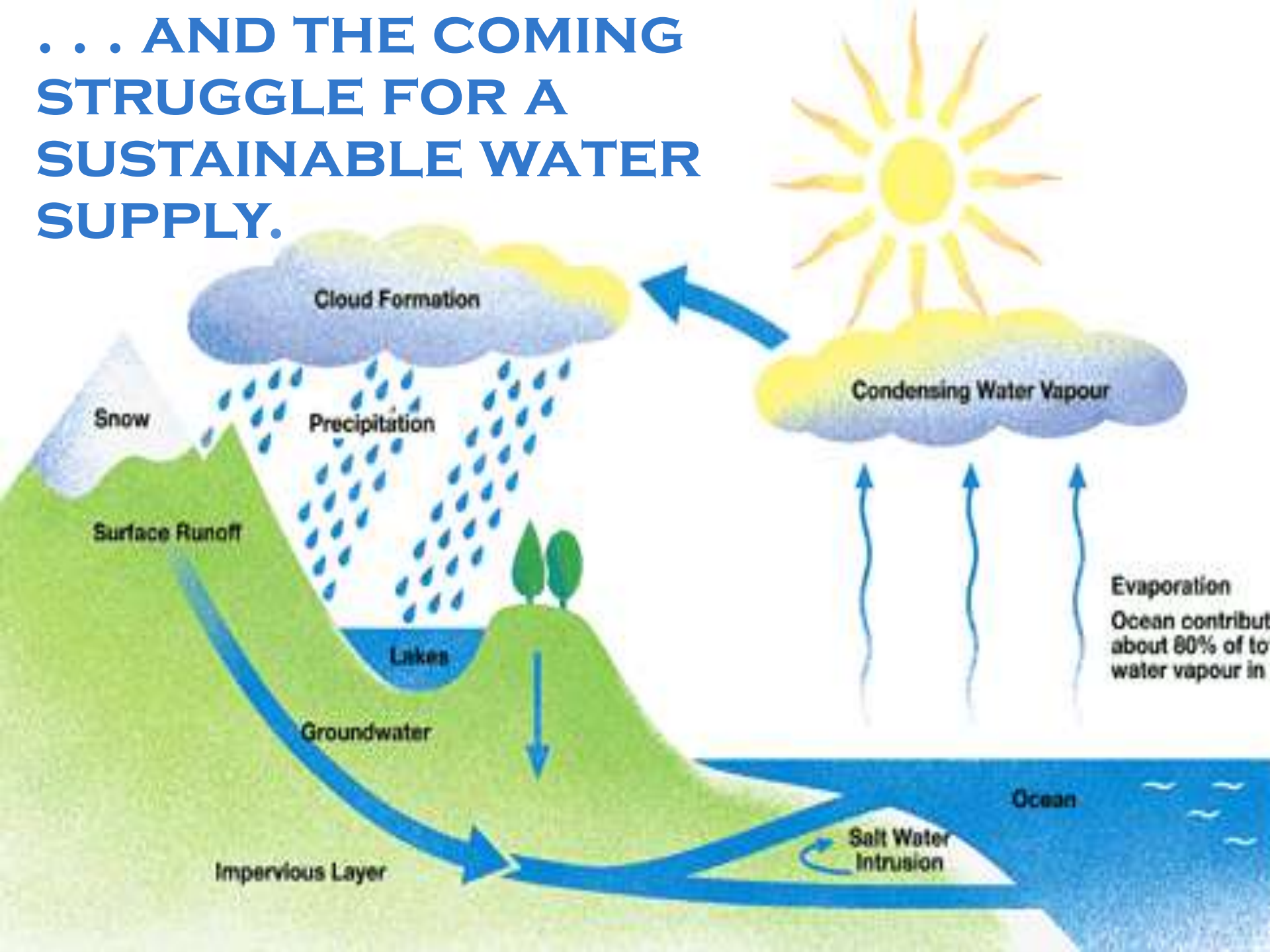


# THE END OF THE ERA OF CHEAP AND ABUNDANT WATER



# ... AND THE COMING STRUGGLE FOR A SUSTAINABLE WATER SUPPLY.



Presented by  
**Frank W. Fletcher, PhD, PG**

at

***OUR THREATENED WATER SUPPLY***

Hosted by

**Committee on the Stewardship of Creation  
The Diocese of Virginia**

**September 18, 2010**

# *Foreword*

- For inhabitants of the Eastern United States, water has always been relatively cheap and abundant.
- This era is coming to an end.
- The surface supply of freshwater is nearly “maxed out,” and prospects for large gains in the surface water supply are not promising.
- Groundwater withdrawals from the artesian aquifers of the Atlantic Coastal Plain far exceed the natural rate of replenishment; the regional groundwater system is in overdraft and the supply is steadily shrinking.



- We can no longer depend on expanding the two traditional sources of freshwater—surface water and groundwater.
- In the coming new era, we will shift from reliance on the traditional sources of freshwater to a diversified and sustainable water supply characterized by nontraditional water sources,

***especially water recycling and reuse.***



# ***Virginia's Water Supply***

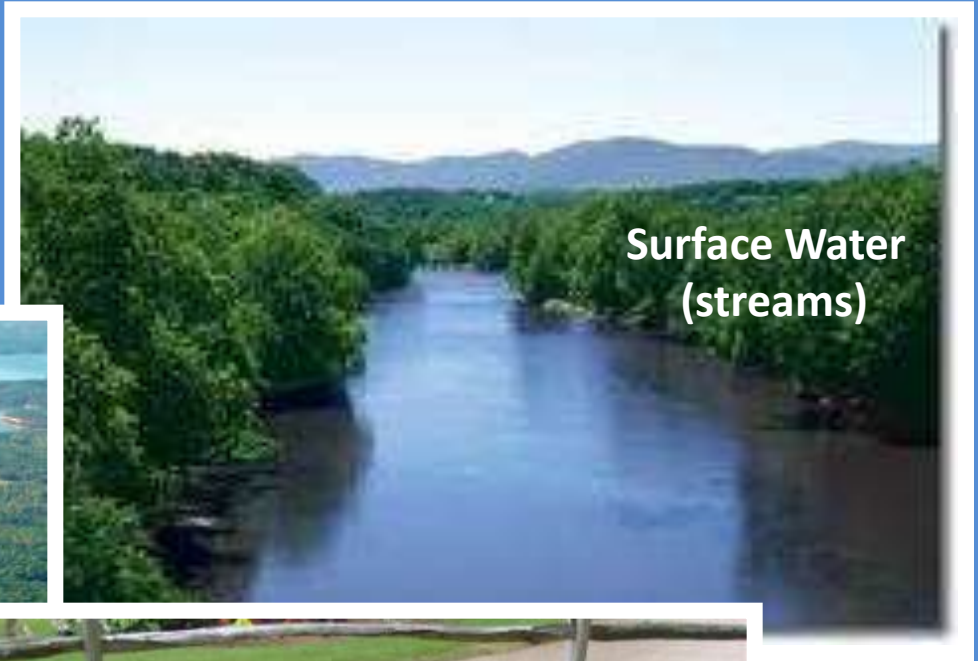




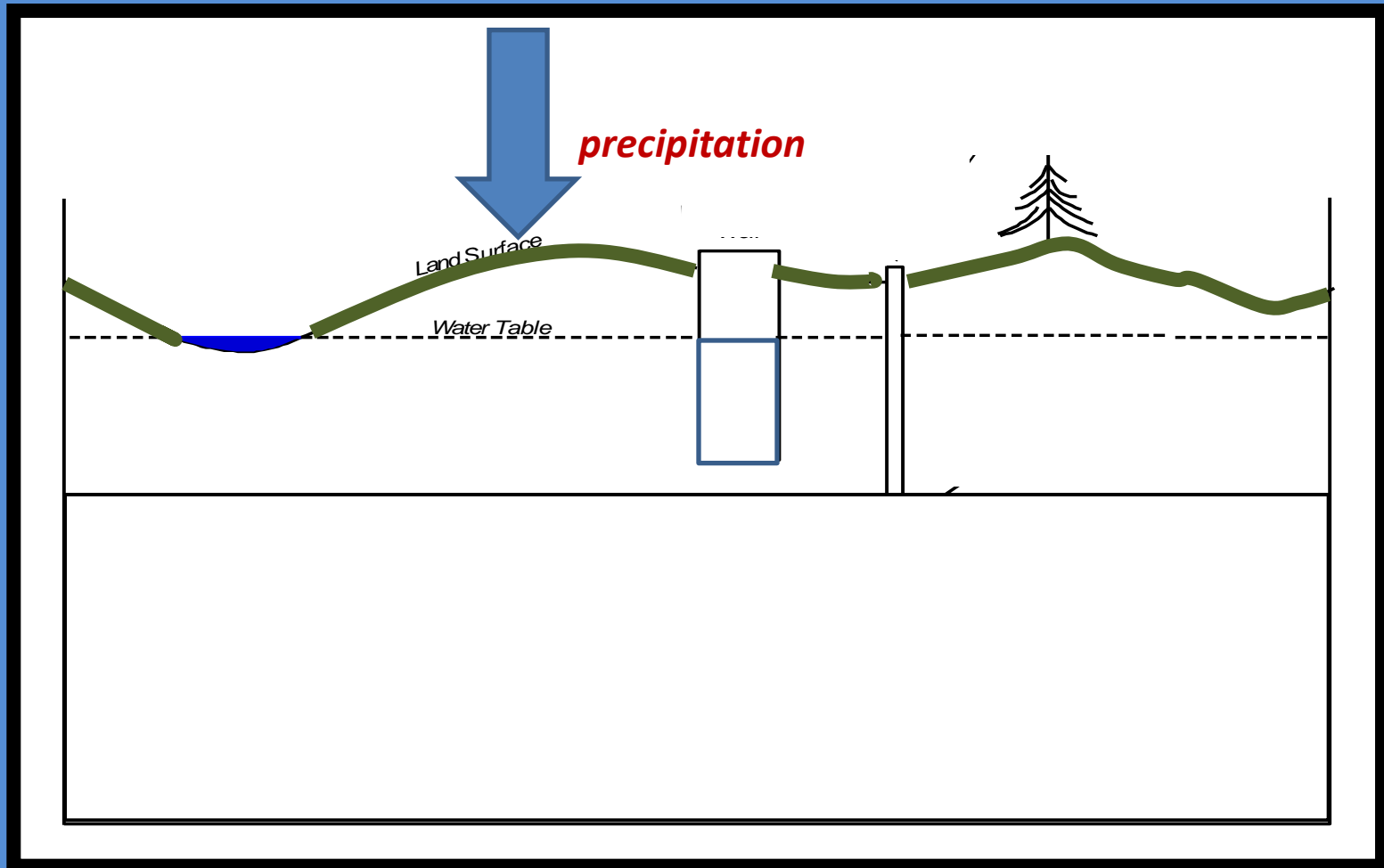
## *Water Supply*

The quantity of water available  
for human and other uses.

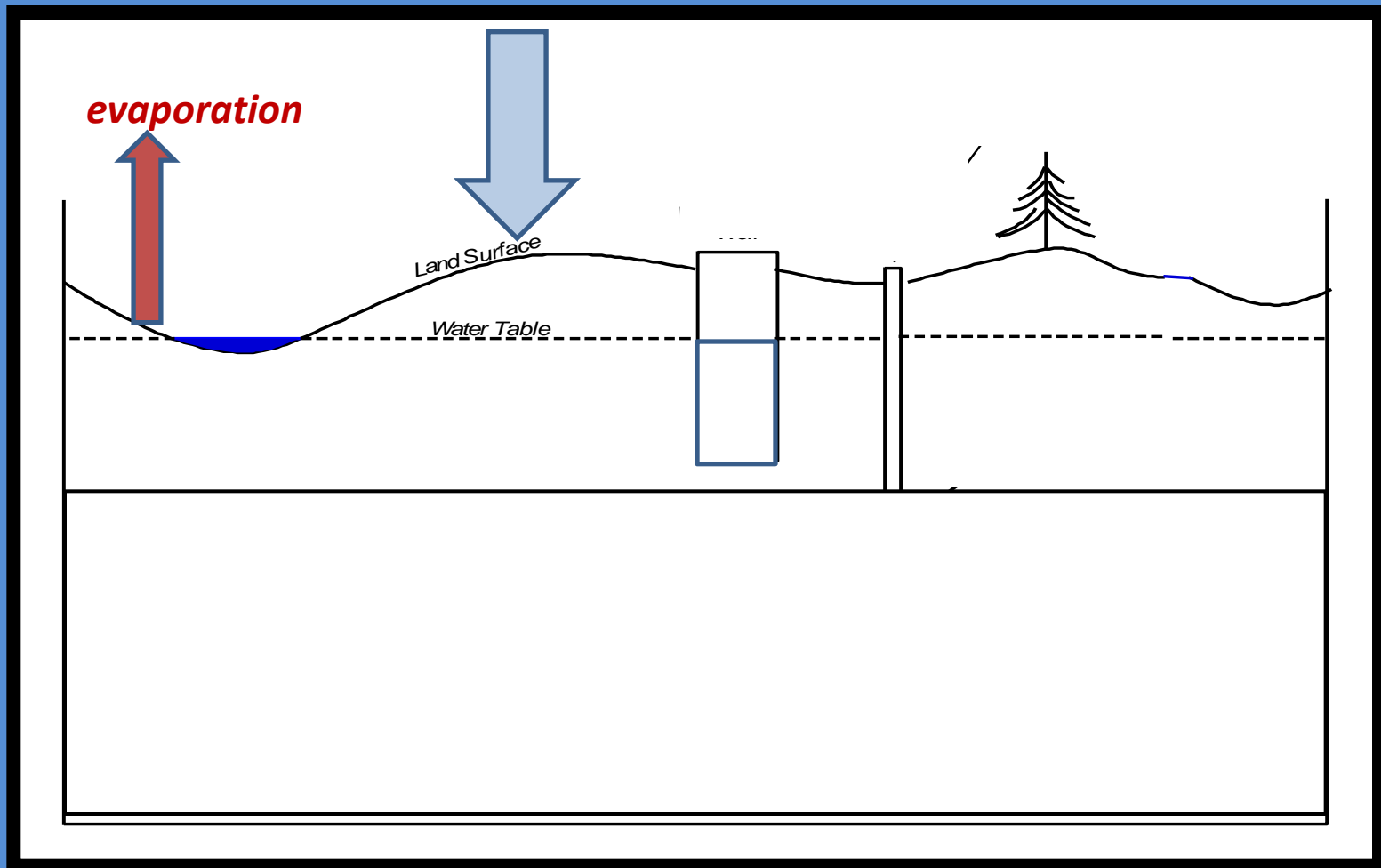
# What are Virginia's traditional water supply sources?



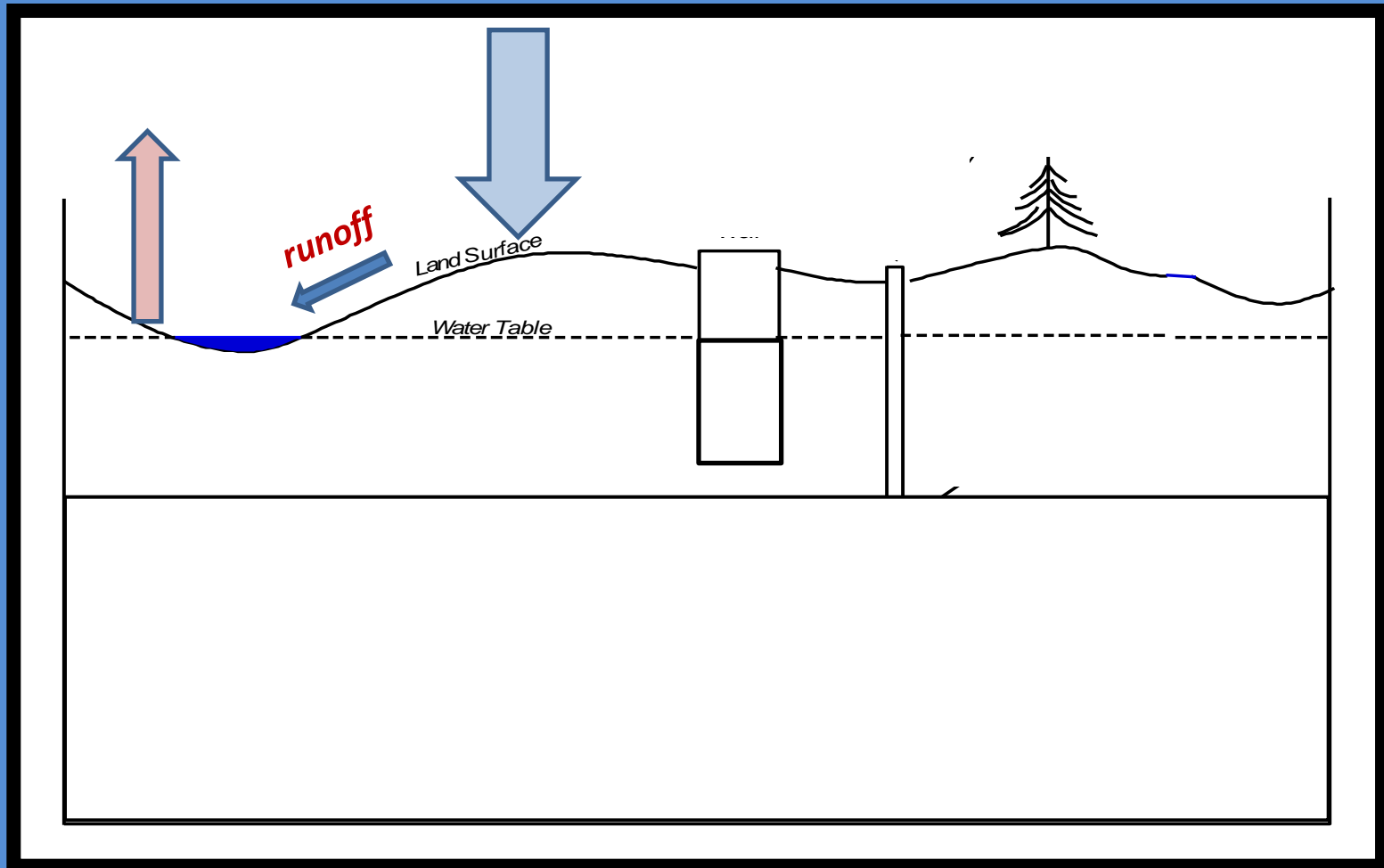
Virginia's water supply is continuously replenished by precipitation.



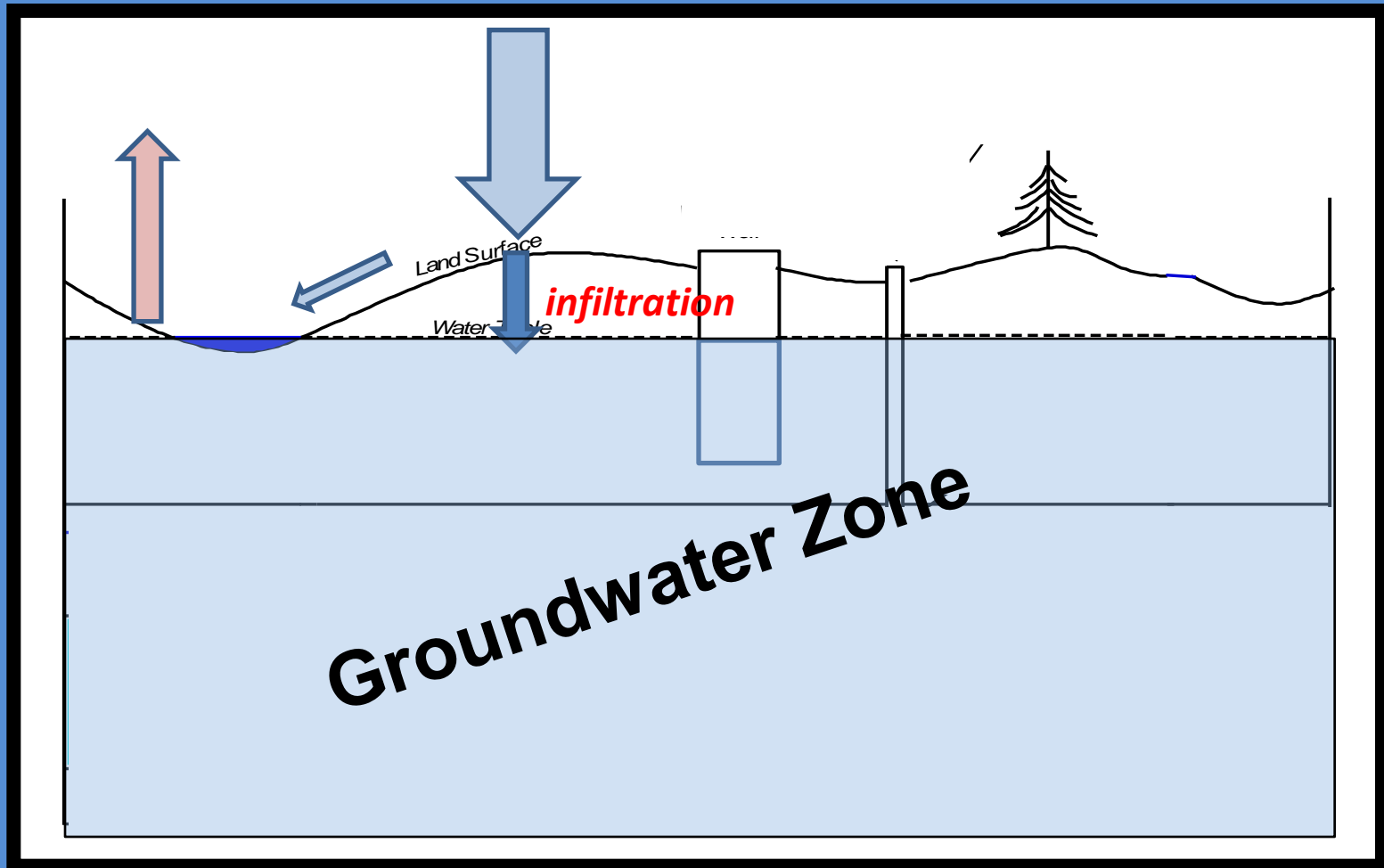
A portion of the water that falls to the land surface evaporates.



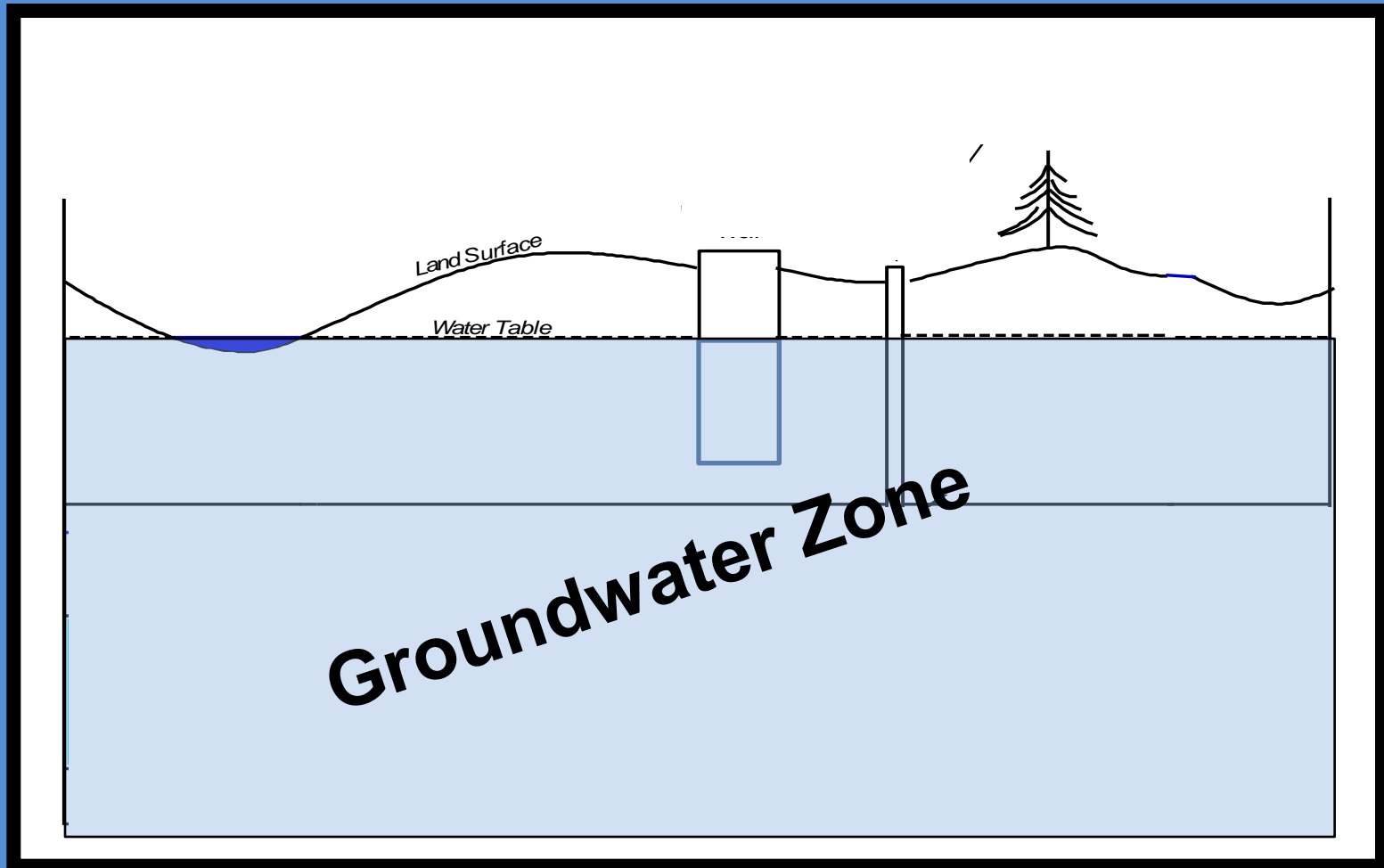
Another portion recharges streams, lakes, and other surface water bodies – making surface water a *renewable resource*.



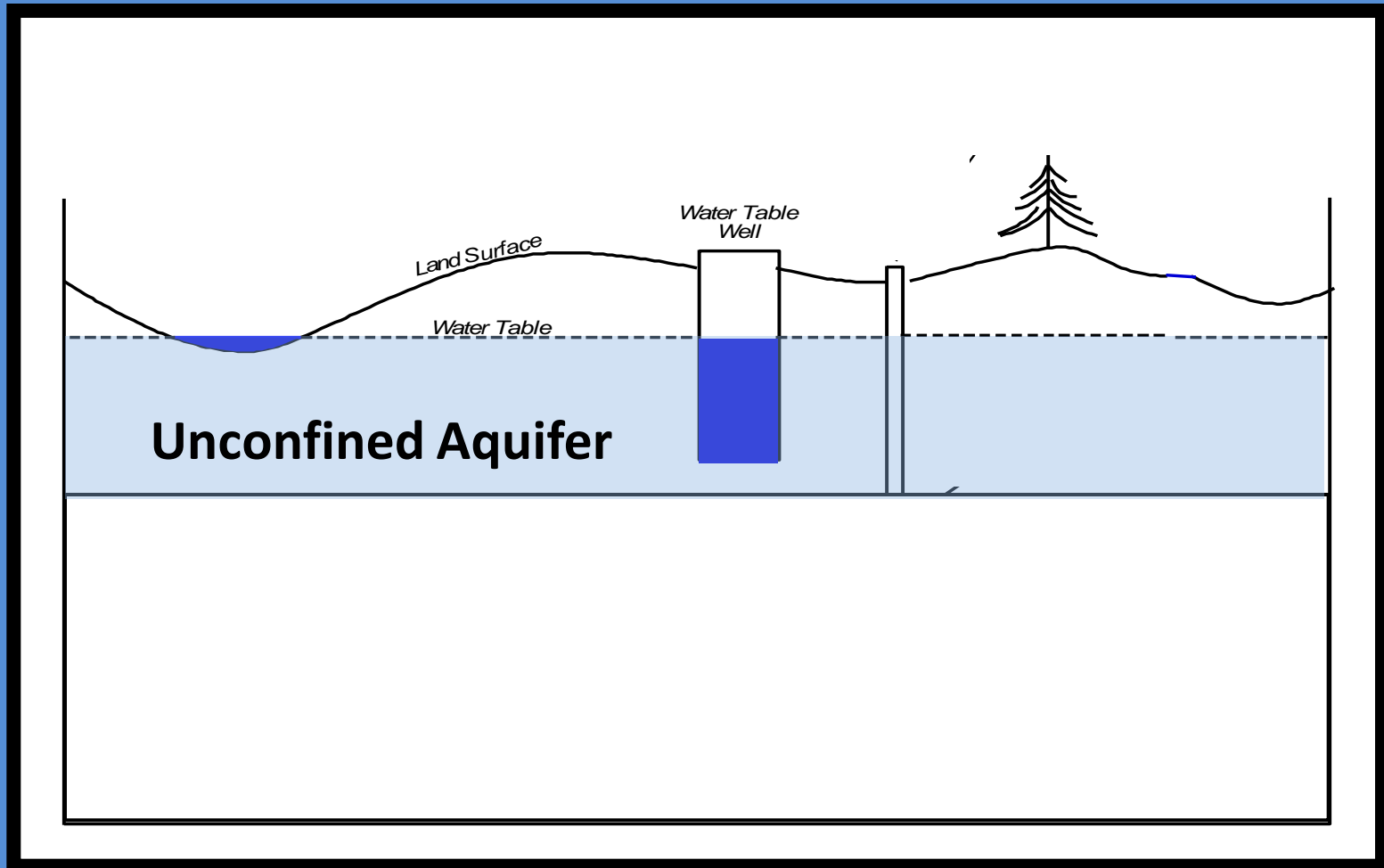
Still another portion infiltrates downward into the *groundwater zone*.



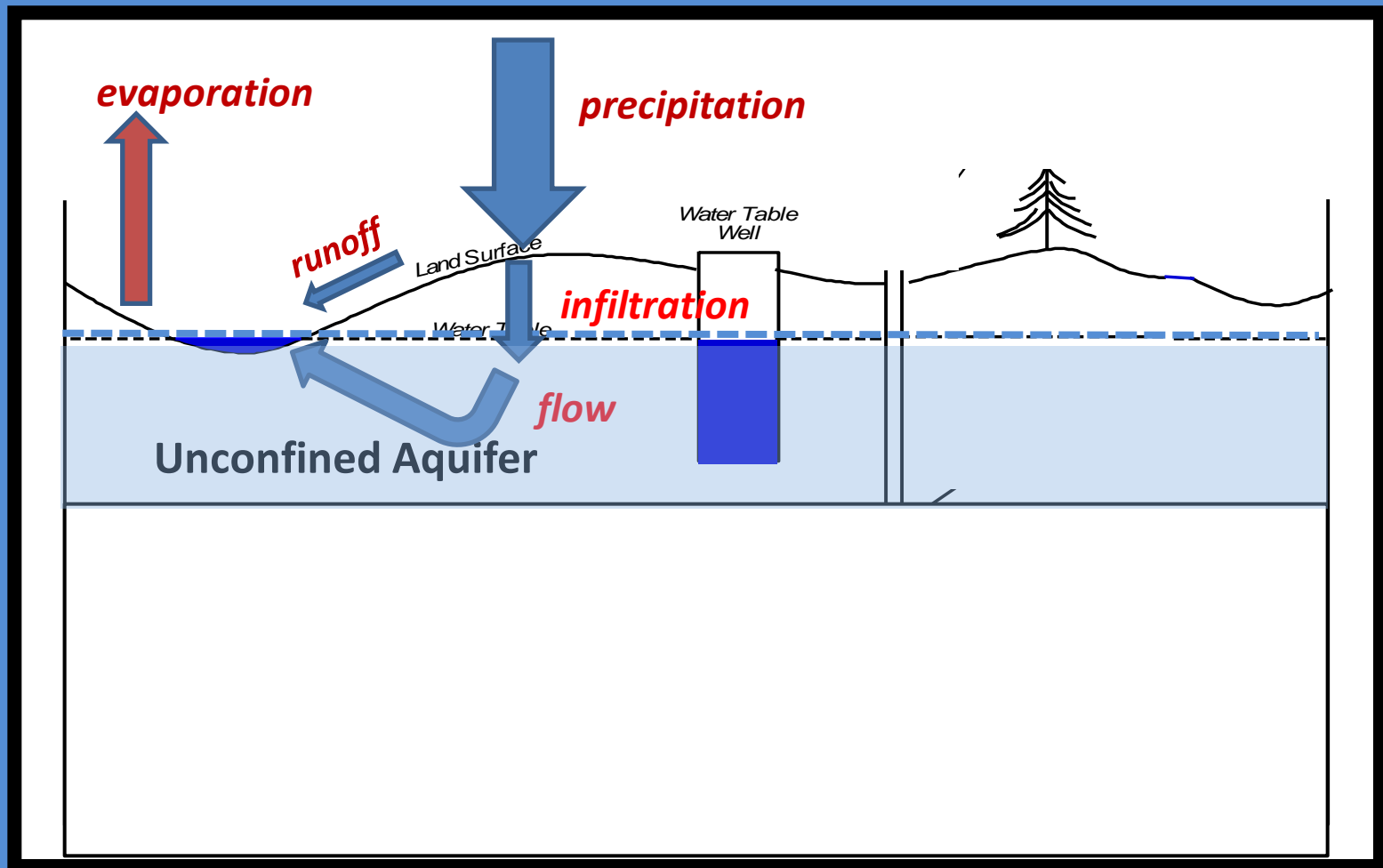
The groundwater zone is composed of two types of permeable, water bearing units called *aquifers*.



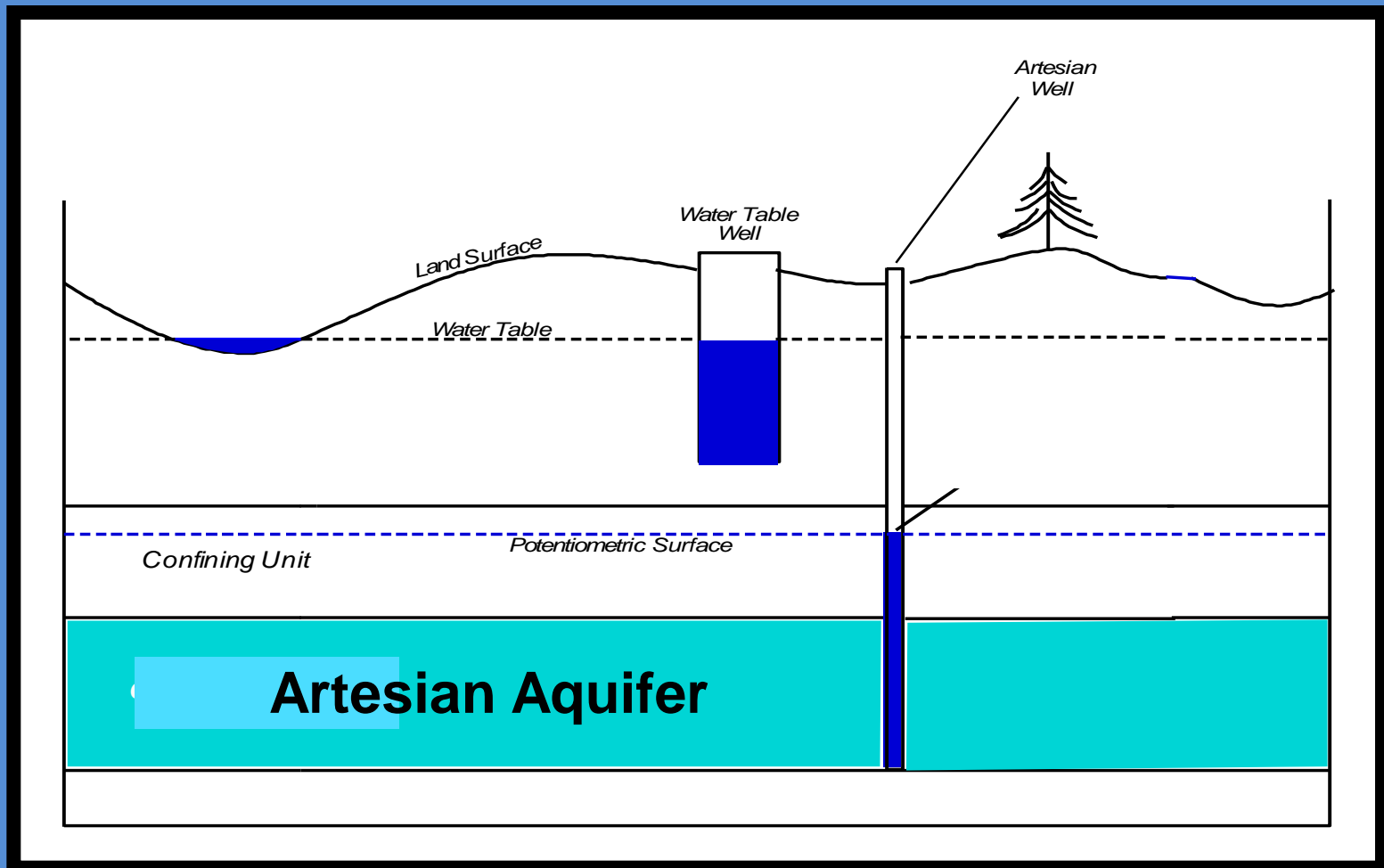
The shallow aquifer is called the *unconfined* (or *water table*) aquifer.



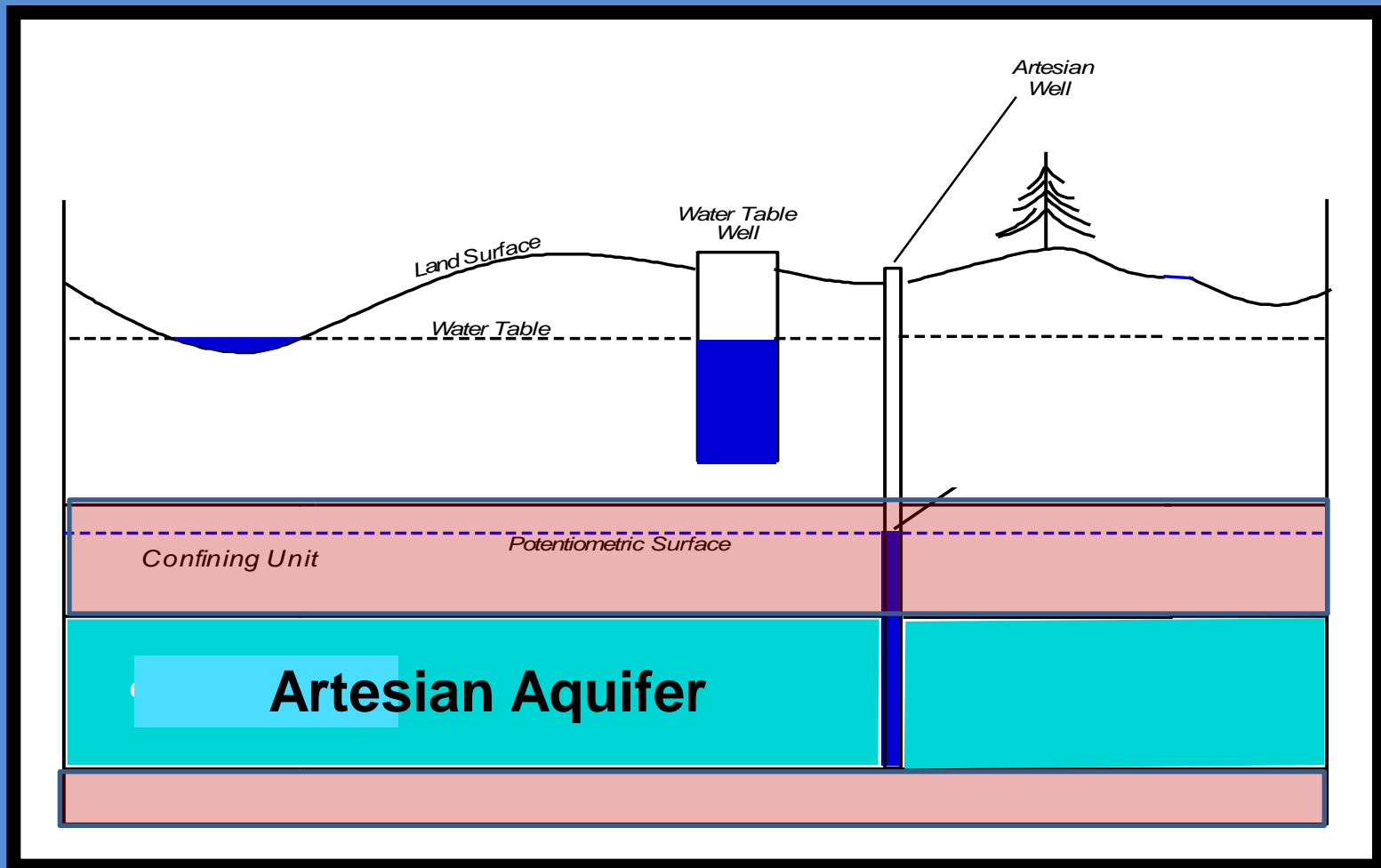
Surface water and shallow groundwater of the unconfined aquifer form an interconnected system.



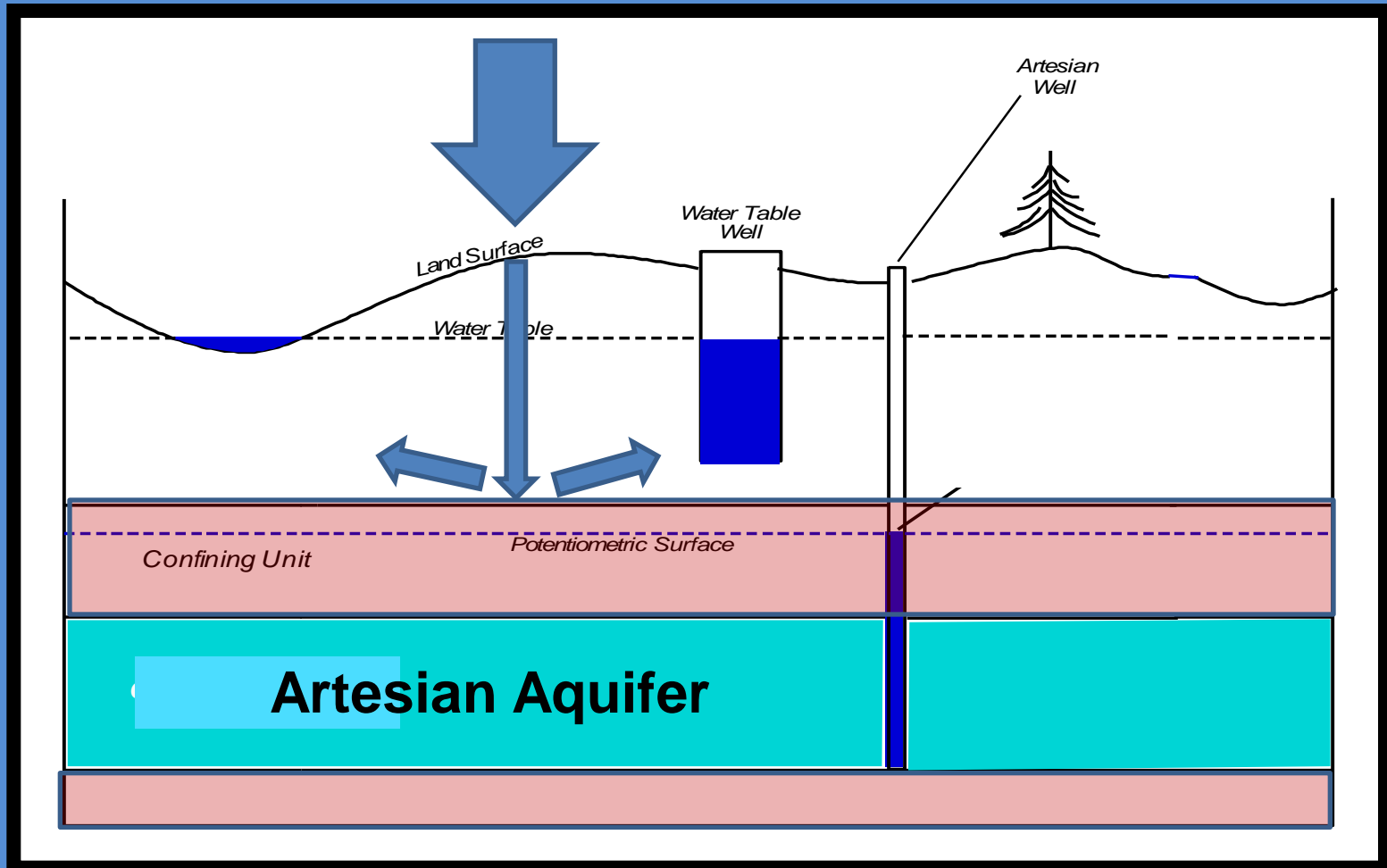
The deep aquifers are called *artesian* (or *confined*) aquifers.



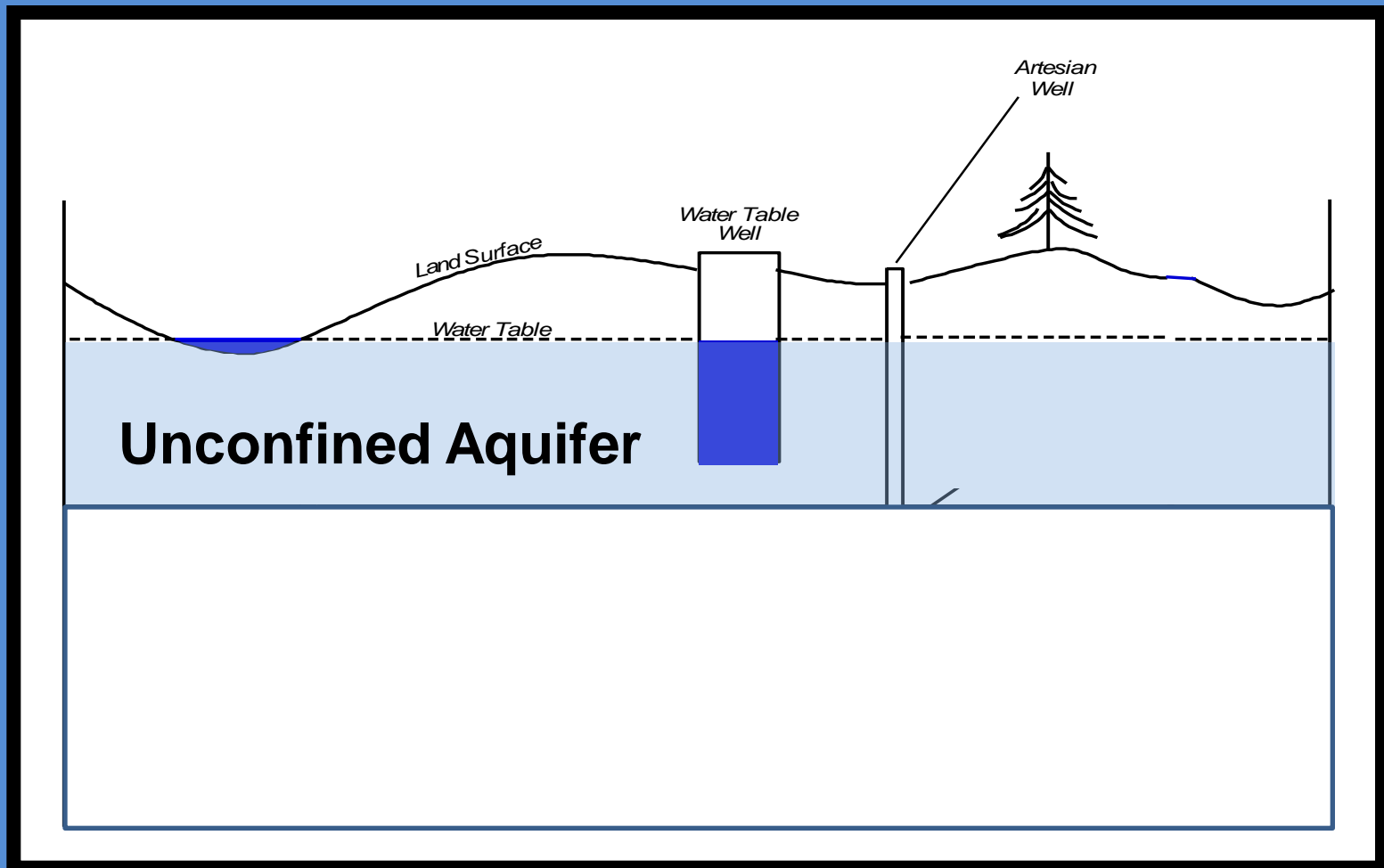
Artesian aquifers are separated by poorly permeable layers called *confining units*.



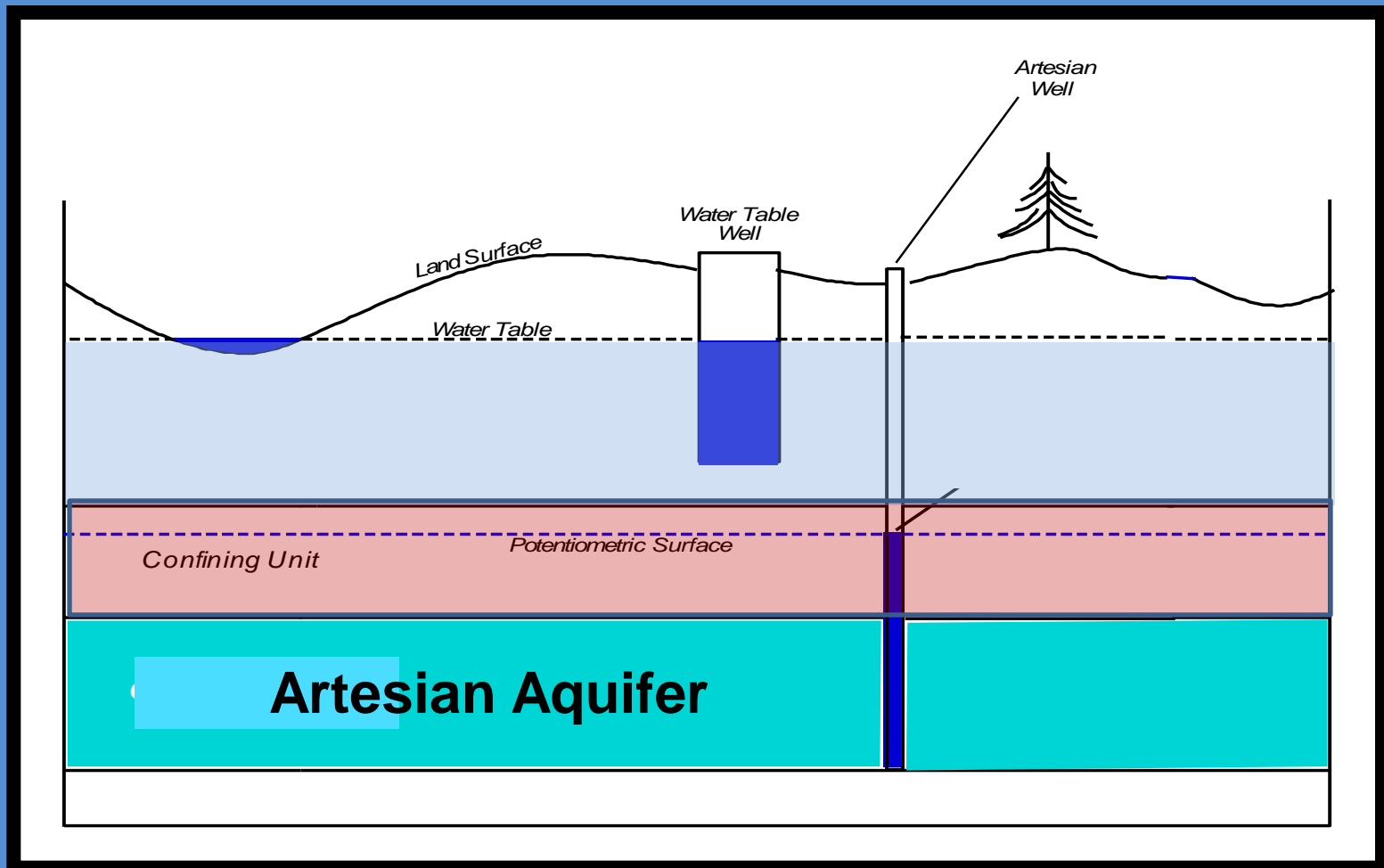
Confining units retard deep infiltration and, therefore, inhibit aquifer recharge from precipitation.



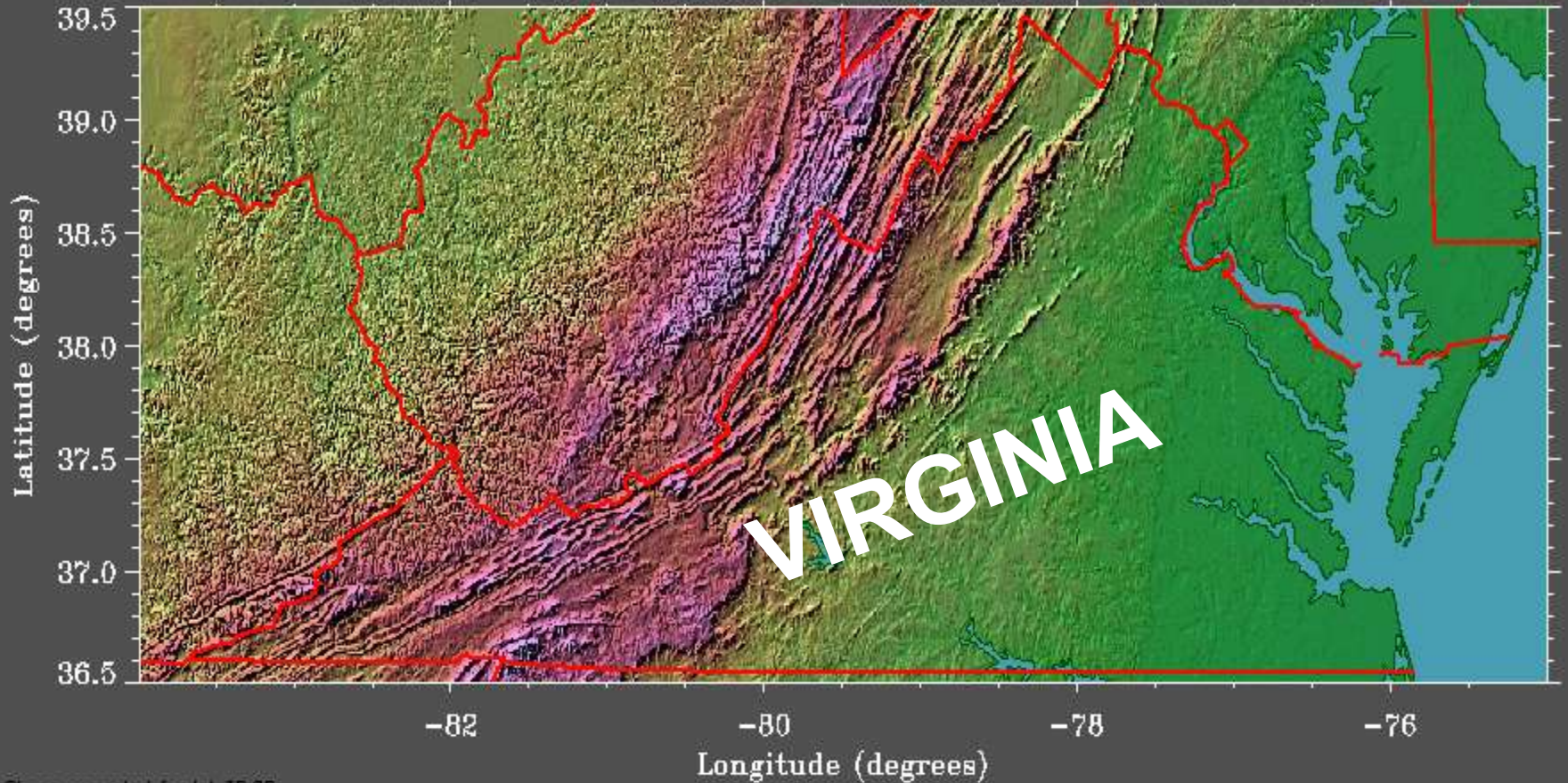
Thus, unconfined aquifers may be considered a *renewable resource*.



The artesian aquifers should be viewed as  
*a nonrenewable resource.*



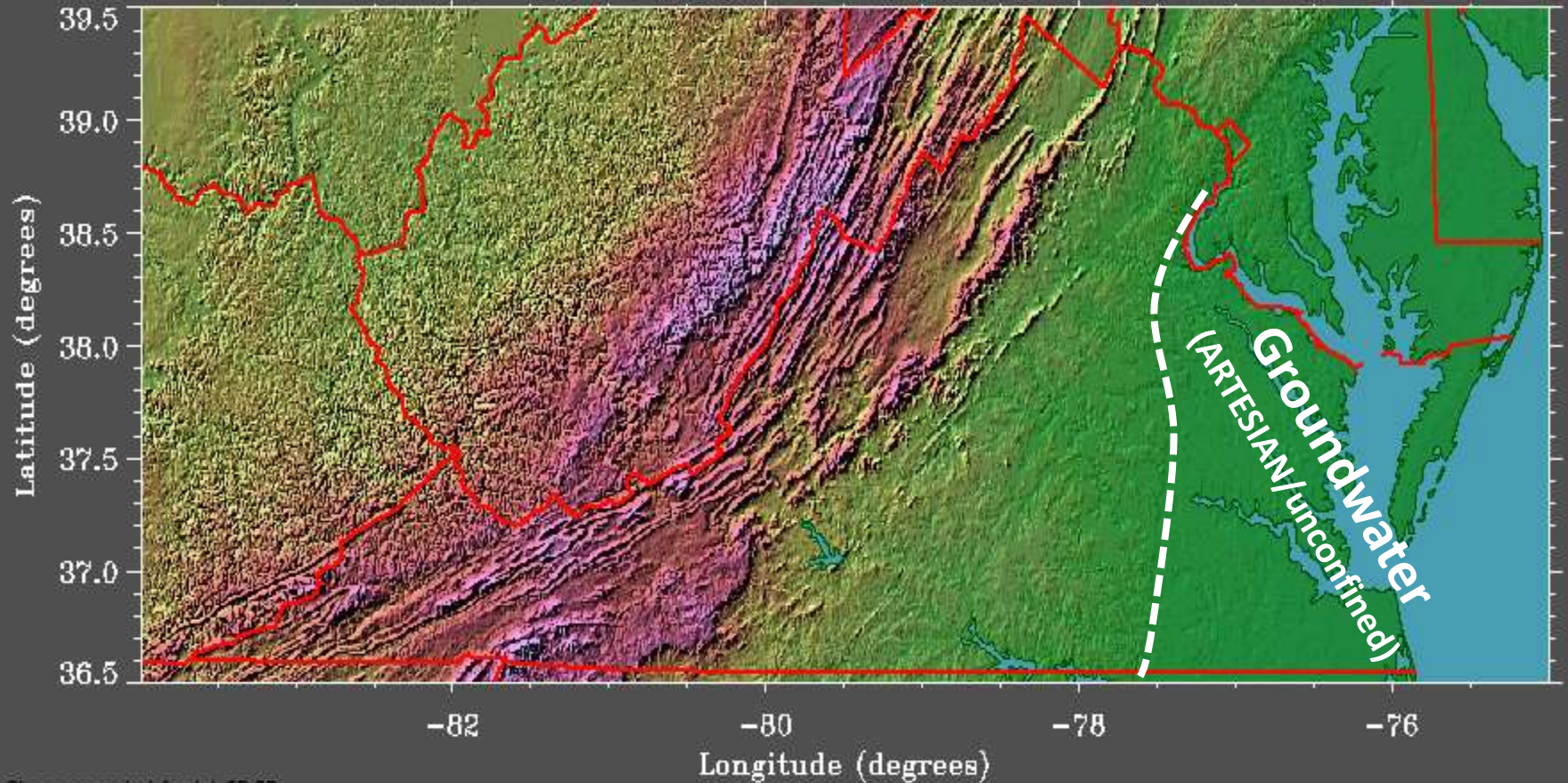
The water sources of choice depend on where you live.



Shape corrected for lat 38.00

V 2.2 COPYRIGHT © 1995 by RAY STERNER, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

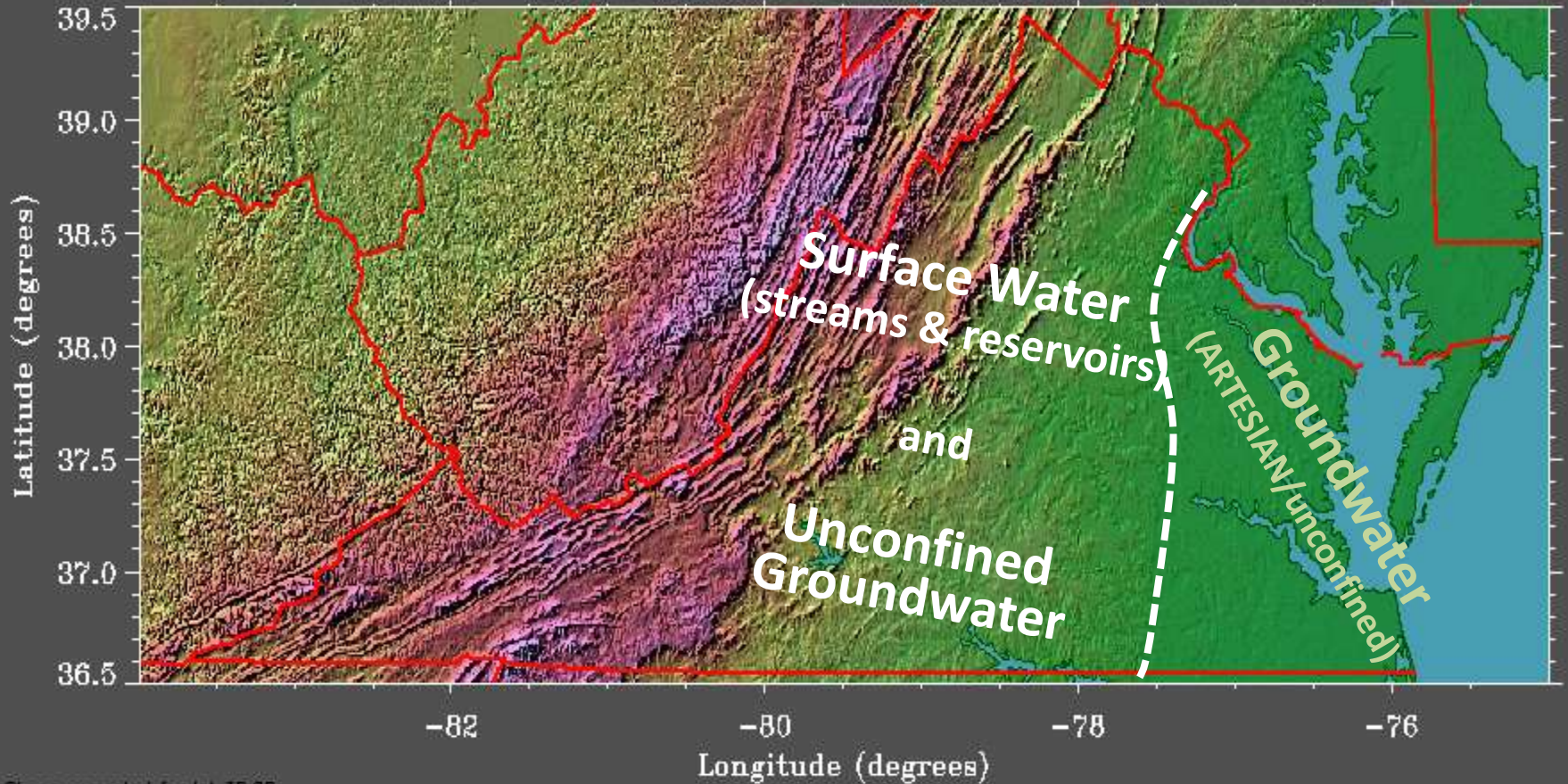
# The Virginia Coastal Plain



Shape corrected for lat 38.00

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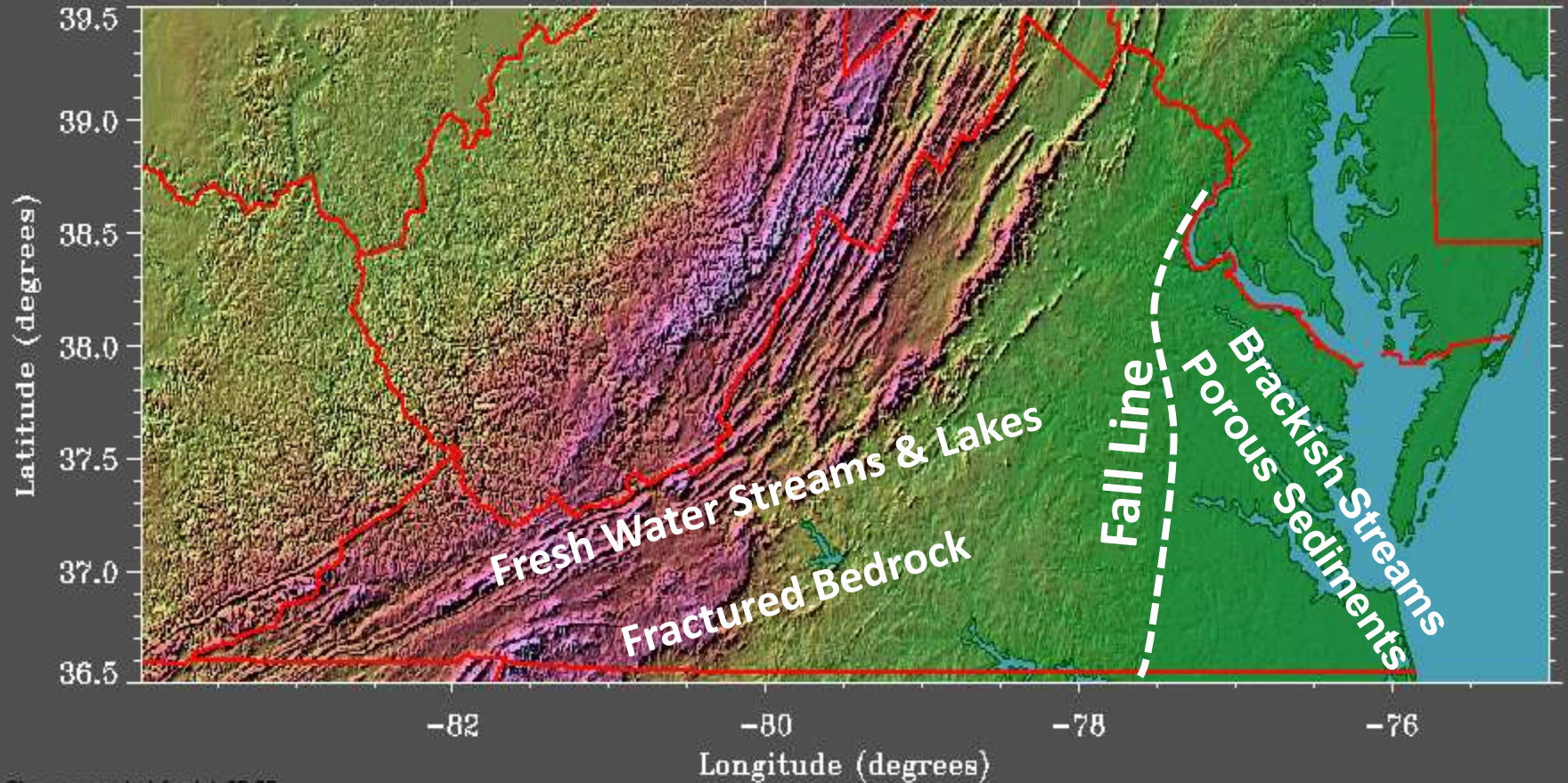
# The Piedmont and Appalachian Provinces.



Shape corrected for lat 38.00

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The choice is dictated by geology and hydrology.



Shape corrected for lat 38.00

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How much  
water do  
we use?



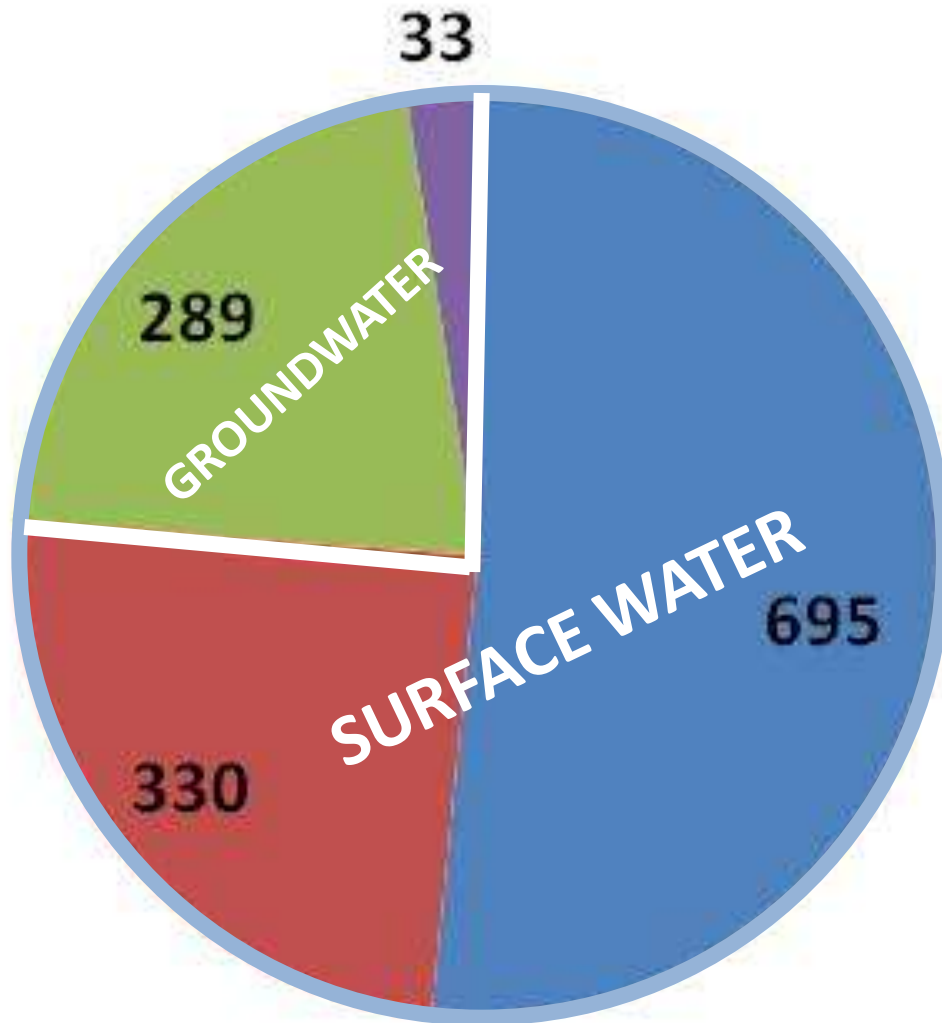


## *Water Withdrawal*

Removal of water from any natural source or reservoir such as a lake, stream, or aquifer for human use.

## Virginia Water Withdrawals by Source

*million gallons per day*



■ Stream

■ Reservoir

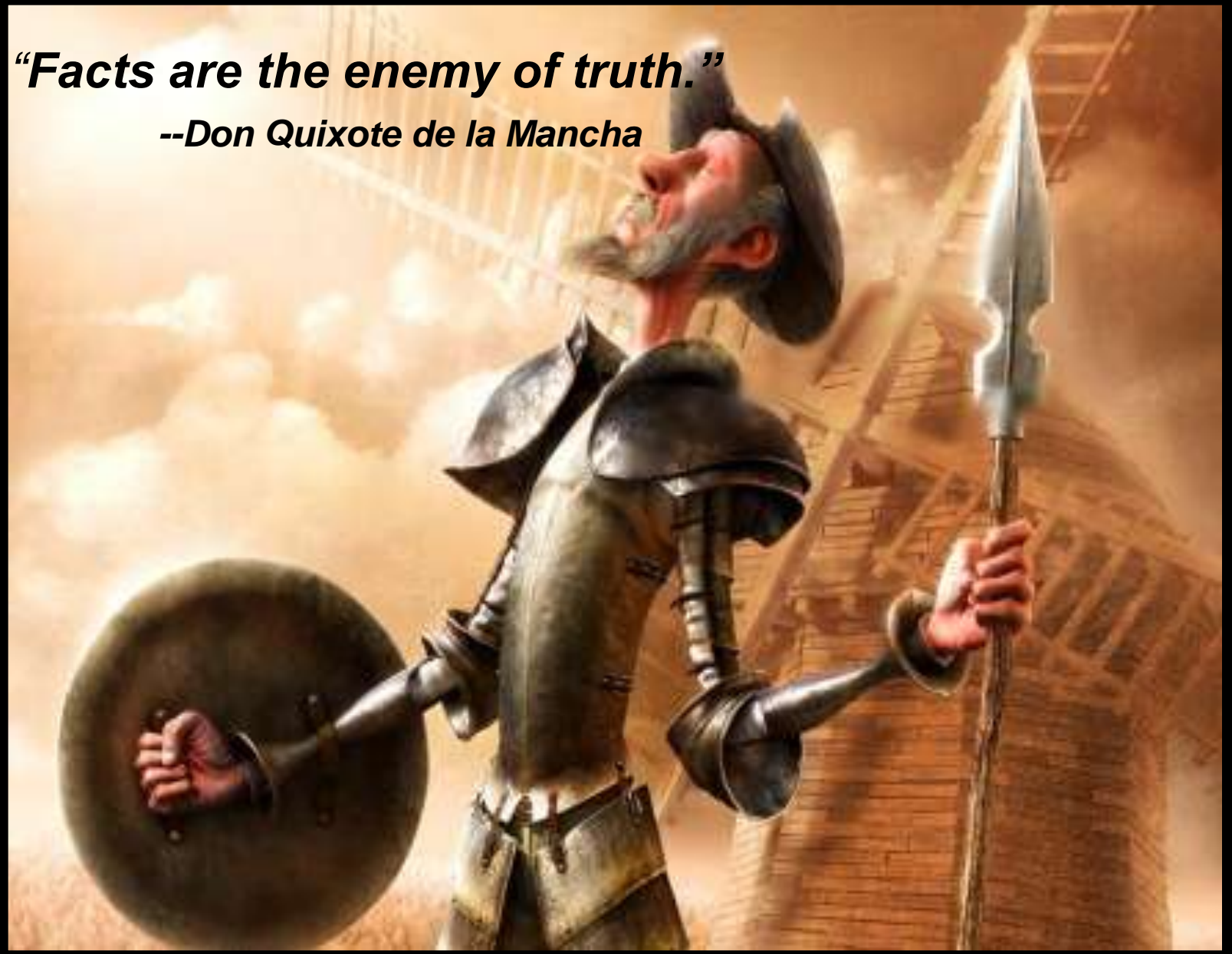
■ Well

■ Spring\*

**TOTAL: 1,347 mgd**

***“Facts are the enemy of truth.”***

***--Don Quixote de la Mancha***

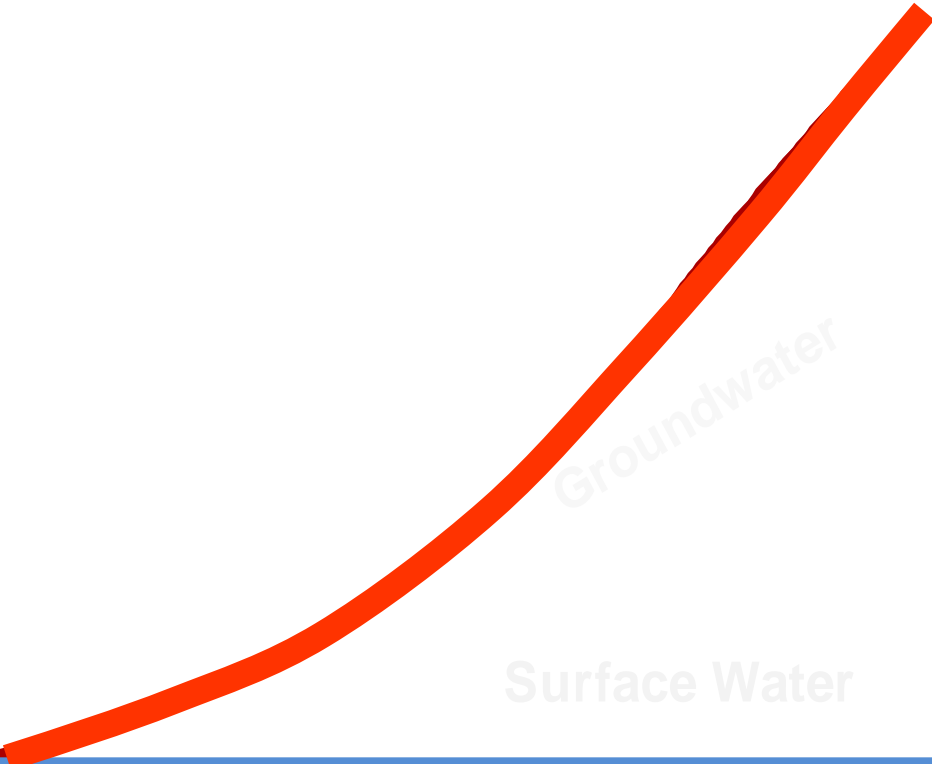


**Virginia's water use has risen steadily for more than a century, in response to population and economic growth.**

*quantity of use*

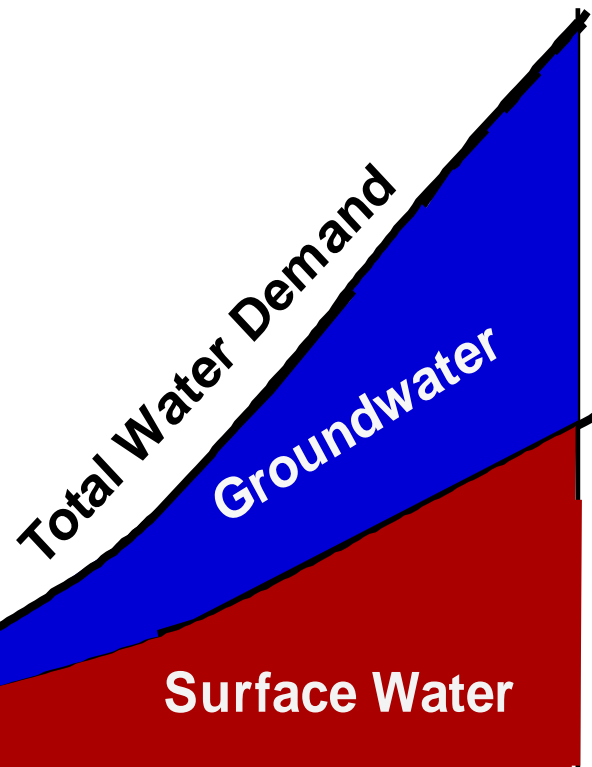
*time*

Groundwater  
Surface Water



Historically, demand has been fulfilled by withdrawals from a water supply made up of the two traditional water sources.

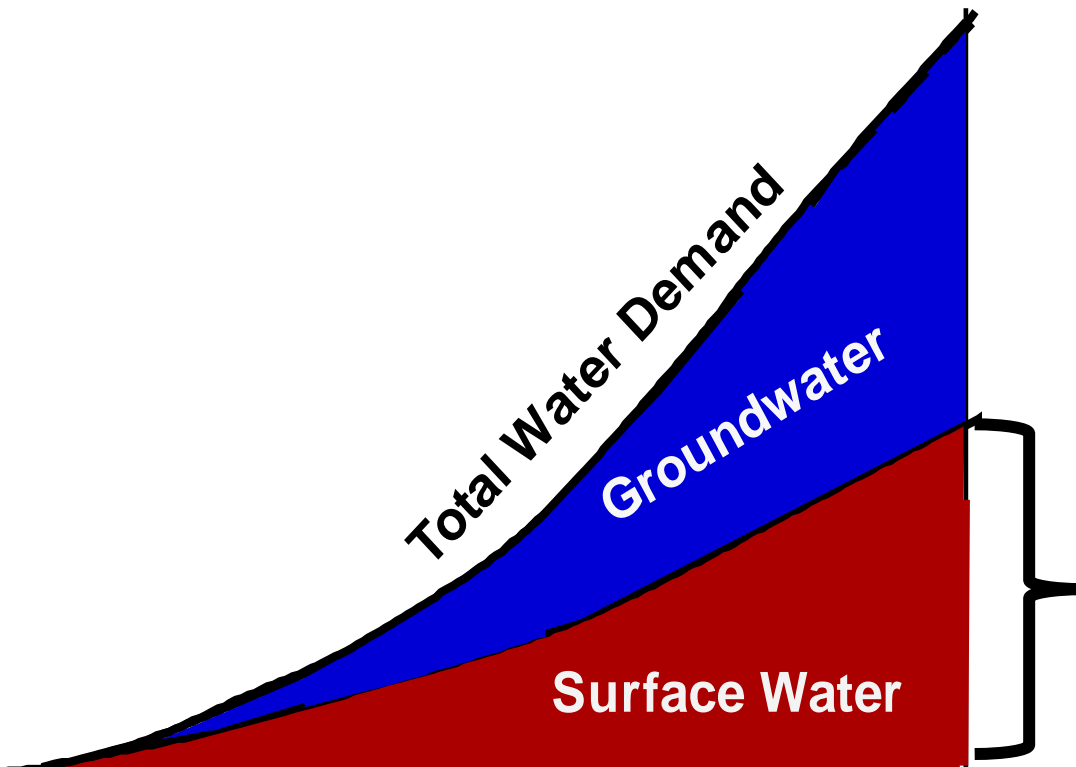
*quantity of use*



*time*

Historically, demand has been fulfilled by withdrawals from a water supply made up of the two traditional water sources.

*quantity of use*



Surface Water

Total Water Demand

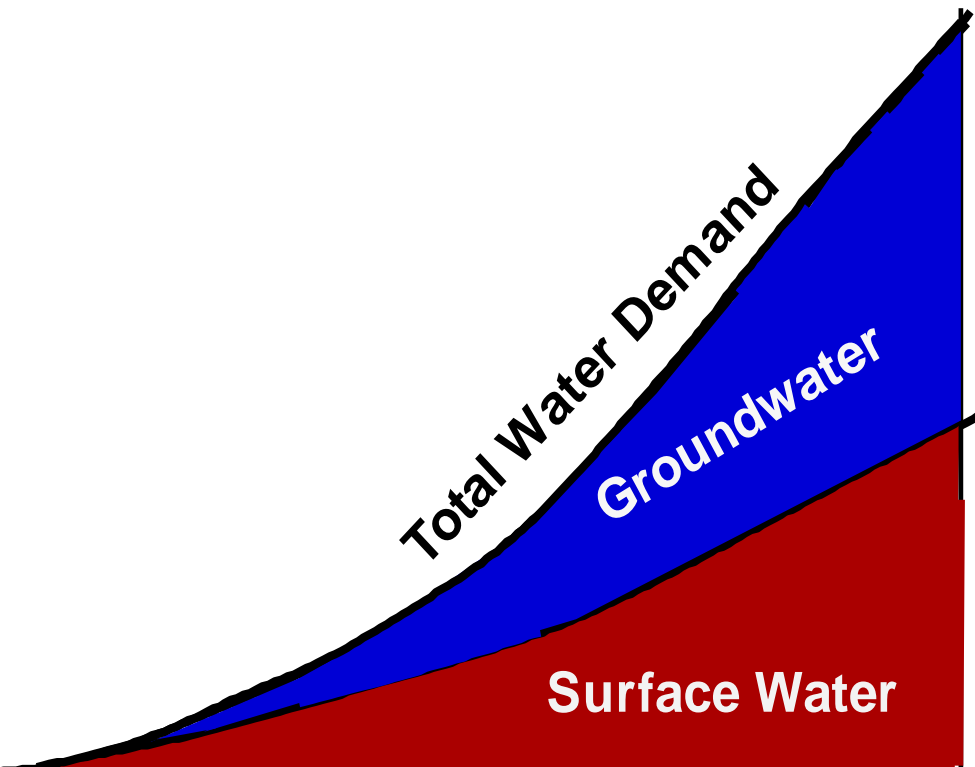
Groundwater

Renewable,  
but with  
limits

*time*

Historically, demand has been fulfilled by withdrawals from a water supply made up of the two traditional water sources.

*quantity of use*



**Total Water Demand**

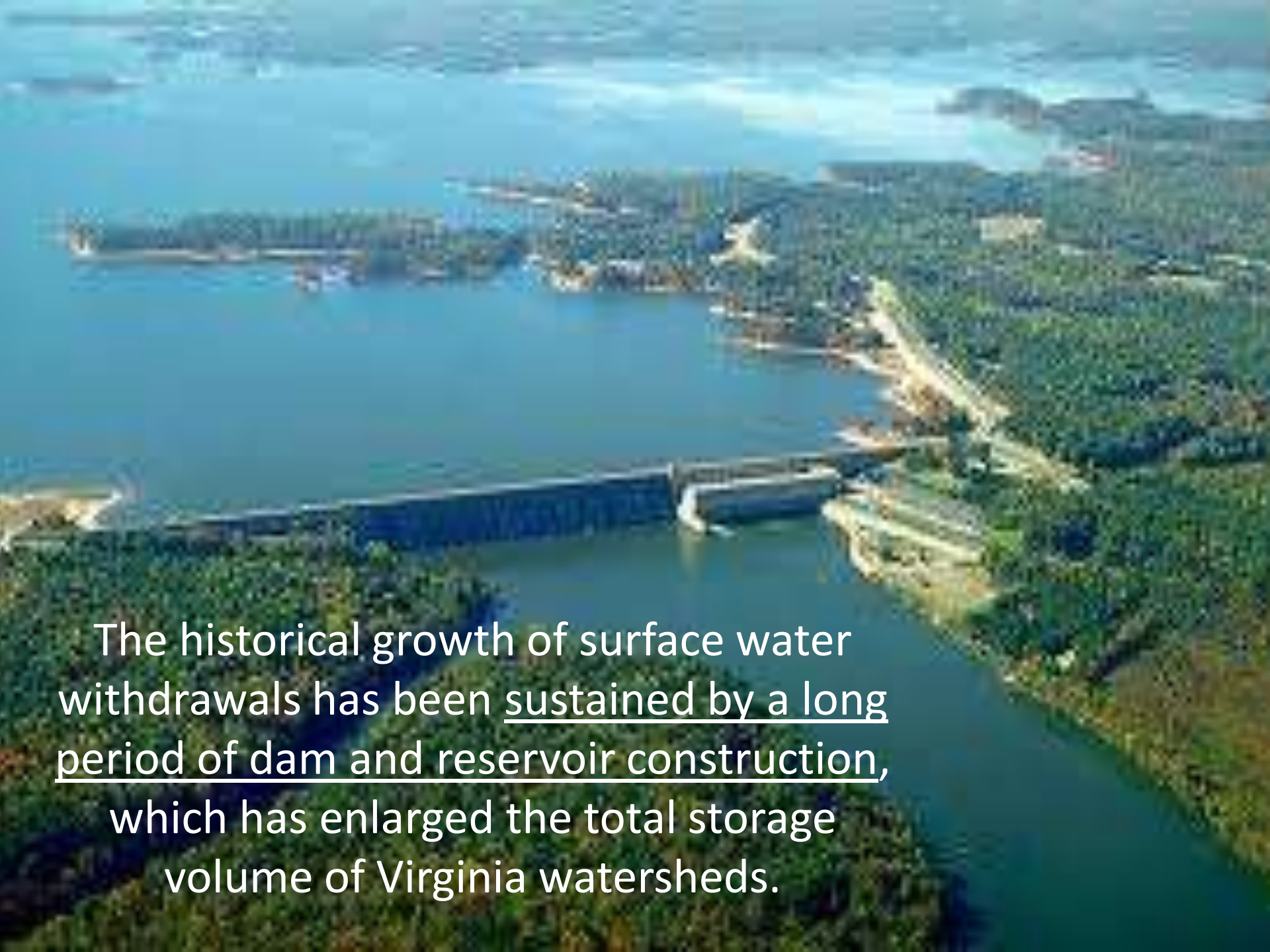
**Groundwater**

**Surface Water**

**Largely nonrenewable**

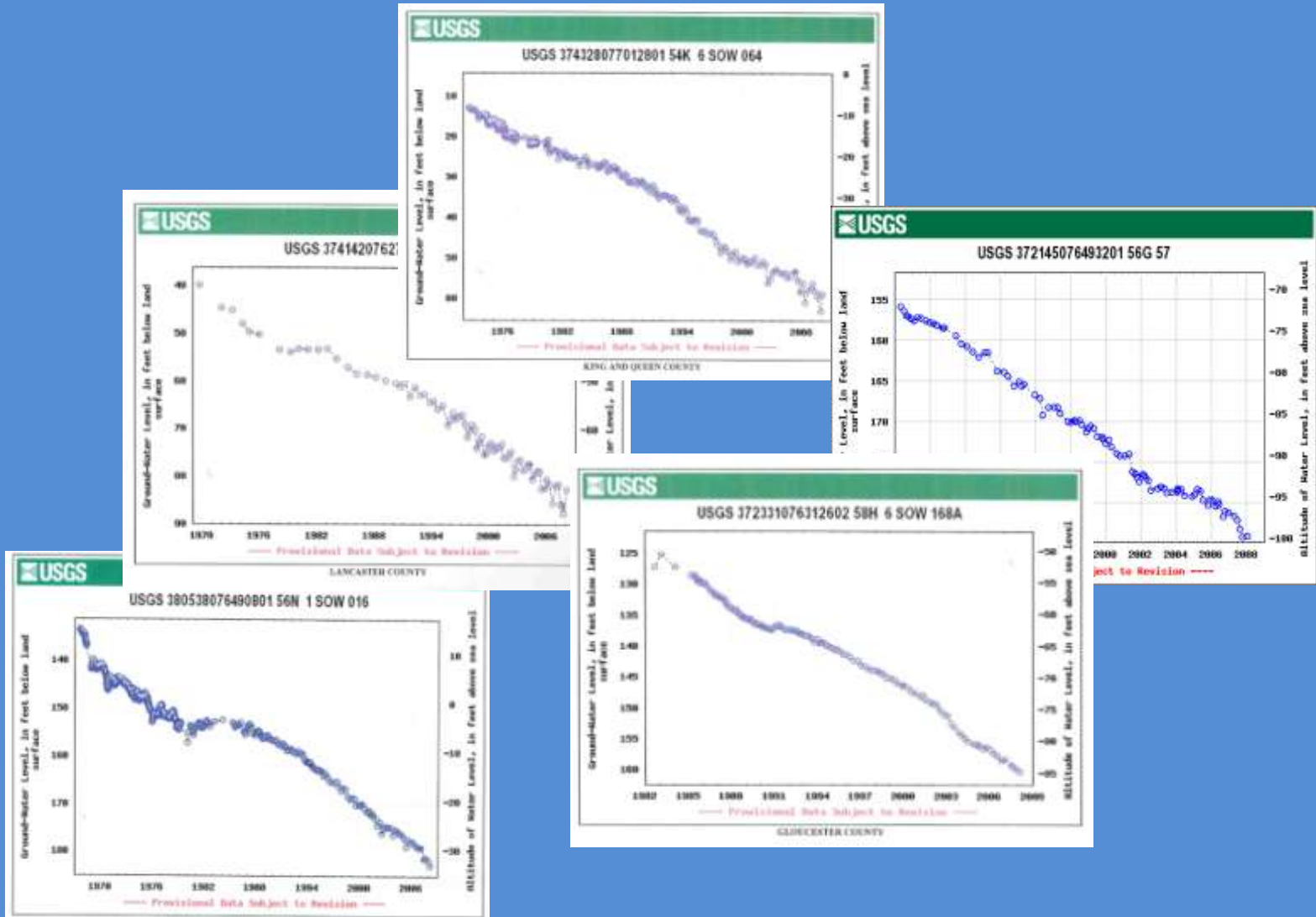
**Renewable, but with limits**

*time*

An aerial photograph showing a large concrete dam across a river. The reservoir behind the dam is filled with blue water. The surrounding landscape is densely forested with green trees. In the distance, more land and water are visible under a clear sky.

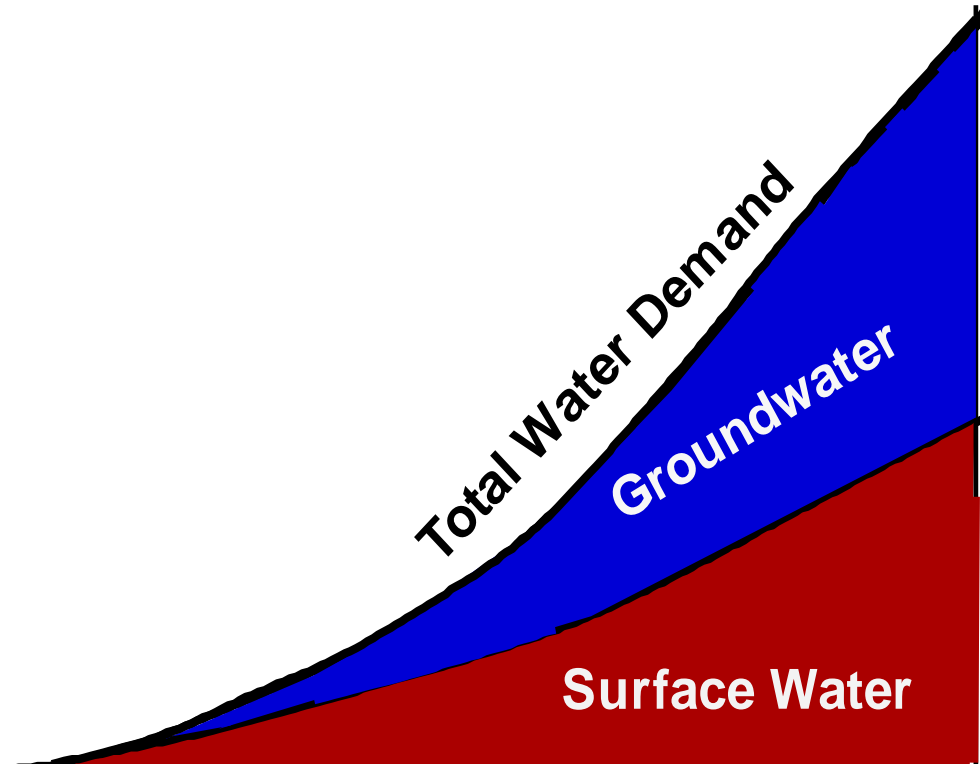
The historical growth of surface water withdrawals has been sustained by a long period of dam and reservoir construction, which has enlarged the total storage volume of Virginia watersheds.

The historical growth of groundwater withdrawals has been sustained by a steady and long term reduction of aquifer storage — evidenced by the decline of artesian water levels.

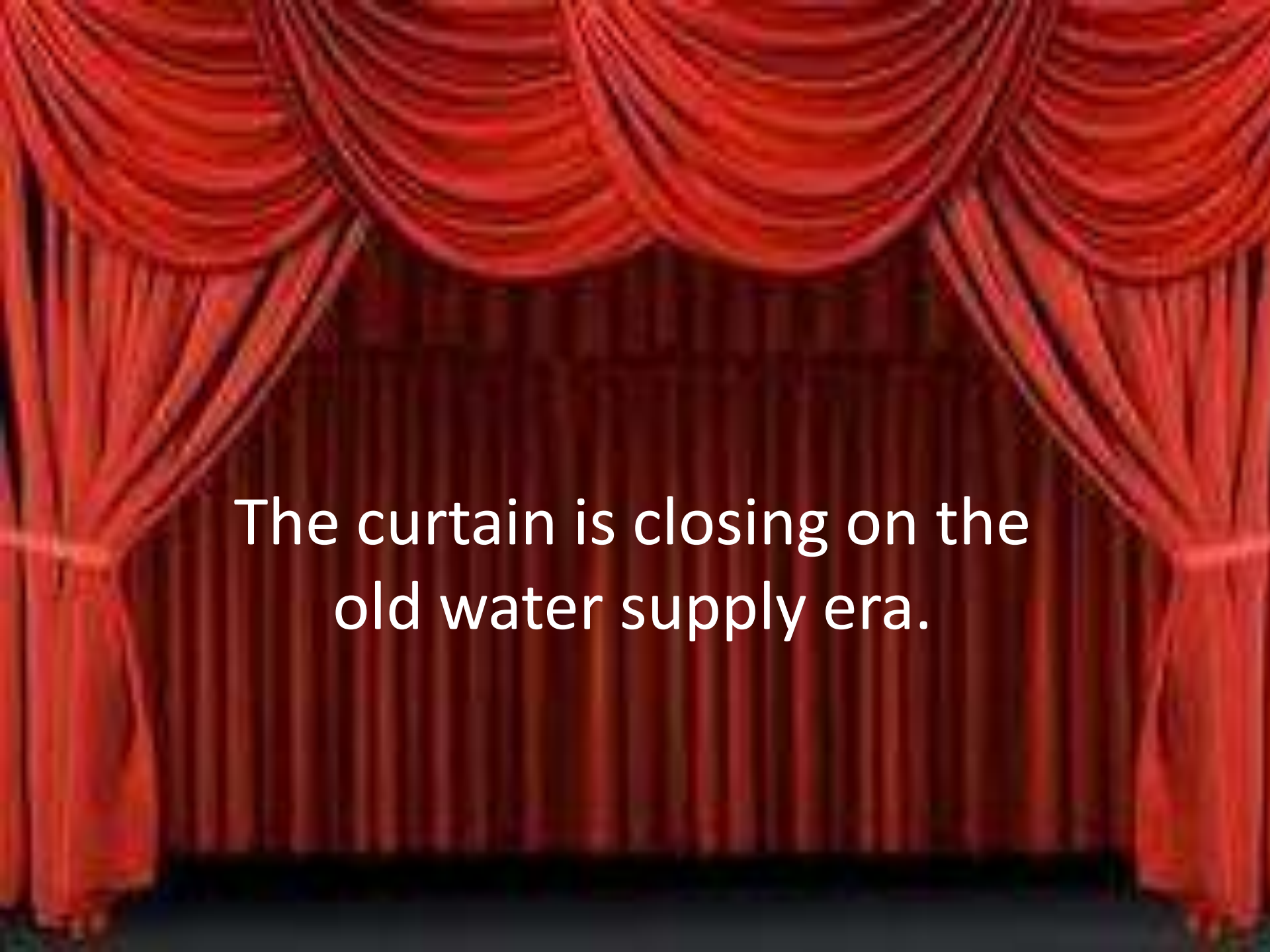


**In the future hydrologic, ecologic and socioeconomic factors will constrain new dam and reservoir construction, and shrinking aquifer storage will curtail groundwater withdrawals.**

*quantity of use*



*time*

A photograph of a stage with red curtains. The curtains are drawn back, revealing a dark floor. The text is centered on the stage.

The curtain is closing on the  
old water supply era.

*Virginia's Water Supply:  
A New Era*



## *A New Era*

At the foundation of the old water supply era was a belief in bountiful if not unlimited water—the *Myth of Superabundance*.



In the new era we must recognize that natural sources of water are limited, and that our supply must come from sustainable sources.





***“...the light which experience gives us is a lantern on the stern which shines only on the waves behind us.”***

***Samuel Taylor Coleridge (1772-1834), British poet***

## *Sustainable Yield*

The maximum quantity of water that may be withdrawn from a water source for an indefinite time without producing an unacceptable result.

*a value judgment  
not an analytical measure*

The sustainable yield of a fresh surface water source is an optimal compromise between water needs and other conflicting values.

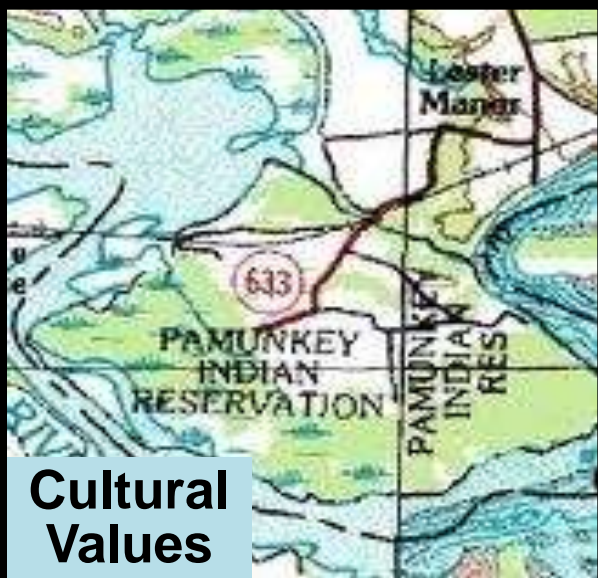
**Hydrologic  
Values**



**Ecologic  
Values**



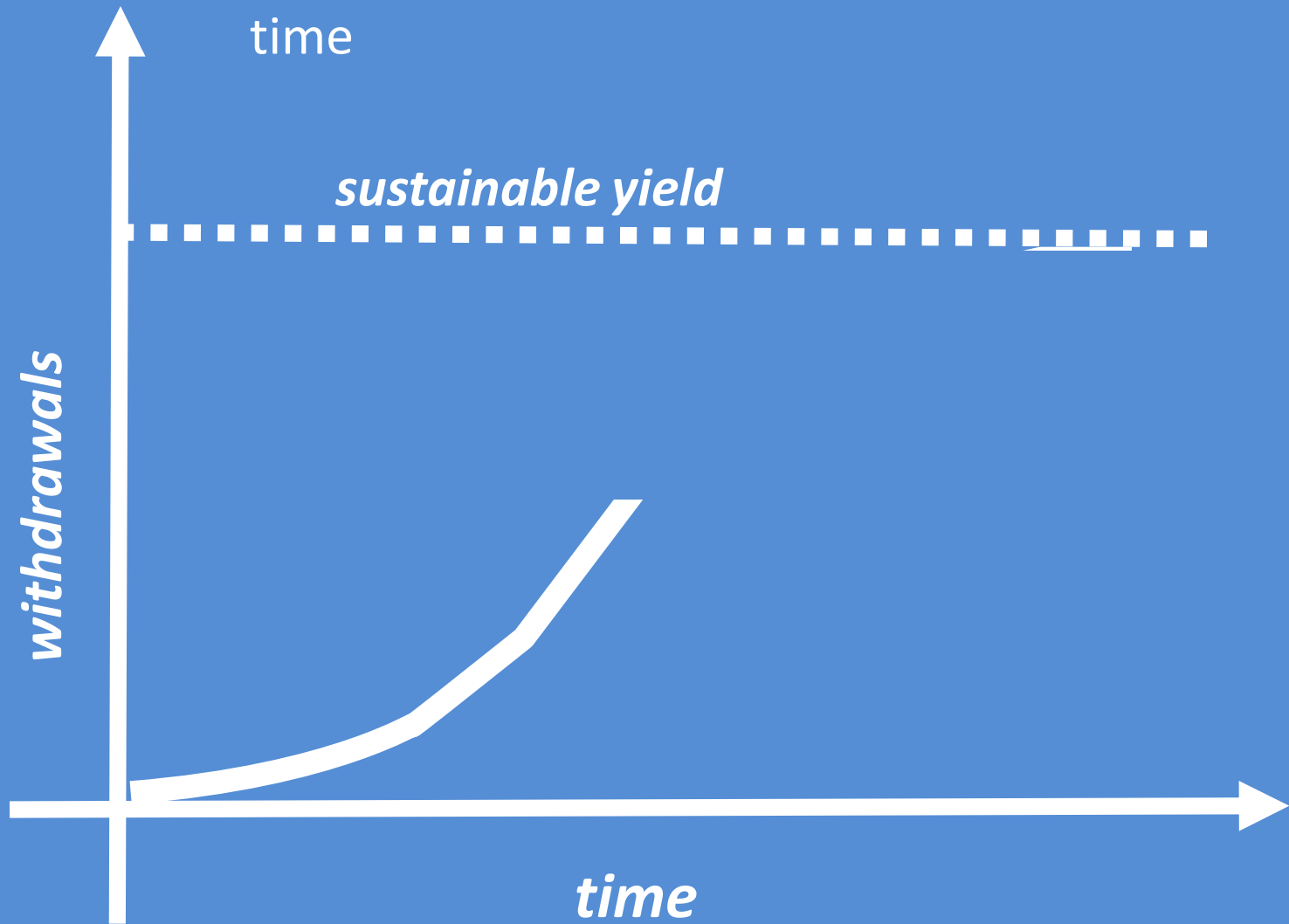
**Cultural  
Values**



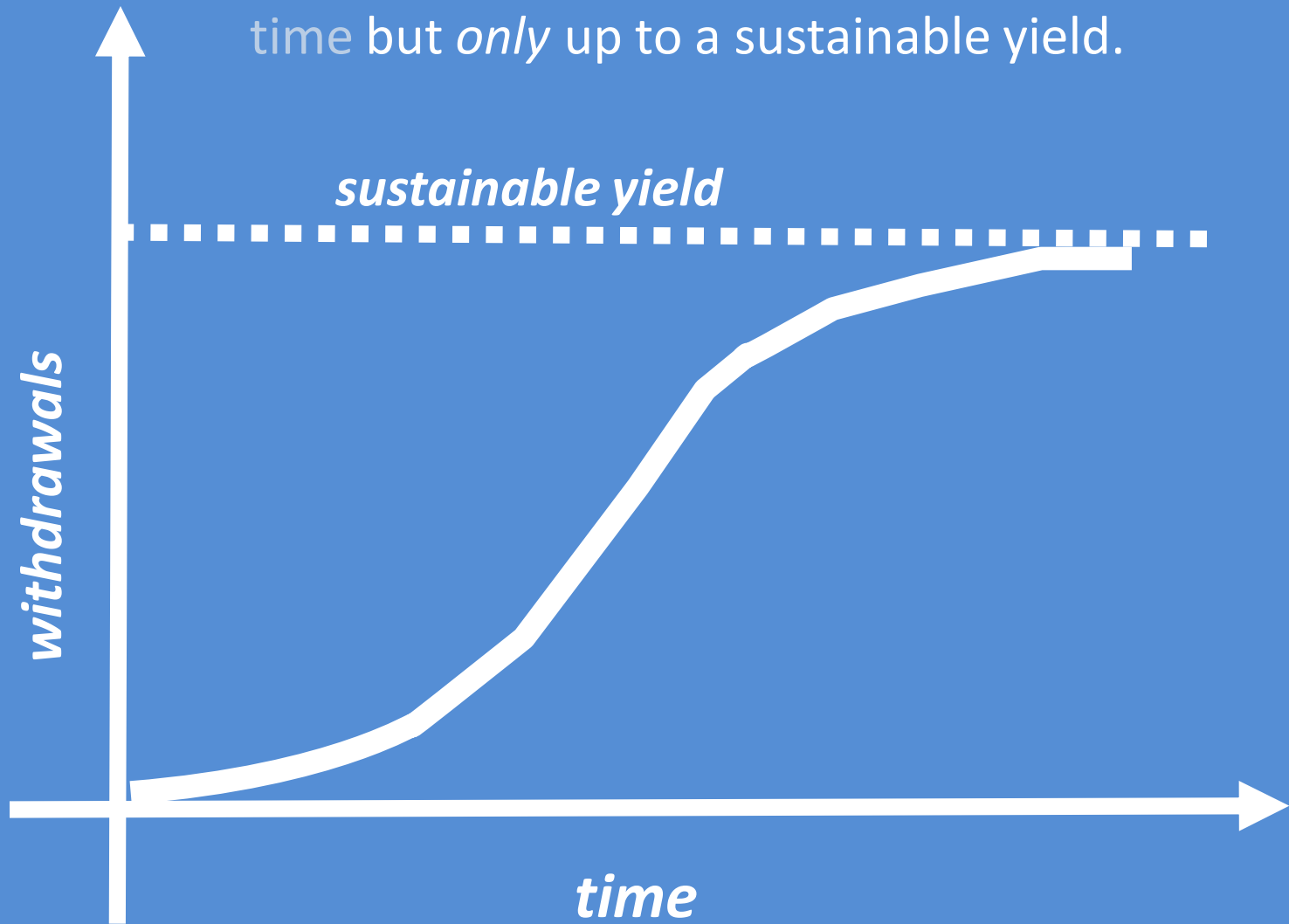
**Recreation, etc.**



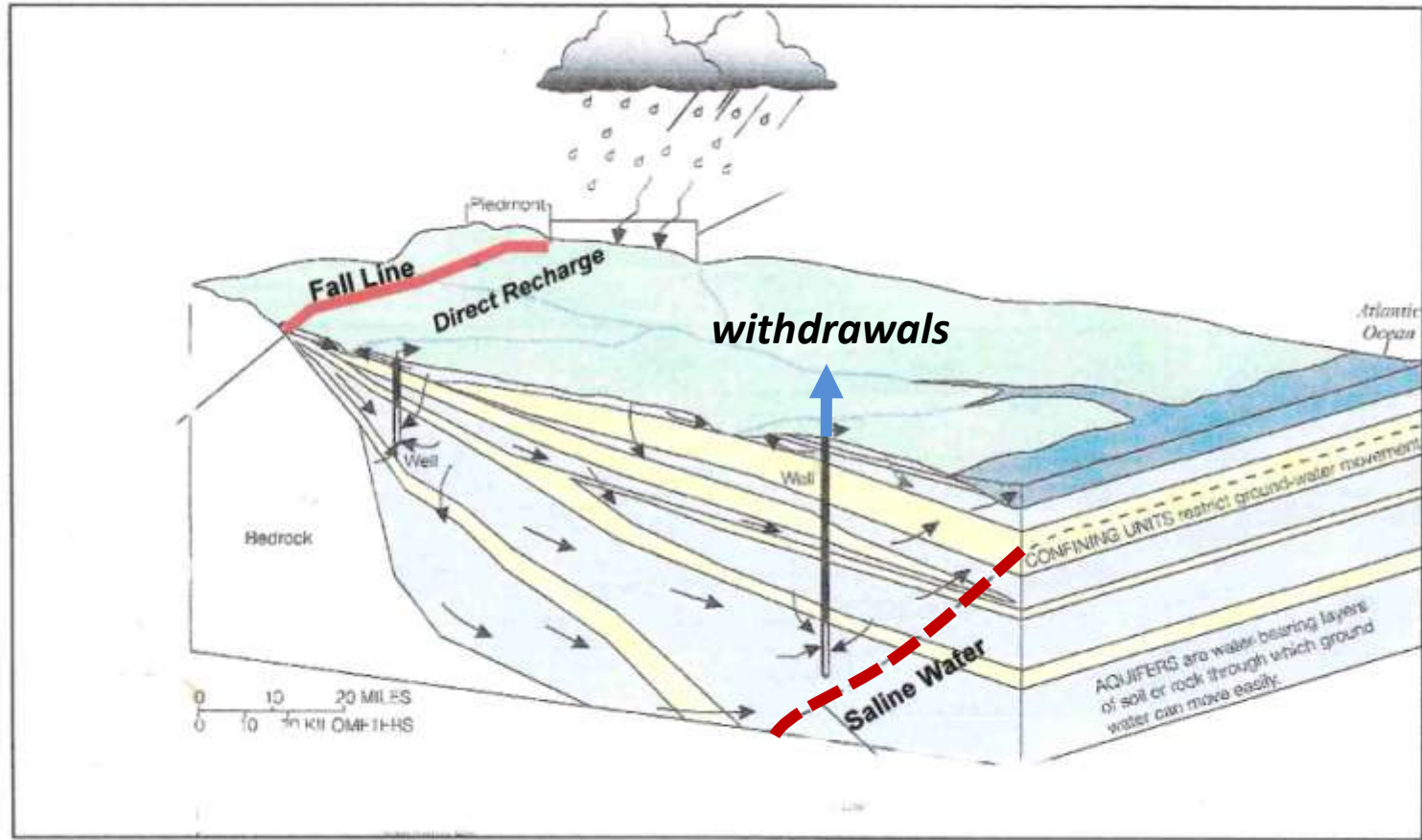
Withdrawals from fresh surface water (and shallow groundwater) sources can grow for a time



Withdrawals from fresh surface water (and shallow groundwater) sources can grow for a time but *only* up to a sustainable yield.

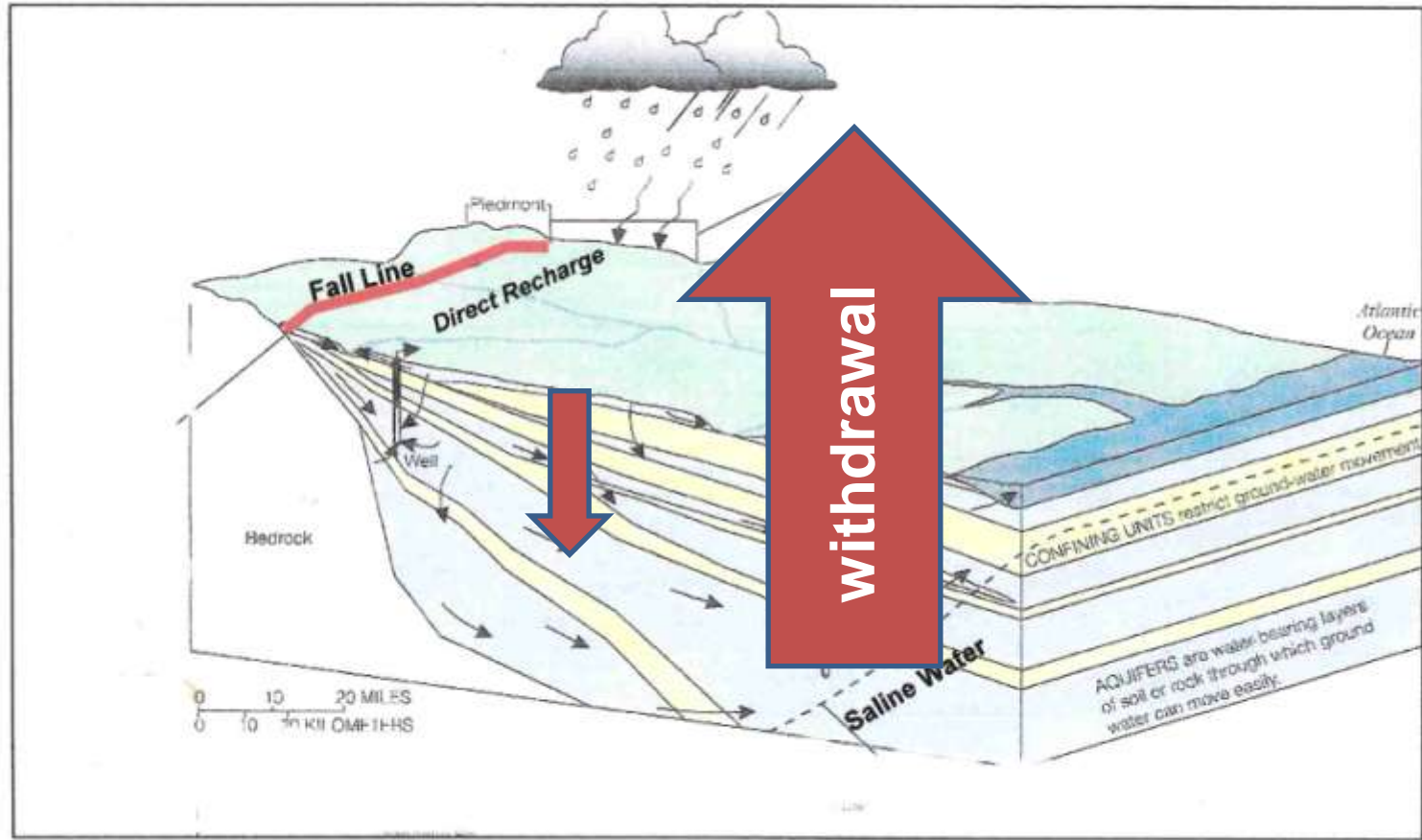


A sustainable yield of an artesian groundwater system is difficult to assess, but it must be less than the rate of recharge to the entire groundwater flow system (aquifers plus confining units).



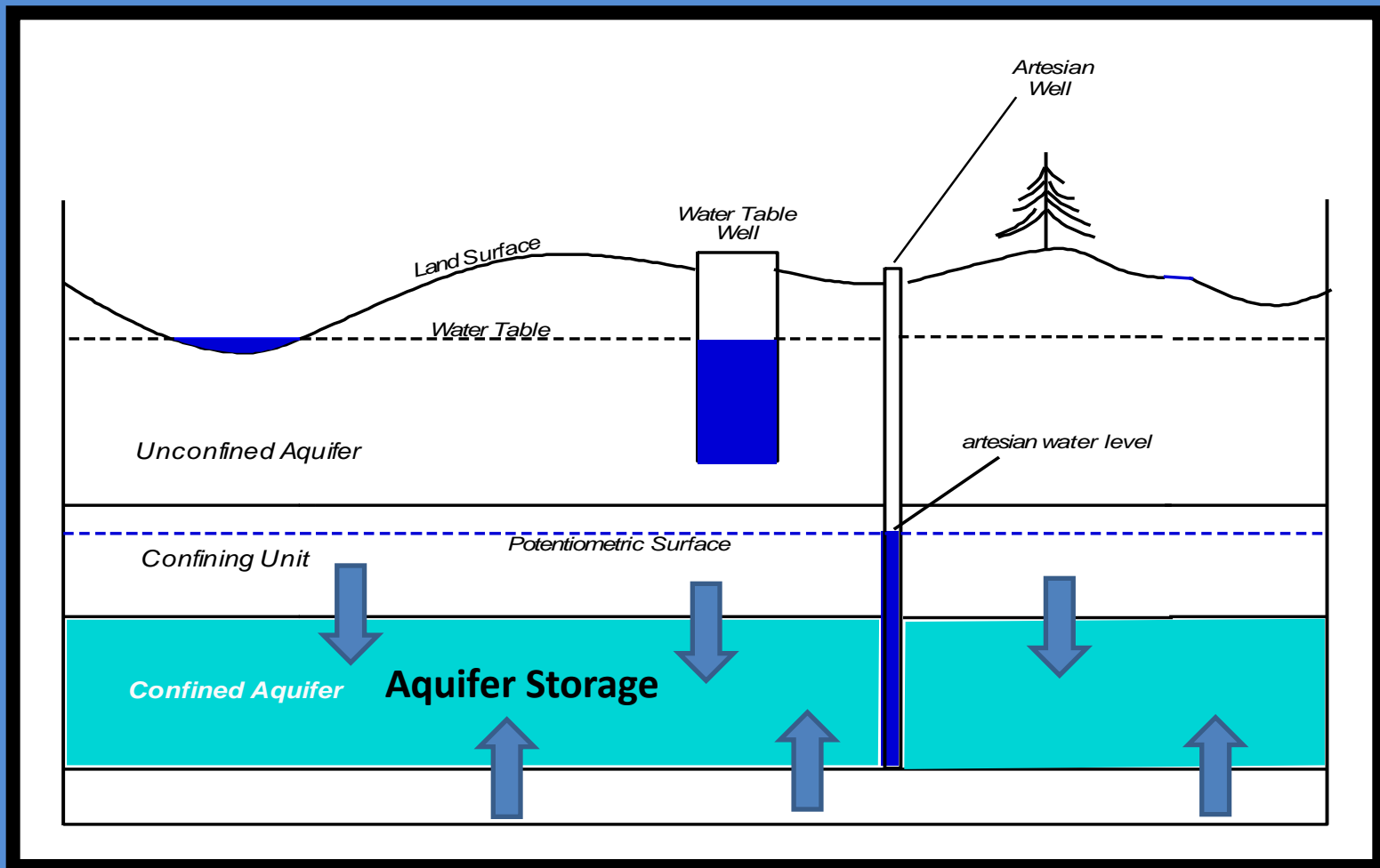
**GROUNDWATER FLOW IN VIRGINIA COASTAL PLAIN AQUIFER SYSTEM**

For many developed artesian aquifer systems, the rate of groundwater withdrawal is many magnitudes greater than the rate of recharge.

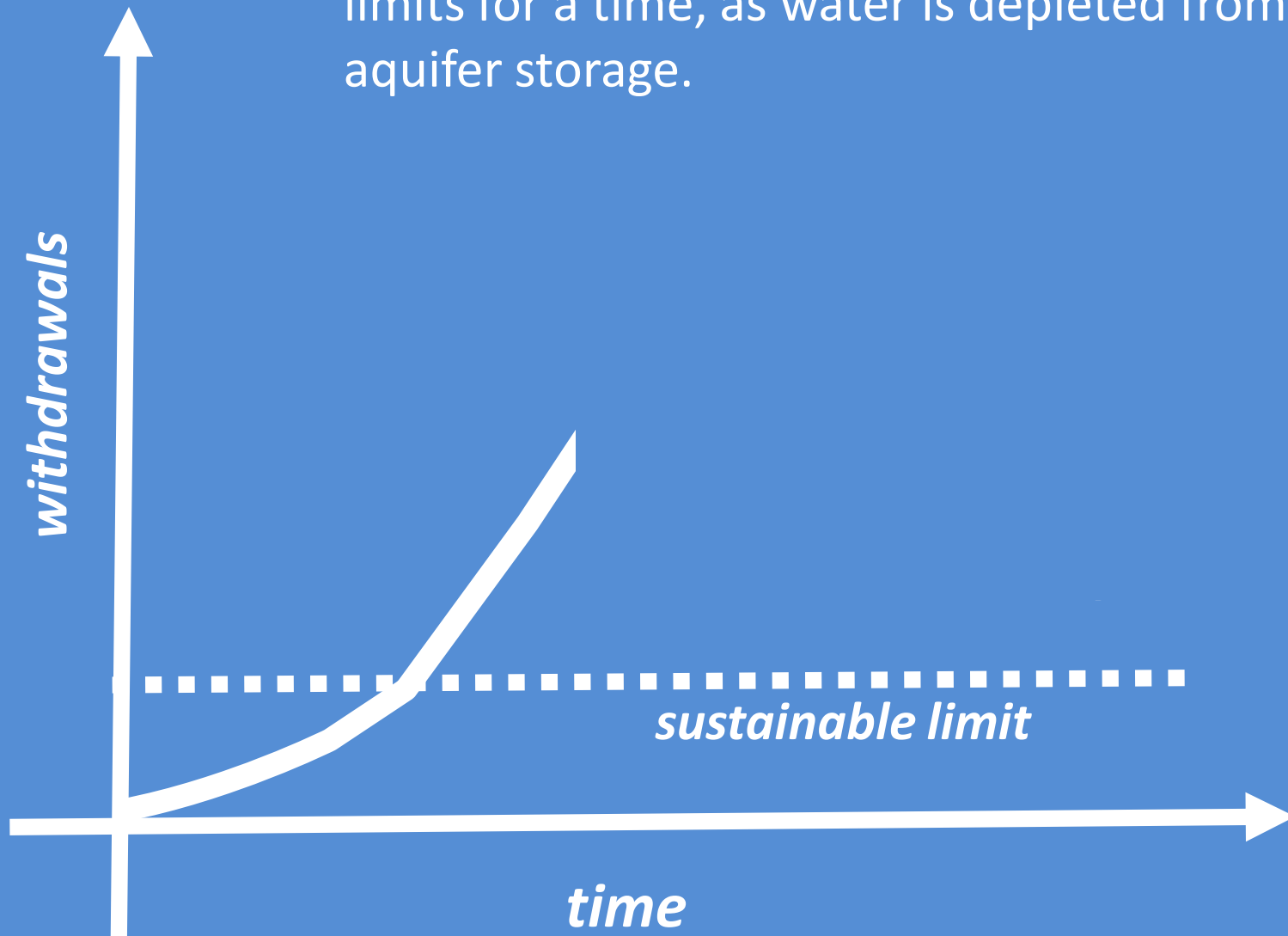


GROUNDWATER FLOW IN VIRGINIA COASTAL PLAIN AQUIFER SYSTEM

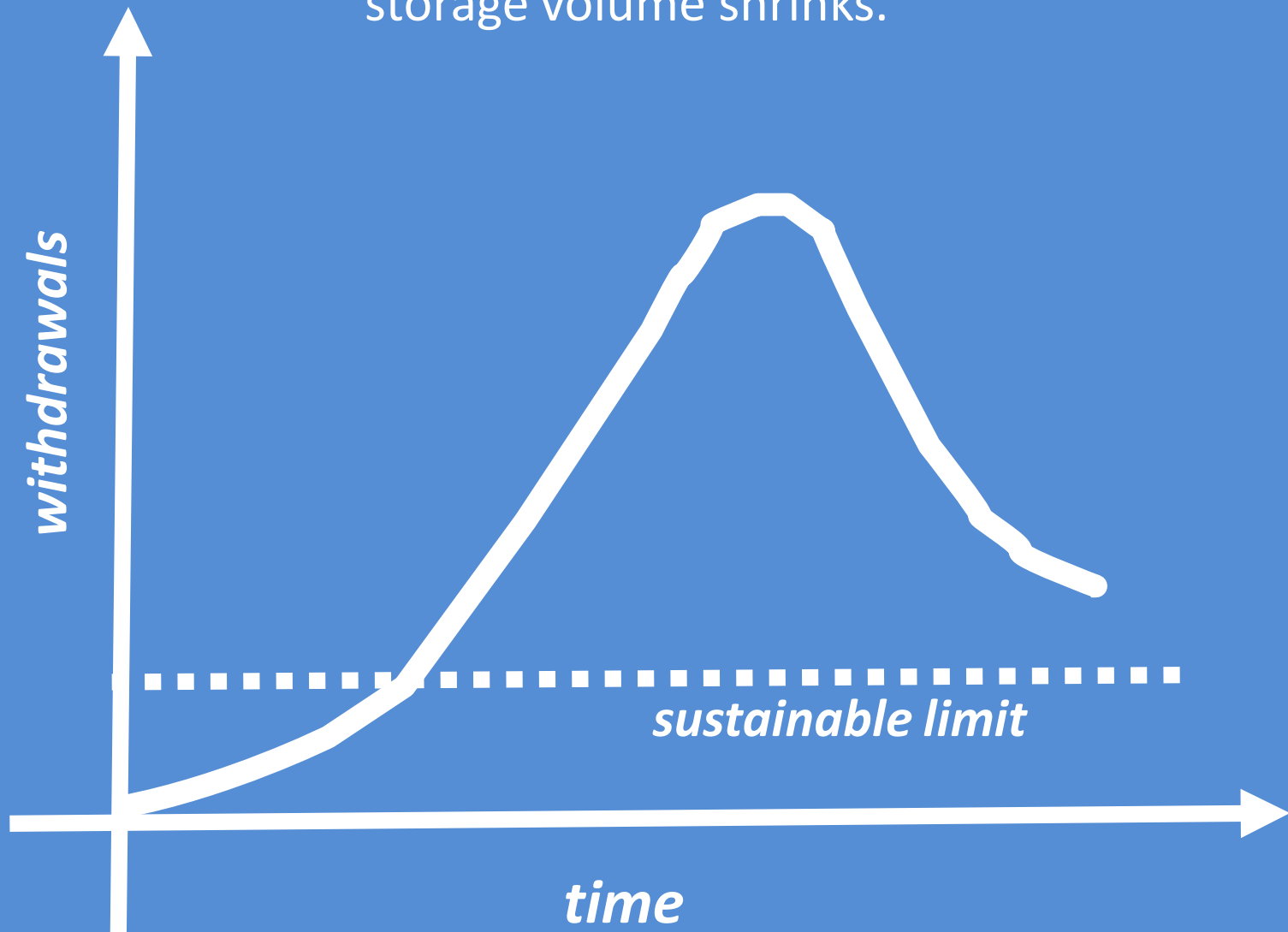
Therefore, virtually all withdrawals come from a loss of aquifer storage and slow leakage out of confining units.



Groundwater withdrawals from artesian aquifers can grow and overshoot sustainable limits for a time, as water is depleted from aquifer storage.



But withdrawals will eventually peak and decline as artesian water levels fall and storage volume shrinks.



Because of these limits, the new water supply is not likely to look much like the old one.

quantity of use

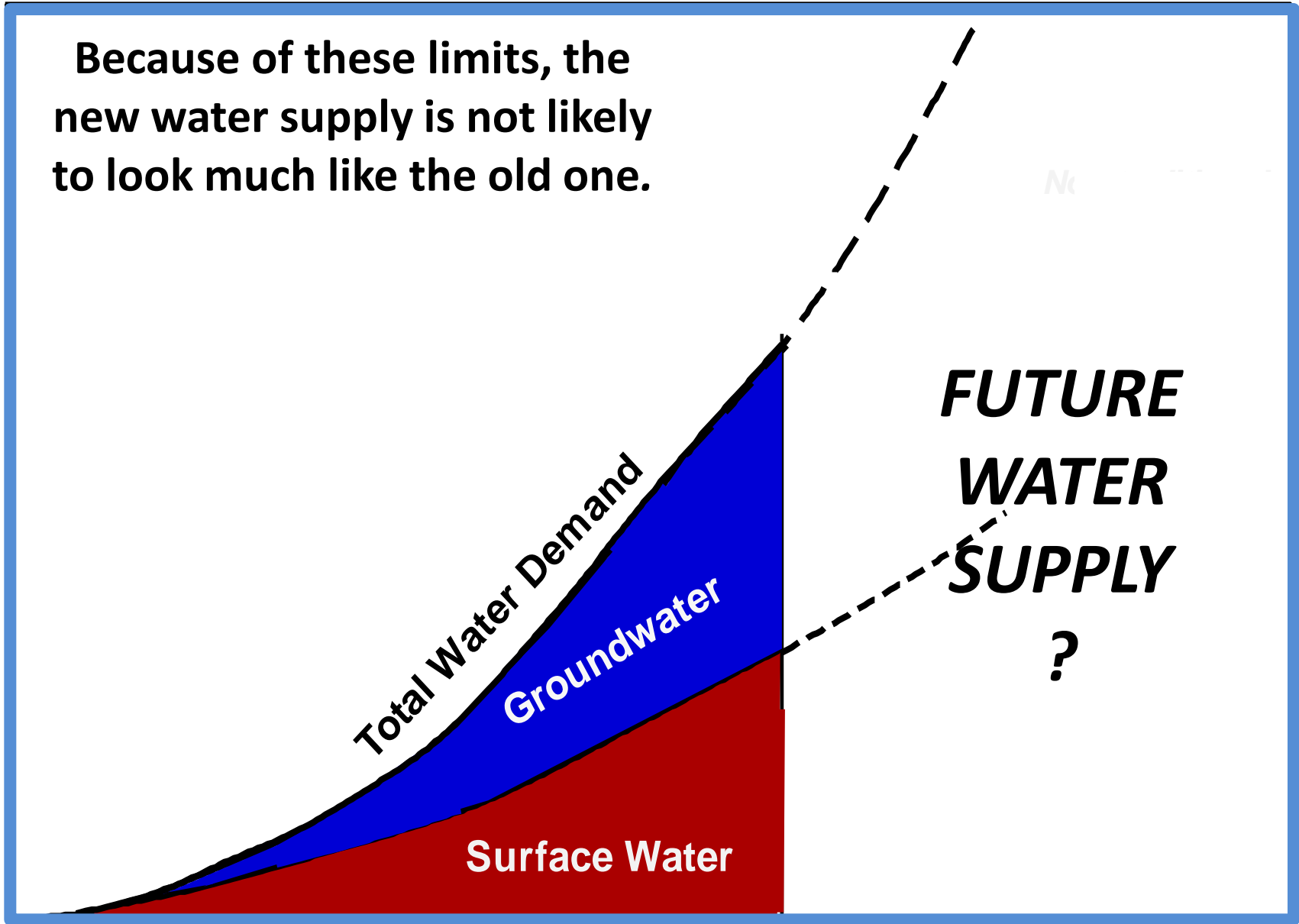
Total Water Demand

Groundwater

Surface Water

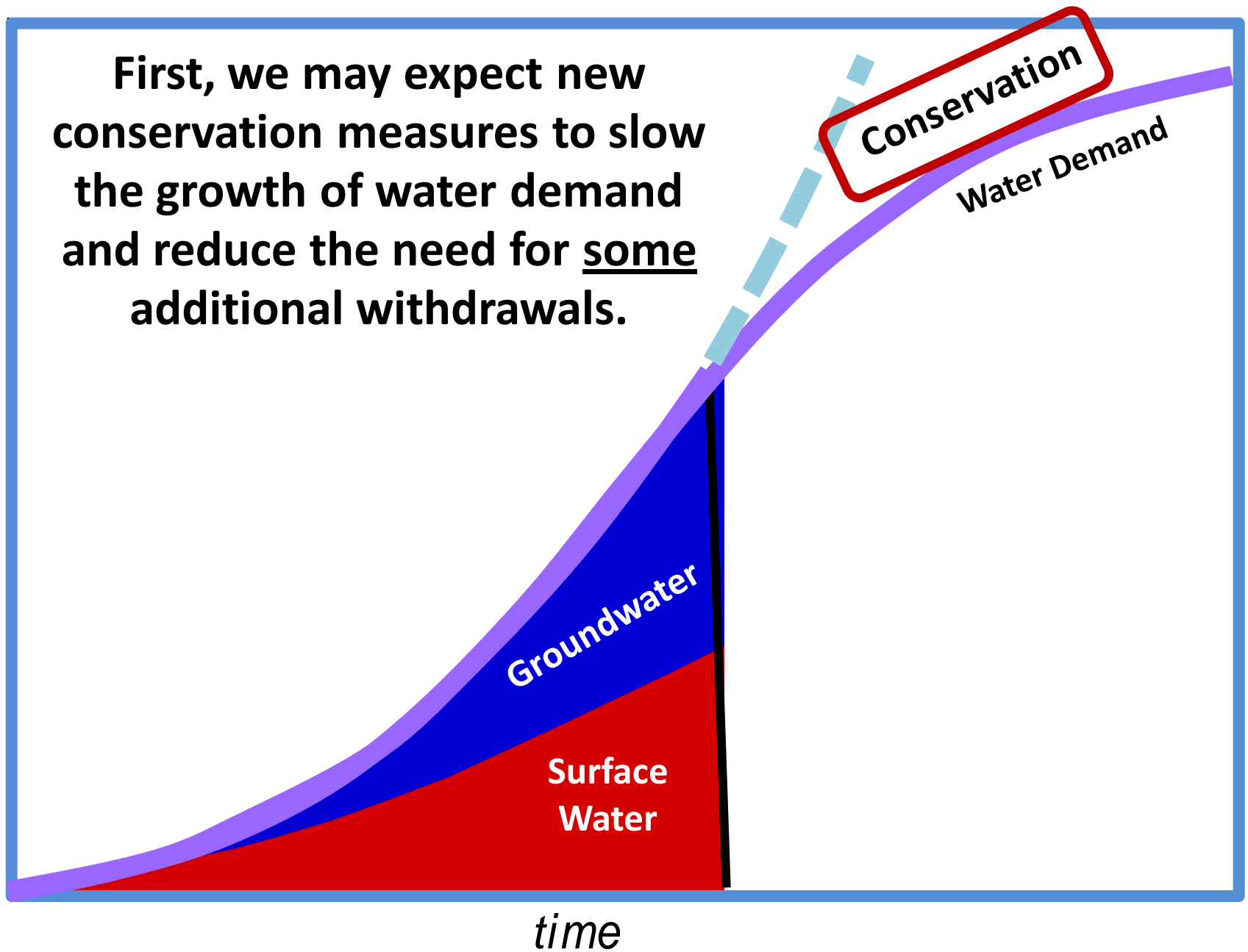
time

**FUTURE  
WATER  
SUPPLY  
?**



First, we may expect new conservation measures to slow the growth of water demand and reduce the need for some additional withdrawals.

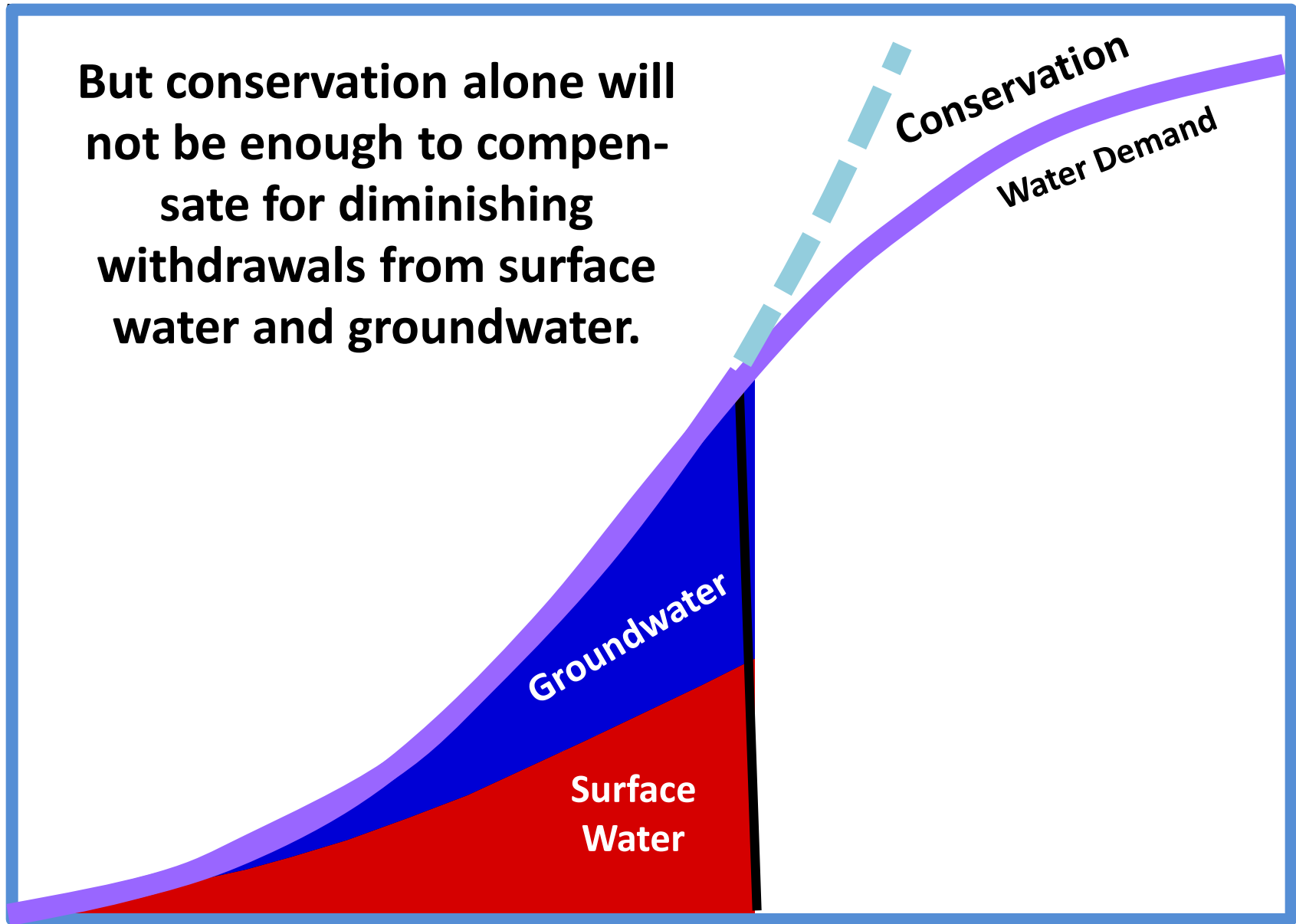
*quantity of use*



*time*

But conservation alone will not be enough to compensate for diminishing withdrawals from surface water and groundwater.

*quantity of use*



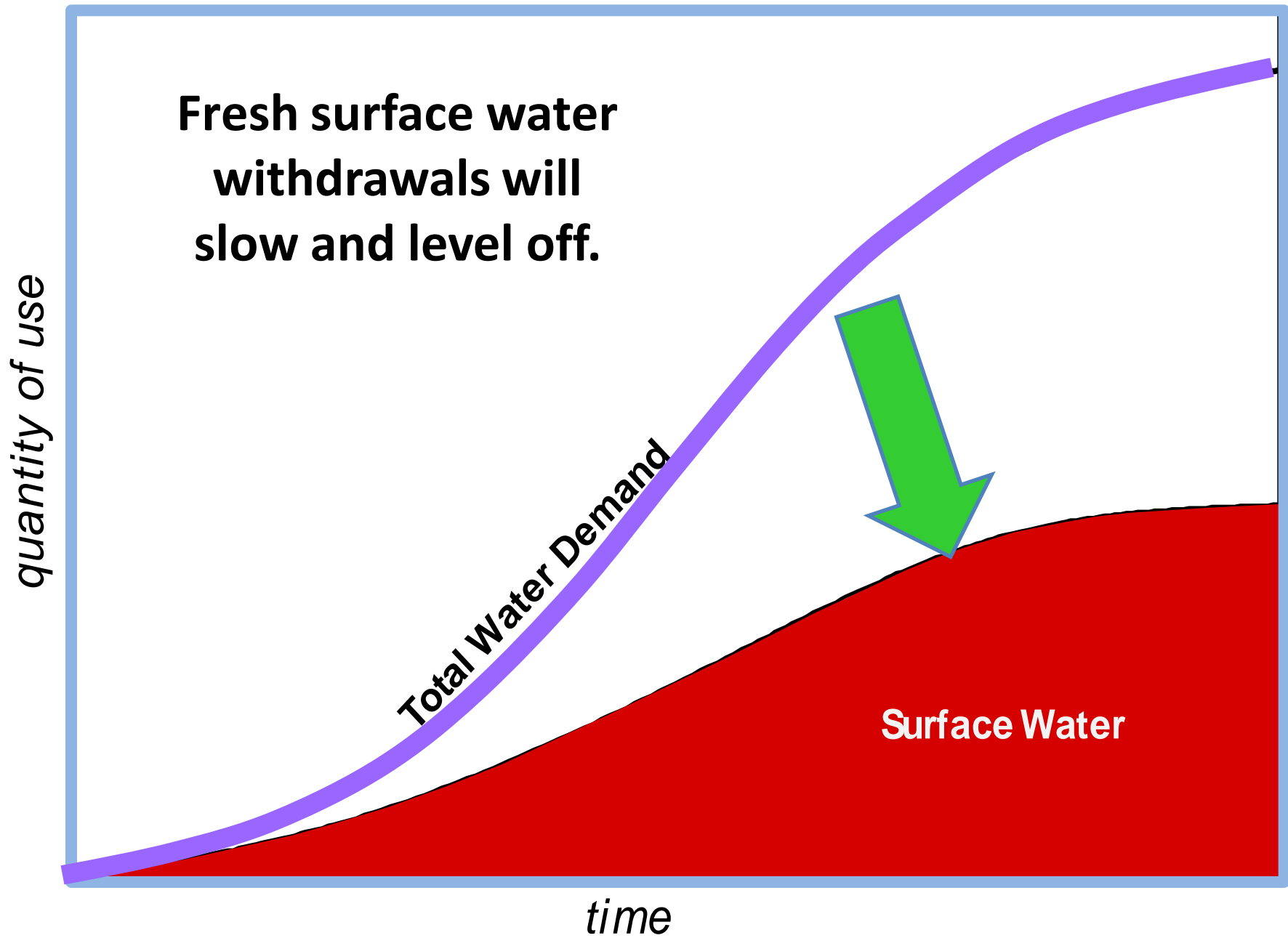
Groundwater

Surface Water

*time*

Conservation

Water Demand



**Artesian groundwater  
withdrawals will peak  
and decline.**

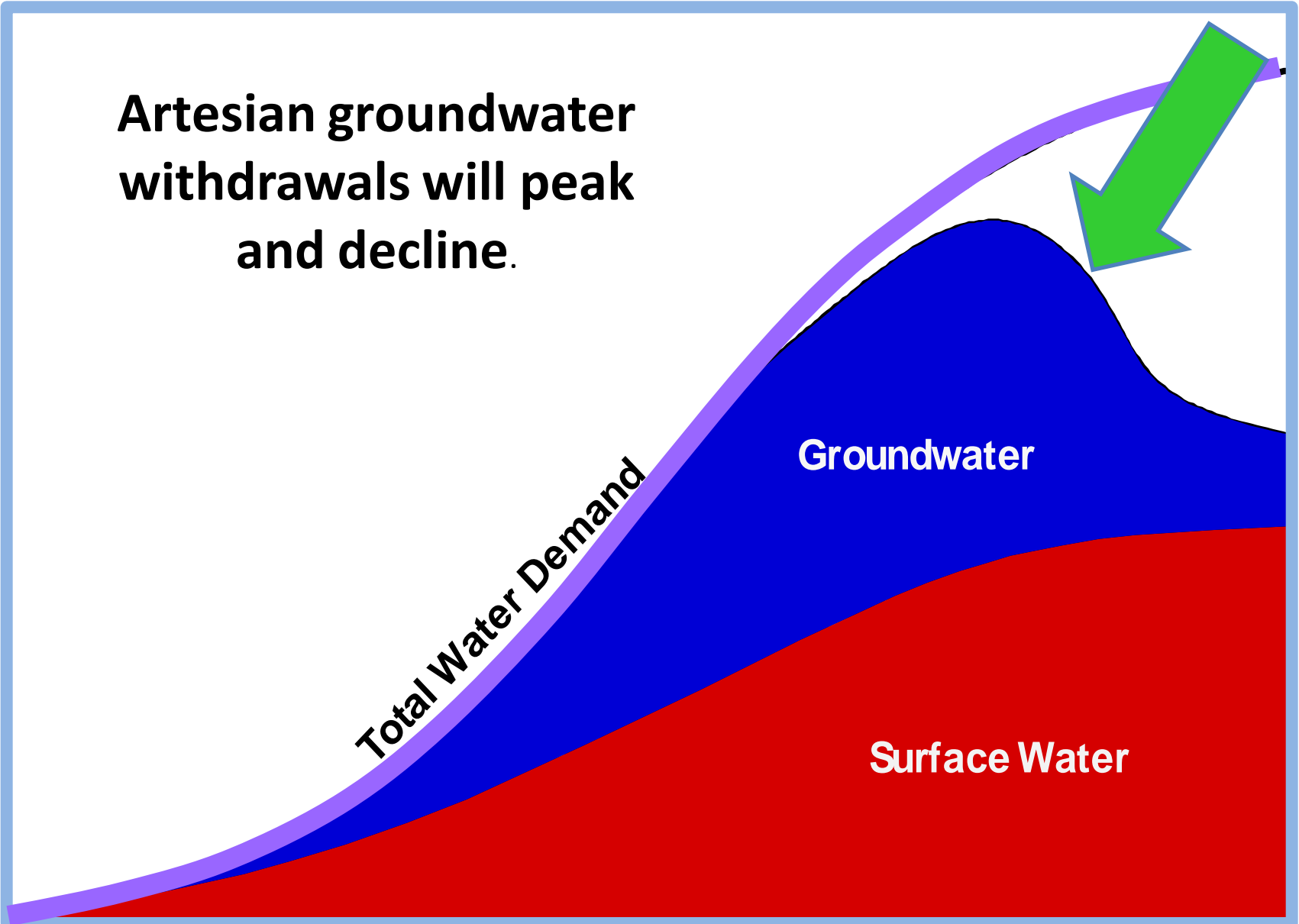
*quantity of use*

*Total Water Demand*

**Groundwater**

**Surface Water**

*time*



**Withdrawals from the traditional water sources will not be adequate to meet demand.**

*quantity of use*

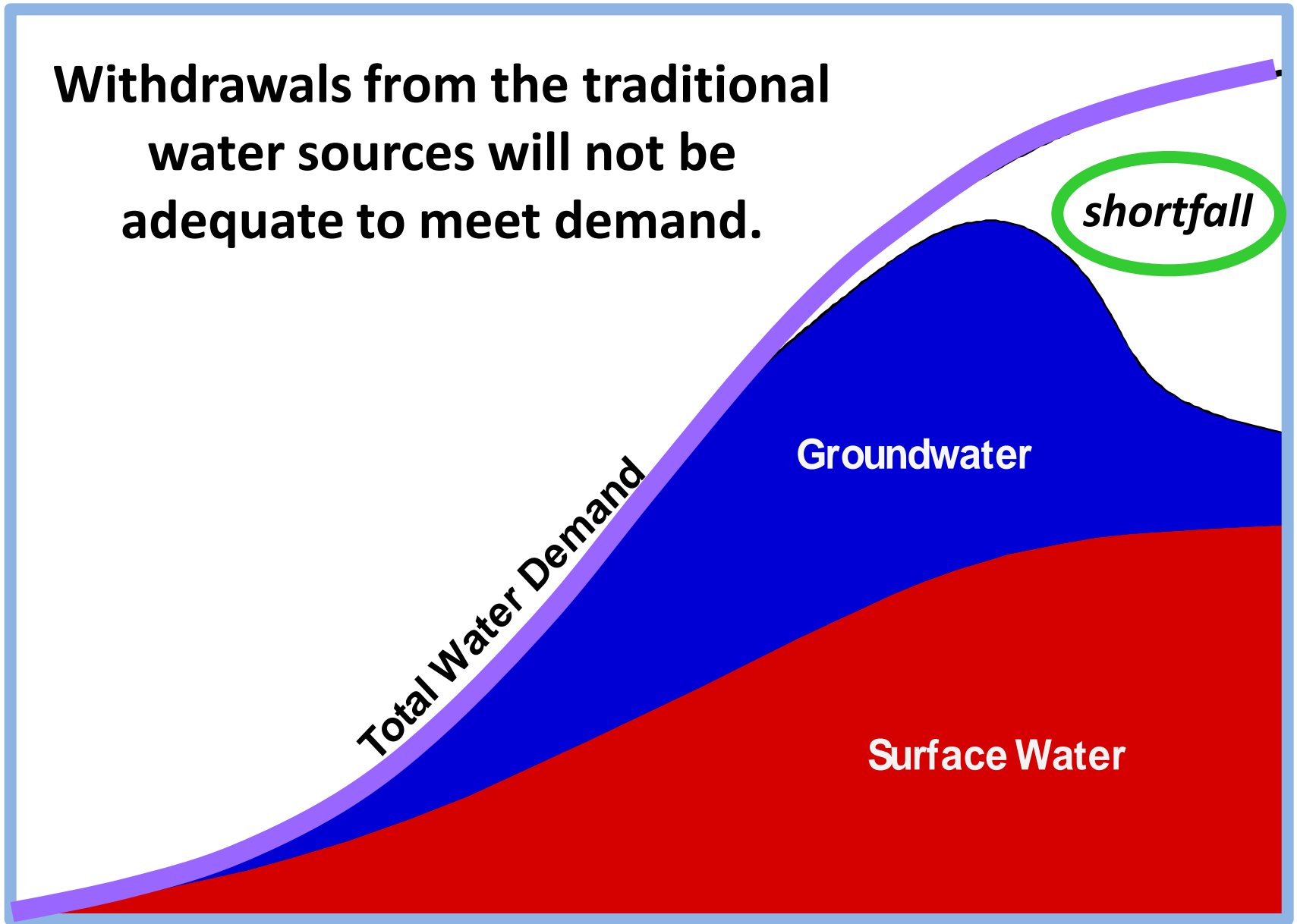
*Total Water Demand*

**Groundwater**

**Surface Water**

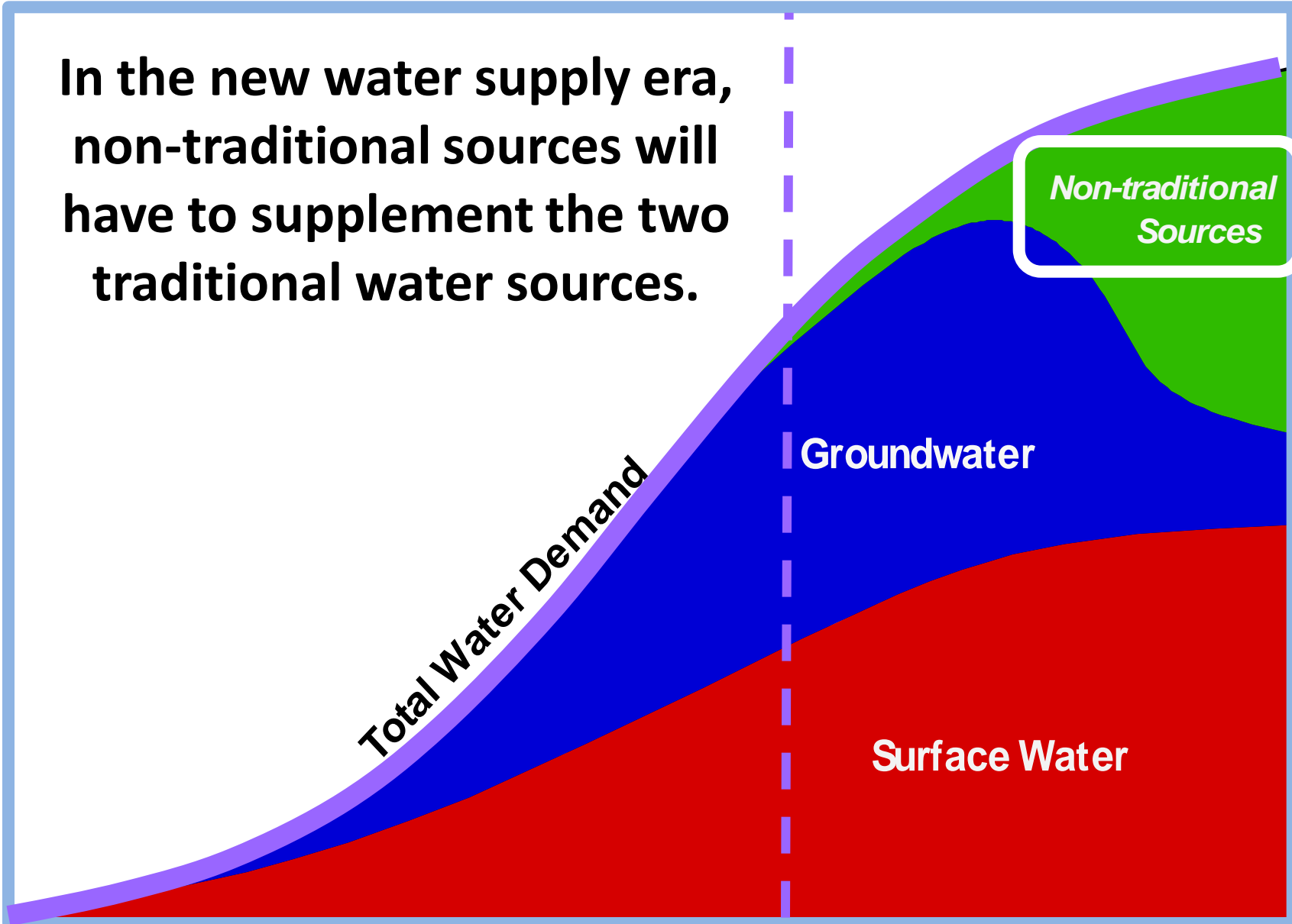
*shortfall*

*time*



**In the new water supply era,  
non-traditional sources will  
have to supplement the two  
traditional water sources.**

*quantity of use*



*Total Water Demand*


**Groundwater**

**Surface Water**

*Non-traditional  
Sources*

*time*

*present day*



**We must approach the future  
not with a precise chart but a  
compass direction.**

**Which points toward  
new rules.**

## *Rules of a New Water Supply Era*

Federal and state laws that focus on the long term preservation of the water supply, not just restrain water withdrawals or mitigate short term events like droughts.

Land use regulations that administer water use based on the availability of the local and regional supply.

Universal building codes that advance water conservation, recycling, and reuse by households communities, commercial and industrial water users.

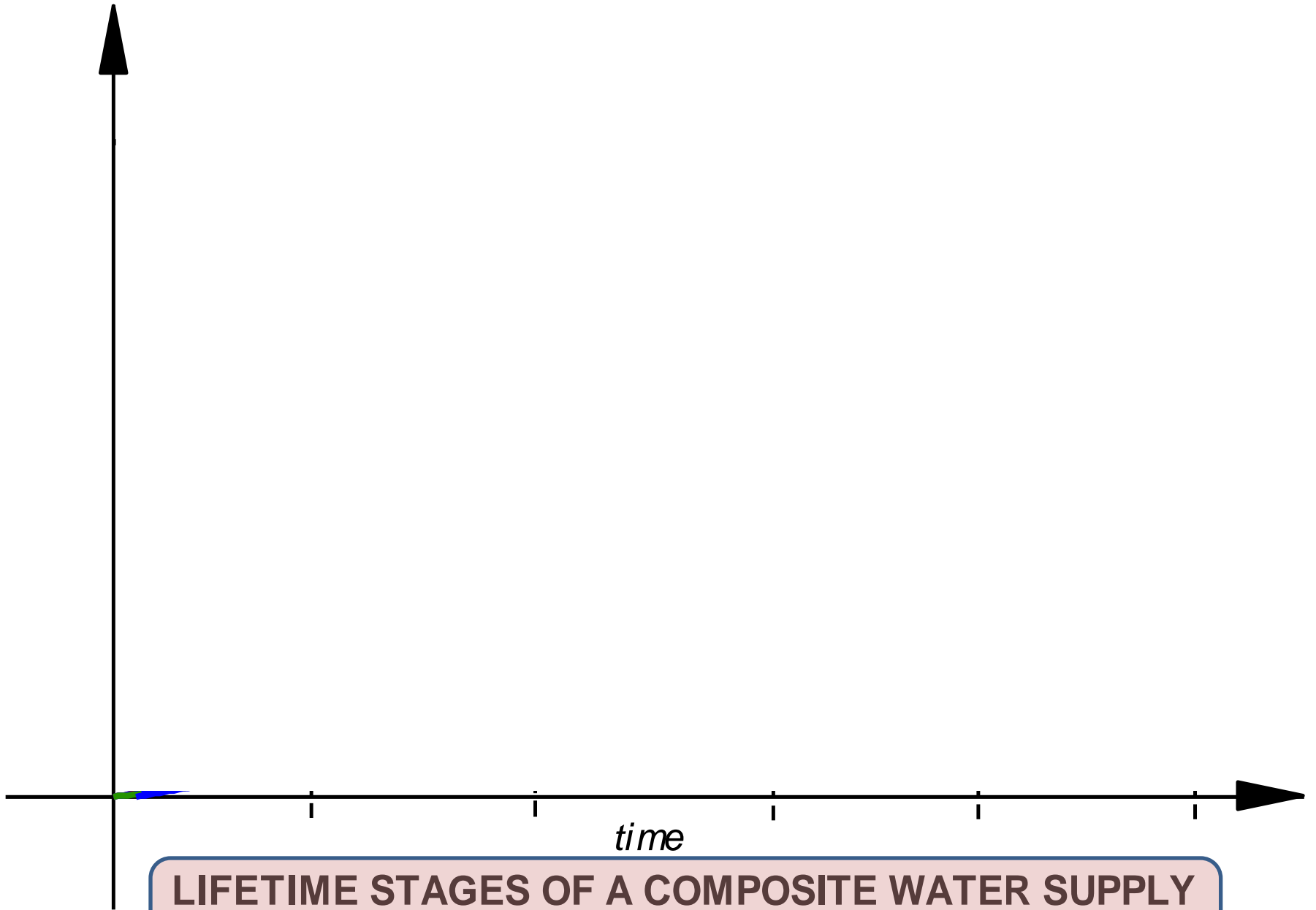
Technologies that reduce total water use or increase water reuse rather than exploit a natural water source.

Cultural values that are based on environmental limits rather than the myth of superabundance.

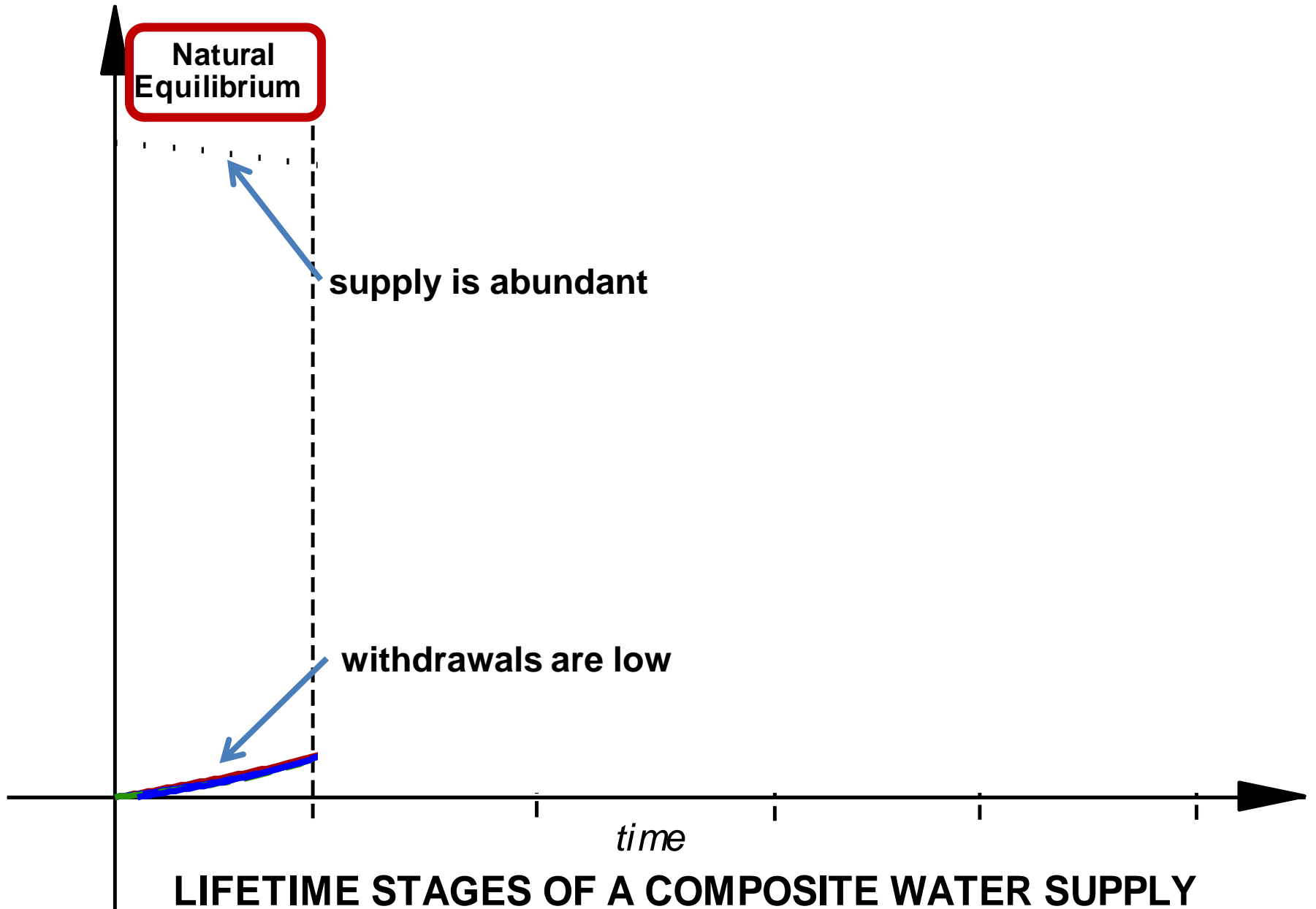
An economic system that rewards qualitative growth rather than simply quantitative growth.

**Let's put our water supply  
in a historical perspective.**



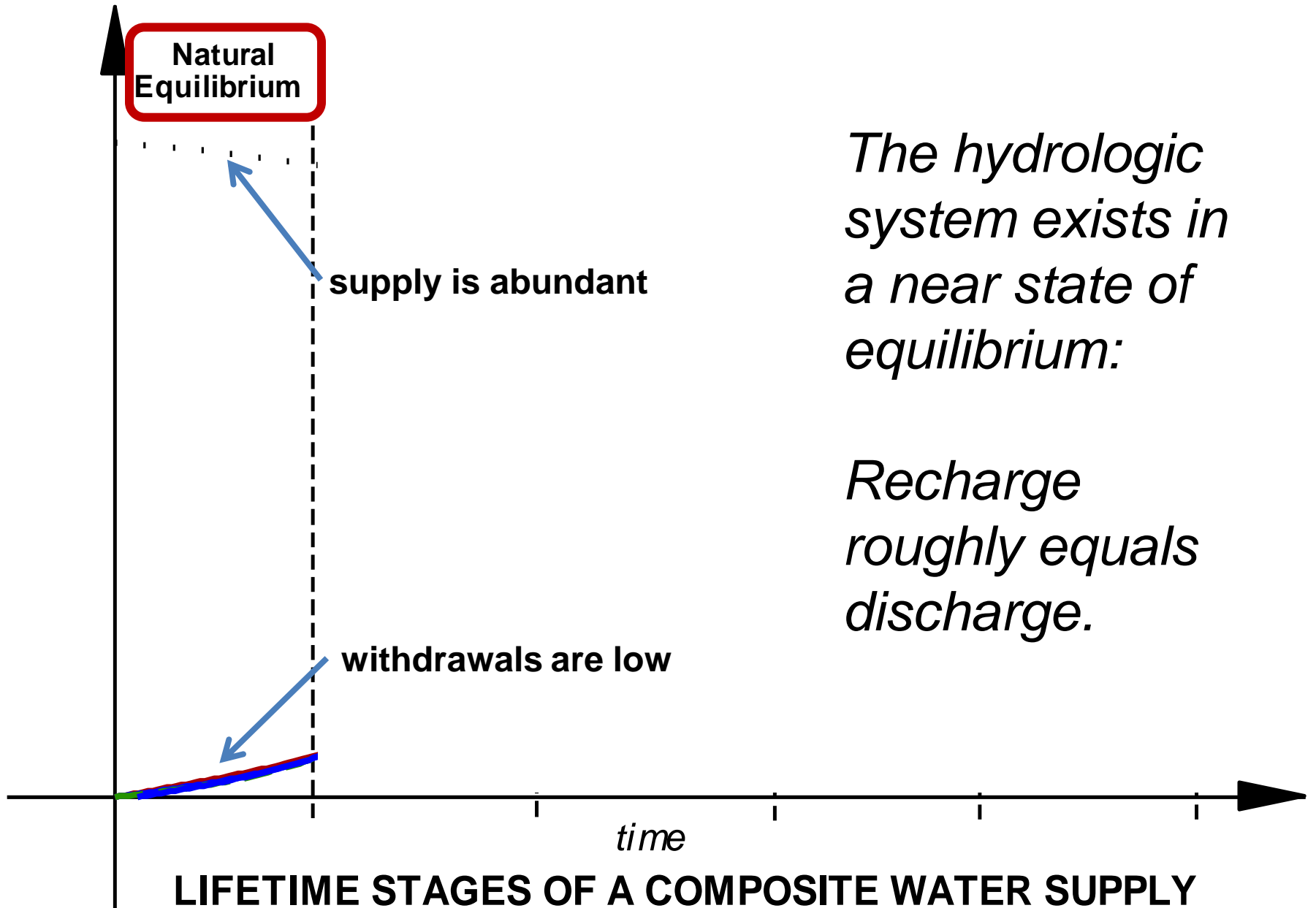


**LIFETIME STAGES OF A COMPOSITE WATER SUPPLY**  
(surface water, artesian groundwater, and unconfined groundwater)



## **LIFETIME STAGES OF A COMPOSITE WATER SUPPLY**

(surface water, artesian groundwater, and unconfined groundwater)

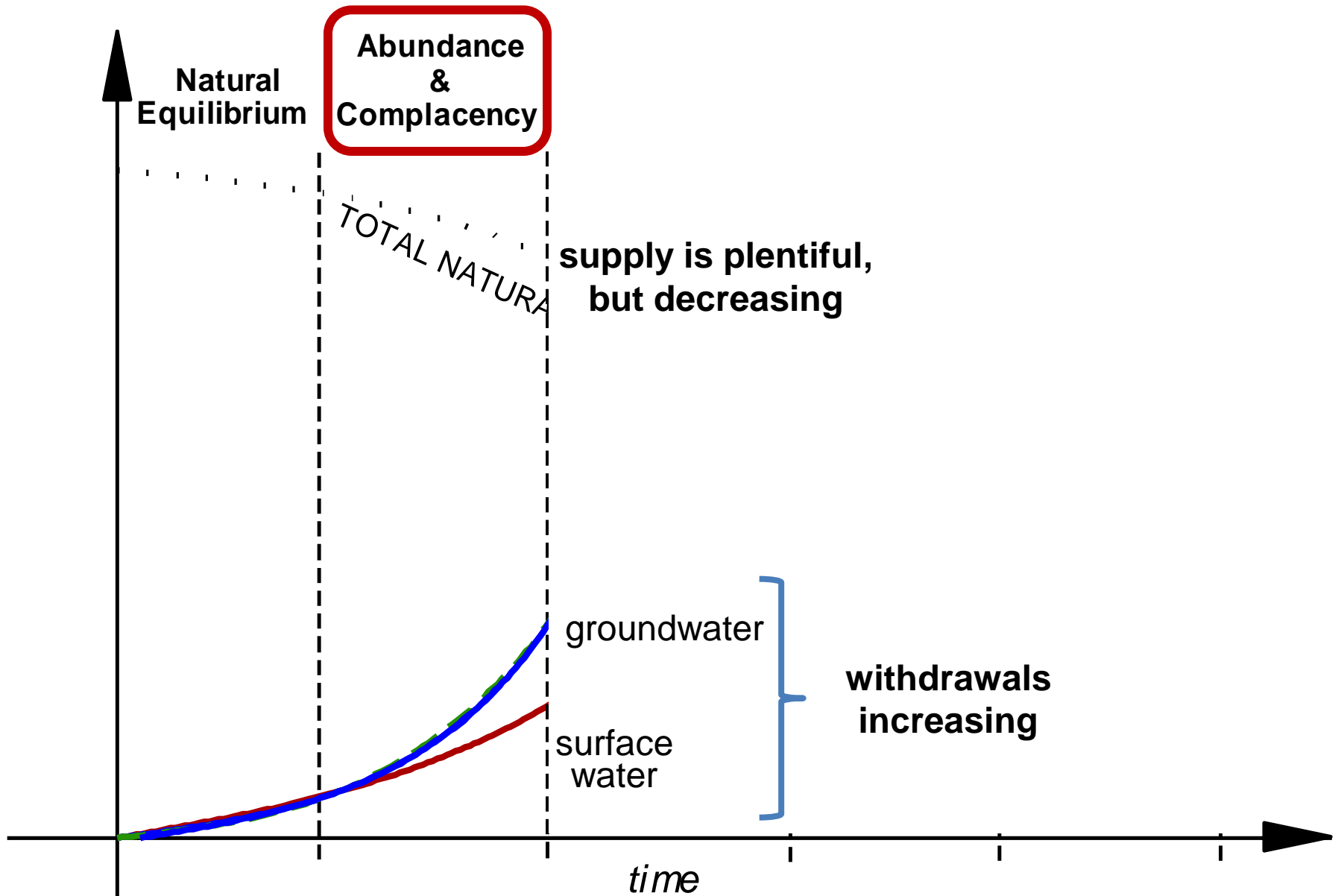


*The hydrologic system exists in a near state of equilibrium:*

*Recharge roughly equals discharge.*

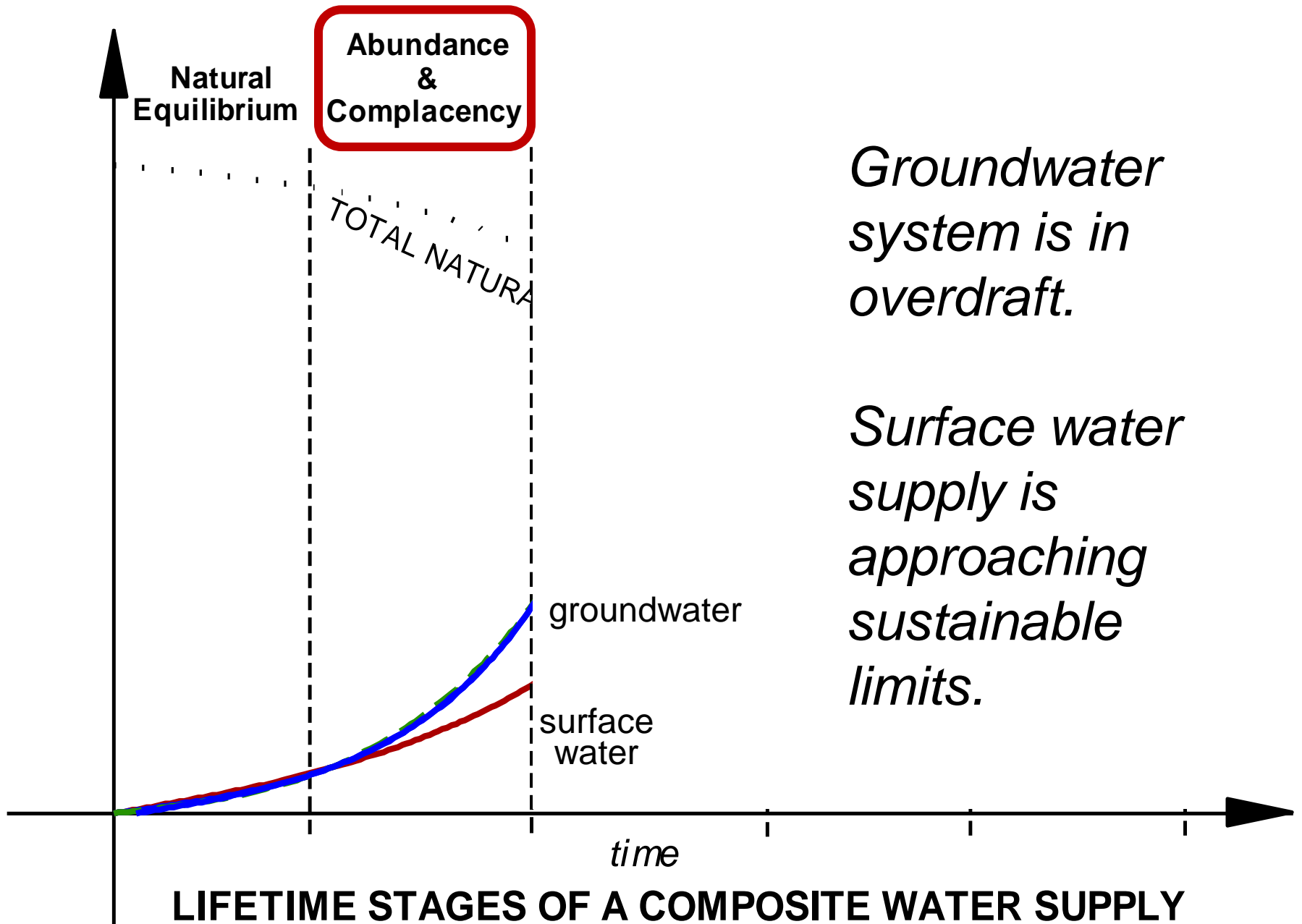
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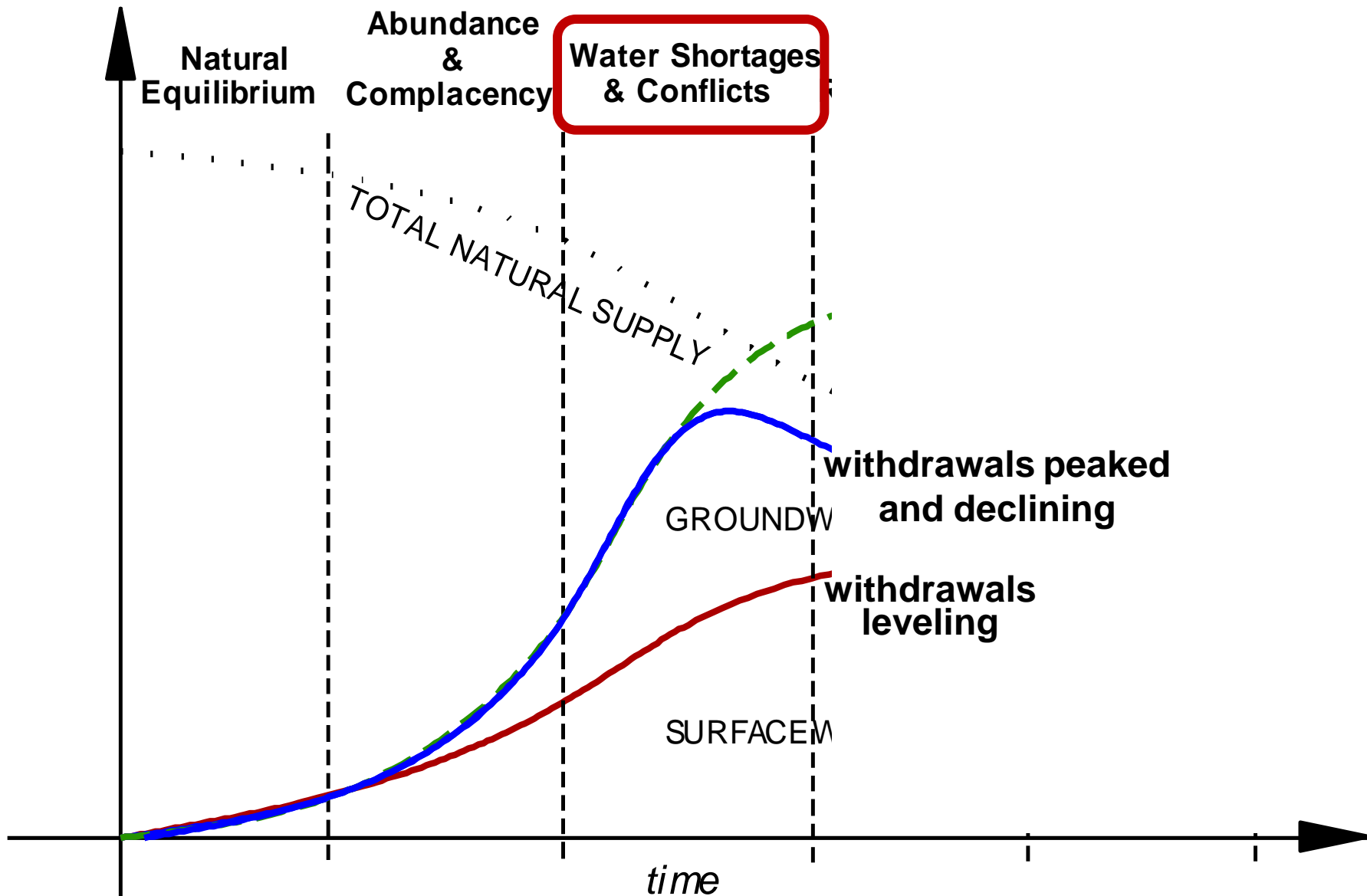
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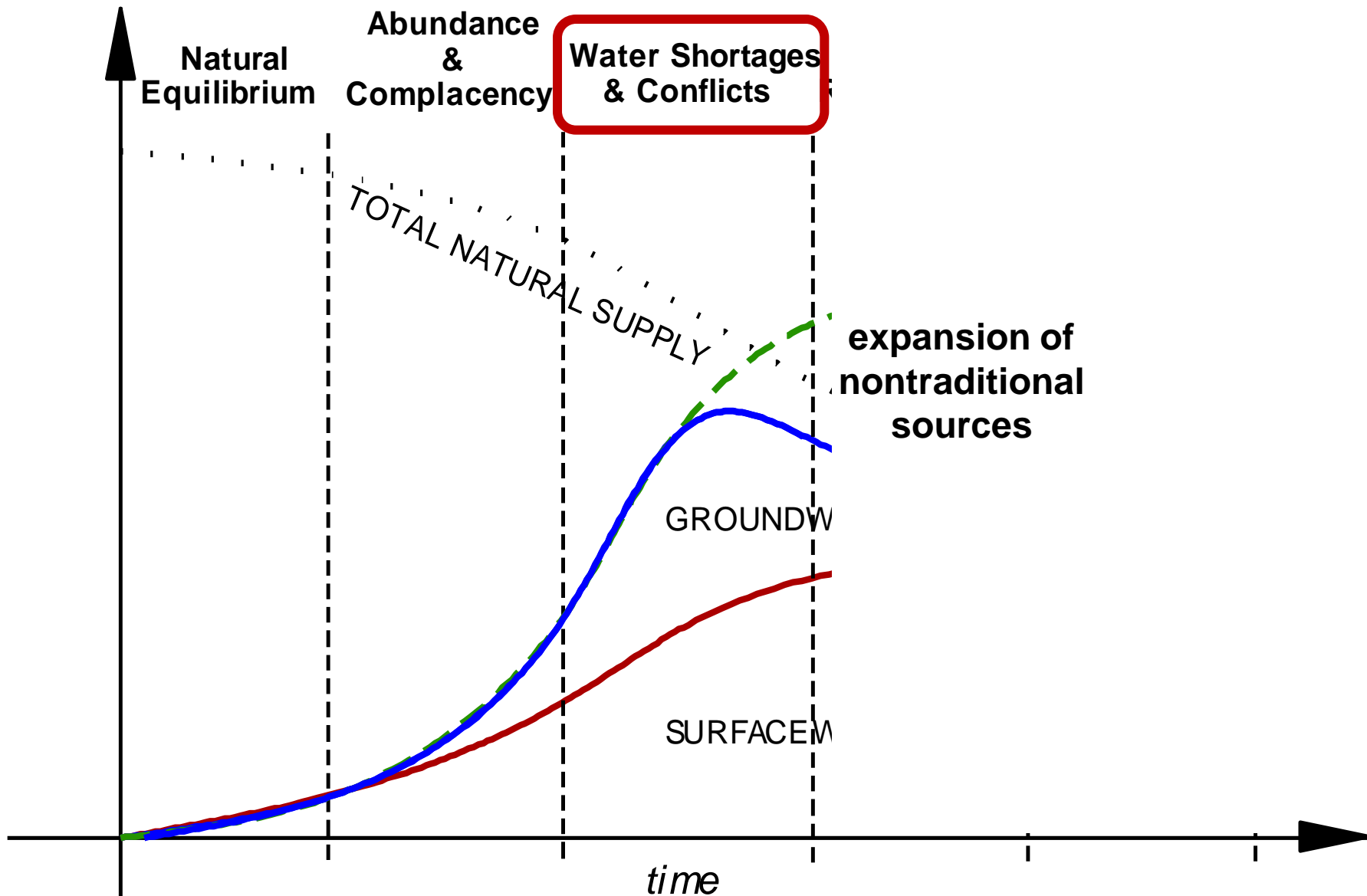
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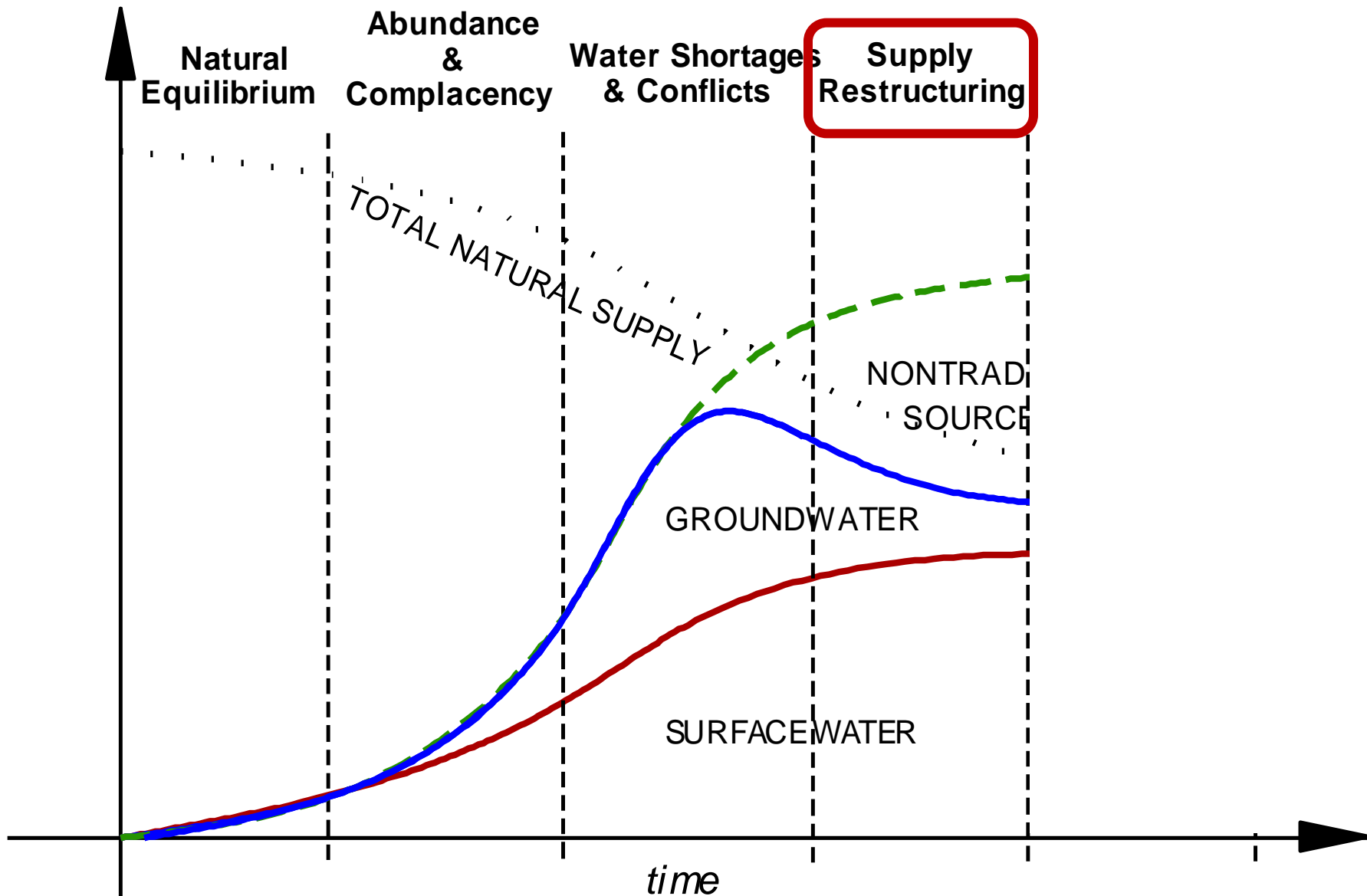
## LIFETIME STAGES OF A COMPOSITE WATER SUPPLY

(surface water, artesian groundwater, and unconfined groundwater)



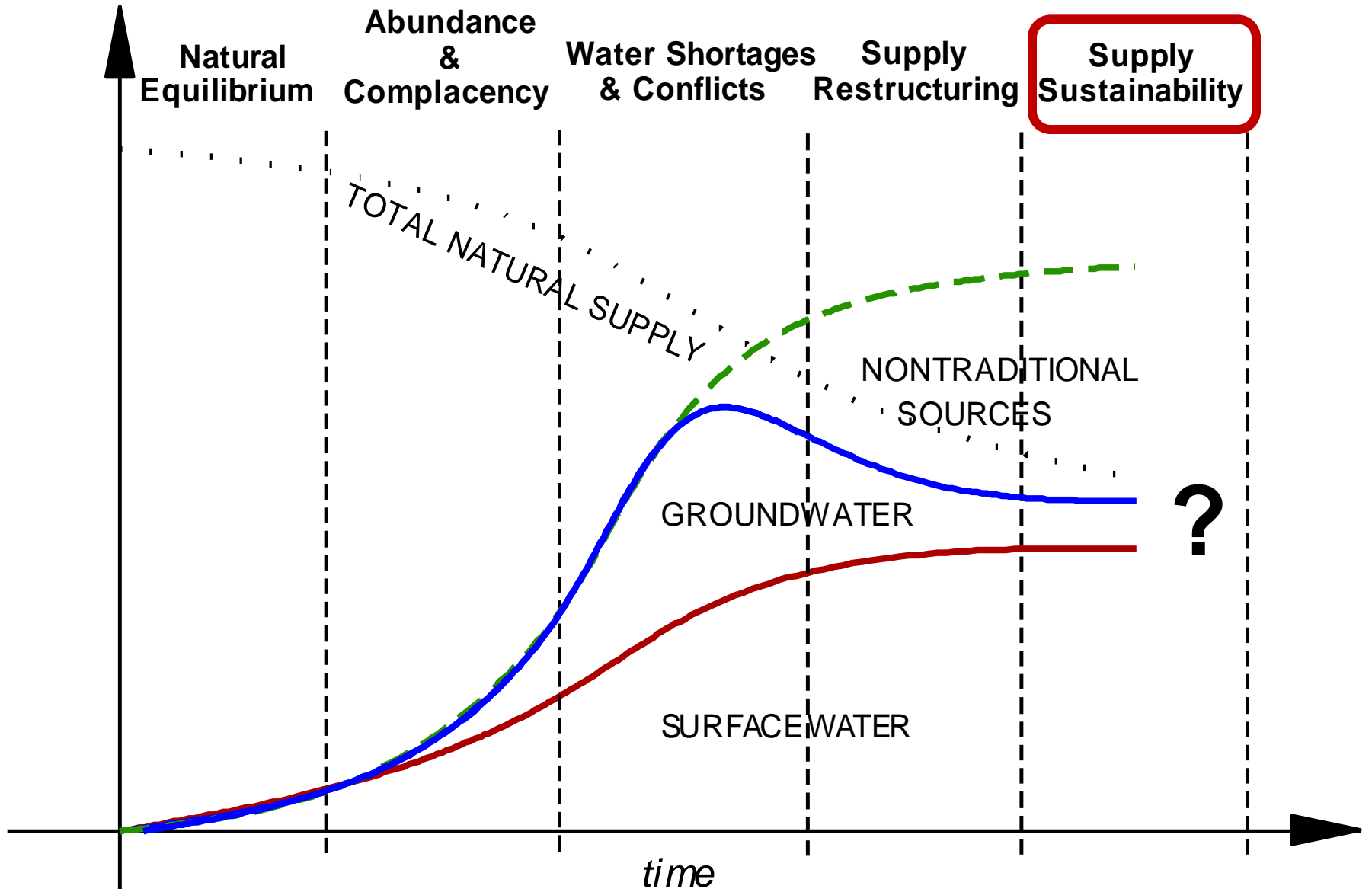
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(surface water, artesian groundwater, and unconfined groundwater)



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(surface water, artesian groundwater, and unconfined groundwater)

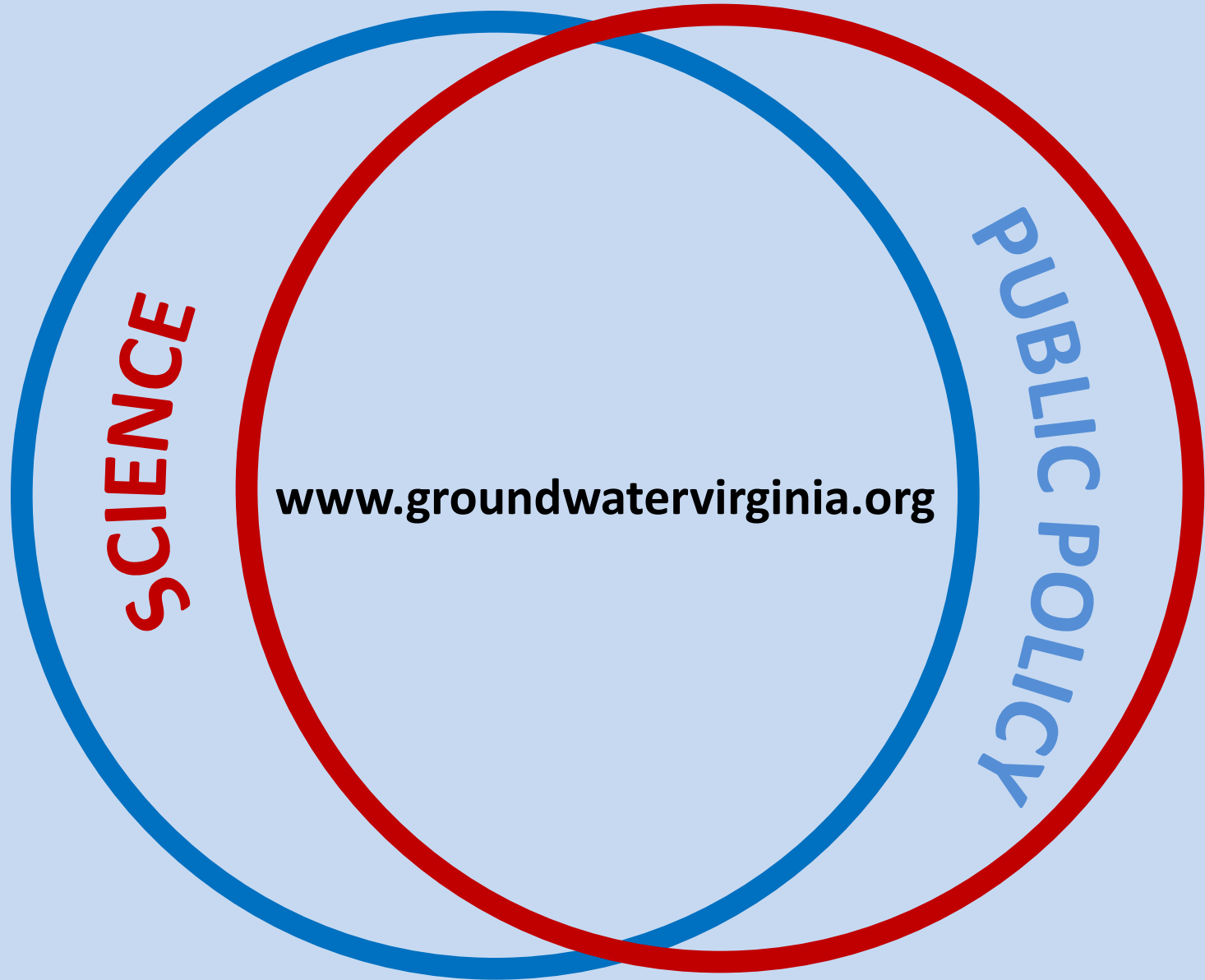


## LIFETIME STAGES OF A COMPOSITE WATER SUPPLY

(surface water, artesian groundwater, and unconfined groundwater)



*Let the struggle begin.*



**SCIENCE**

**PUBLIC POLICY**

[www.groundwatervirginia.org](http://www.groundwatervirginia.org)