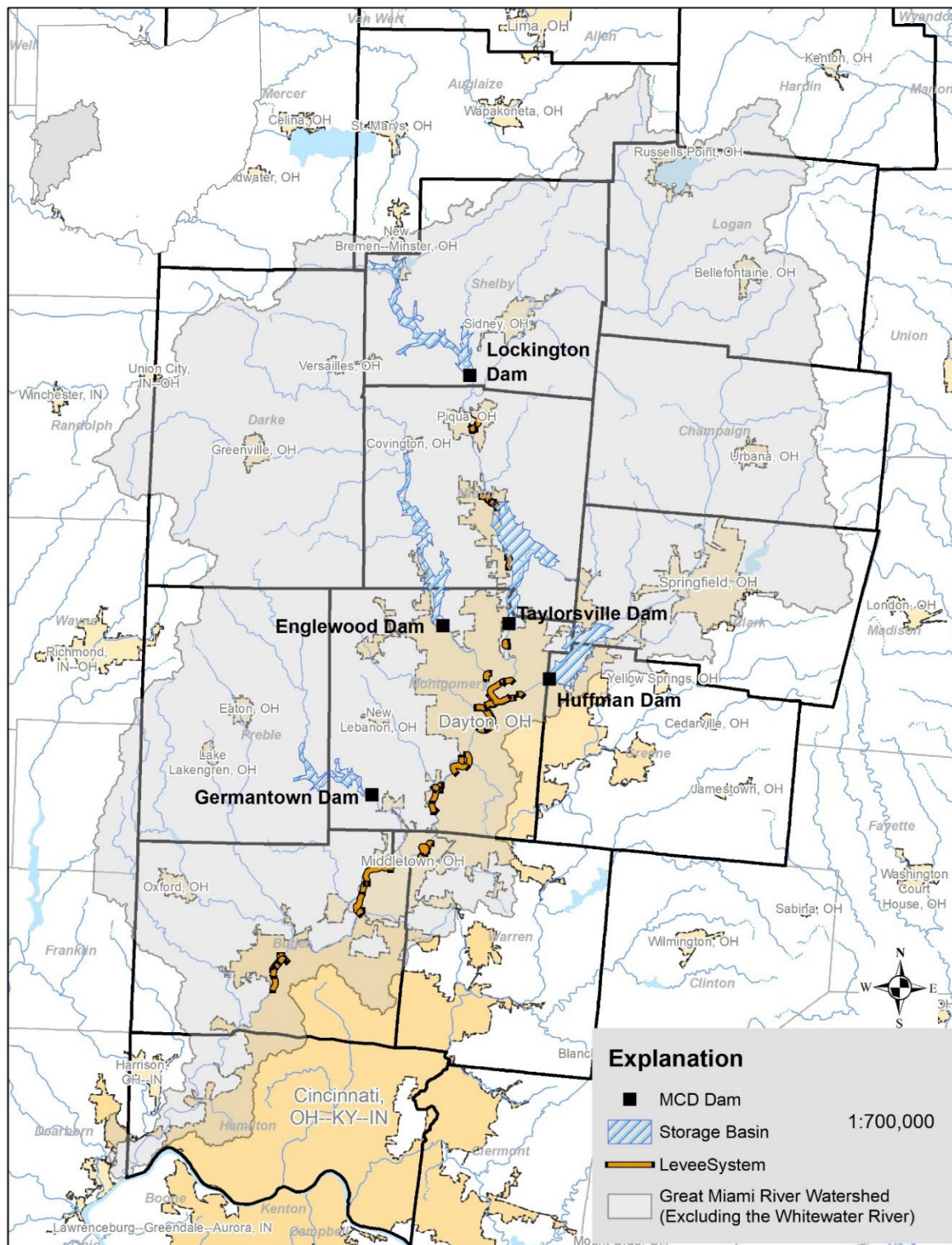


Figure 12 – Number of storage events by month in 2024.

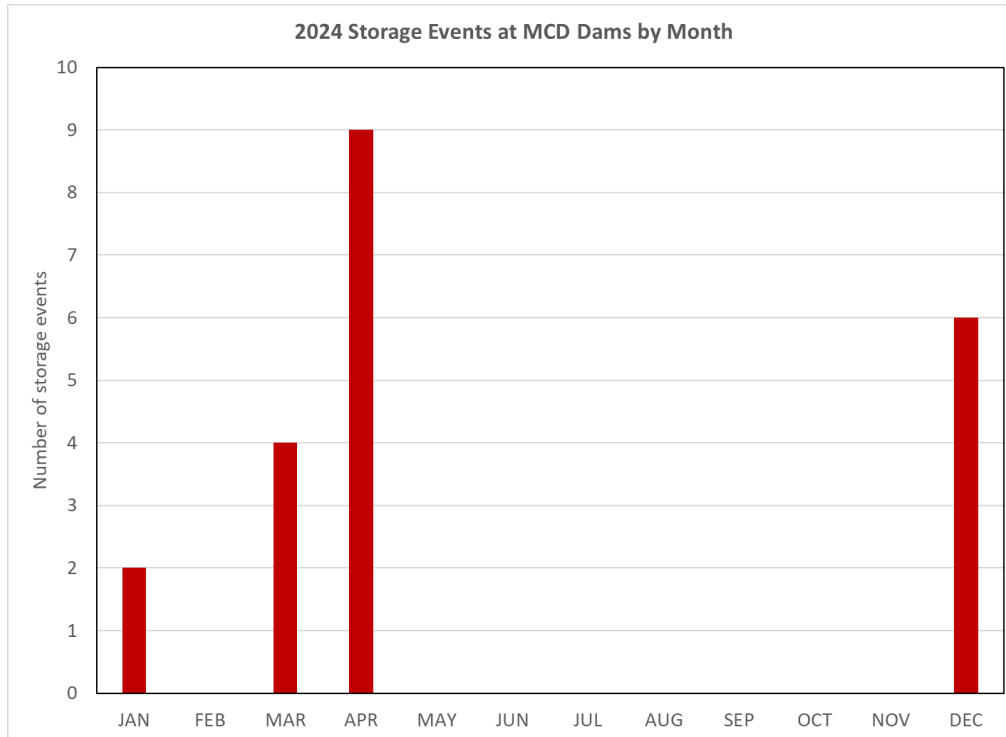


Figure 13 – Number of storage events recorded by Miami Conservancy District for each decade.

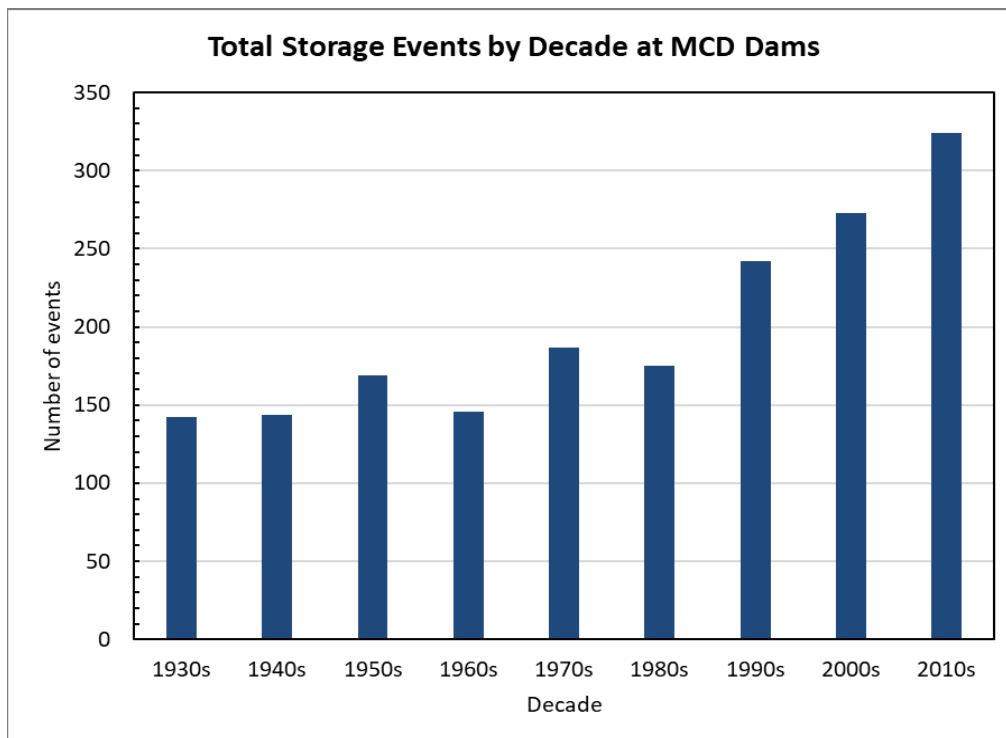


Figure 14 – Map showing the locations of index observation wells.

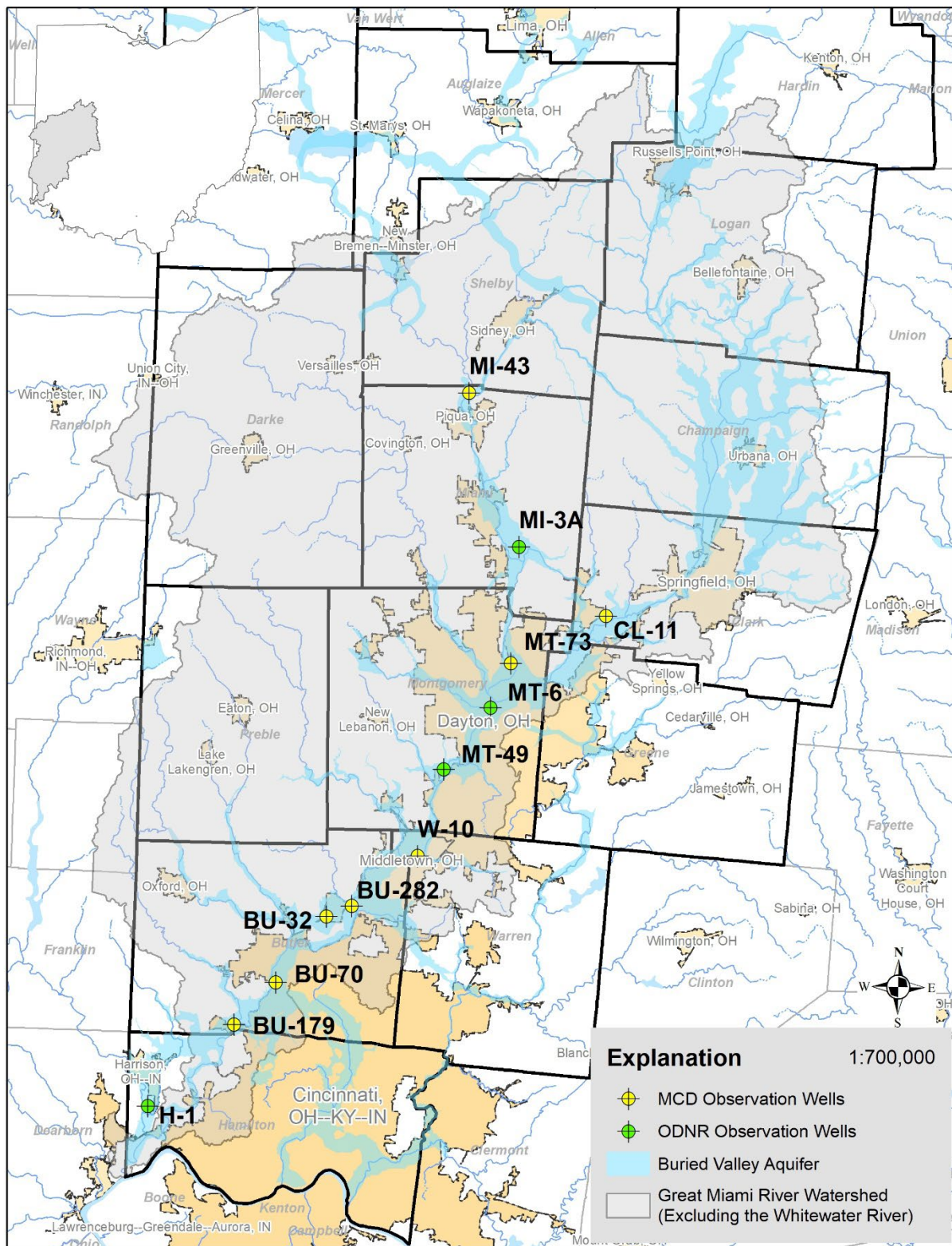


Figure 15 Depth below ground surface at index observation wells in 2024.

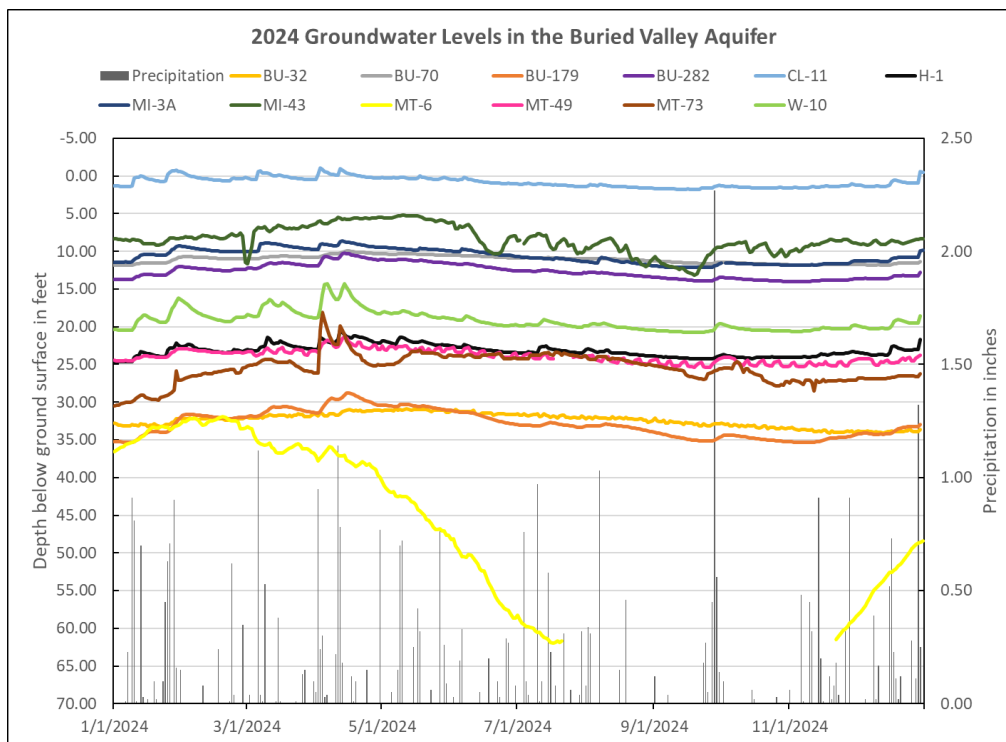


Figure 16 – Average annual depths to groundwater at index observation wells.

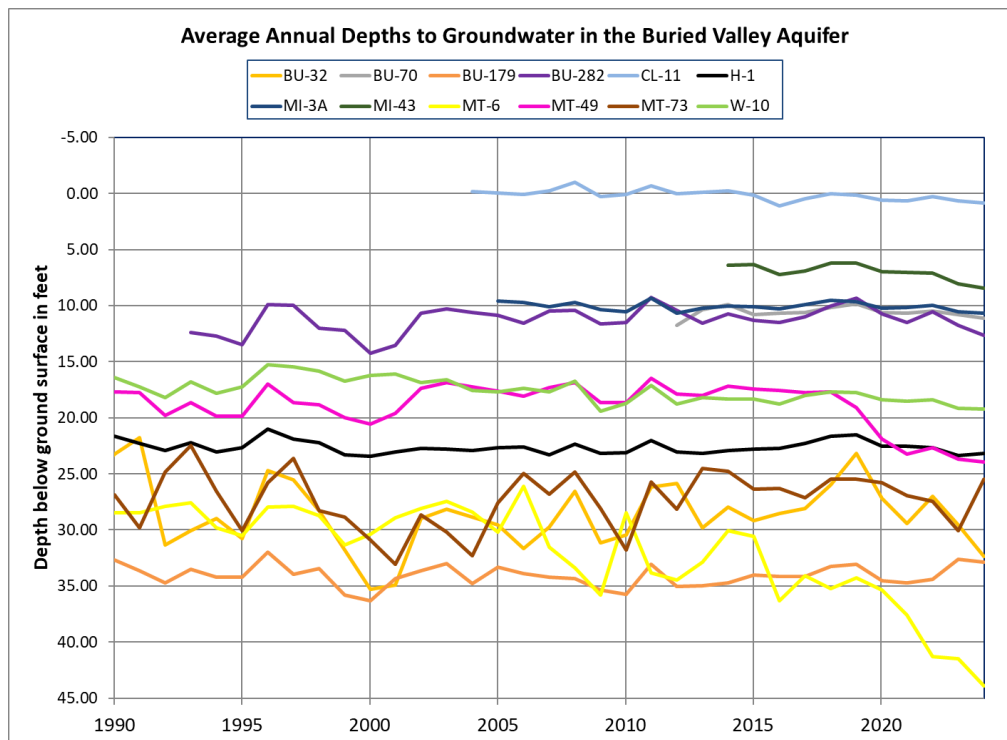


Figure 17 – Groundwater use in the Great Miami River Watershed during the year 2023.

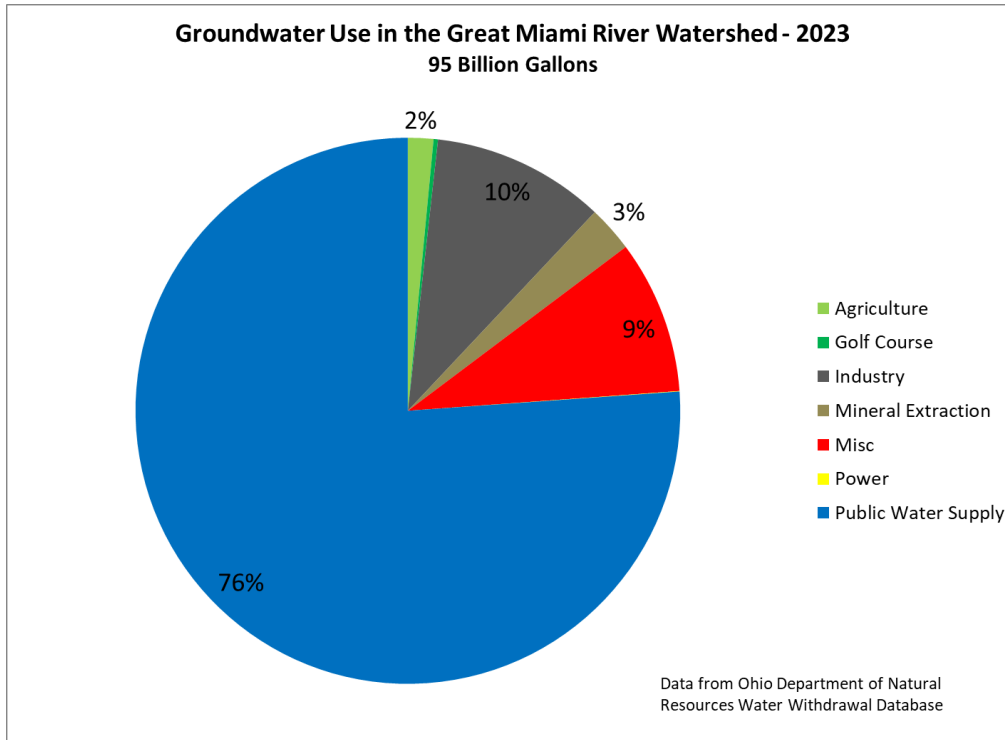
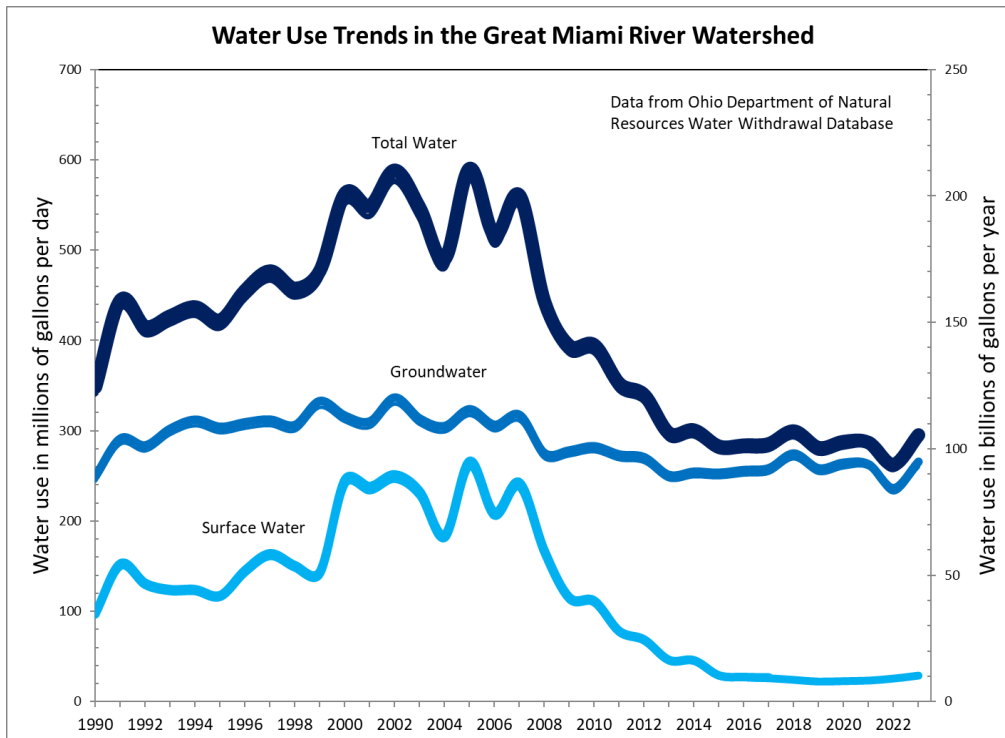


Figure 18 – Water use trends in the Great Miami River Watershed.





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