



# The ABC's of Groundwater

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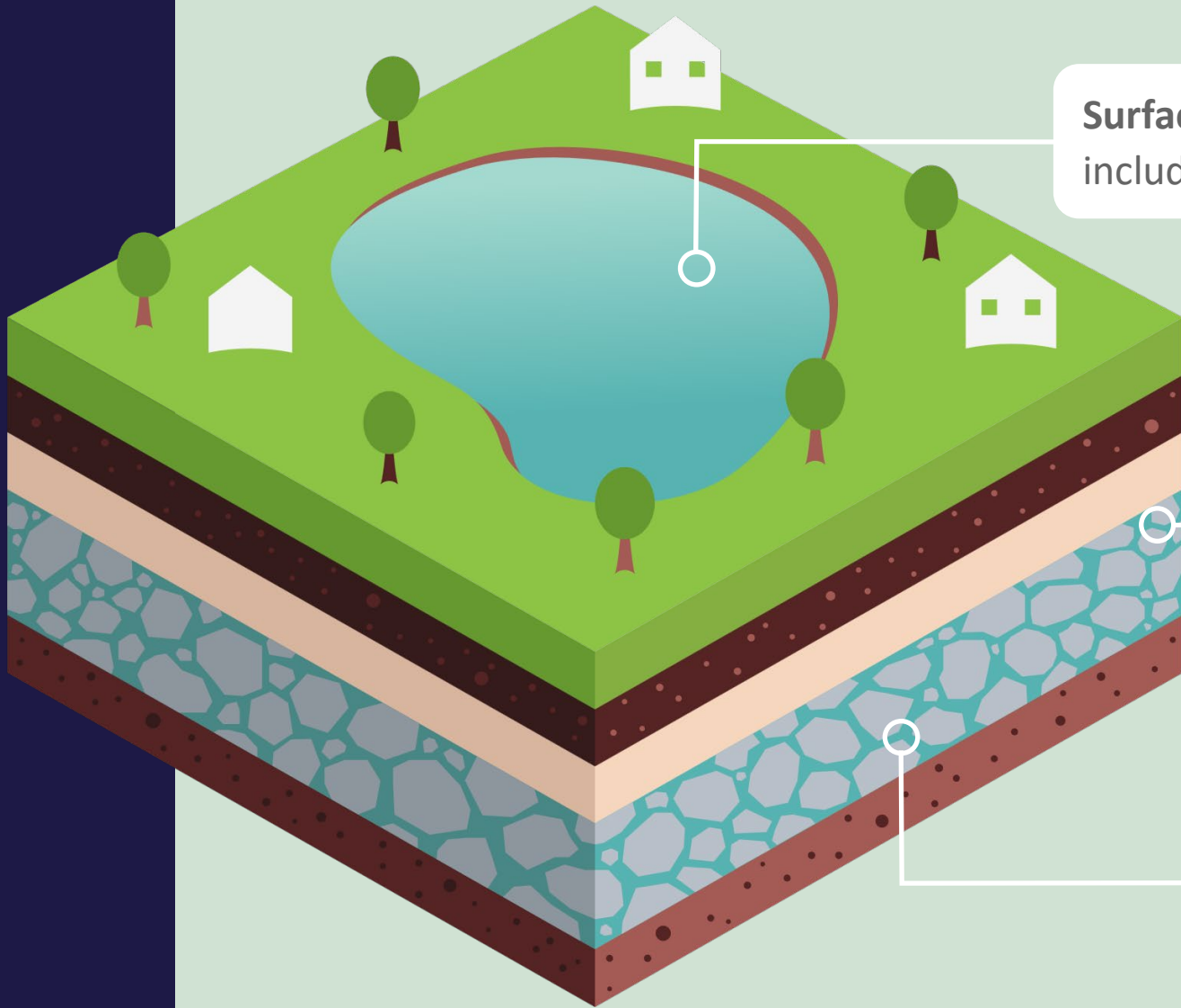
# What is groundwater?

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Water that exists underground in saturated zones beneath the land surface (e.g., pore spaces in sediments, fractures in rock). This research specifically studied groundwater in Allegan County.



# Groundwater vs Surface Water



**Surface Water:** Water bodies that exist above ground, including streams, rivers, lakes, and reservoirs.

**Water Table:** The upper boundary of the zone of saturation, where groundwater fills the pore spaces in soil and rock.

**Groundwater:** Water that exists underground in saturated zones beneath the land surface.

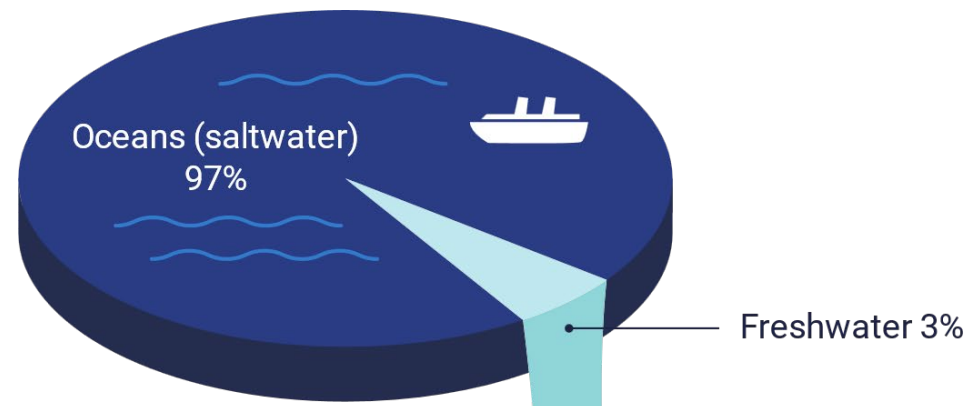
# Groundwater in the “Big Picture”

Groundwater is popular in Michigan because of our extensive aquifers.

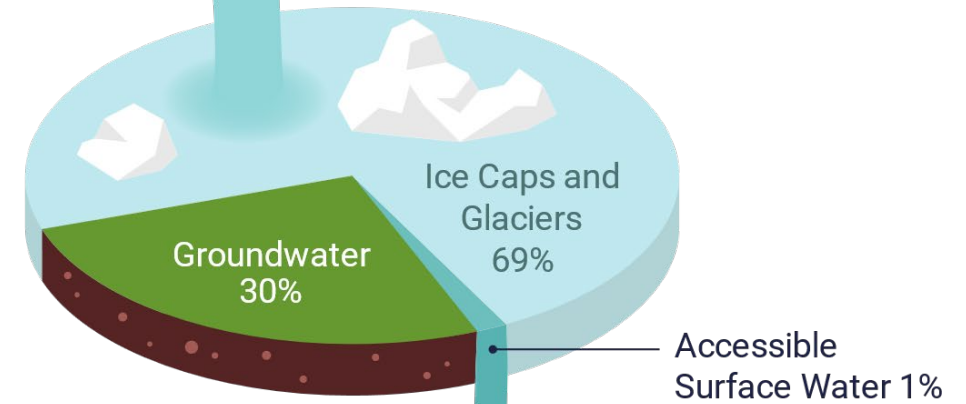
## Source & Use of Water in the USA, 2015

- 37% of water used in the USA is groundwater
- Irrigation wells use the most groundwater nationally.
- Domestic wells, mining, and livestock use greater quantities of groundwater than surface water supplies.

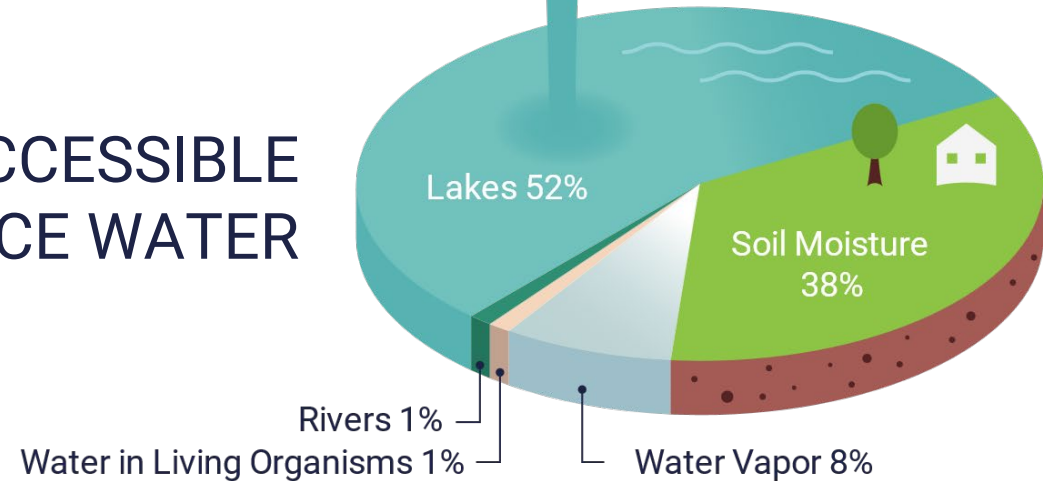
ALL WATER



FRESHWATER



ACCESSIBLE SURFACE WATER





# Allegan County is rich in surface water resources

The major surface water systems include Lake Michigan, the Kalamazoo River, the Black River, the Rabbit River, and the Macatawa River, along with numerous connecting tributary streams and nearly 100 inland lakes.



# But Allegan County also has a wealth of groundwater



- Like most of Michigan, Allegan County sits on large freshwater reserves (groundwater) that is tapped for water supply.
- Groundwater is source of drinking water for about  $\frac{1}{2}$  of Michigan's population.

**The volume of fresh groundwater in the Great Lakes basin is about equal to the volume of water in Lake Huron.**

# Groundwater is the preferred source of water supply because of its

General protection from surface contaminants

Consistent quality

Lower vulnerability to weather events

Reliability and cost-effectiveness



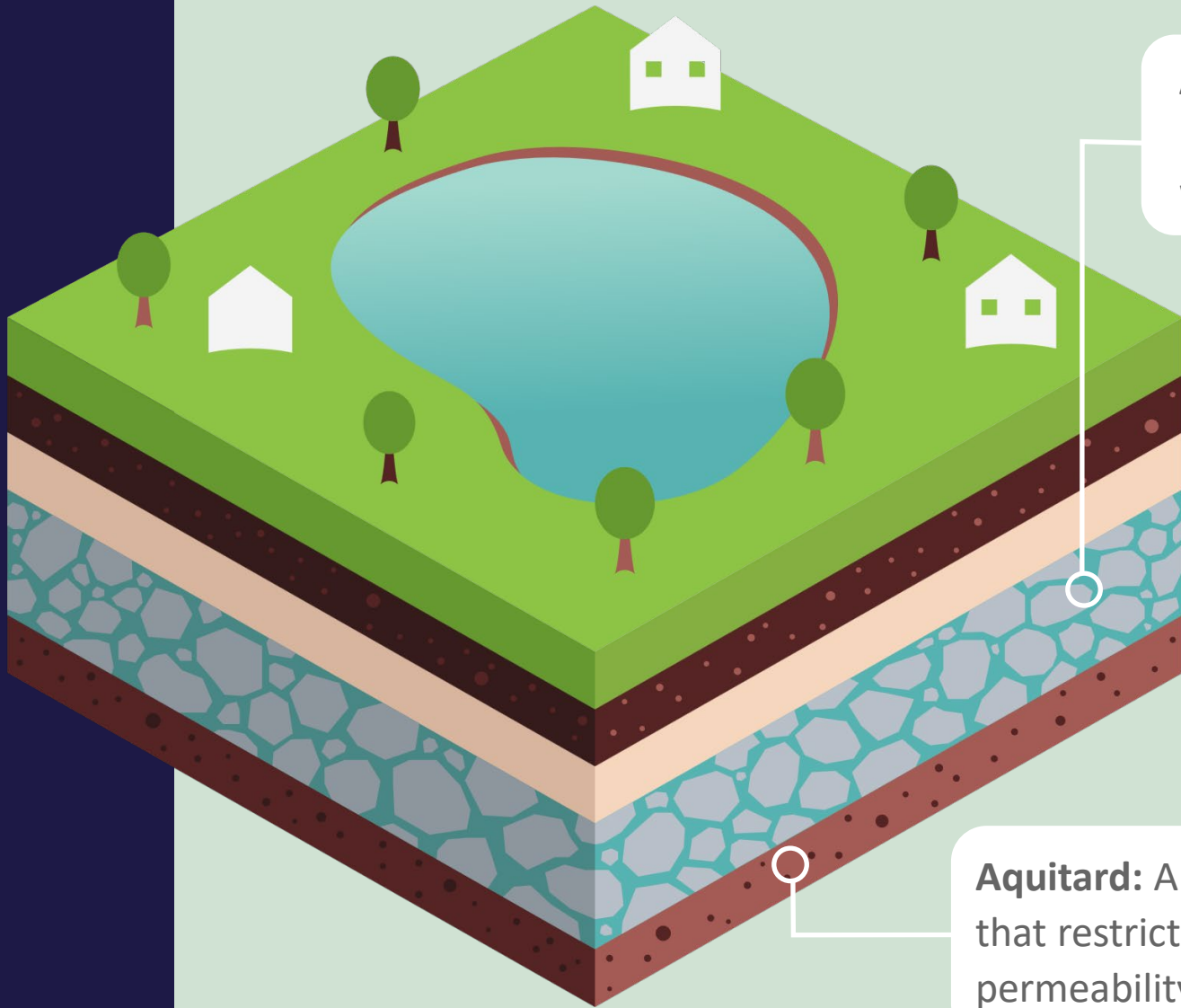




**It isn't always  
easy to measure  
or identify when  
groundwater  
needs attention.**

**Groundwater is often perceived as an invisible resource, something that we all need but simply turn on a tap and it appears.**

# Groundwater Sources



**Aquifer:** Underground layers of water-bearing permeable rock and/or soil that readily transmits water to wells and springs.

**Subsurface:** Underground, sometimes referred to as the *subsurface geology*. Like the land above, it's important to remember that the subsurface has its own terrain and depending on the underground geological formations, water moves down through the subsurface as well as horizontally across it.

**Aquitard:** A geological formation or layer of rock or sediment that restricts the flow of groundwater due to its low permeability. Sometimes referred to as a *Confining Layer*.





# Allegan's Geologic Framework and Groundwater Hydrology

Understanding the variability in the subsurface geology of Allegan County provides valuable insights into how quickly water (and the substances it carries) moves through the ground and how much water can be pumped.

**All private and municipal well owners in Allegan County draw from only two underground water sources.**

**Glacial  
Aquifer**



**Bedrock  
Aquifer**



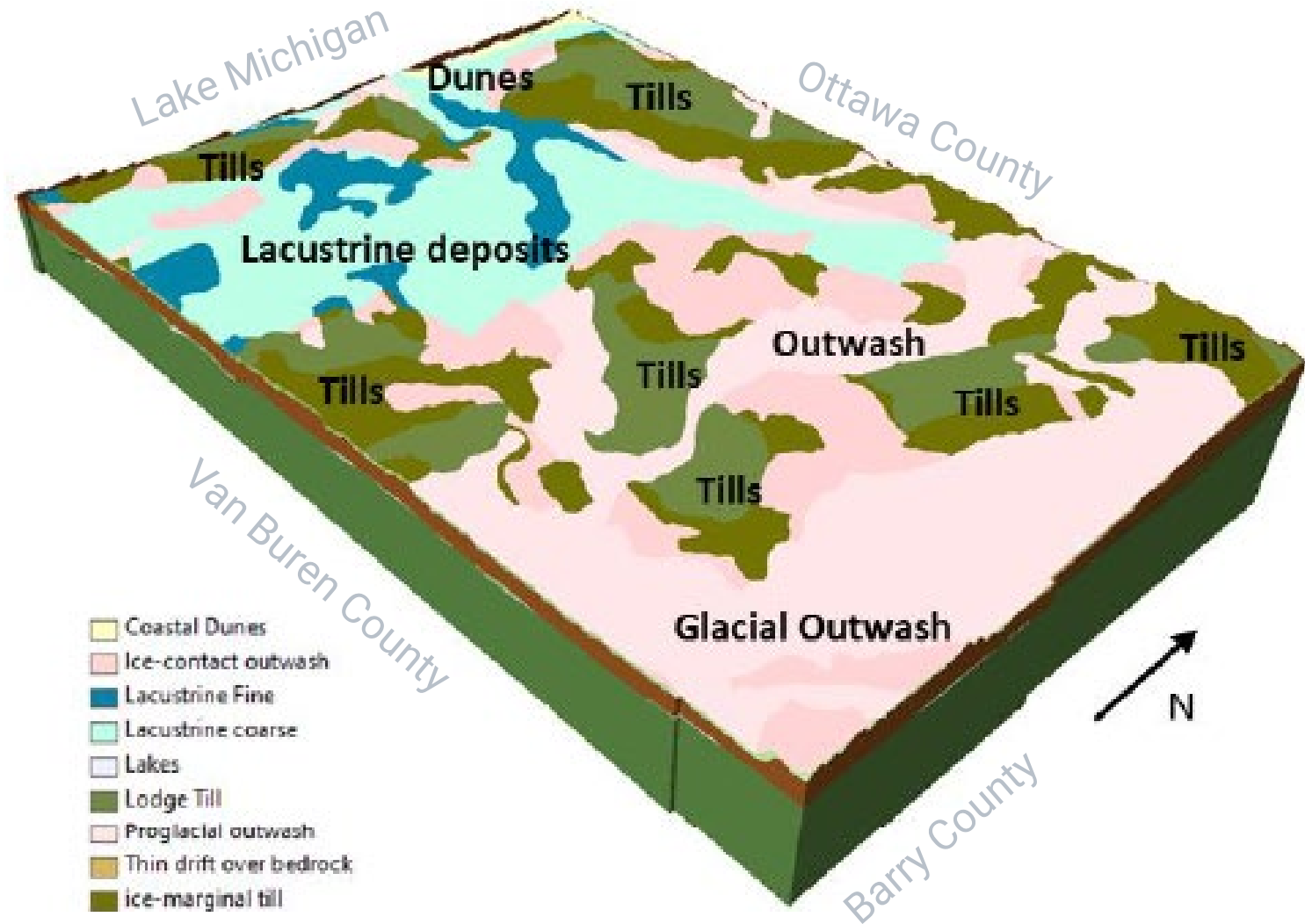
# Glacial Drift Aquifers

**Depth:** Shallow Aquifers

**Accessibility:** Across all of Allegan County

**Composition:** Glacial Drift Formation

**Use:** 88% of all water wells utilize this aquifer



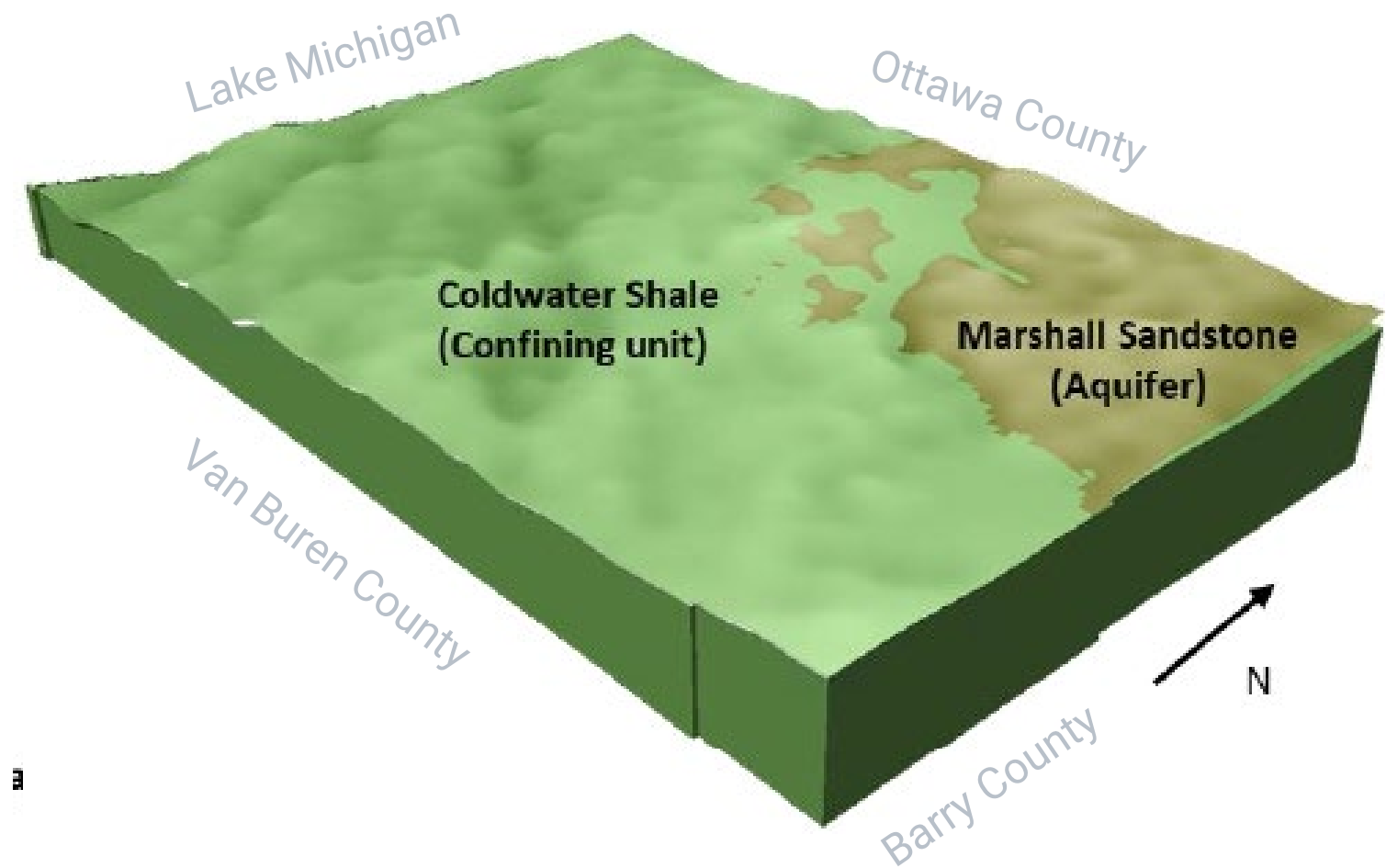
# Bedrock Aquifer

**Depth:** Deep Aquifer

**Accessibility:** NE  
Allegan County




**Composition:** Marshall  
Sandstone Formation

**Use:** 7% of all water  
wells utilize this aquifer



Lake Michigan



-  Permeable sands, gravels, etc.  
(more permeable)
-  Fine sands, silty sands, etc.  
(less permeable)
-  Clays, silts, etc.  
(not permeable)

The glacial drift aquifer is complex (lots of spatial variation)

Groundwater availability may change quickly from one location to another (more on this later)

# Detailed Lithology (Aquifer Materials)



# Hydraulic Conductivity (K)

Measures **PERMEABILITY**,  
or the ability of water to move  
through different sediments.

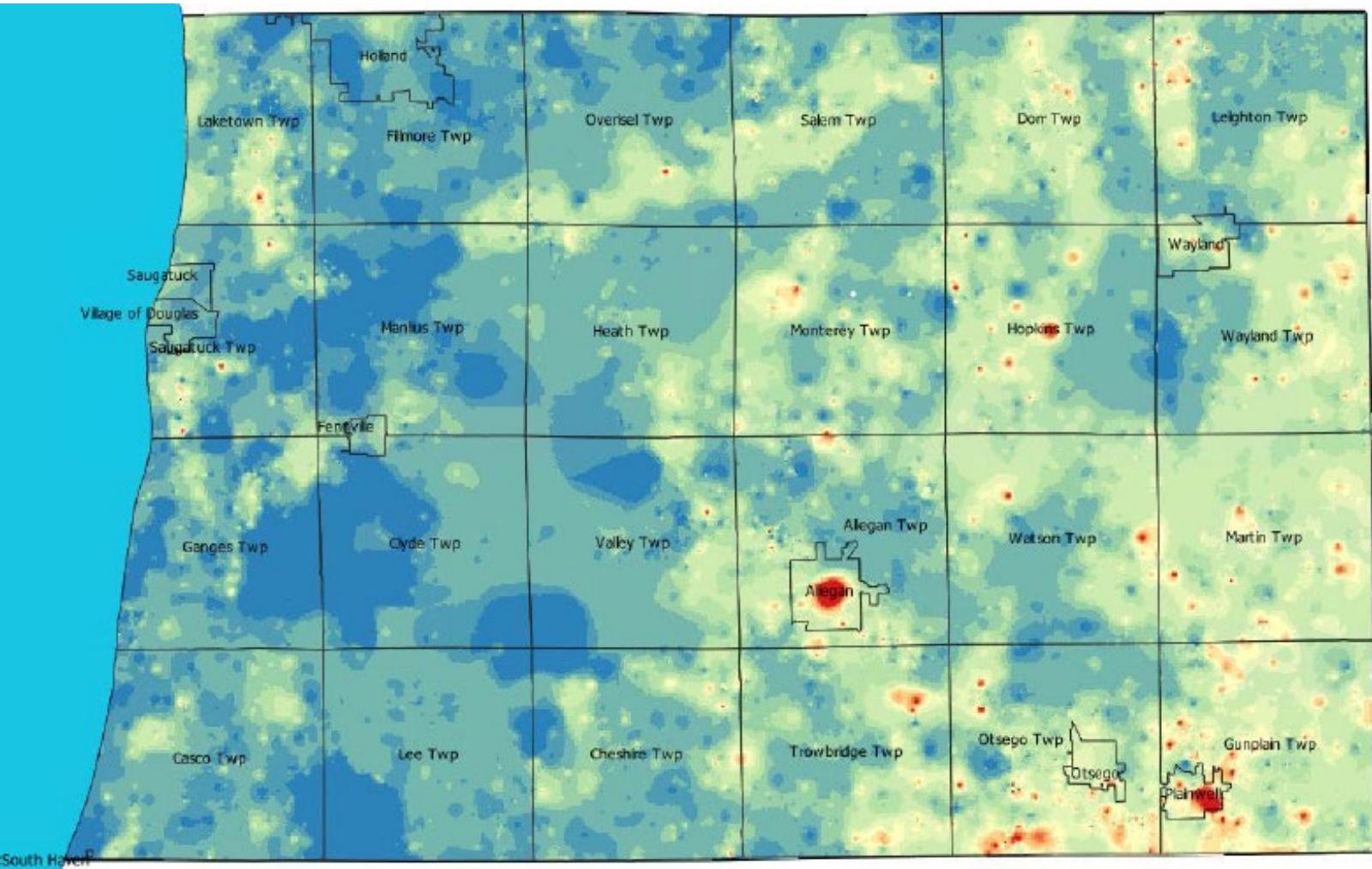
Influences the **SPEED** of  
groundwater (and pollutant)  
movement.

Aquifer  
Properties

# Transmissivity (T)

Hydraulic Conductivity (K) +  
Aquifer Thickness.

Transmissivity controls aquifer  
**PRODUCTIVITY**.



Varies significantly across the County because of the complex geology and how sediments were formed/deposited.

- More permeable materials result in higher K (faster flow)
  - Like coarse sands & gravels
- Less permeable materials result in lower K (slower flow)
  - Like clays, silts, & fine sands



# Hydraulic Conductivity – Glacial Aquifer

How groundwater flows doesn't just depend on geology – surface water, topography, climate, and even humans play an important role, too!

## Groundwater Flow

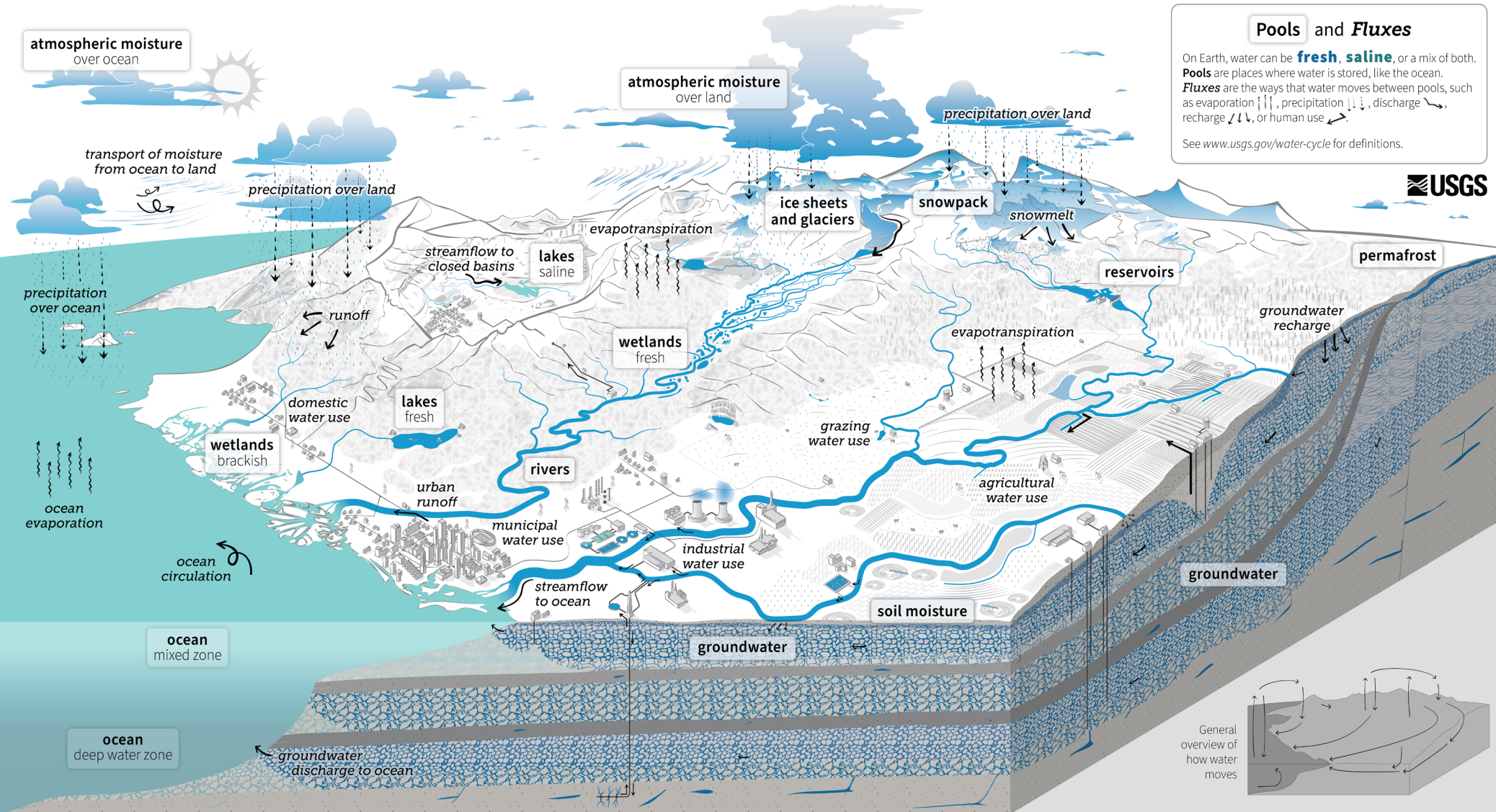
## Recharge & Discharge Zones





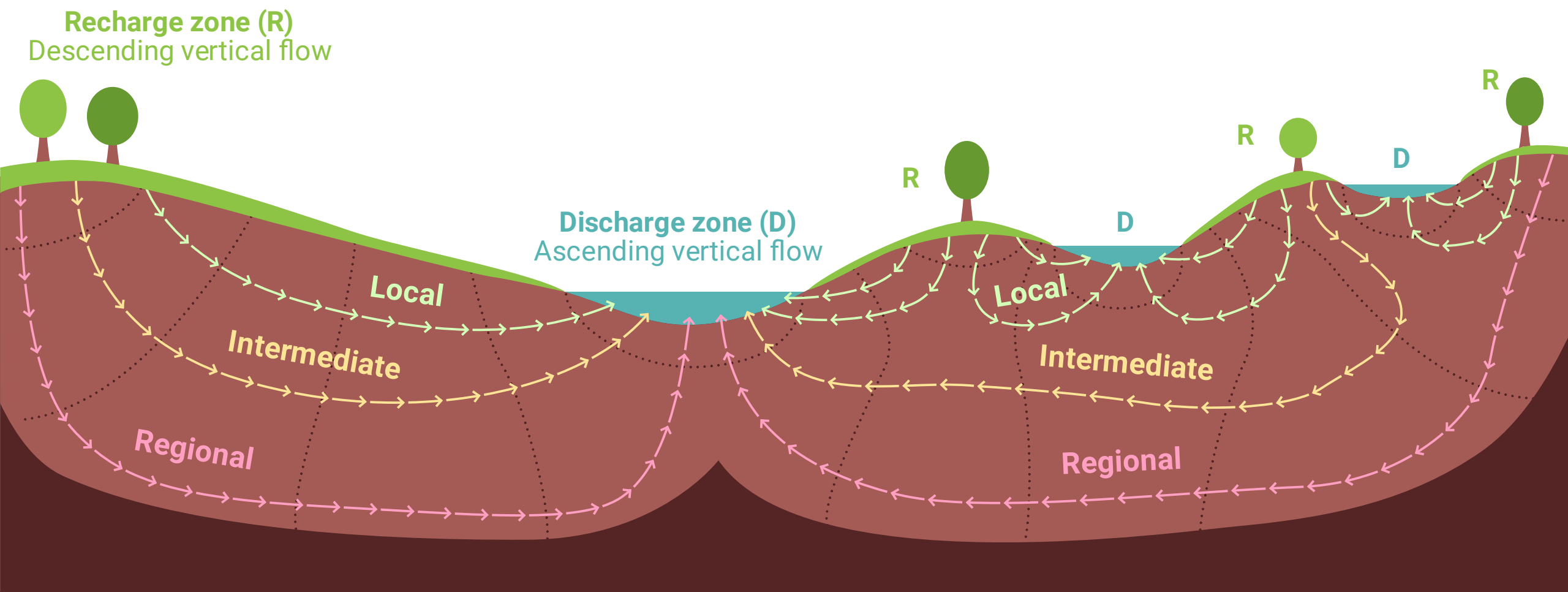
**Recharge:** Net infiltration of water reaching the water table.

**Discharge:** groundwater leaving the aquifer to surface water or wells.



# Water Cycle Refresher

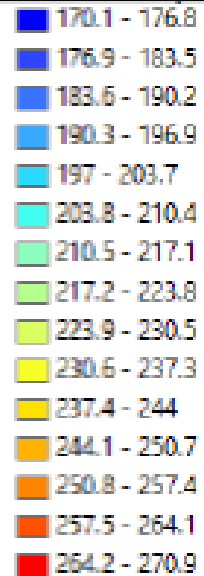




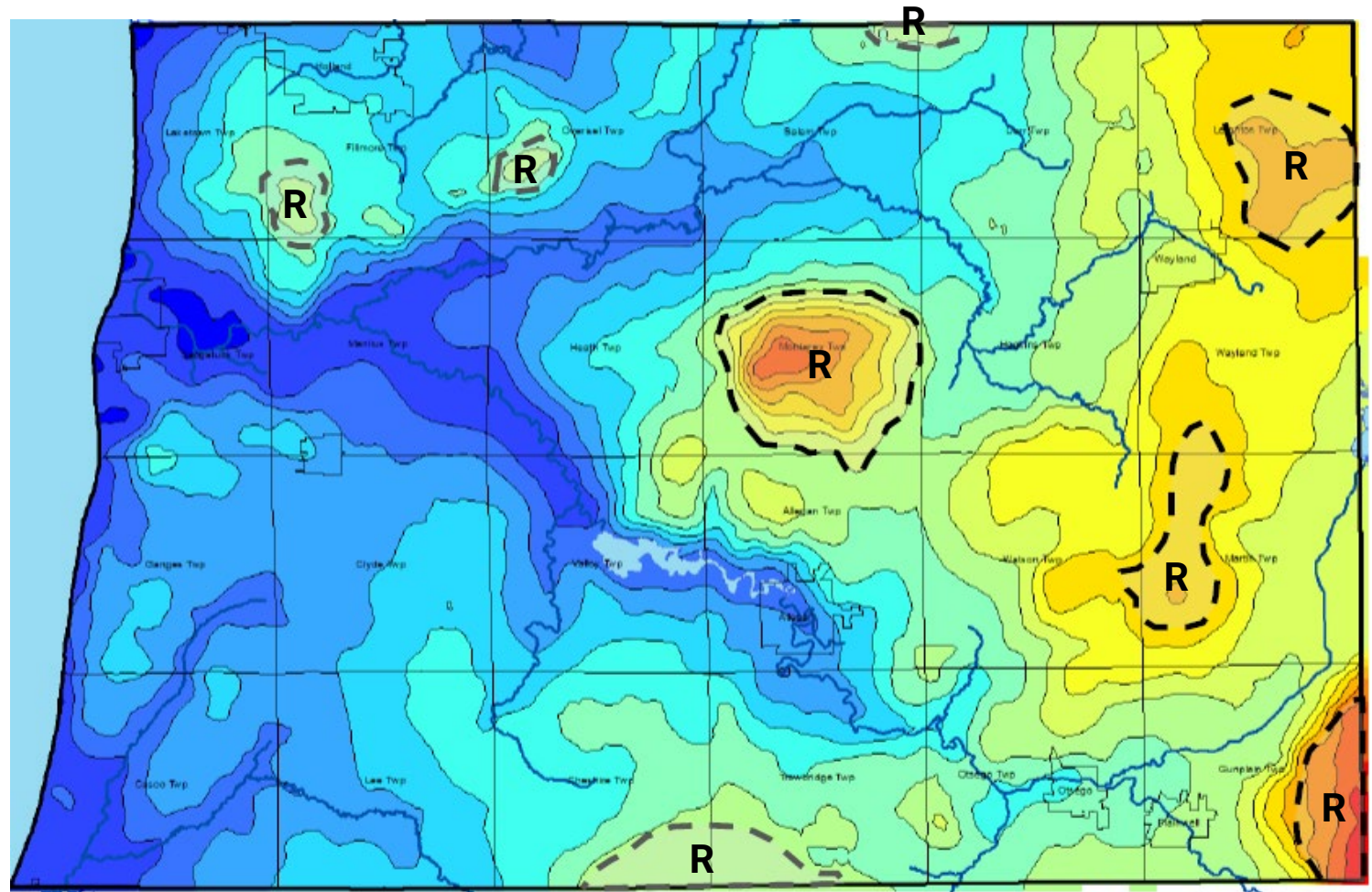
# Master Discharge & Recharge Zones

# Master Recharge Areas (Groundwater Mounds)

## Water Level (m)



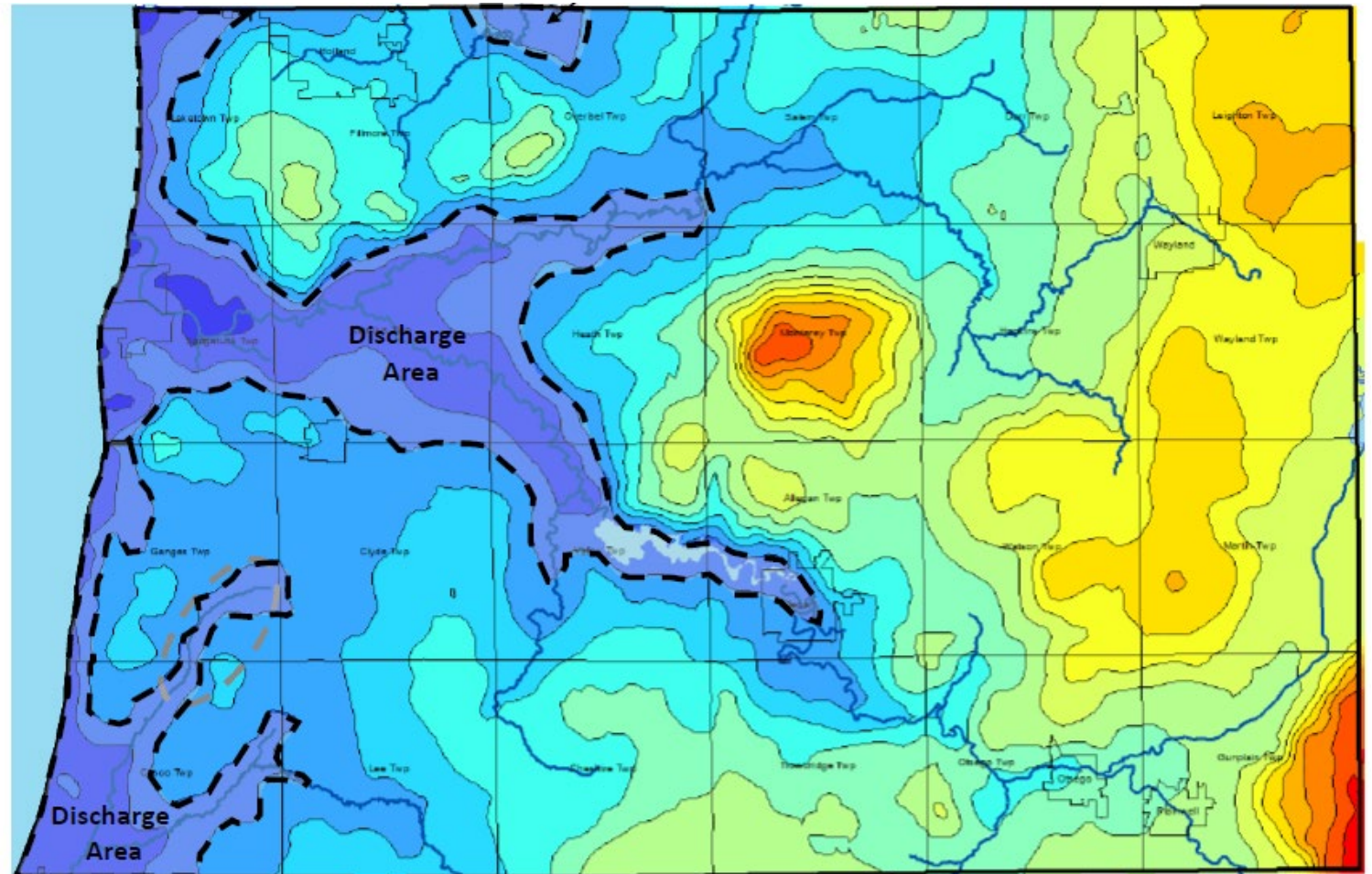
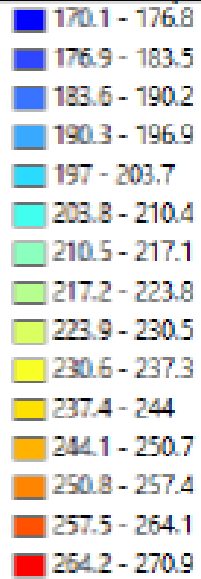
R = Recharge Area



# Master Recharge Areas in Alleghen County

# Master Discharge Areas

## Water Level (m)



# Master Discharge Areas in Alleghen County

**To manage /  
protect ground-  
water, we need  
to know where it  
is coming from.**

**Source  
Water Areas**



**Wellhead  
Protection  
Areas  
(WHPAs)**



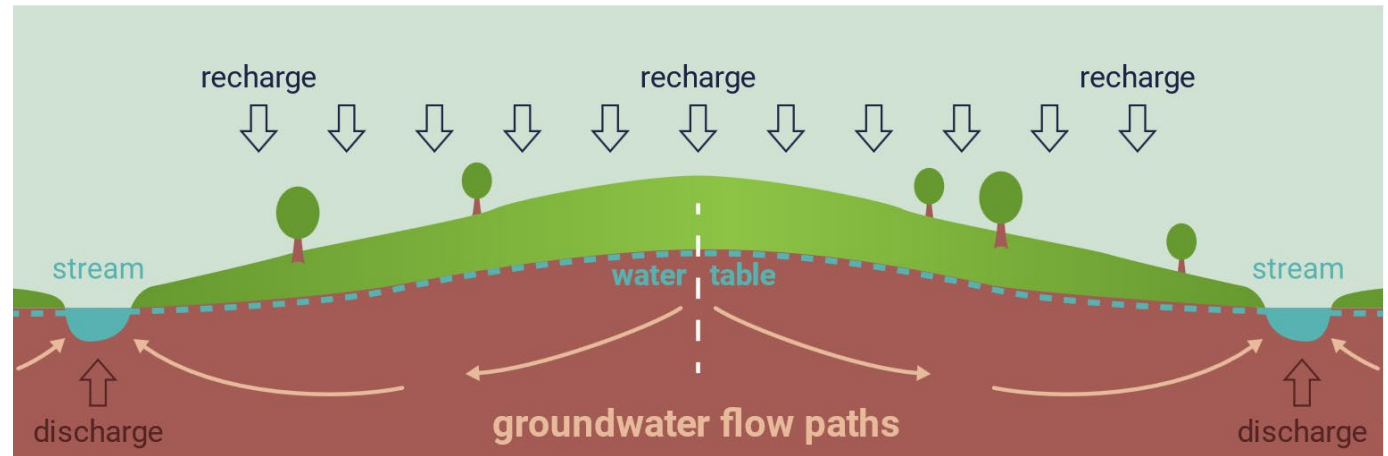
# Groundwater Divides

Using Flow Patterns to Delineate Source Areas

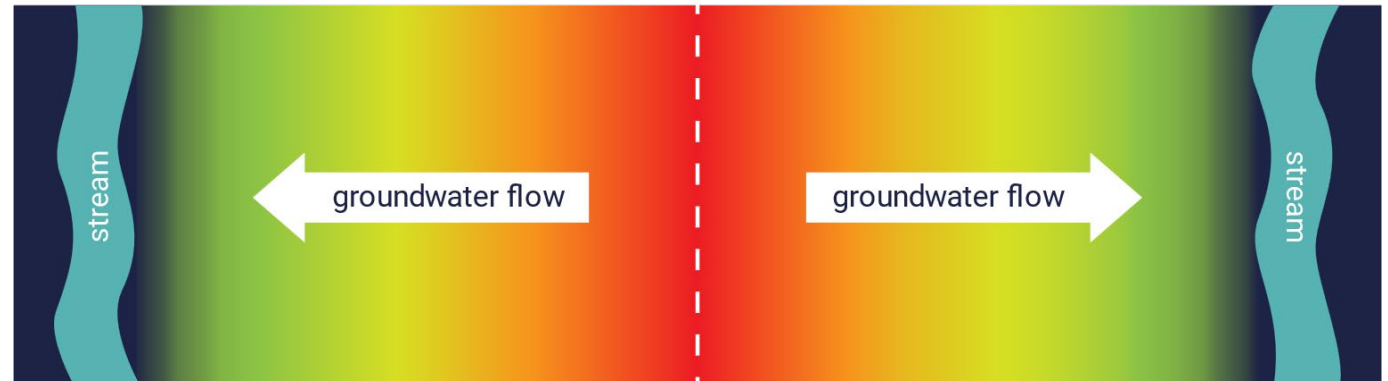
Plan View

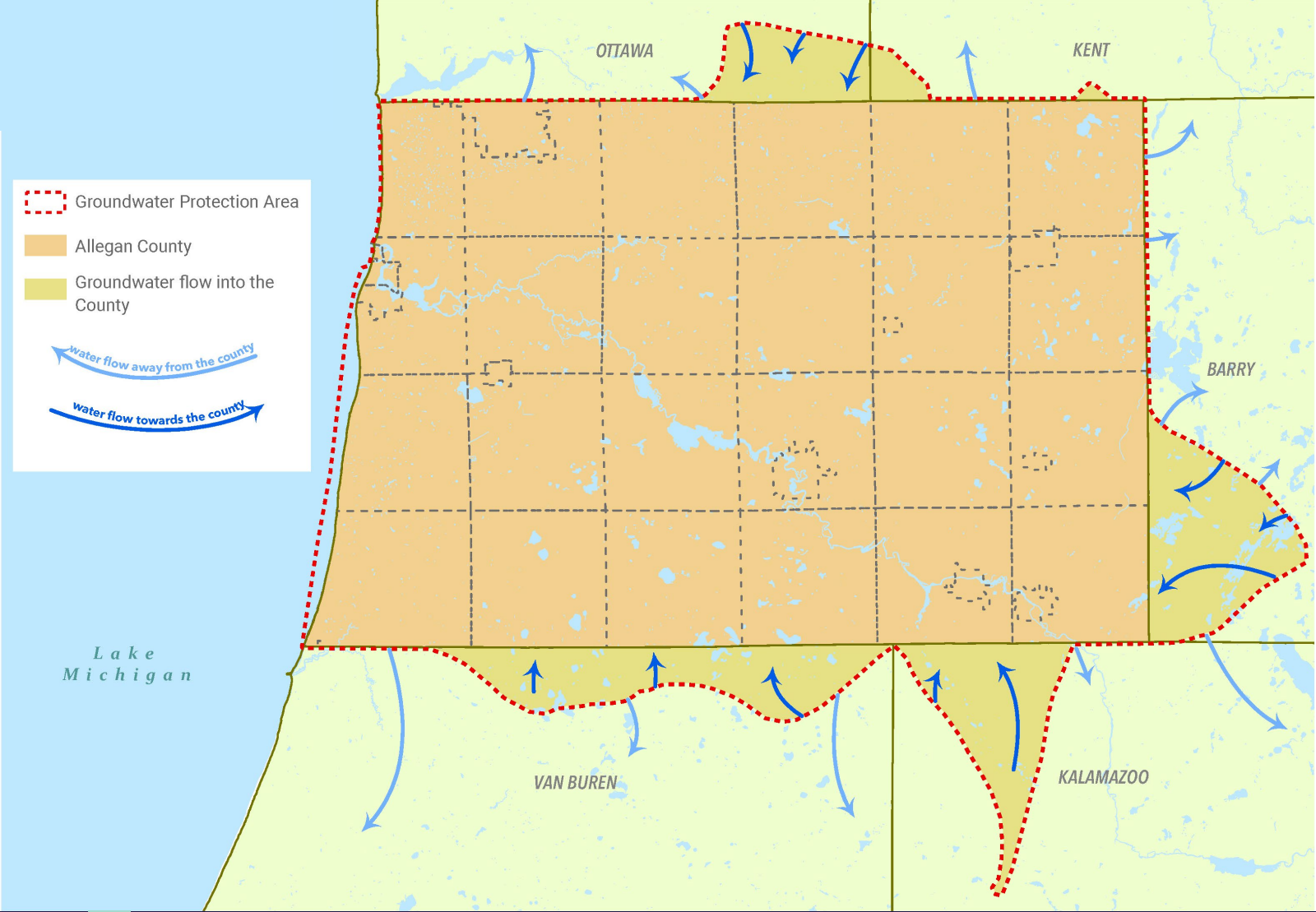


Cross-Section View



groundwater level





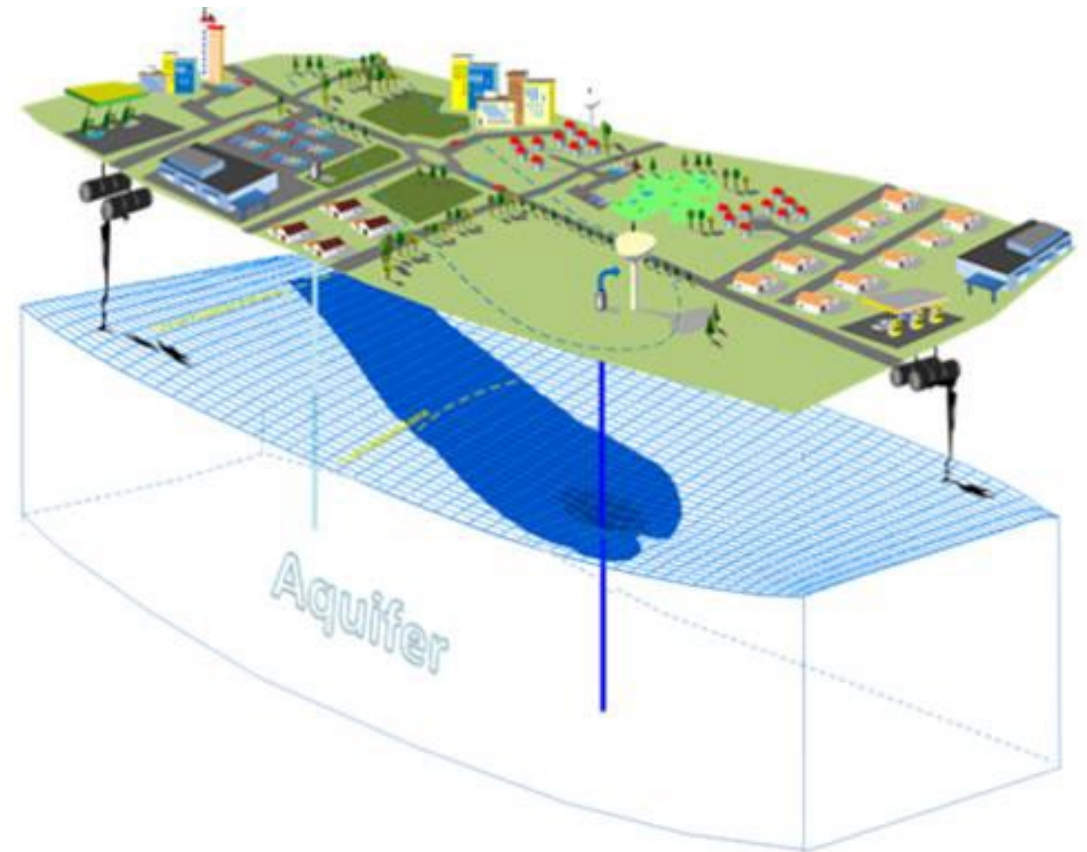
**The Groundwater Protection Area** also includes portions of Ottawa, Kent, Barry, Kalamazoo, and Van Buren Counties where groundwater is entering Alleghen County.

# Groundwater Protection Area

# Wellhead Protection Area (WHPAs)

Wellhead Protection Areas are the source water (or capture) area of individual wells or clusters of wells for 10 years of assumed travel time.

WHPA delineation helps local governments manage land use and human activities in the key source water area for drinking water wells.





# Wellhead Protection Areas (WHPA) of Type 1 Public Supply Wells in Allegan County

**139**  
Active Type 1 Wells

**65**  
WHPAs

**Map Key:**

- Active Type 1 Public Supply Well
- Wellhead Protection Area (WHPA)

\*Type 1 Well provides water to at least 25 residents or 15 living units year-round.

# Wellhead Protection Areas – Type 1 Wells

# Aquifer Yield

# Sustainable Yield

(More difficult to quantify)

## Aquifer Properties

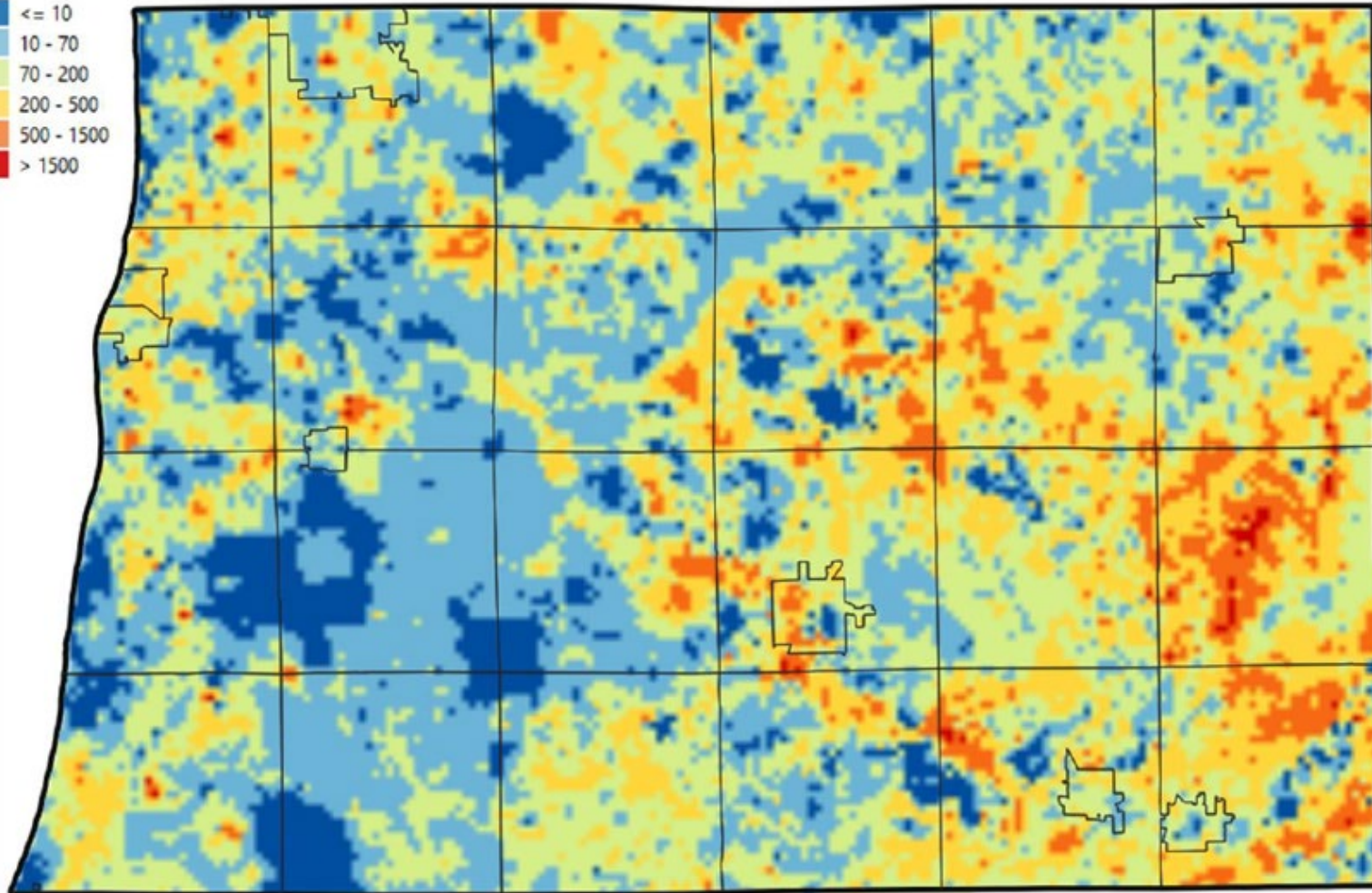
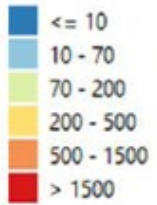
Ability of the aquifer to ***PRODUCE WATER***.

Aquifer yield is directly related to the aquifer's ***TRANSMISSIVITY***.

Water withdrawals that will ***PRESERVE*** groundwater resources over the long-term.

Accounts for aquifer properties, pumping rates, well density, and long-term aquifer recharge.

## Aquifer Yield (GPM)



Aquifer yield is **large** in the East.

- Martin, Gunplain, Hopkins, Otsego, and smaller areas in Monterey and Allegan Townships.

Aquifer yield is **small** in the Central-West.

- Manlius, Clyde, and Lee, as well as in large portions of Overisel, Heath, Valley, and Ganges Townships.

# Estimated Aquifer Yield





# The importance of data collection.



- State Databases (RIDE, Well Logic)
- Monitoring and Testing
- Accurate Reporting