

BUILDING THE WATER CYCLE DIAGRAM

Based on the USGS Water Cycle Diagram

LESSON OVERVIEW

Even before they have had any instruction about the water cycle, students have likely had real life experiences with where water is stored (generally called “pools”) and how it moves through the environment (generally called “fluxes”). This lesson uses an unlabeled version of the 2022 USGS Water Cycle Diagram to activate and assess prior knowledge about the water cycle. As the lesson progresses, key vocabulary is added to the diagram and the diagram is revisited periodically so students can continually build their knowledge of the water cycle. Once students are familiar with the different pools and fluxes of water, they will explore an online interactive displaying the various sizes of pools and fluxes and create a display of the relative amounts of water in seven major groups.

BACKGROUND*

The water cycle describes where water is on Earth and how it moves. Water is stored in the atmosphere, on land, and below the ground. It can be a liquid, a solid, or a gas. Liquid water can be fresh or saline (salty). Water moves between the places it is stored. Water moves at large scales through watersheds, the atmosphere, and below the Earth's surface. Water moves at very small scales too. It is in us, plants, and other organisms. Human activities impact the water cycle, affecting where water is stored, how it moves, and how clean it is.

Learn more about the water cycle (including pools, fluxes, how humans alter the water cycle, climate change impacts, and water availability) from the [U.S. Geological Survey Water Science School](#).

**Background information reproduced, with permission, from USGS.*

ACTIVATE PRIOR KNOWLEDGE

1. Have students explore and annotate the unlabeled water cycle diagram (either on their own, or in a think-pair-share exercise). Ask students:
 - a. What do you notice?
 - b. What components of the water cycle can you identify in this diagram?
 - i. Consider where water might be stored or held (pools) within this diagram.
 - ii. Consider how water might move (fluxes) between pools.
 - c. Is there anything on the diagram that makes you wonder what it is, what it does, and/or its role in the water cycle? If so, place a question mark next to the object or location.
2. Project the unlabeled diagram onto a whiteboard or print out a large poster-sized copy (optionally laminated).
 - a. Have a classroom discussion while students share their thoughts about (and possibly while labeling) the diagram.
 - b. Make a word bank of the vocabulary that students are using while describing the diagram. Keep the list up for students to see.

REINFORCE LEARNING

3. As you teach about content related to the water cycle and specific elements of the hydrosphere, revisit the water cycle diagram, adding vocabulary to the word bank and making connections to other Earth systems (i.e., geosphere, biosphere, atmosphere).
4. As often as you would like, have students revisit and update their annotated water cycle diagram. Ask students to add newly acquired vocabulary onto their diagram. Discuss their annotations and the meaning of the terms with a partner or whole class.

EXPLORE RELATED DATA

5. Compare the sizes of the different pools and fluxes.
 - a. Print the terms associated with types of pools with which your students are familiar. Cut the terms apart so there is one term per card. The cards are color-coded to match the key on the completed water cycle (tan for pools, blue-green for fluxes); if possible, print these cards in color or on colored paper. Ask students to arrange the pools in order on a global scale from the type of pool where the most water (greatest volume) would be found to the pool with the least water.
 - b. Repeat with the different types of fluxes.
6. Visit the USGS Visualization Lab's interactive chart exploring the size of pools and fluxes of water: [Pools and Fluxes in the Water Cycle](#).
 - a. Depending on the student level, choose to view the data on a logarithmic or linear scale. If not discussing scale, it is recommended to use only the logarithmic graph.
 - i. If using both graphs, start with the linear scale and ask students what they notice.
 - ii. Show the graph using the logarithmic scale and have students describe what they notice or wonder about.
 - iii. Discuss the different scales in relation to the water cycle. *For example, the "Ocean – deep" pool has substantially more water than all other pools and viewing the data on a linear scale makes this extremely apparent. However, the differences in amounts of the smaller pools is not discernable on a linear scale.*
 - iv. Click on each pool and flux to see the volume reported numerically, as well as a definition of that pool or flux.
 - b. Depending on the student level, choose to view the data with or without ranges. Discuss with students the benefits of seeing the ranges and not.
 - c. Examine the amount of water stored in the different pools, identified in brown, and the amount in each flux, identified in green. Ask students to compare the results to the way they arranged the cards in step 5.
 - d. Optionally, display the relative amounts of water in the seven groups of pools following the information in the table below.

EXTENSION

Depending on student abilities, consider having the students use the interactive chart or [associated data table](#) to make the calculations themselves and then create their own display showing the relative size of the pools. Note that their calculations might differ from those on the table below. Have them consider why there might be differences (e.g., different methods used for the estimates).

WATER VOLUME OF POOLS AND FLUXES

Grouped Pools	Volume Estimate* (km ³)	Percentage	Total Volume (mL), assuming total World Water = 500.0 mL
Oceans	1,206,000,000 + 134,000,000	96.48%	482.4 mL
Glaciers and other frozen water	25,800,000 + 207,000 + 2,900	1.87%	9.4 mL
Groundwater and soil moisture	22,600,000 + 54,100	1.63%	8.2 mL
Lakes	108,000 + 94,700 + 10,800	0.02%	0.1 mL
Wetlands	14,100	<0.01%	
Atmosphere	10,000 + 3,000	<0.01%	
Rivers	1,900	<0.01%	
Total	1,388,906,500		

*The volume estimate is adapted from Abbott et al. (2019). Abbott et al. note that the **estimate** for each pool or flux "represents the most recent or comprehensive individual estimate".

ASSOCIATED RESOURCES

- To learn more about the new USGS water cycle diagram and to explore the full, interactive USGS Water Cycle Diagram, please visit [water-cycle \(usgs.gov\)](#).
- Visit [Water Pools and Fluxes Data Tables](#) to view the data in table form that is used in the Pools and Fluxes Interactive.
- View the full list of terms and their definitions in the [Glossary of Water Cycle Terms](#) from USGS.

STANDARDS

NGSS

SEP: Developing and Using Models; Analyzing and Interpreting Data

DCI: The Roles of Water in Earth's Surface Processes; Earth's Materials and Systems; Weather and Climate

CCC: Systems and System Models; Energy and Matter; Scale, Proportion, and Quantity; Structure and Function

SDGs

2: Zero Hunger

6: Clean Water and Sanitation

11: Sustainable Cities and Communities

14: Life Below Water

15: Life on Land

Learn more about the United Nation's Sustainable Development Goals (SDGs) and explore resources for educators from UNESCO: <https://en.unesco.org/themes/education/sdgs/material>

WATER CYCLE DIAGRAM TERMS

Global Pools

Ocean — deep

Permafrost

Ocean — mixed

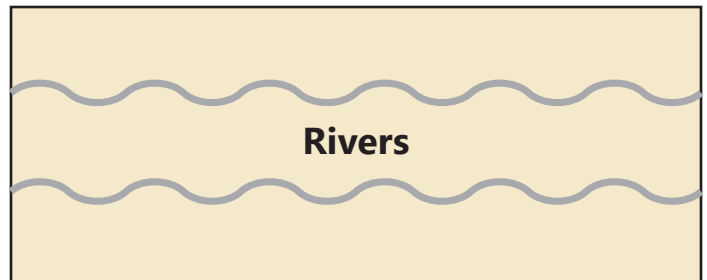
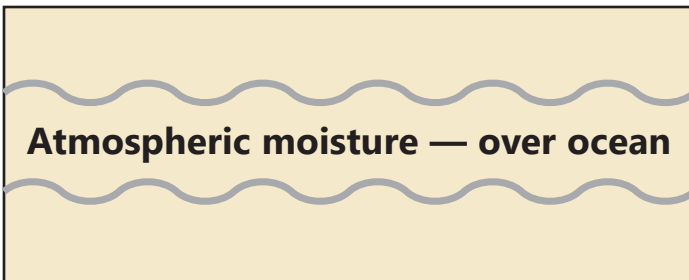
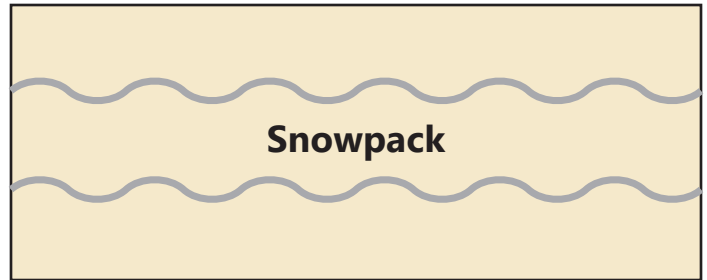
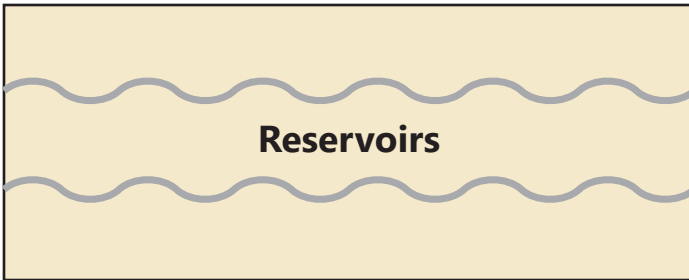
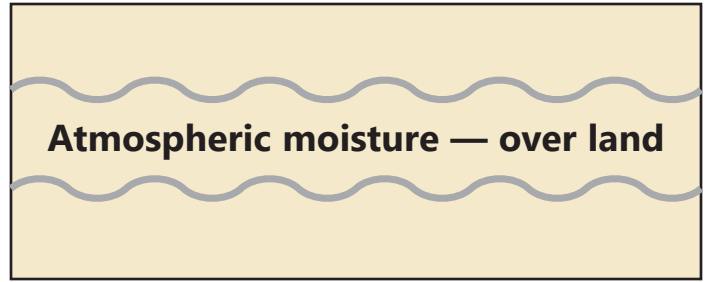
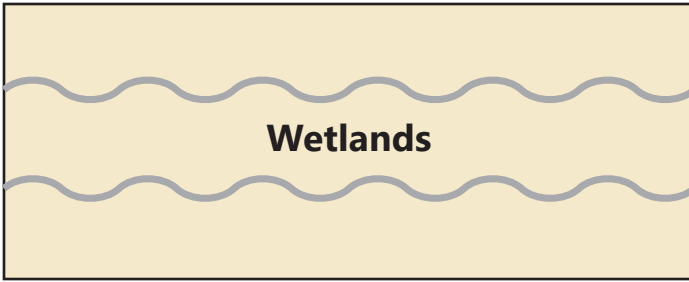
Lakes — fresh

Ice sheets and glaciers

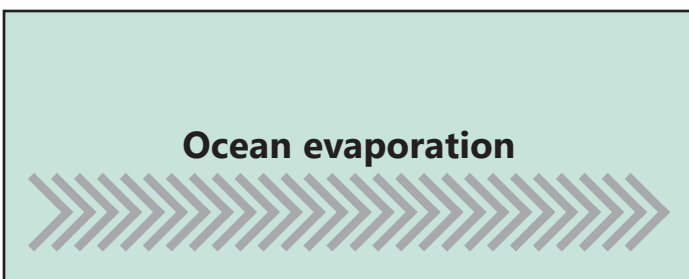
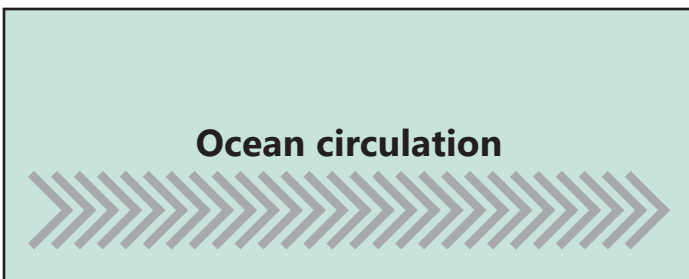
Lakes — saline

Groundwater

Soil moisture



Global Fluxes



Evapotranspiration



Groundwater discharge to ocean



Streamflow to ocean



Streamflow to closed basins



Human water use



**Transport of moisture —
from ocean to land**



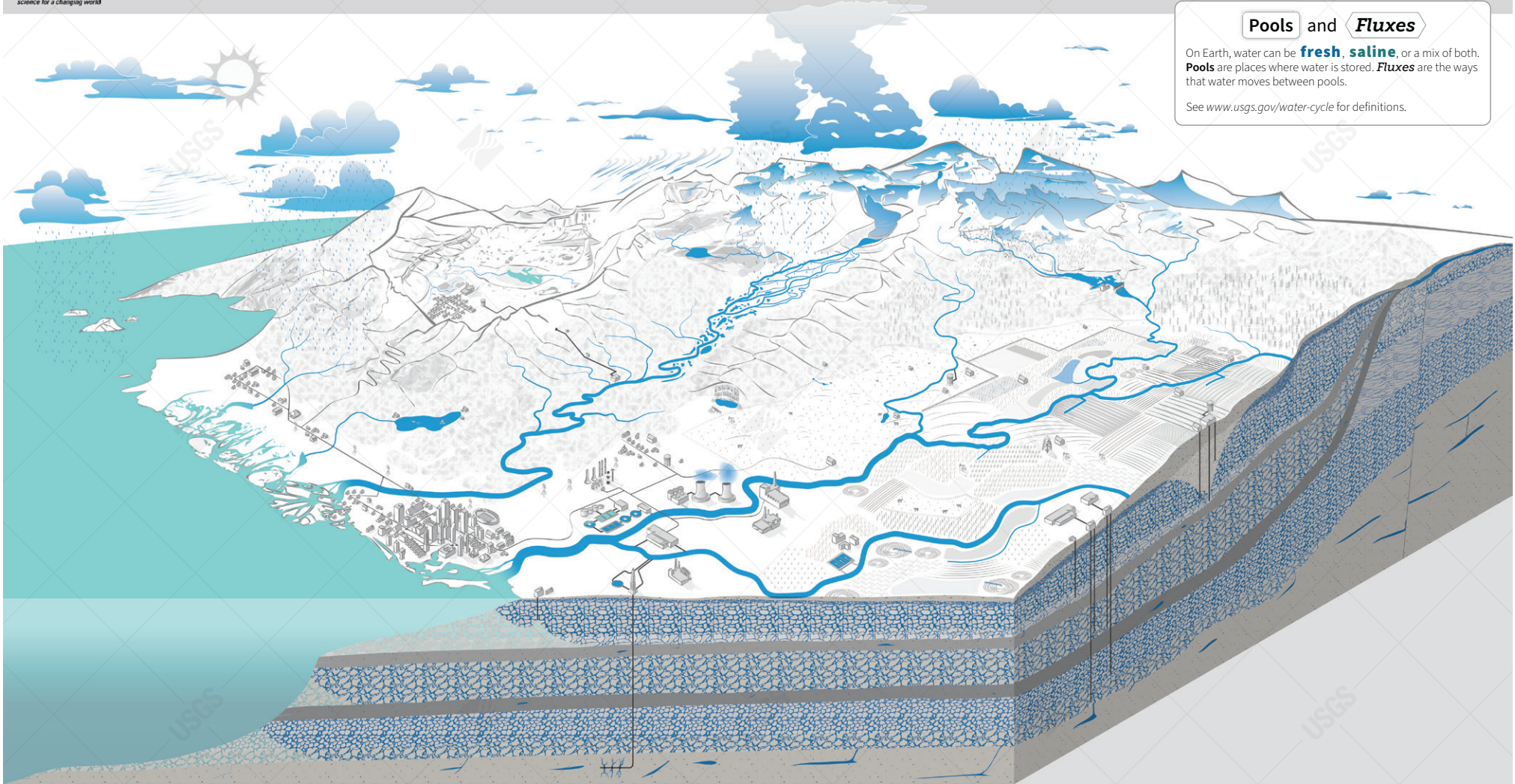
Groundwater recharge



Pools and **Fluxes**

On Earth, water can be **fresh, saline**, or a mix of both. **Pools** are places where water is stored. **Fluxes** are the ways that water moves between pools.

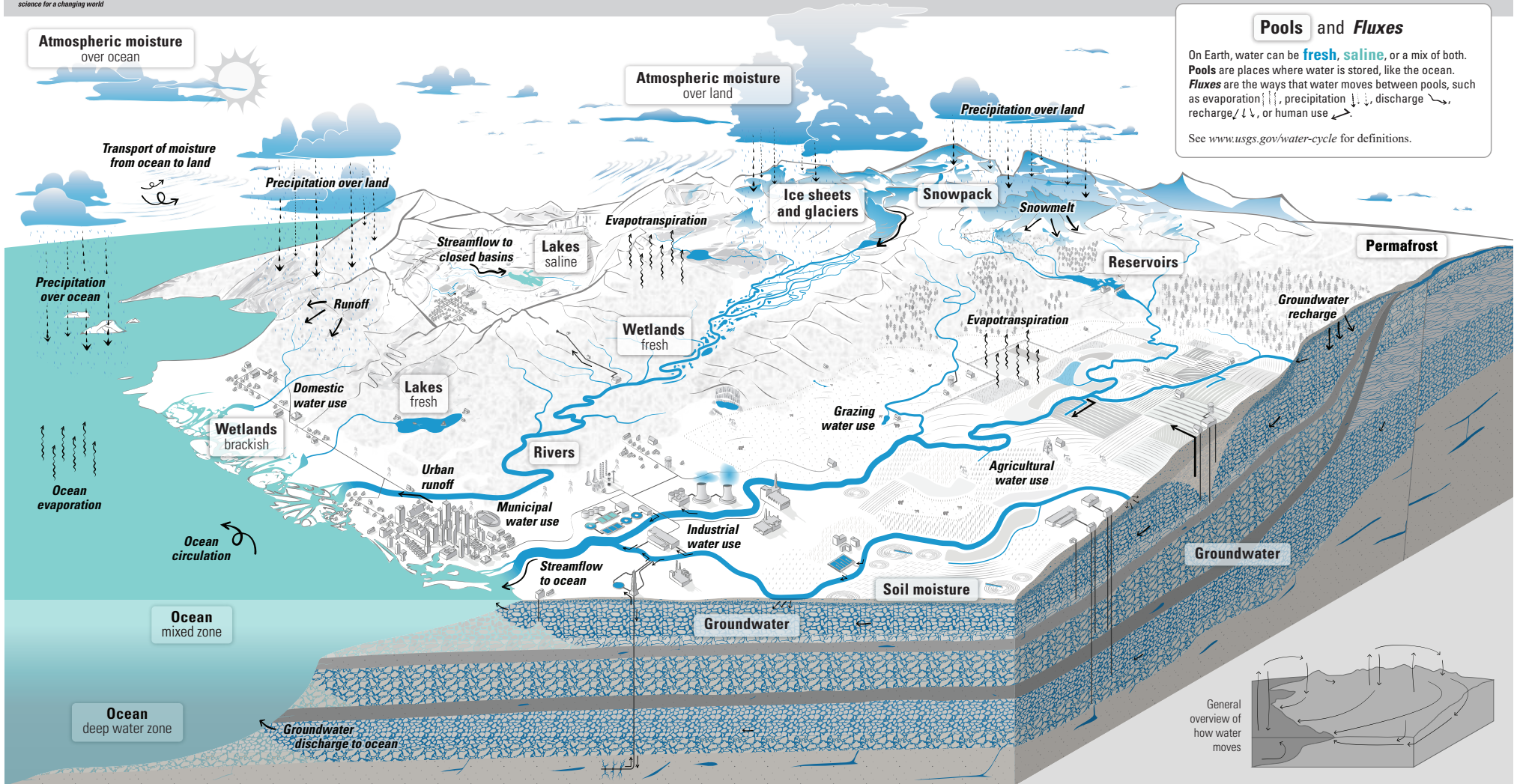
See www.usgs.gov/water-cycle for definitions.



Identify the places where water is stored (pools) and the ways water moves (fluxes) on this illustration.

This unlabeled illustration is for educational use only.

Visit www.usgs.gov/water-cycle to view and download a labeled diagram of Earth's water cycle.



Pools and Fluxes

On Earth, water can be **fresh, saline**, or a mix of both. **Pools** are places where water is stored, like the ocean. **Fluxes** are the ways that water moves between pools, such as evaporation (↑↑), precipitation (↓↓), discharge (↘), recharge (↙), or human use (↔).
See www.usgs.gov/water-cycle for definitions.

The Water Cycle

The water cycle describes where water is found on Earth and how it moves. Water can be stored in the atmosphere, on Earth's surface, or below the ground. It can be in a liquid, solid, or gaseous state. Water moves between the places it is stored at large scales and at very small scales. Water moves naturally and because of human interaction, both of which affect where water is stored, how it moves, and how clean it is.

Liquid water can be fresh, saline (salty), or a mix (brackish). Ninety-six percent of all water is saline and stored in **oceans**. Places like the ocean, where water is stored, are called **pools**. On land, saline water is stored in **saline lakes**, whereas fresh water is stored in liquid form in **freshwater lakes**, artificial **reservoirs**, **rivers**, **wetlands**, and in soil as **soil moisture**. Deeper underground, liquid water is stored as **groundwater** in aquifers, within the cracks and pores of rock. The solid, frozen form of water is stored in **ice sheets**, **glaciers**, and **snowpack** at high elevations or near the Earth's poles. Frozen water is also found in the soil as **permafrost**. Water vapor, the gaseous form of water, is stored as **atmospheric moisture** over the ocean and land.

As it moves, water can transform into a liquid, a solid, or a gas. The different ways in which water moves between pools are known as **fluxes**. **Circulation** mixes water in the oceans and transports water vapor in the atmosphere. Water moves between the atmosphere and the Earth's surface through **evaporation**, **evapotranspiration**, and **precipitation**. Water moves across the land surface through **snowmelt**, **runoff**, and **streamflow**. Through infiltration and **groundwater recharge**, water moves into the ground. When underground, groundwater flows within aquifers and can return to the surface through **springs** or from natural **groundwater discharge** into rivers and oceans.

Humans alter the water cycle. We redirect rivers, build dams to store water, and drain water from wetlands for development. We use water from rivers, lakes, reservoirs, and groundwater aquifers. We use that water (1) to supply our **homes and communities**; (2) for **agricultural** irrigation and **grazing** livestock; and (3) in **industrial** activities like thermoelectric power generation, mining, and aquaculture. The amount of available water depends on how much water is in each pool (water quantity). Water availability also depends on when and how fast water moves (water timing), how much water is used (water use), and how clean the water is (water quality).

Human activities affect **water quality**. In agricultural and urban areas, irrigation and precipitation wash fertilizers and pesticides into rivers and groundwater. Power plants and factories return heated and contaminated water to rivers. Runoff carries chemicals, sediment, and sewage into rivers and lakes. Downstream from these types of sources, contaminated water can cause harmful algal blooms, spread diseases, and harm habitats. **Climate change** is also affecting the water cycle. It affects water quality, quantity, timing, and use. Climate change is also causing ocean acidification, sea level rise, and extreme weather. Understanding these impacts can allow progress toward sustainable water use.