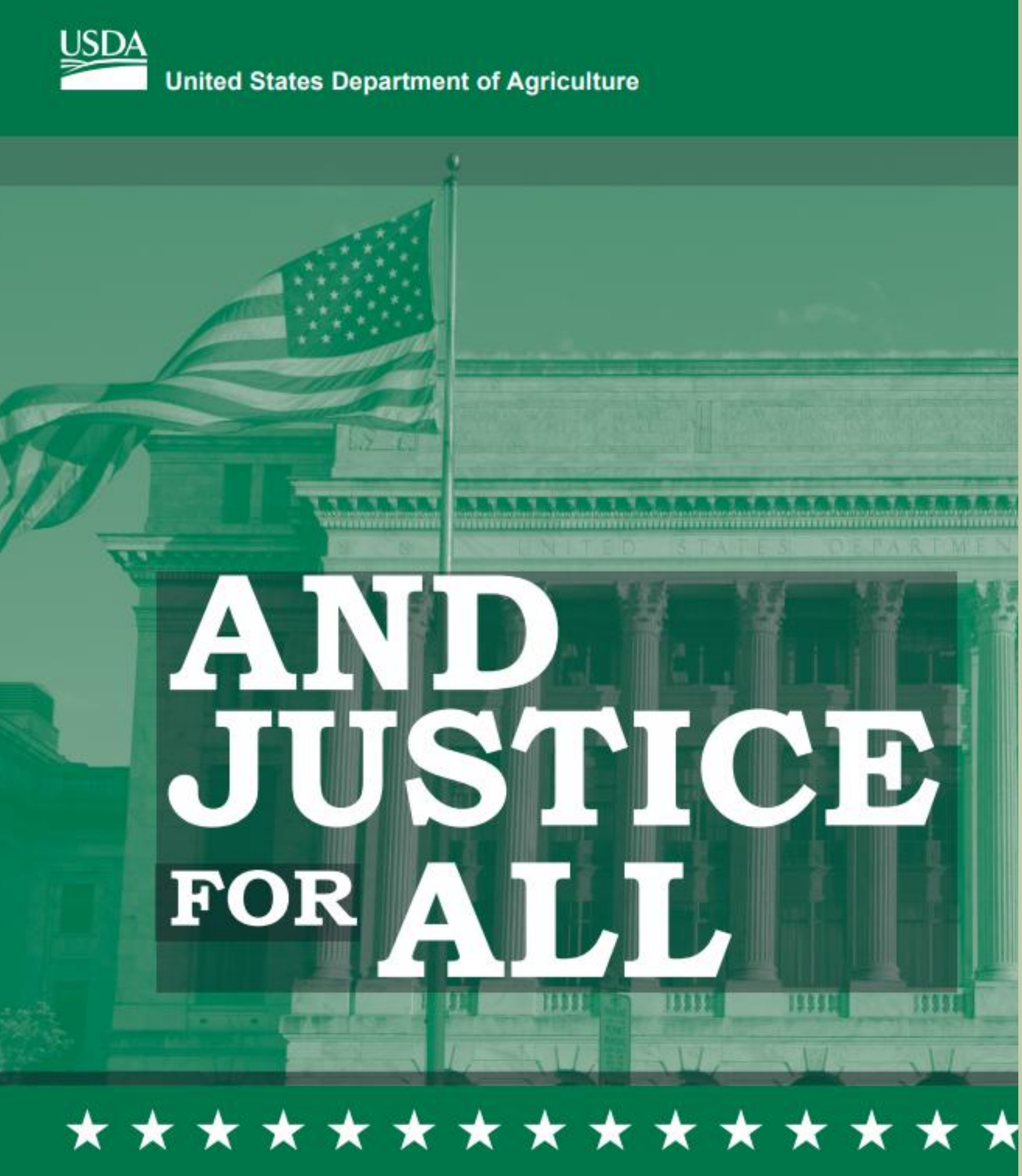
IRRIGATION STEWARDSHIP AND EFFICIENCY

College of the Muscogee Nation
Muscogee-Creek Water Conservation

Andrew Fleet, Water Conservation Educator

March 19th, 2026



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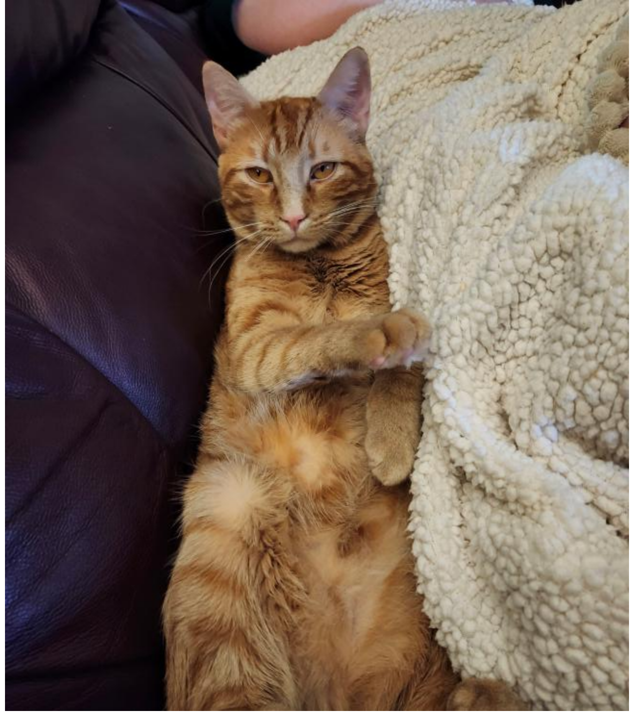
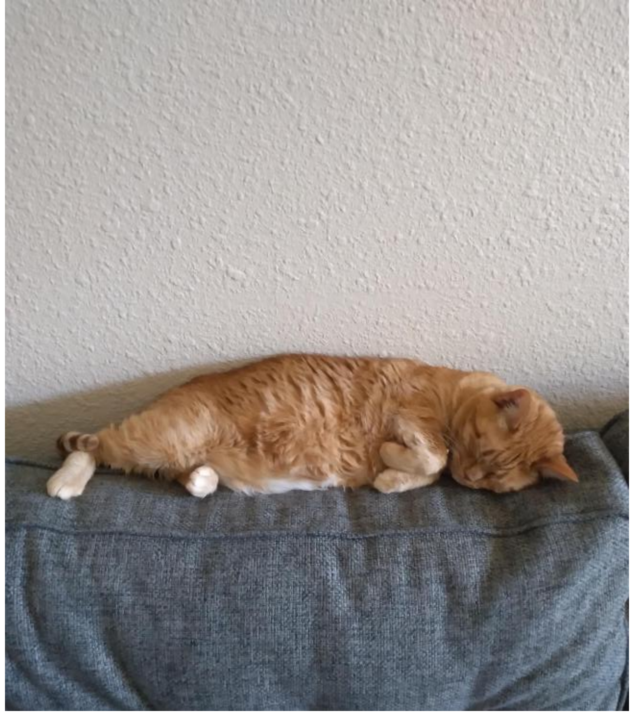
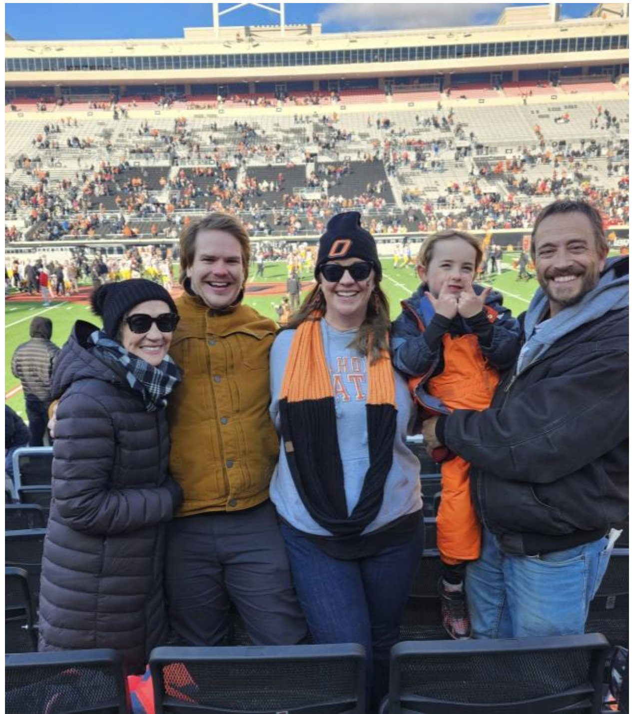



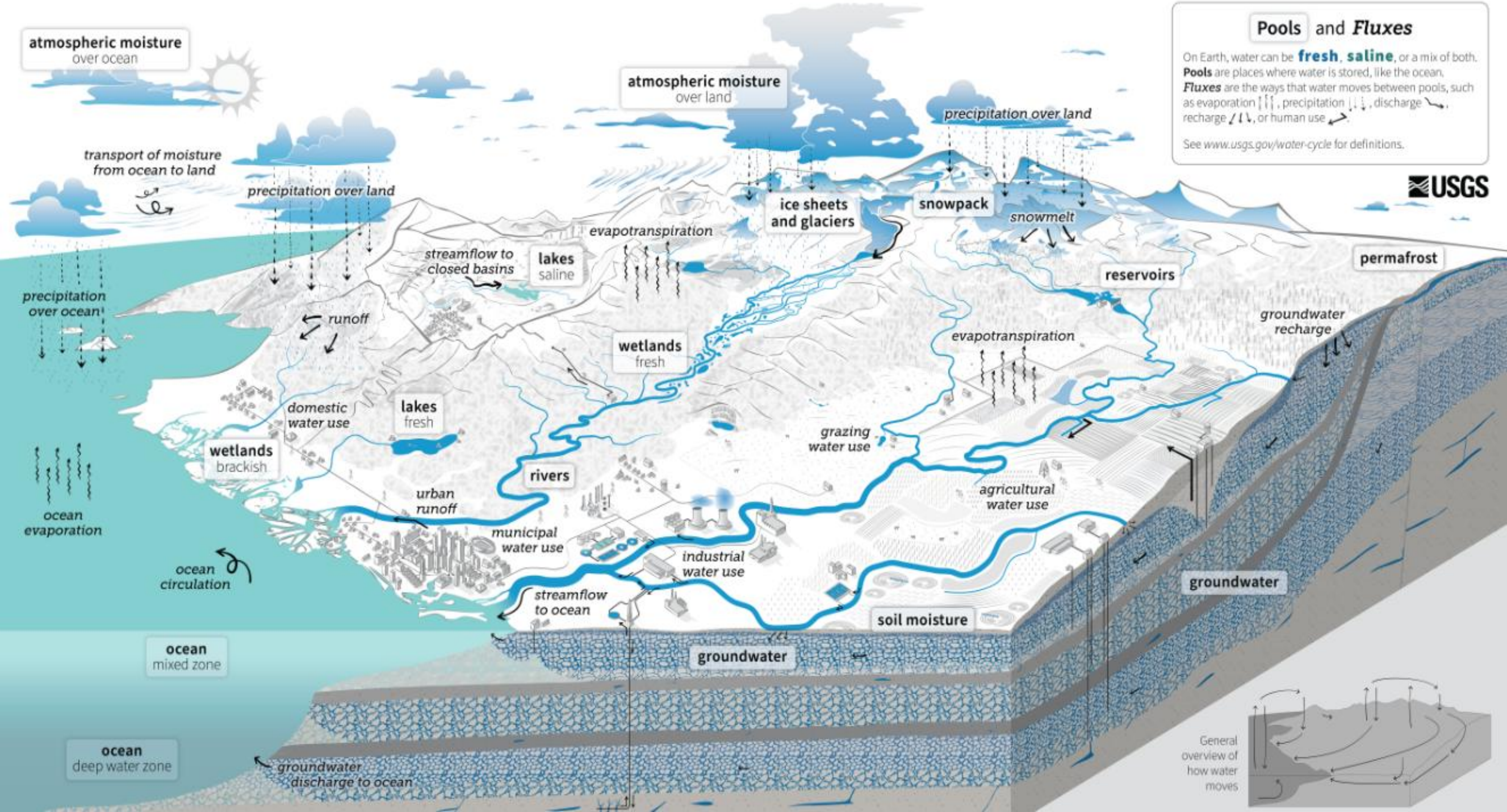
Who is this guy?

WHY DOES WATER MATTER?

- **Water is the foundation of public health, economic development, climate resilience, and culture.**

- **Mindful water conservation is the conscious management and respect of a finite resource under growing demand.**

- **Where does your water come from? Where does it go?**



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.
USGS
atmospheric moisture over ocean
transport of moisture from ocean to land
precipitation over land
atmospheric moisture over land
precipitation over land
ice sheets and glaciers
snowpack
snowmelt
evapotranspiration
streamflow to closed basins
lakes saline
permafrost
reservoirs
precipitation over ocean
runoff
wetlands fresh
groundwater recharge
evapotranspiration
domestic water use
lakes fresh
wetlands brackish
grazing water use
rivers
agricultural water use
ocean evaporation
urban runoff
municipal water use
industrial water use
ocean circulation
streamflow to ocean
groundwater
soil moisture
groundwater
ocean mixed zone
ocean deep water zone
groundwater discharge to ocean
General overview of how water moves

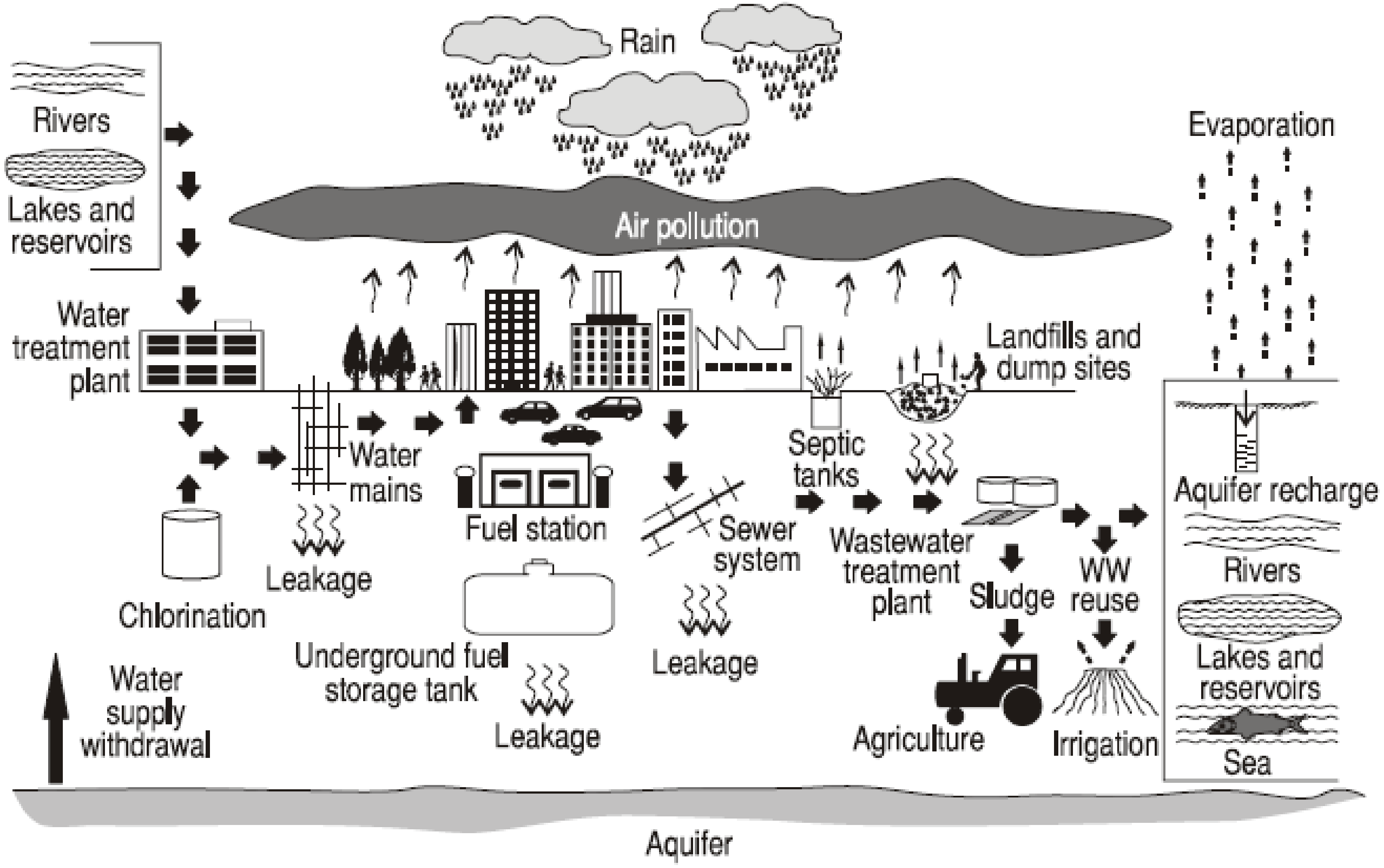


Fig. 1.1 Urban water cycle

Source: "Urban water cycle processes and interactions" UNESCO, International Hydrological Programme

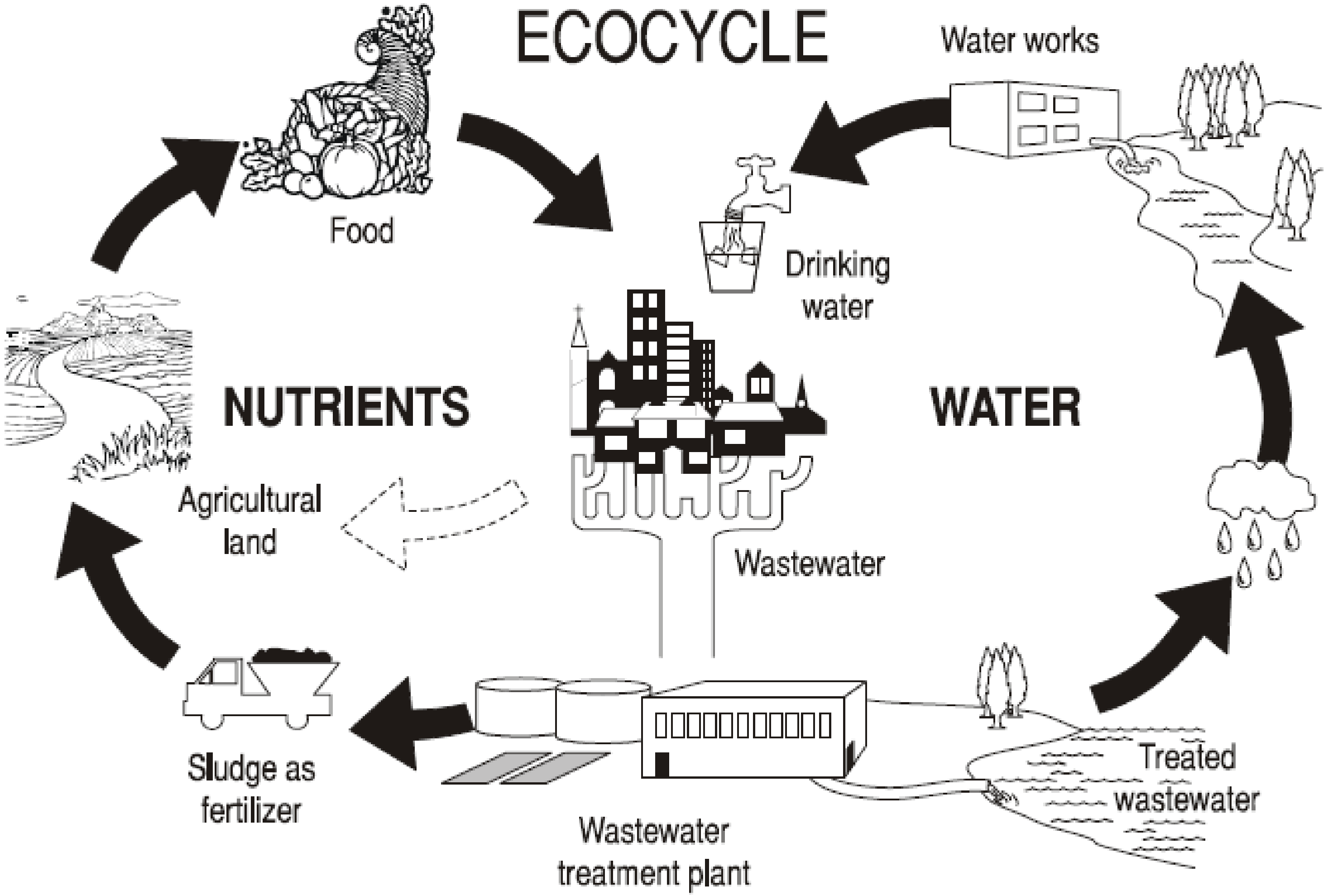


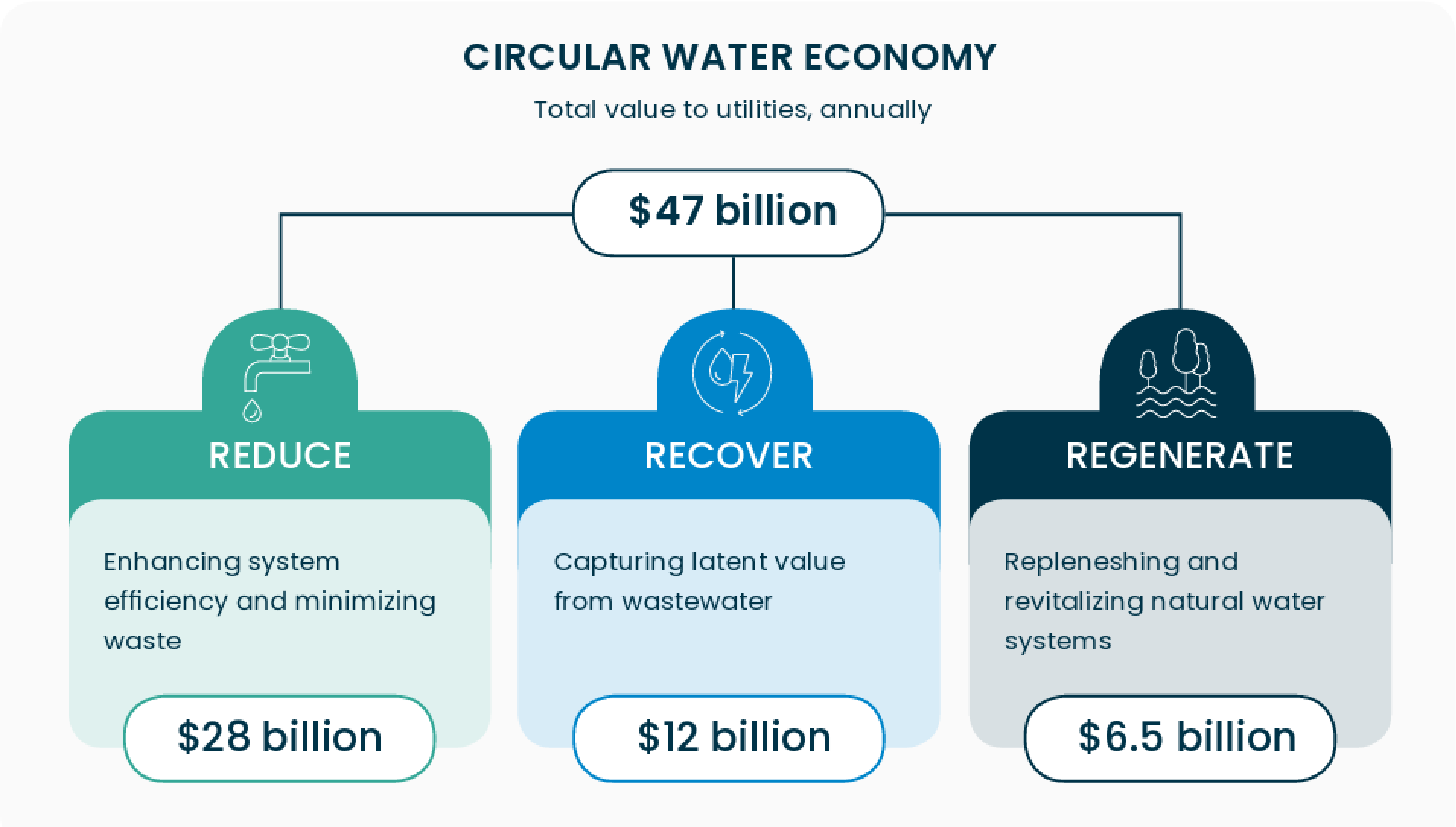
Fig. 3.1 Ecocycles of water and nutrients supporting urban areas

Source: "Urban water cycle processes and interactions" UNESCO, International Hydrological Programme

CIRCULAR WATER ECONOMY

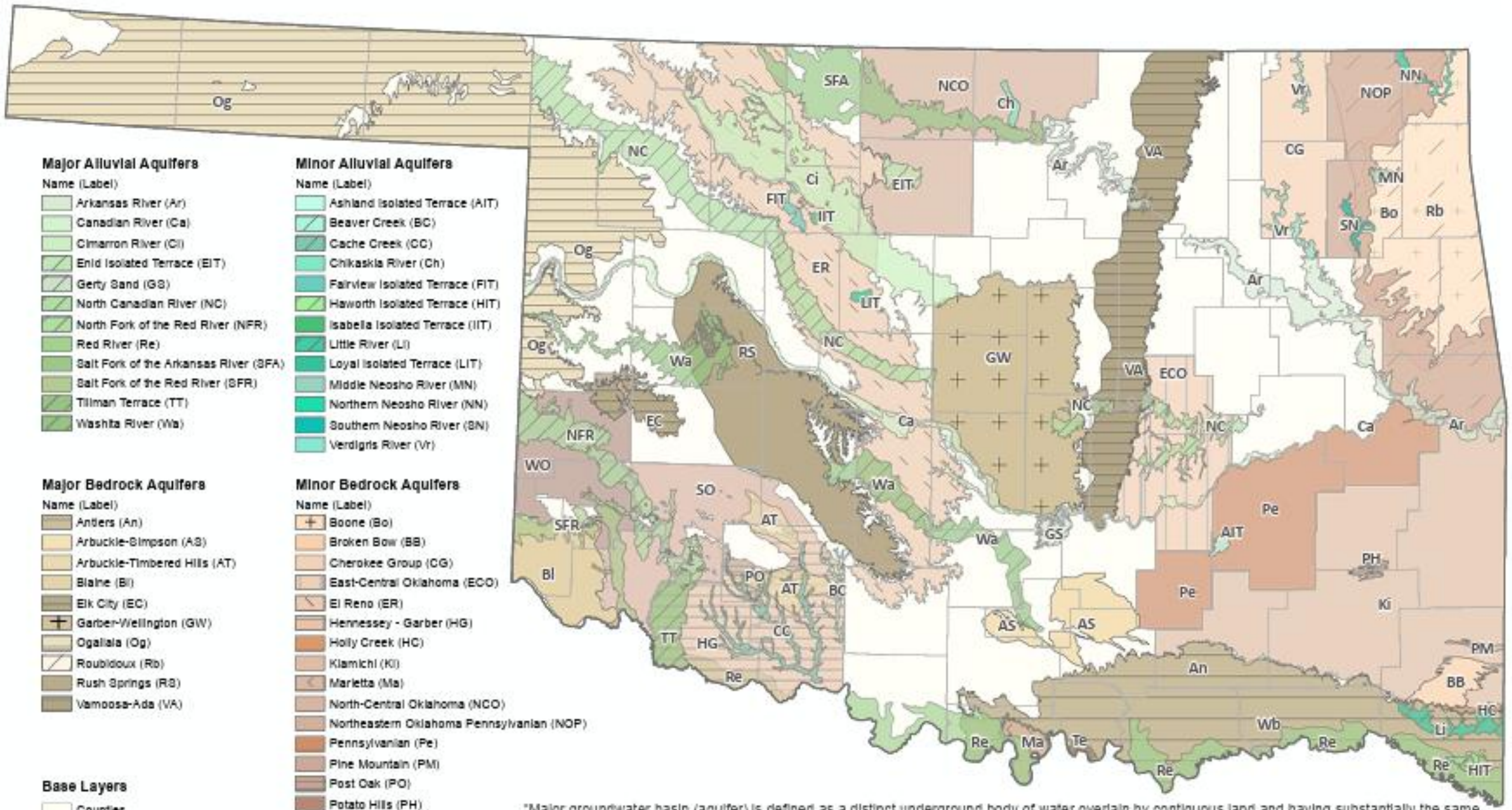
Three Rs	Interventions
REDUCE	1. Detecting leaks and repairing pipes to reduce non-revenue water and redundant treatment of water for enhanced efficiency 2. Recycling wastewater to meet freshwater demand from agriculture, manufacturing, and other sectors
RECOVER	3. Recovering phosphorus and nitrogen from wastewater for use as agricultural fertilizer 4. Using anaerobic digestion to convert waste solids into biogas to generate energy for facilities or the grid 5. Applying treated biosolids to land as nutrient-rich fertilizer
REGENERATE	6. Coordinating green infrastructure development and restoring wetlands to manage stormwater flooding 7. Using treated wastewater or stormwater to recharge surface water supplies, or replenish overdrawn aquifers and prevent saltwater intrusion

https://www.wef.org/circular-water-economy/circular-water-economy/


CIRCULAR WATER ECONOMY
Total value to utilities, annually
$47 billion
REDUCE
Enhancing system efficiency and minimizing waste
$28 billion
RECOVER
Capturing latent value from wastewater
$12 billion
REGENERATE
Replenishing and revitalizing natural water systems
$6.5 billion

Oklahoma Groundwater Resources

Major and Minor Aquifers of Oklahoma

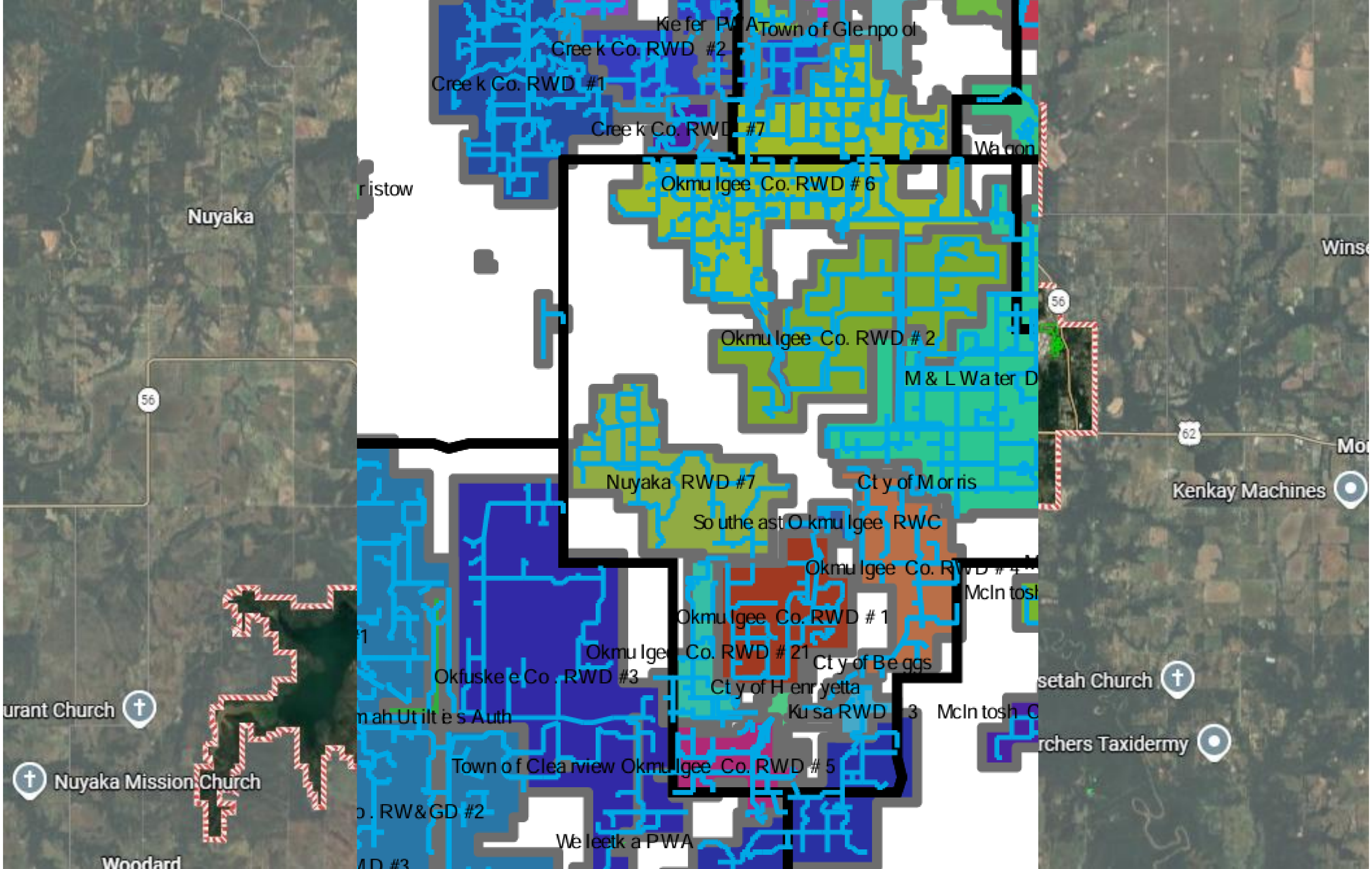


"Major groundwater basin (aquifer) is defined as a distinct underground body of water overlain by contiguous land and having substantially the same geological and hydrological characteristics and from which groundwater wells yield at least fifty (50) gallons per minute on the average basinwide if from a bedrock aquifer and at least one hundred fifty (150) gallons per minute on the average basinwide if from an alluvium and terrace aquifer, or as otherwise designated by the Board.

"Minor groundwater basin (aquifer) is defined as a distinct underground body of water overlain by contiguous land and having substantially the same geological and hydrological characteristics and which is not a major groundwater basin.

For more information please visit the OWRB's web site at: (http://www.owrb.ok.gov)

State of Oklahoma OWRB Water Resources Board the water agency


Kie fer PWA
Town o f Gle npo ol
Cree k Co. RWD #2
Cree k Co. RWD #1
Cree k Co. RWD #7
Wa gon
ristow
Nuyaka
Okmu lgee Co. RWD # 6
Winse
56
Okmu lgee Co. RWD # 2
M & L Wa ter D
56
62
Mor
Nuyaka RWD #7
Ct y of Mor ris
Kenkay Machines
So uthe ast O kmu lgee RWC
Okmu lgee Co. RWD # 4
McIn tosh
Okmu lgee Co. RWD # 1
Okmu lgee Co. RWD # 21
Ct y of Be ggs
Okfuske e Co . RWD #3
Ct y of H enr yetta
setah Church
urant Church
m ah Ut ilt ie s Auth
Ku sa RWD
McIn tosh
rchers Taxidermy
Nuyaka Mission Church
Town o f Clea rview Okmu lgee Co. RWD # 5
o . RW&GD #2
We leetk a PWA
Woodard

Irrigation Scheduling and Water Budgeting

4 Main Factors to Consider:

- Landscape Water Requirement
- Soil Information
- Irrigation System Performance
- Irrigation Schedule



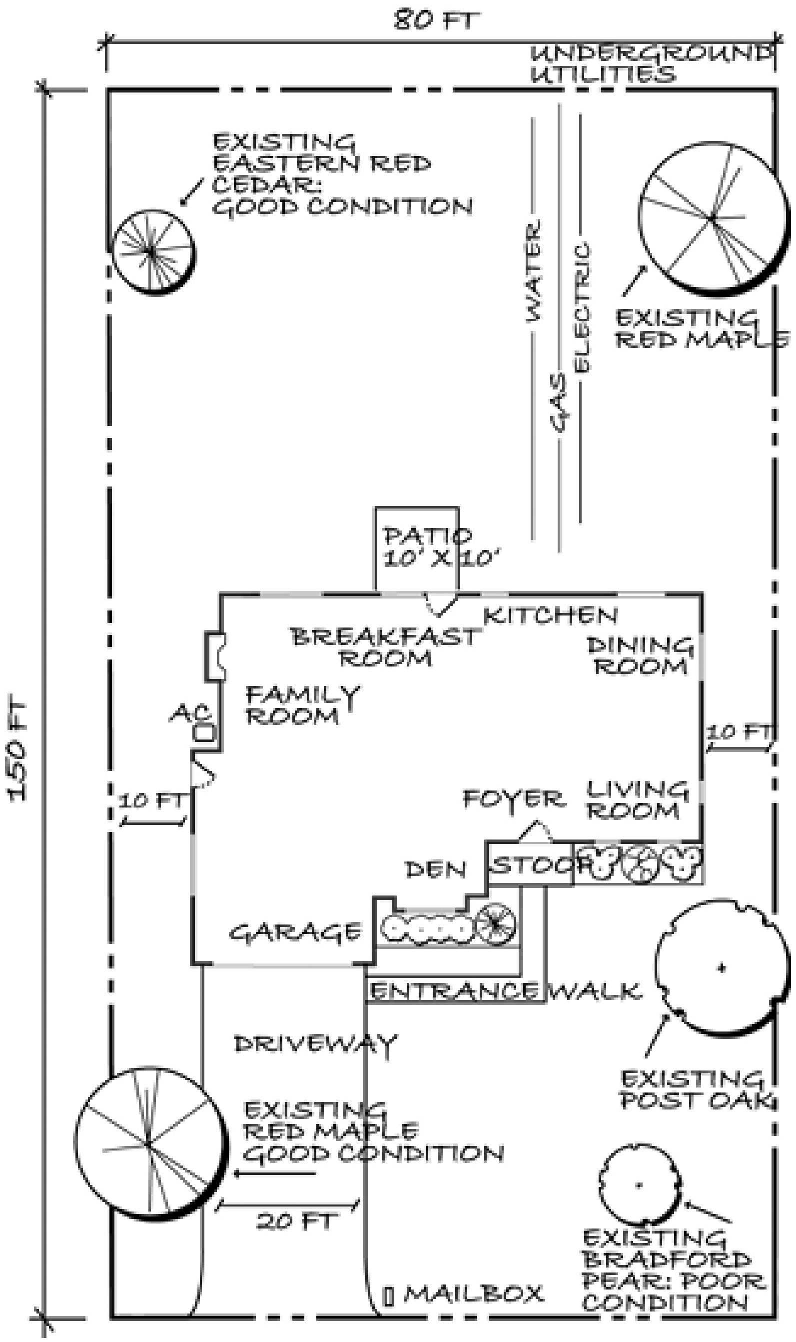



Figure 1. Site inventory documents existing plants, structures and utilities.

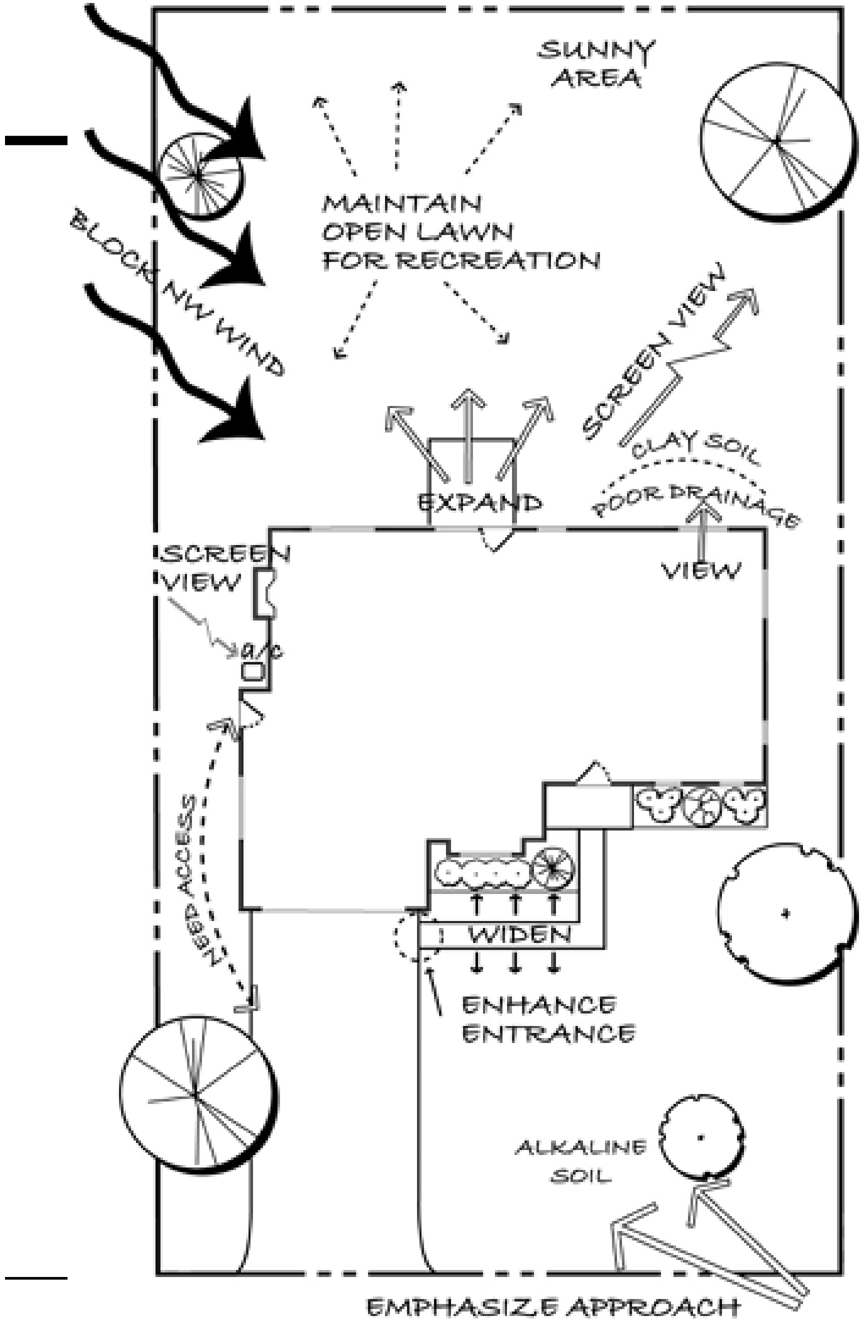


Figure 2. Site analysis identifies challenges and positive features of the landscape.

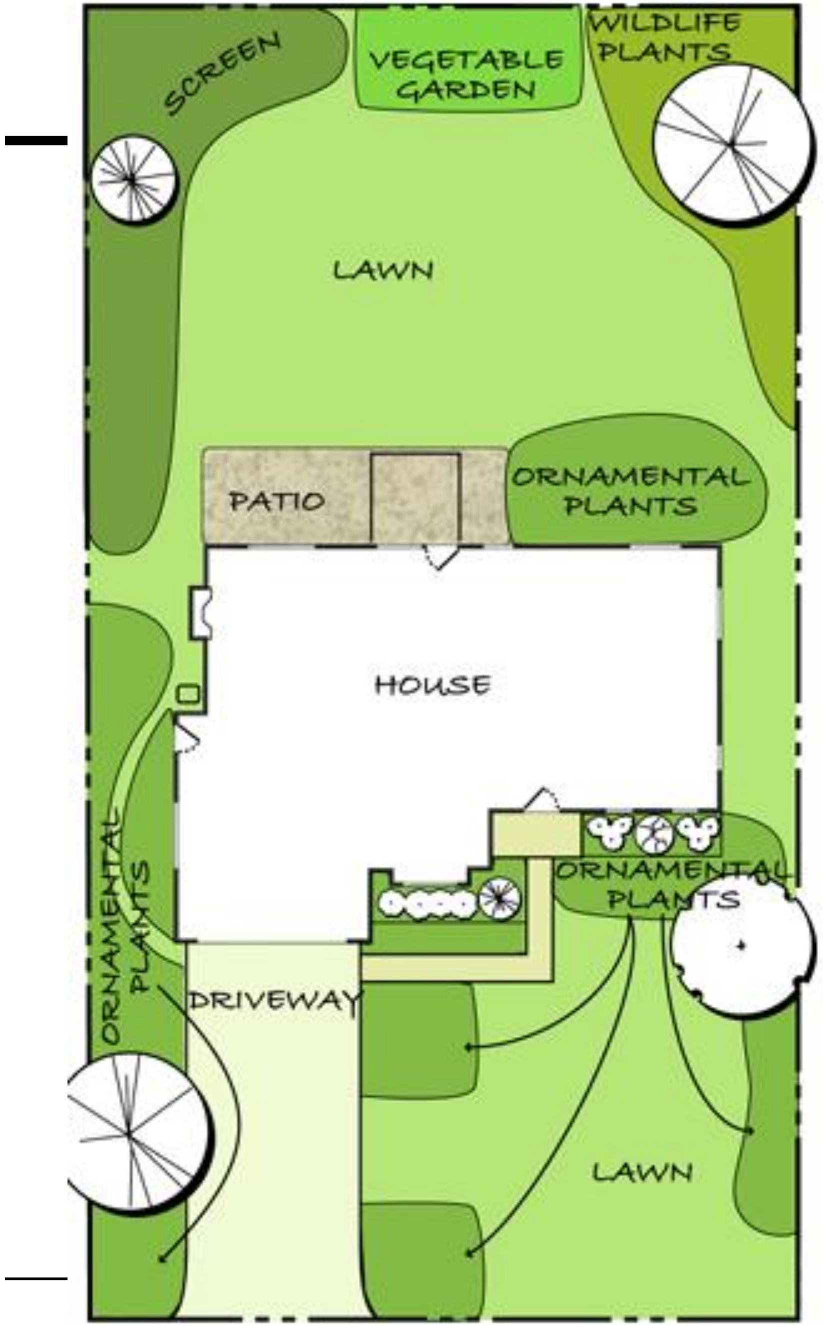


Figure 4. Bubble drawing with areas identified for vegetable gardening, lawn, wildlife habitat and mixed beds.

LANDSCAPE IRRIGATION DESIGN PROCESS

Backflow preventer

- **Required at the cross connection; any link between a potable water supply and a source of contamination**
- **Can occur two different ways:**
  - ***Back-pressure*: when more pressure builds up on the outlet side of the backflow device than exists at the water source**
    - **Usually caused by a pump or other pressure producing equipment**
  - ***Back-siphonage*: caused by a drastic drop in pressure in the water source (usually by undersized pipes, line repair or break, main pressure lowered due to high demand, reduced supply in main pressure on suction side of booster pump**

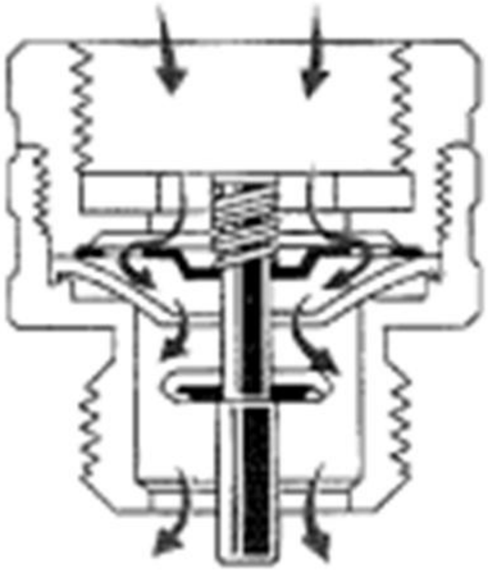
LANDSCAPE IRRIGATION DESIGN PROCESS

“Where lawn sprinkler and irrigation systems have pumps, connections for pumping equipment, auxiliary air tanks or are otherwise capable of creating backpressure, the potable water supply shall be protected by the following type of device if the backflow prevention device is located upstream from the source of backpressure: 1) Reduced pressure principle backflow preventer – ASSE 1013 (RP)”

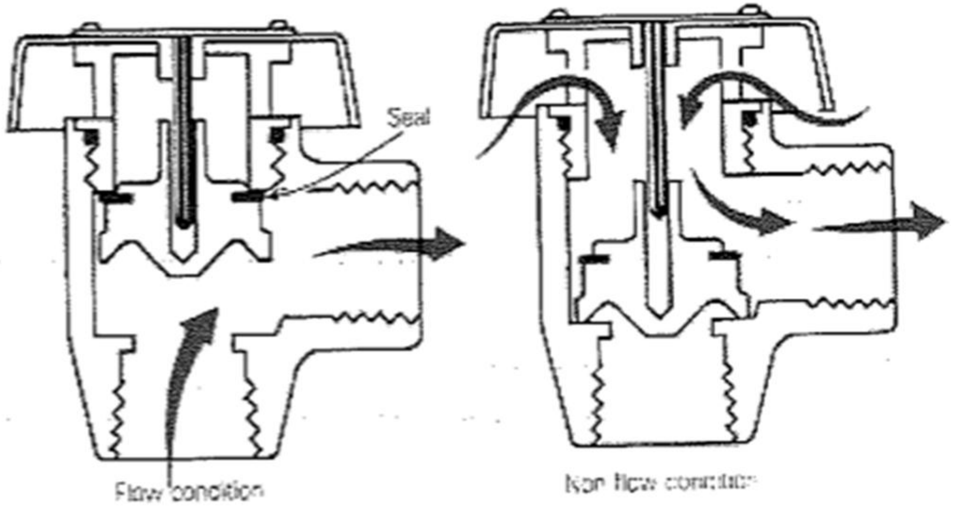
-2024 National Standard Pluming Code, pg. 143

Source: https://iapmo.org/codes-standards-development/code-development/national-standard-plumbing-code

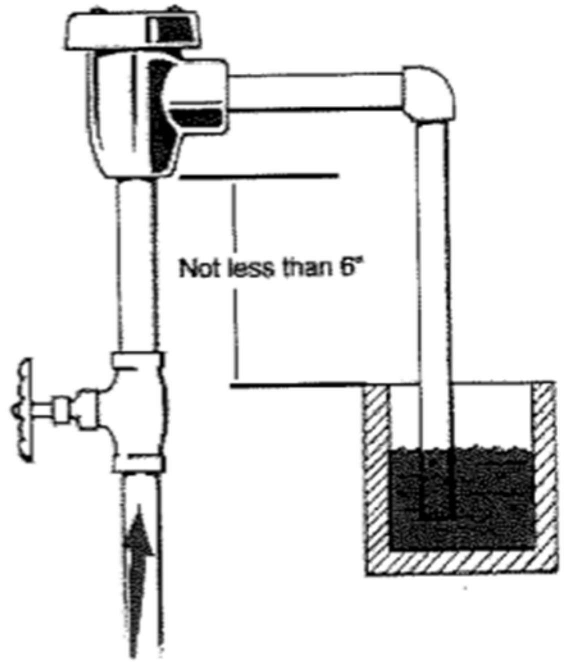
TYPES OF BACKFLOW PREVENTERS

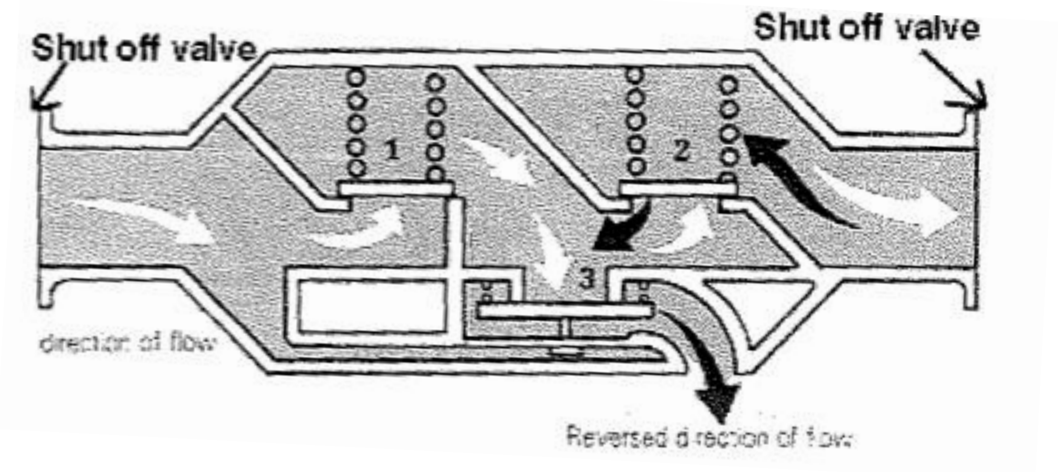


Atmospheric Vacuum Breaker



Atmospheric Vacuum Breaker
Typical Installation





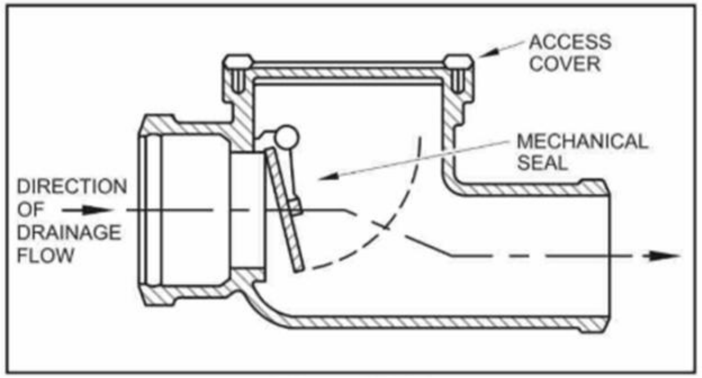


Figure 1.2.10
A BACKWATER VALVE

Water Flow Meter Capacity

- ***Rule 1***: **"The pressure loss through the water meter should not exceed 10% of the minimum static pressure available in the city water main".**
- ***Rule 2***: **"The maximum flow through the meter for irrigation should not exceed 75% of the maximum safe flow of the meter according to the American Water Works Association standards".**
- ***Rule 3***: **"The velocity of flow through the service line should not exceed 5 FPS for plastic pipes of 7 FPS for metal".**
    - **Source: Rain Bird's "Landscape Irrigation Design Process", pg. 25-26**

SPRINKLER IRRIGATION

Advantages of Sprinkler Systems:

- **Coverage**
  - **Sprinklers can cover large areas and are usually better for open space where coverage across plant canopies from above is needed.**
- **Variety**
  - **There are a wide range of sprinkler systems (overhead, micro-sprinkler, etc.) what can cater to different crop types and environmental conditions**
- **Longer Lifespan:**
  - **Sprinkler systems tend to last longer than drip system when properly maintained**
- **Freeze Protection:**
  - **Overhead sprinklers can provide freeze protection for some plants if used correctly during cold weather events**

Disadvantages of Sprinkler Systems:

- **Water Efficiency:**
  - **Sprinkler systems are generally less efficient than drip systems due to higher evaporation rates, especially in windy conditions; Distribution Uniformity (DU)**
- **Foliage Wetting:**
  - **Sprinkler systems wet the foliage, which can increase the risk of plant diseases (especially if watered at inappropriate times).**

DRIP IRRIGATION

Advantages of Drip Irrigation:

- **Water Efficiency**
- **Targeted Application**
- **Disease Prevention**
- **Lower Labor Requirements**

Disadvantages of Drip Irrigation:

- **Initial Cost**
- **Clogging Issues**
- **Limited Coverage Area**

Light Requirements	
Full Sun	
Full Sun to Partial Shade	
Partial to Full Shade	

Plant Size	
Height	
Width	

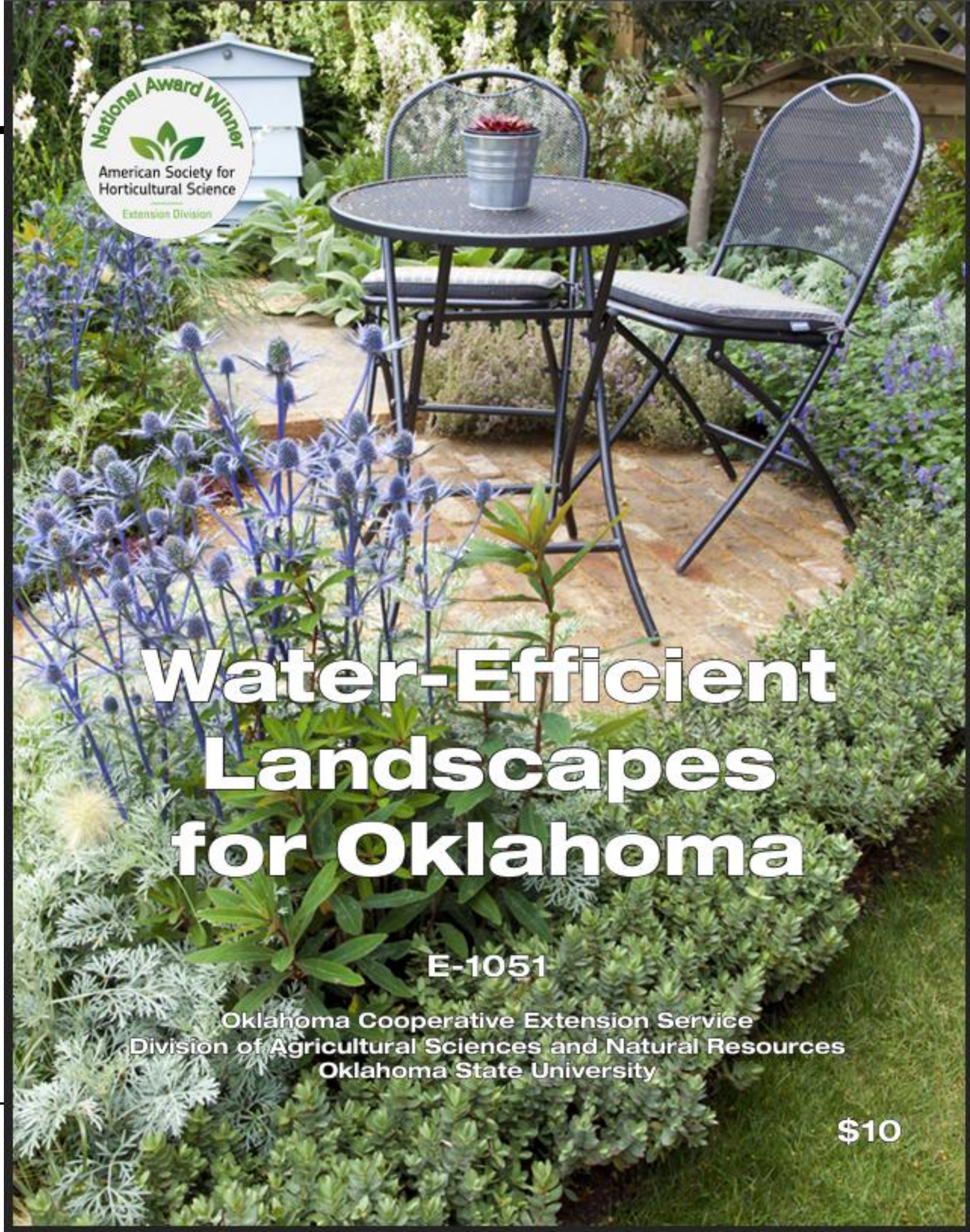
Soil pH Requirements	
Acidic (Low pH)	L
Neutral (pH 7.0)	N
Alkaline (High pH)	H

Water Requirements*	
Moderate	
Low	
Very Low	

Season of Interest	
Summer	SUM
Fall	FALL
Winter	WIN
Spring	SPR
All	ALL

Place of Origin	
Outside of US	Not Native
Continental US	Native
Oklahoma	OK-Native

*Water requirements can be drastically reduced by the liberal use of mulch. Some plants listed are marginally xeric in the absence of mulch. For more information about mulch go to facts.okstate.edu and check out L-436 and HLA-6005.



Mexican Feather Grass
Nassella tenuissima

ALL	pH: N	18 inches ↑ / 12 inches →	Native

Remove the top third of the plant in the spring. Will reseed each growing season and can spread vigorously if not maintained.

Lavender
Lavandula spp.

SUM	pH: N	24 to 36 inches ↑ / 24 to 48 inches →	Not Native

Needs very well-drained soil.

Eastern Red Columbine
Aquilegia canadensis

SPR	pH: H	2 to 3 feet ↑ / 1 to 1.5 feet →	OK-Native

A wonderful addition to native plant gardens, woodland gardens, cottage gardens or naturalized areas. Photos courtesy Sally and Andy Wasowski, LBJ Wildflower Center, (left) and Stephan Bloodworth, LBJ Wildflower Center (right).

Big Bluestem
Andropogon geradii

ALL	pH: N	3 feet ↑ / 4 feet →	OK-Native

Works as a tall background or a screen, cut back in the spring before new growth starts. Photo courtesy Sally and Andy Wasowski, LBJ Wildflower Center (left).

Catmint
Nepeta x faassenii

SUM	pH: N	24 inches ↑ / 30 inches →	Not Native

Thrives in heat and drought once established. Aromatic foliage. Photo courtesy OSU (left).

Texas Bluebonnet
Lupinus texensis

SPR	pH: N	6 to 12 inches ↑ / 12 to 15 inches →	OK-Native

Texas state flower. Most readily available by seed. Photos courtesy Melody Lytle, LBJ Wildflower Center (left) and Lisa Henry, LBJ Wildflower Center (right).

Turf Irrigation Water Quality: A Concise Guide

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Research and Extension Specialist

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This Fact Sheet helps turf managers assess their irrigation water by using four key water properties that are listed on water reports and four key soil properties listed on soil salinity and texture reports. The second half of this Fact Sheet provides six illustrative case-studies for bermudagrass lawns to model site-specific irrigation strategies.

Four Key Irrigation Water Properties

Total salts is typically reported in units of milligrams per liter (mg/L) as TDS (total dissolved solids) or TSS (total soluble salts); for all practical purposes, TDS and TSS are interchangeable terms. However, TDS and TSS are often indirectly measured as EC (electrical conductivity) multiplied by 0.64. While EC is the historical method of classifying irrigation water, total salts makes more intuitive sense; either can be used (Table 1).

The **SAR** (sodium adsorption ratio) is used for determining the ratio of sodium to calcium and magnesium in soils. This relationship is important because sodium strips calcium from soil particles and prevents soil aggregates from forming and creating flow paths in the soil. Although SAR is typically a soil parameter, it can also be used to classify irrigation water (Table 2) because that water will eventually determine the salt chemistry of the soil. The SAR is unitless because it is a ratio.

The **Adj SAR** (adjusted sodium adsorption ratio) is another parameter typically used for soils. It adjusts for lost calcium in the form of calcium carbonate deposits. This calcium loss essentially increases the SAR of irrigation water and decreases the soil's ability to form soil aggregates. Use Adj SAR when it exceeds the unadjusted ratio. The regular classification system for SAR (Table 2) is still used after the adjustment.

The SAR and total salts together help predict water infiltration rates. Infiltration rates are improved by high total salts, but high salts may damage turfgrass. Therefore, water with high salts can be helpful (Figure 1, page 2) and harmful (Table 1) simultaneously.

Boron is a nutrient, but in high concentrations is toxic to plants. In addition, boron is difficult to leach from the soil. It requires about three times the water to leach boron from the soil as it does salts. Water containing less than 1.0 mg/L boron should be of no concern for most plant materials, while water with more than 2.0 mg/L boron is unsuitable for irrigation use.

Table 2. Classification of irrigation water based on SAR.

SAR	*Classification*	*Management*
< 1	Excellent	None
1–2	Good	Little concern; add pelletized gypsum periodically
2–4	Fair	Aerify soil, sand topdress, apply pelletized gypsum, monitor soils
4–8	Poor	Aerify soil, sand topdress, apply pelletized gypsum, monitor soils closely, leach regularly
8–15	Very Poor	Requires special attention; consult water specialist
> 15	Unacceptable	Do not use

Table 1. Classification of irrigation water based on total salts (mg/L or ppm) and EC (µS/cm or µmhos).

Total Salts	*EC*	*Classification*	*Management*
< 320	< 500	Excellent	None
320–960	500–1,500	Good	Little concern, especially with periodic rainfall
960–1,920	1,500–3,000	Fair	Leach salts from soil as needed
1,920–3,200	3,000–5,000	Poor	Routinely leach; monitor soils
3,200–3,840	5,000–6,000	Very Poor	Requires special attention; consult water specialist
> 3,840	> 6,000	Unacceptable	Do not use

1 Water with high total salts makes for a saline soil.

Water report	*Soil salinity report*	*Texture report*
Total Salts ǀ **2,700 mg/L**, Poor	TSS ǀ **6,000 mg/L**, Saline	35% Sand
SAR ǀ 1.5, Good	SAR ǀ 2.2, Normal	30% Silt
HCO_3 ǀ 0.0 mg/L; No Adj SAR	Boron ǀ 0.03 mg/L, No Concern	**35%** Clay
Boron ǀ 0.05 mg/L, No Concern		

This irrigation water is classified as **Poor** because of the high total salts.
This soil is classified as **Saline** because of the high TSS.
This soil is classified as a **Clay Loam** with low permeability.

Plant symptoms. Brown areas, similar to drought stress.
Management strategy. Regularly use excess irrigation water to leach salts from the soil. Use best available water.

2 Water with high sodium makes for a sodic soil.

Water report	*Soil salinity report*	*Texture report*
Total Salts ǀ 1,320 mg/L, Fair	TSS ǀ 2,000 mg/L, Normal	35% Sand
SAR ǀ **7.0**, Poor	SAR ǀ **16**, Sodic	20% Silt
HCO_3 ǀ 0.0 mg/L; No Adj SAR	Boron ǀ 0.45 mg/L, No Concern	**45%** Clay
Boron ǀ 0.12 mg/L, No Concern		

This irrigation water is classified as **Poor** because of the high SAR.
This soil is classified as **Sodic** because of the high SAR.
This soil is classified as a **Clay** with very low permeability.

Plant symptoms. Brown areas, similar to drought stress; soil water fails to drain.
Management strategy. Aerify soil and sand topdress; apply 10 pounds pelletized gypsum/1,000 sq. ft. and repeat in 30 days. Utilize a maintenance program of 5 pounds pelletized gypsum/1,000 sq. ft. per month during growing season. Leach regularly with best available water.

3 Water with both high total salts and high sodium makes for a saline-sodic soil.

Water report	*Soil salinity report*	*Texture report*
Total Salts ǀ **2,120 mg/L**, Poor	TSS ǀ **5,400 mg/L**, Saline	40% Sand
SAR ǀ **6.6**, Poor	SAR ǀ **14**, Sodic	40% Silt
HCO_3 ǀ 0.0 mg/L; No Adj SAR	Boron ǀ **0.95 mg/L**, Concern for Sensitive Ornamentals	20% Clay
Boron ǀ 0.55 mg/L, No Concern		

This irrigation water is classified as **Poor** because of high total salts and high SAR.
This soil is classified as **Saline-Sodic** because of the high TSS and the high SAR.
This soil is classified as a **Loam** with moderate permeability.

Plant symptoms. Brown areas, similar but not identical to drought stress.
Management strategy. Aerify soil and sand topdress; apply 10 pounds pelletized gypsum/1,000 sq. ft. and repeat in 30 days; utilize a maintenance program of 5 pounds pelletized gypsum/1,000 sq. ft. per month during growing season. Leach regularly with best available water. Use different water supply for ornamental trees.

Soil Texture & Structure

- *Soil texture* is determined by the size and proportion of soil particles that make up the soil.
- *Soil structure* is the grouping of particles of sand, silt, and clay into larger groups (aggregates) of different sizes and shapes

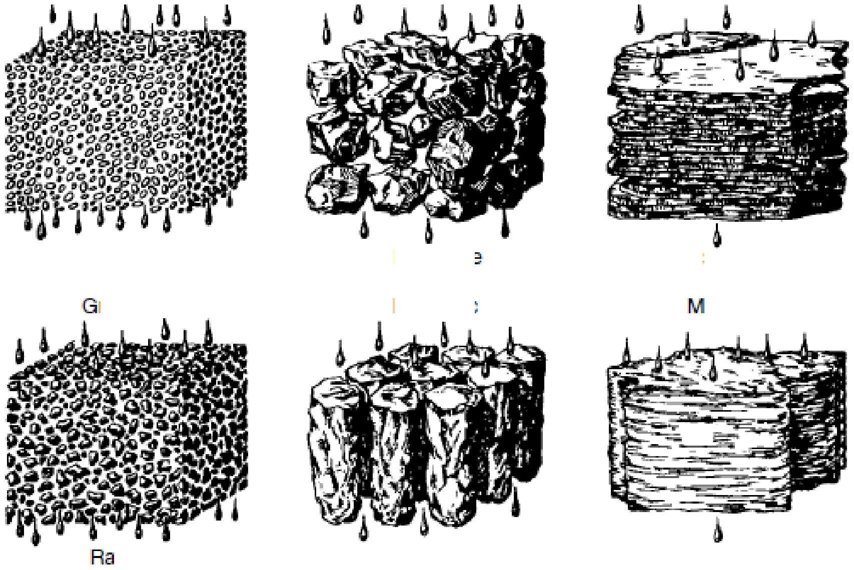


Figure 3. Examples of the most common soil structures. Also shown is the structures' effect on downward movement (infiltration) of water. (Courtesy of the NRCS, Section 15 of the National Engineering Handbook)

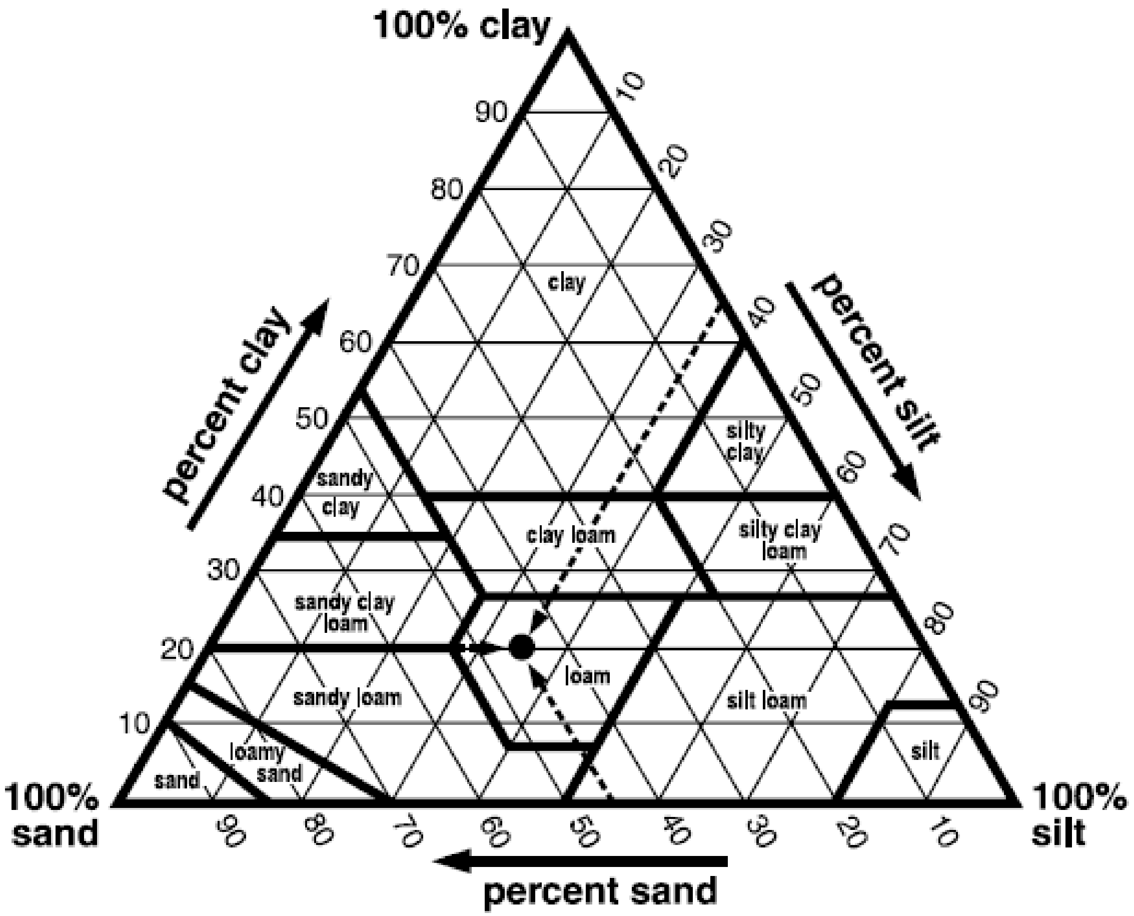
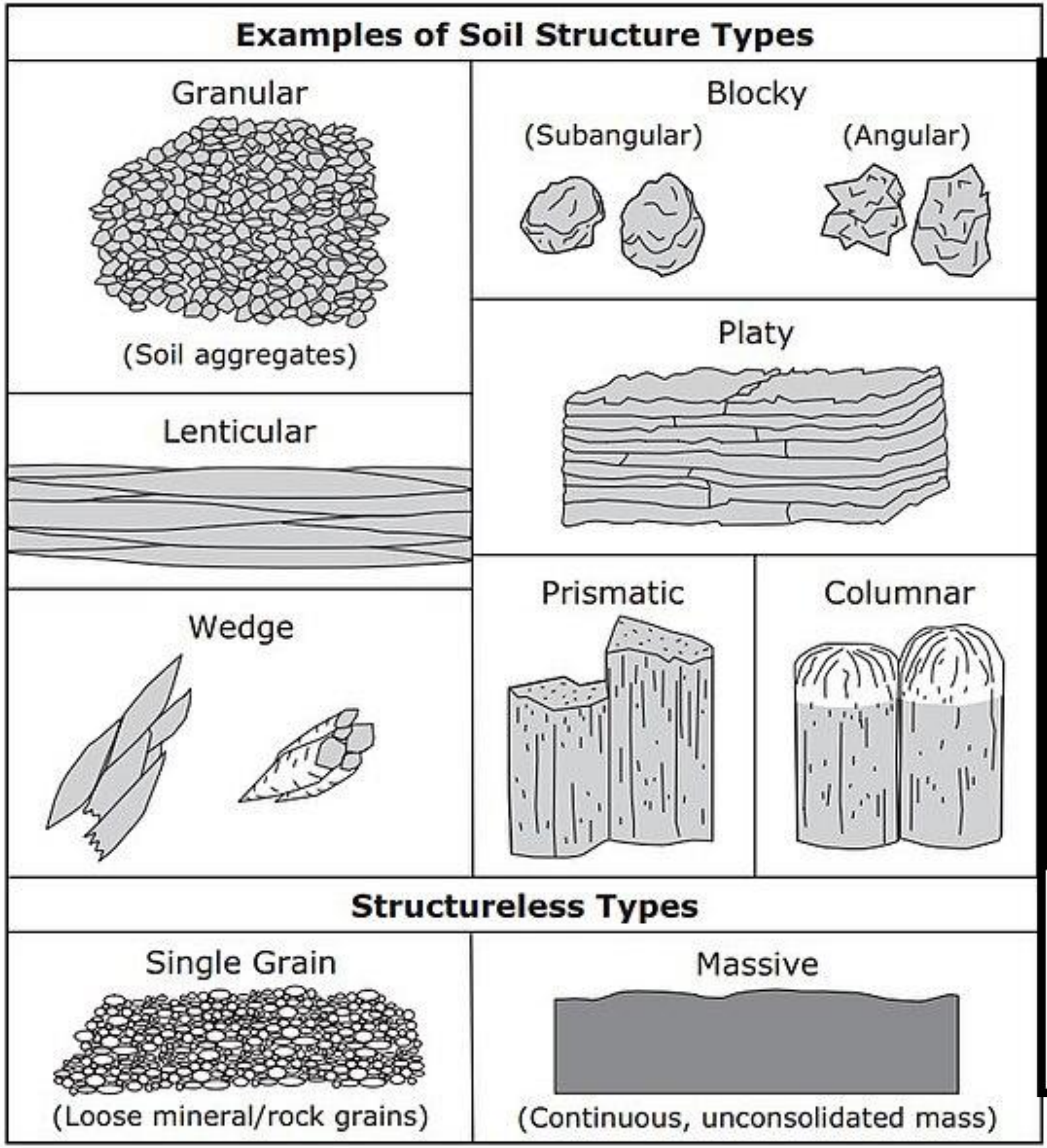


Figure 2. U.S. Department of Agriculture (USDA) soil textural triangle. The percent (by weight) of the sand, silt and clay fraction determines the texture of the soil. The dotted line depicts a loam soil that has 45% sand, 35% silt and 20% clay content.



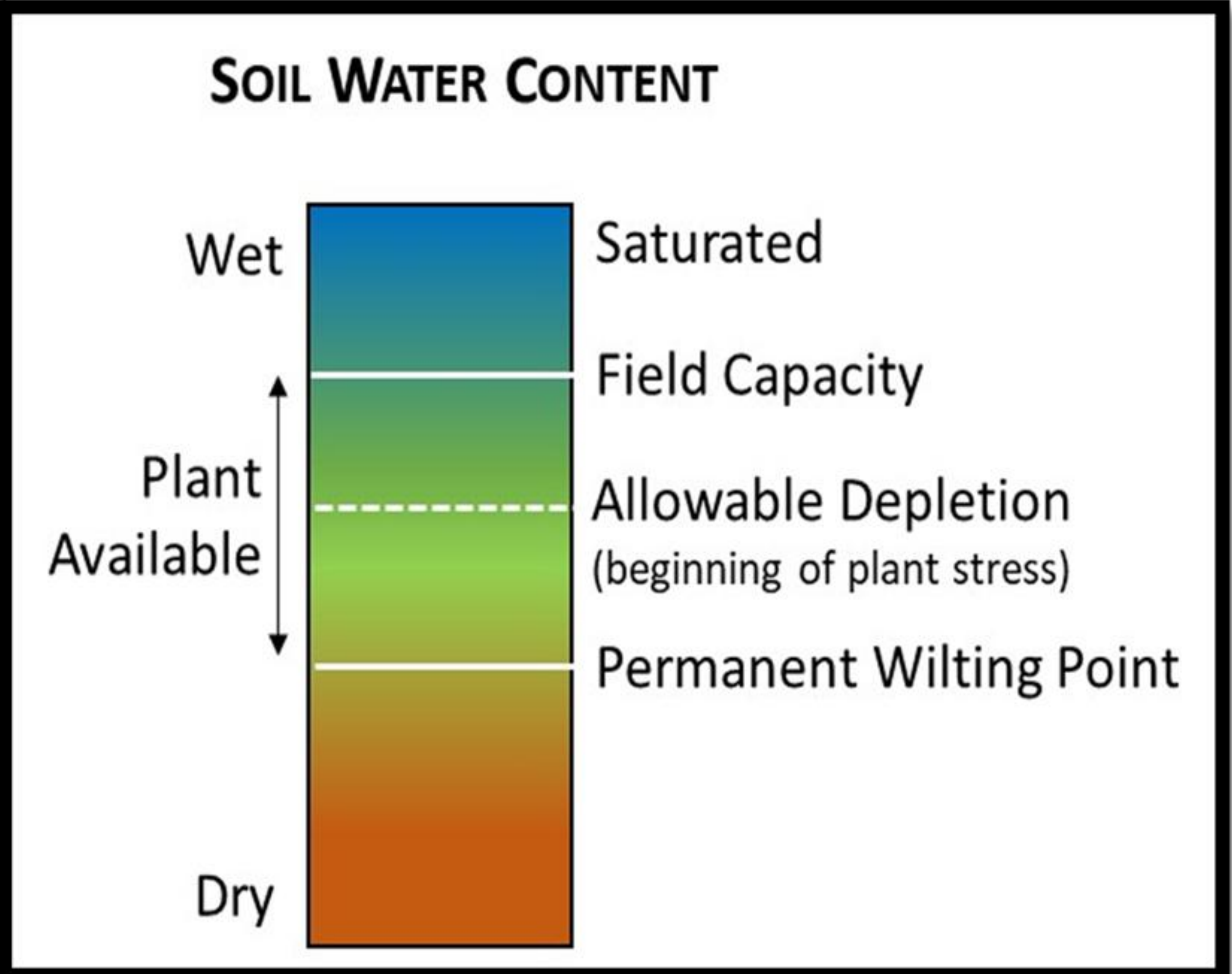


Figure 1. *Typical Relationship of Soil Water Content for Any Soil Type: Saturated, Field Capacity, Plant Available Water, Allowable Depletion, and Permanent Wilting Point*

Infiltration

- The rate of infiltration depends on soil type, land cover, and the amount of rainfall.
- Factors Affecting Infiltration
  - Soil texture and structure
  - Vegetation cover
  - Soil management
  - Surface conditions
- Environmental Importance
  - Erosion control
  - Support for vegetation
- Practices such as the use of rain gardens, French drains, and adding organic matter or compost improve infiltration rates and reduce flooding risks.

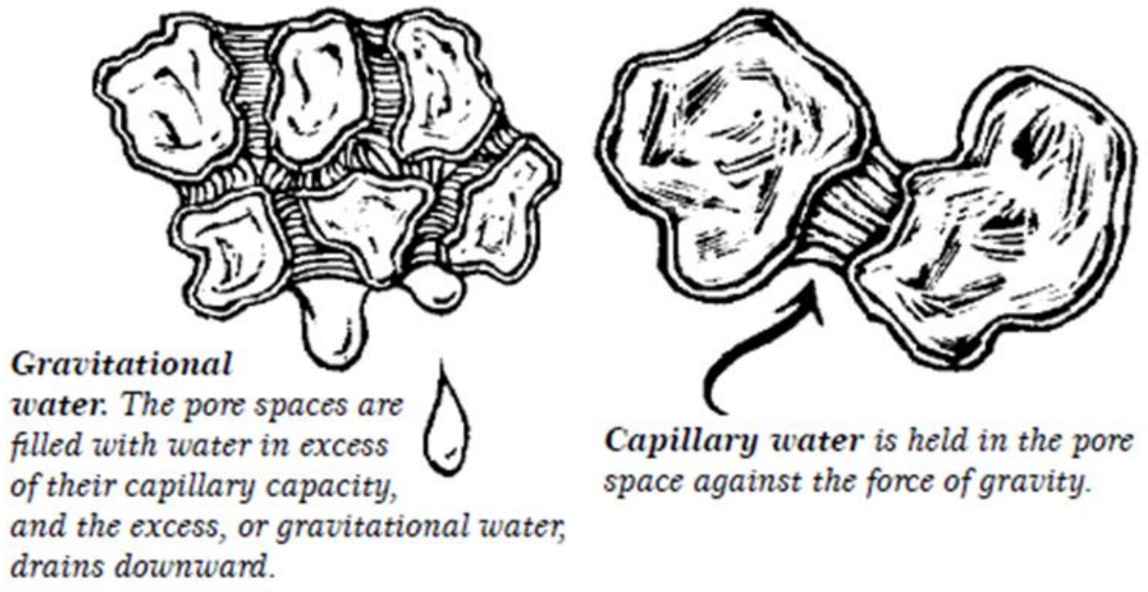


Figure 6. The two primary ways that water is held in the soil for plants to use are capillary and gravitational forces.

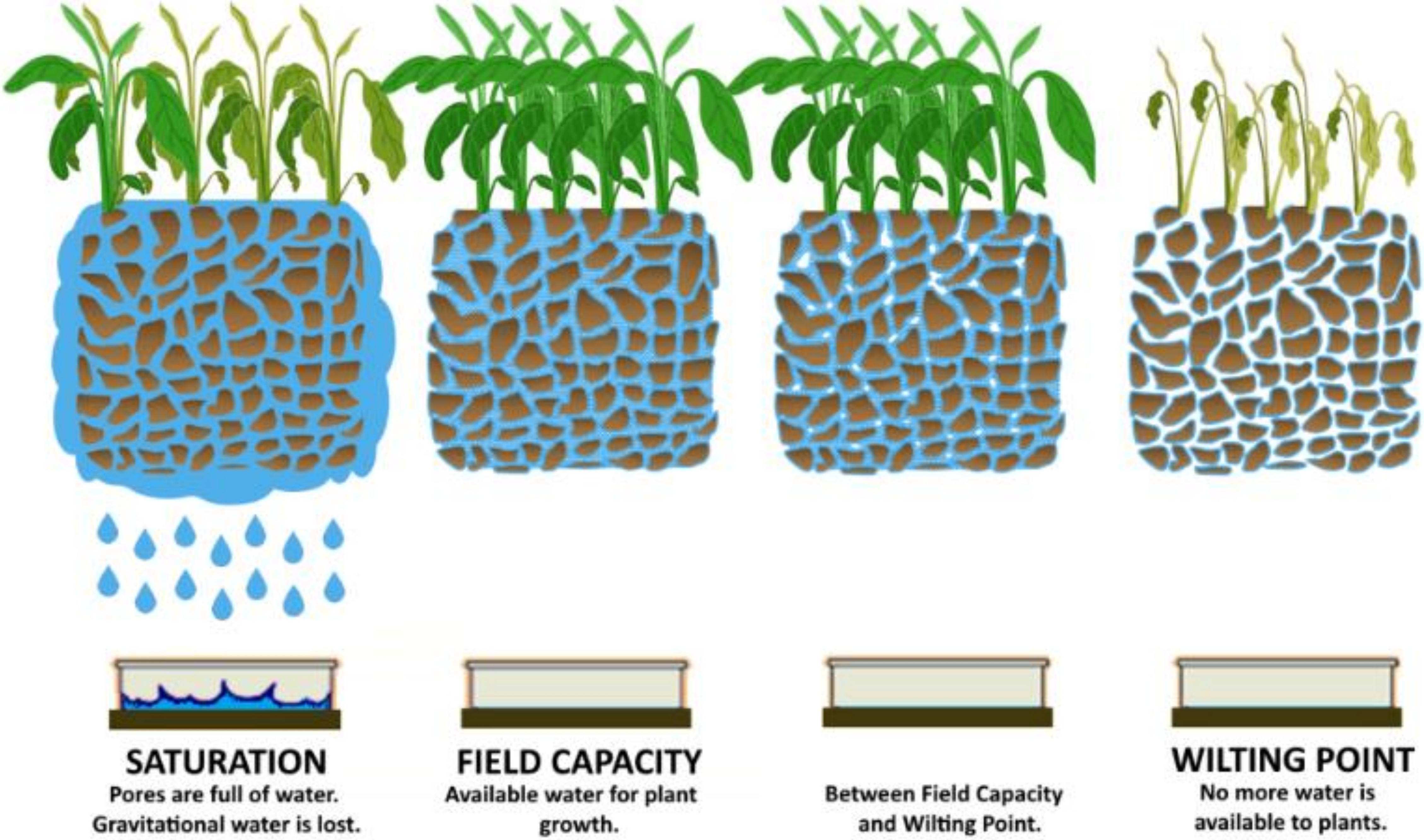
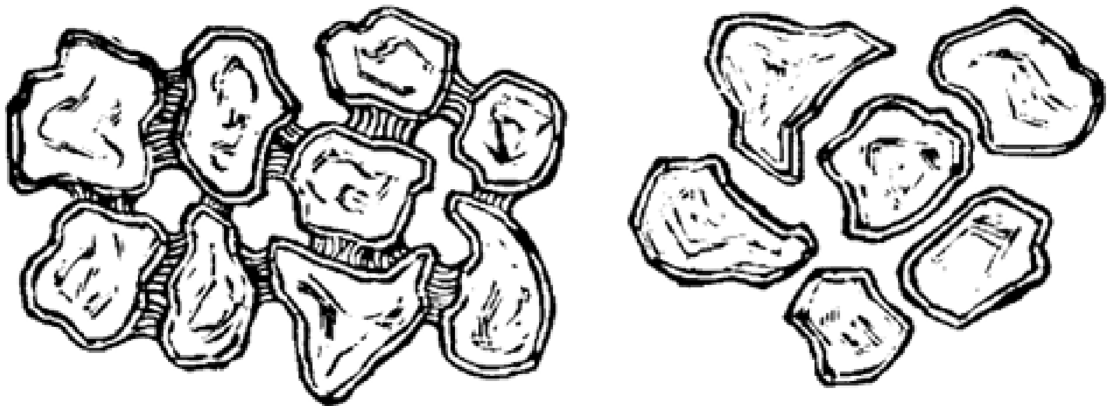

SATURATION
Pores are full of water.
Gravitational water is lost.
FIELD CAPACITY
Available water for plant
growth.
Between Field Capacity
and Wilting Point.
WILTING POINT
No more water is
available to plants.

Table 1. Range of plant-available water for different soil textures.

Soil Texture	Inches of Water per Inch of Soil	Inches of Water per Foot of Soil
Coarse sand and gravel	0.02 to 0.06	0.2 to 0.7
Sands	0.04 to 0.09	0.5 to 1.1
Loamy sands	0.06 to 0.12	0.7 to 1.4
Sandy loams	0.11 to 0.15	1.3 to 1.8
Fine sandy loams	0.14 to 0.18	1.7 to 2.2
Loams and silt loams	0.17 to 0.23	2.0 to 2.8
Clay loams and silty clay loams	0.14 to 0.21	1.7 to 2.5
Silty clays and clays	0.13 to 0.18	1.6 to 2.2

Table 2. Typical range of crop root depths in deep soils, along with the recommended irrigation water management depth.

Crop	Depth of Fully Developed Root Zone (inches)	Depth of Root Zone for Irrigation Water Management (inches)
Potatoes	24 to 30	18
Soybeans, dry edible beans	30 to 36	24
Wheat, barley, oats	42 to 48	36
Corn, sugarbeets, sunflowers	48 to 54	36
Established alfalfa and forage grasses	60 to 72	48



Field capacity. *The capillary pores are full and the remaining pore space is filled with air.*

Wilting point. *The water available to plants is exhausted.*

Figure 7. Soil moisture available to plants is the amount held between field capacity and wilting point.

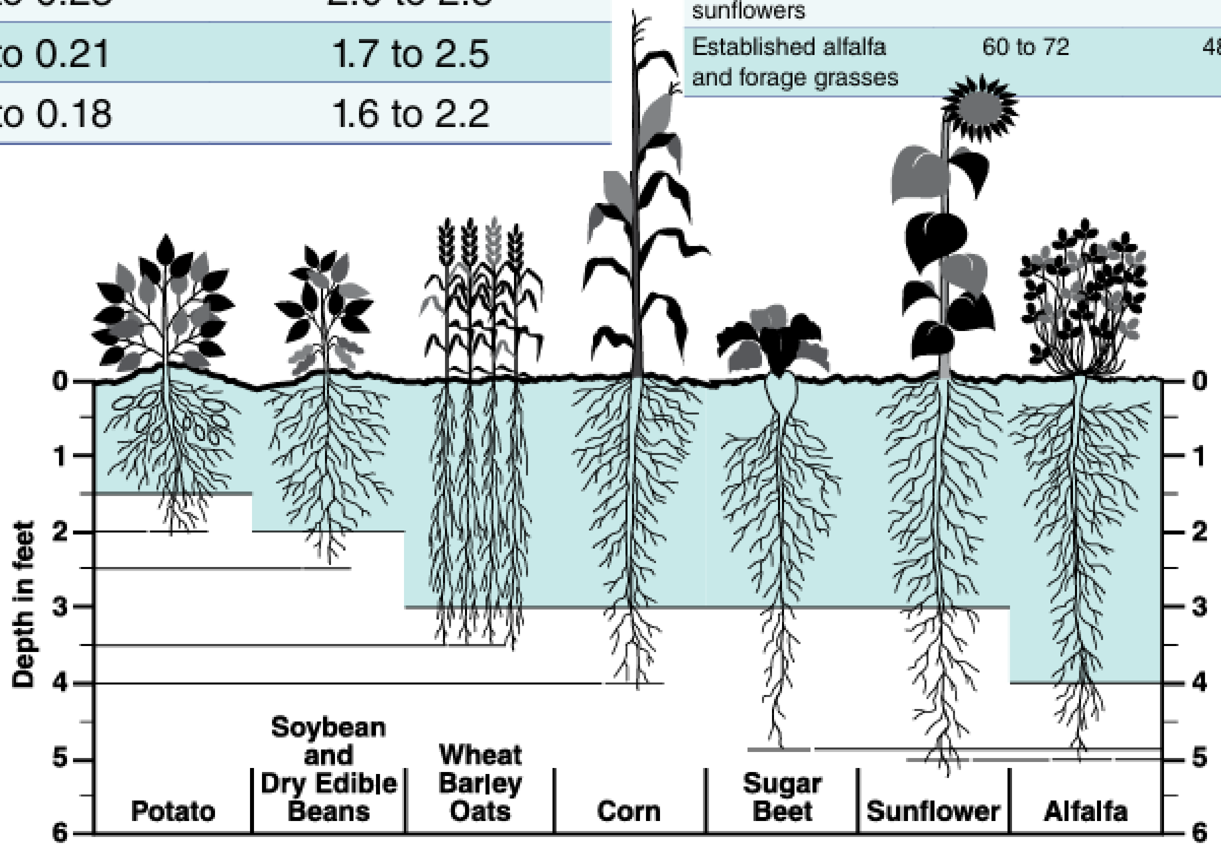
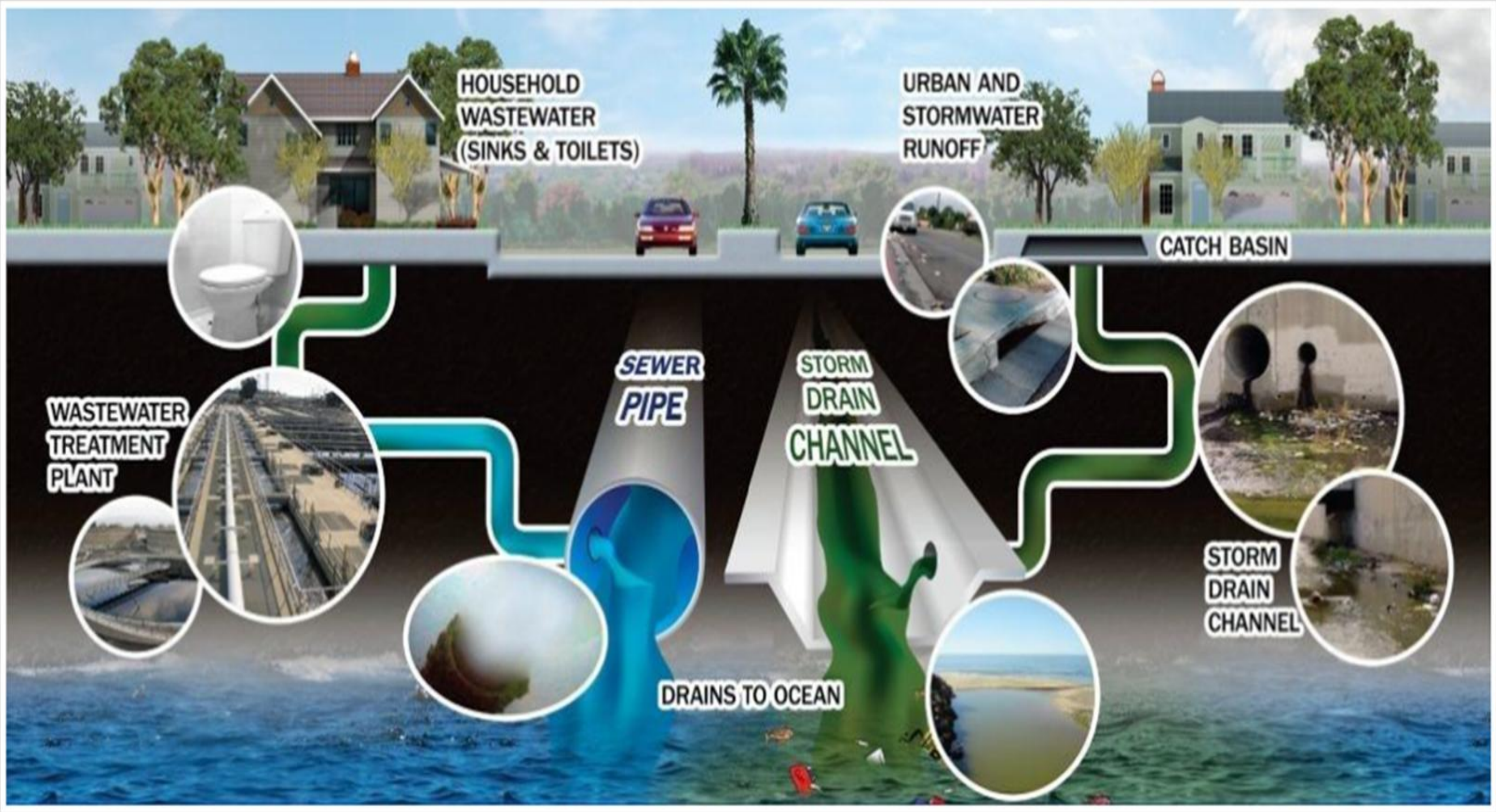


Figure 1. Typical fully developed root zone depths for the commonly irrigated crops in North Dakota. The shaded area is the irrigation water management depth.

Runoff

- Water that does not infiltrate flows over the land's surface into streams, rivers, and eventually larger bodies of water like lakes and oceans.
- Types of Runoff:
  - Infiltration-Excess Runoff
  - Saturation-Excess Runoff
- Impacts of Runoff:
  - Erosion and Sedimentation
  - Water Quality Degradation
  - Flooding
  - Stream Channel Alteration
- Management Strategies
  - Green Infrastructure
  - Vegetative Buffers
  - Stormwater Management
  - Buffer Strips
  - Contour Farming



pH 6.0 of soil
BI 7.3

The average, optimal range is 6.0-7.0. While some plants can vary widely in their preferred pH range, the vast majority prefer a slightly acidic pH below 7. Extremes in pH that are too high or too low can make soil nutrients unavailable to the plant, effectively causing malnutrition. Adjustments to soil pH take time and require retesting each year until an ideal pH range is reached.

14 Nitrogen (N) lbs/acre. Ideal 60

- ☐ high
- ☐ sufficient
- ☐ medium
- ☑ low

Nitrogen (N): Needed for top growth in plants (the green part). About 60lbs/acre is ideal. It is being used up any time there is active growth. It is water soluble so is leached out of the soil quicker than the other nutrients and must be supplied regularly. No application needed when plants are dormant. High excess is problematic. Available alone as 46-0-0 or 34-0-0, or in blends with P and K. Also available as ammonium sulfate 21-0-0-24 where the 4th number in the ratio is sulfur to help lower pH. Even if your soil has good levels of nitrogen now, a regular maintenance schedule is recommended.

240 Phosphorus (P) lbs/acre. Ideal 65

- ☑ high
- ☐ sufficient
- ☐ medium
- ☐ low

Phosphorus (P): Essential for flower and strong root development. About 65lbs/acre is ideal. It is held in the soil and will accumulate with repeated application. Should be applied on a need only basis, as determined by a soil test. Over application is problematic and will contribute to algae blooms in lakes via runoff. Available by itself as super phosphate 0-46-0 or in blends with N and K. Blends are also available containing sulfur (N-P-K-S) for use only when pH is too high (generally above 7.0).

310 Potassium (K) lbs/acre. Ideal 300

- ☑ high
- ☐ sufficient
- ☐ medium
- ☐ low

Potassium (K): Enhances fruit/flower production, and disease and stress resistance. About 300lbs/acre is ideal. It is held in the soil and will accumulate with repeated application. Should be applied on a need only basis, as determined by a soil test. Over application is problematic and will contribute to algae blooms in lakes. Available in blends of N-P-K or by itself as potash 0-0-60.

- Routine Test -

pH:	6.5
Buffer Index:	
NO3-N (lbs/A):	
Surface:	2
Subsoil:	
Soil Test P Index:	73 (36 ppm)
Soil Test K Index:	282 (141 ppm)

- Secondary Nutrients -

SO4-S (lbs/A)
Surface:
Subsoil:

- Additional Tests -

- Micronutrients -

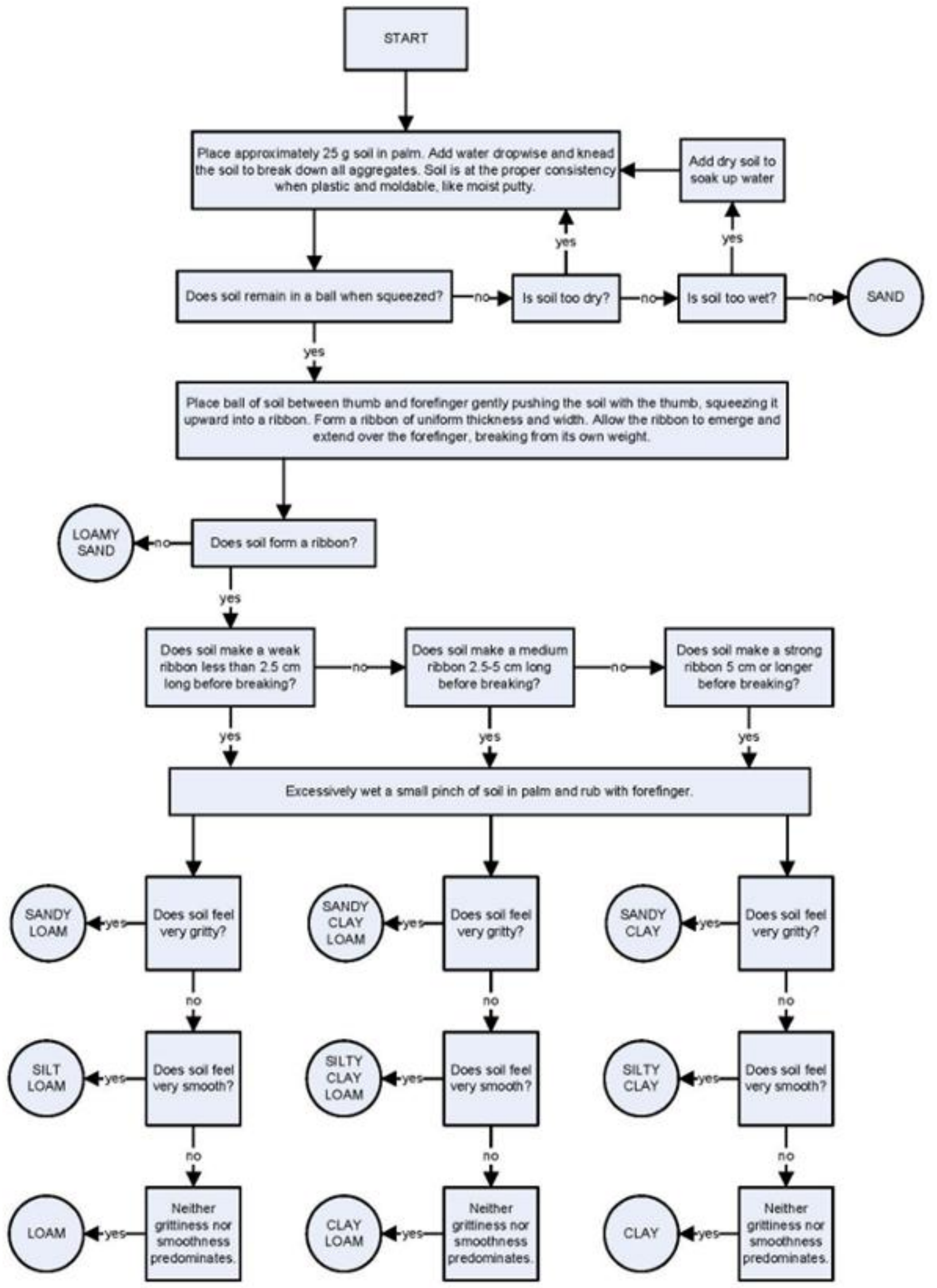
*** DL = Detection Limit**

INTERPRETATION AND REQUIREMENTS FOR *Wildlife Plot* **(No Yield Goal Needed for N recommendation)**

Test	Interpretation	Requirement
pH	Adequate	No lime required
	Low Medium High	
Nitrogen		1 lbs/1000 sq. ft. N
Phosphorus		None
Potassium		1 lbs/1000 sq. ft. K2O annually until next soil test

Guide to Texture by Feel

Modified from S.J. Thien. 1979. *A flow diagram for teaching texture by feel analysis.* Journal of Agronomic Education. 8:54-55.



Key Water Quality Parameters

***Electrical Conductivity* (EC):** Measures salinity levels to determined total dissolved solids (TDS); excessive EC affects plant growth; ideally less than 1500 µmhos/cm

***Sodium Adsorption Ratio* (SAR):** a ratio of the concentration of sodium compared to calcium and magnesium**;** high SAR leads to soil permeability issues; ideally, should be less than 10.0 SAR

Sodium percentage: *Ideally, should be less than 15%*

***pH Levels*:** Optimal range for irrigation water is 6.5–8.4.

***Alkalinity* :** Should be less than 150 ppm to prevent elevated pH of growth media.

Test Results for Irrigation Water

---------- Cations ---------------		----------- Anions -------------		------------- Other --------------	
Sodium (ppm)	207.3	Nitrate-N (ppm)	4.0	pH	8
Calcium (ppm)	345.7	Chloride (ppm)	129.9	EC (µmhos/cm)	2500
Magnesium (ppm)	70.1	Sulfate (ppm)	1024.6		
Potassium (ppm)	2	Boron (ppm)	1.25		
		Bicarbonate (ppm)	373.6		
			373.6		

------------ Derived Values -----------------		-------- Derived Values(cont'd) --------------	
Total Dissolved Solids (TDS in ppm)	2157.3	Sodium Percentage	28.1 %
Sodium Adsorption Ratio (SAR)	2.7	Hardness (ppm)	1151.0
Potassium Adsorption Ratio (PAR)	0.0	Hardness Class	Very Hard
		Alkalinity (ppm as CaCO3)	306.3

*** DL = Detection Level**

INTERPRETATION AND REQUIREMENTS FOR *Irrigation Water*

This water can be used satisfactorily for most crops if care is taken to prevent accumulation of soluble salts including sodium in the soil. Good soil management and irrigation practices should be followed. This water can be used with little danger on permeable, well-drained soils.

If this water is used extensively, it is recommended that a soil sample be obtained every few years from the irrigated fields to determine the extent to which sodium or salts may be accumulating and the need for special management practices.

Boron toxicity may occur in poorly drained soils.

Types of Pollution:

- Point Source Pollution
- Non-point Source Pollution

Consequences of Pollution:

- Environmental Impacts
- Cultural Impacts
- Economic Costs
- Human Health Risks

Pollution Management Strategies:

- Best Management Practices (BMPs)
- Green Infrastructure
- Policy and Regulation (Clean Water Act)
- Buffer Zones
- Sediment Control

WHAT ARE HARMFUL ALGAL BLOOMS (HABS)?

- **Cyanobacteria: Produces toxins harmful to humans, pets, and wildlife.**
- **Potentially lead to eutrophication**
- **Common HAB-Forming Algae in OK and NM**
  - **Microcystis (produces microcystins, a liver toxin)**
  - **Anabaena (produces anatoxins, affecting the nervous system)**
  - **Aphanizomenon (forms dense mats, suffocating aquatic life)**
  - **Golden Algae (*Prymnesium parvum*)**
    - **Produce toxins called prymnesins (primarily harm gill-breathing organisms)**

- **"Learn to Identify Cyanobacteria Blooms" from the Interstate Technology and Regulatory Council**

https://www.youtube.com/watch?v=1Aknc7dZHMg

Figure 1. BGA dispersed in water. Photo credit: USGS.

Figure 1. An algal bloom washing up on shore. Photo credit: NOAA.

OSU'S ANIMAL DISEASE DIAGNOSTIC LABORATORY

Bacteriology

Blue Green Algae-Microscopic Screening

Reported Date: November 7, 2025

Specimen ID	Specimen	Result	Organism ID
[redacted]	Water	POSITIVE	Microcystis sp. Anabaena sp. Oscillatoria sp.

Comment

Approximately 100 microliters of sample were observed microscopically. A small number of Microcystis sp. and trace numbers of both Anabaena sp. and Oscillatoria sp. were detected.

Although the presence of blue-green algae is not necessarily indicative of toxic conditions within a body of water, the Oklahoma Department of Agriculture suggests that animals be kept away from water until an algal "bloom" dissipates.

Visit these websites for more information:
(https://extension.okstate.edu/fact-sheets/toxic-blue-green-algal-blooms.html)
(https://oklahoma.gov/health/health-education/acute-disease-service/waterborne-diseases/blue-green-algae.html)

Results authorized by Akhilesh Ramachandran, BVSc, PhD, DACVM, Microbiology/Molecular Section Head

Website: https://sites.google.com/view/osupgml/home

IRRIGATION SYSTEM PERFORMANCE

Simple Irrigation Checkup

- **Step 1: Check controller settings**
- **Step 2: Run each irrigation zone**
- **Step 3: Identify problems and make repairs**

Figure 1. Sprinkler head spraying a sidewalk.

Figure 2. Sprinkler heads with excessive or high pressure causing misting of irrigation water.

Figure 4. Sprinkler head leaking and causing ponding at the base.

IRRIGATION SYSTEM PERFORMANCE

Figure 1. Examples of a short rain gauge (right) that can be used to conduct the simple irrigation audit procedure and a tall rain gauge (left) that should not be used to conduct the simple irrigation audit procedure.

Figure 2. Examples of various catch cups that can be used to conduct the simple irrigation audit and examples of how to mark the side of the catch cups for more accurate irrigation output measurement.

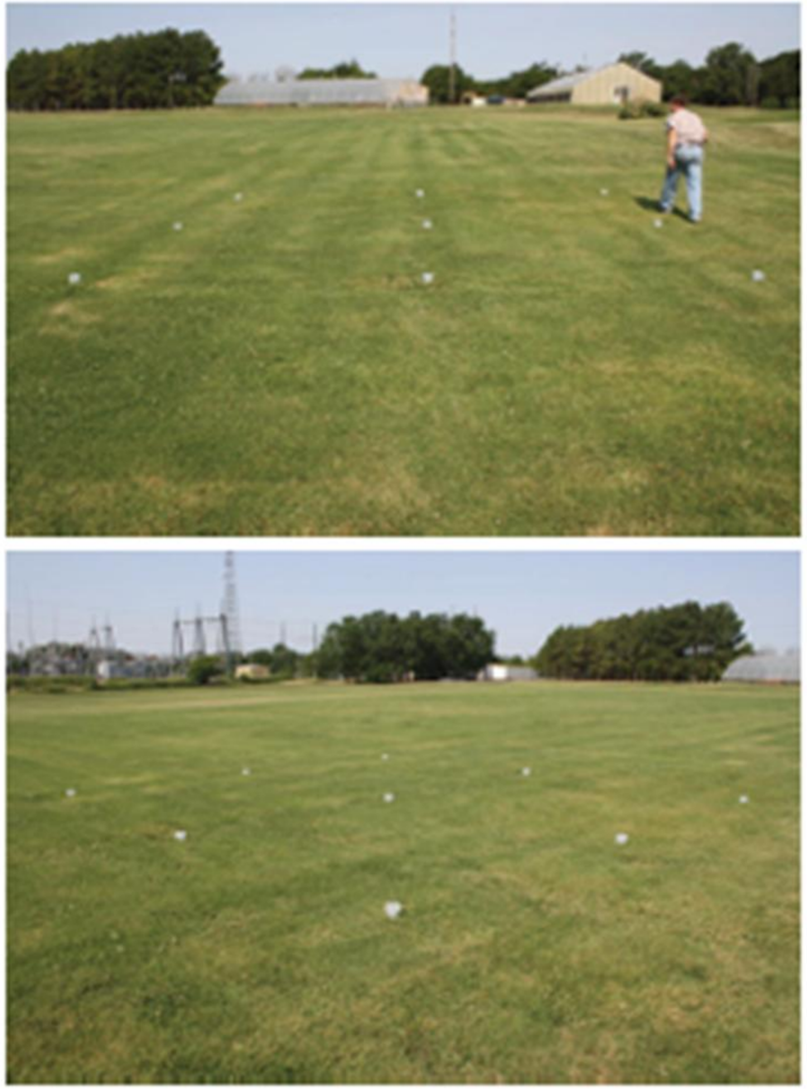


Figure 3. Examples of how to layout the irrigation catch cups in a grid pattern with each cup located about three steps apart from each other.

IRRIGATION SCHEDULE

Basic types of Evapotranspiration Controllers

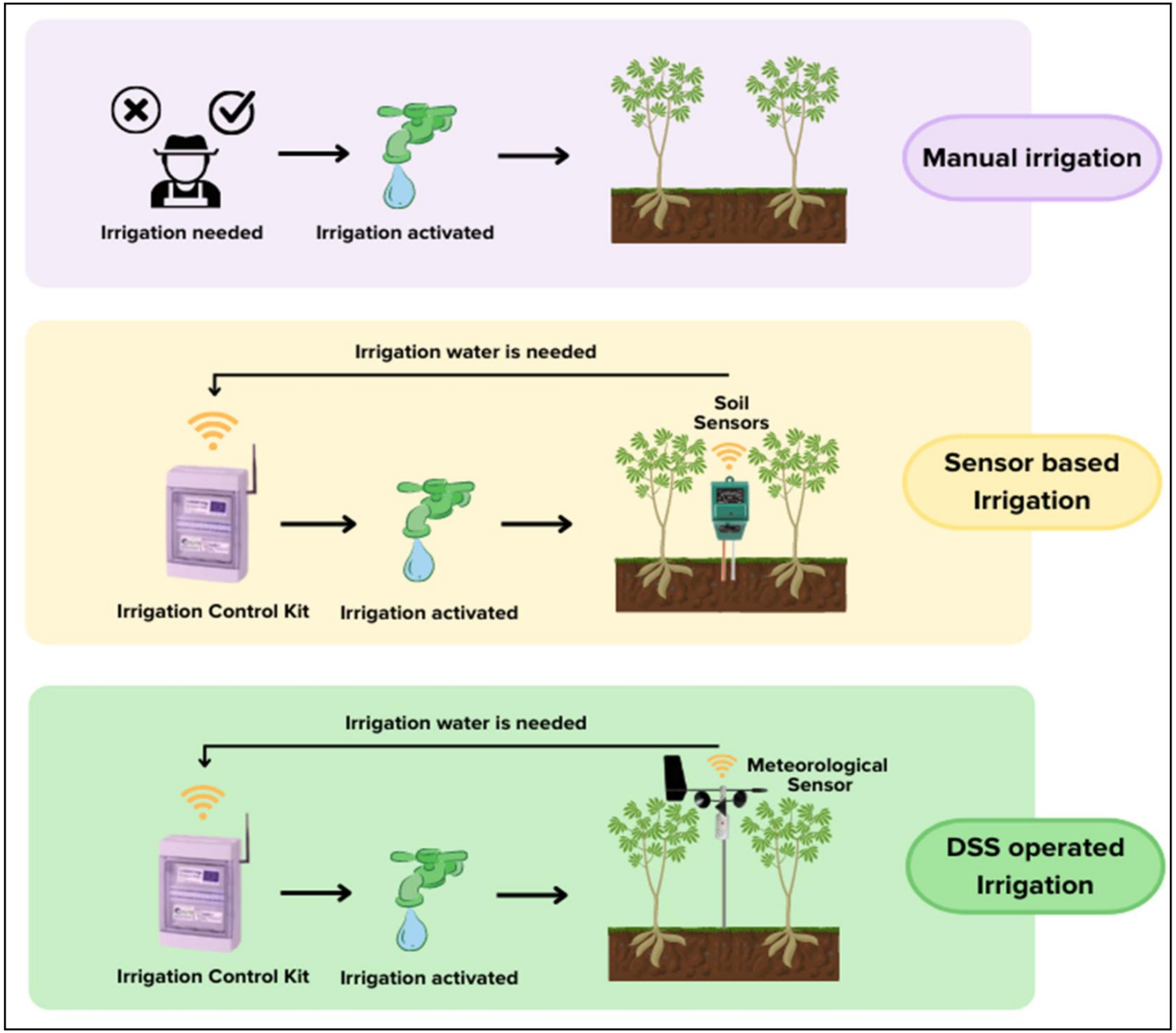
- **Signal-based controllers**
- **Historic ET controllers**
- **On-site weather measurement controllers**

- **Add-on Sensors**
  - **Soil moisture sensors**
  - **Rain & freeze sensors**
  - **Wind sensors**

Figure 4. Rain sensor with a small basin to collect rainfall.

Figure 7. Example wind sensor for use in the landscape. Photo courtesy of Hunter Industries.

Figure 5. Rain sensor attached to a gutter (top) and the inside of an expanding disc rain sensor (bottom). Photos courtesy of Hunter Industries.



Expectations of Smart Irrigation Practices

- Potential 20%-50% water savings.
- Improved landscape health and appearance
- Enables homeowners and contractors to become better at water management.
- Potential for 70-80 percent irrigation efficiency with good design, maintenance and scheduling.

But remember… a smart controller won't fix a bad irrigation system!

WEATHER SENSORS

Rain/freeze sensors

- Wired or wireless versions
- Shut off irrigation at 37 degrees and during and after a rain event
- All rain/freeze sensors can be used by any controller
- If no sensor port inside circuit board, wire into common wire

How could this have been prevented?

Rain sensor!!!

How could this have been prevented?

Freeze sensor!!!

EXTENSION

Irrigation Planner

- https://www.mesonet.org/agriculture/horticulture/irrigation-planner?ref=1943

How to use the Irrigation Planner

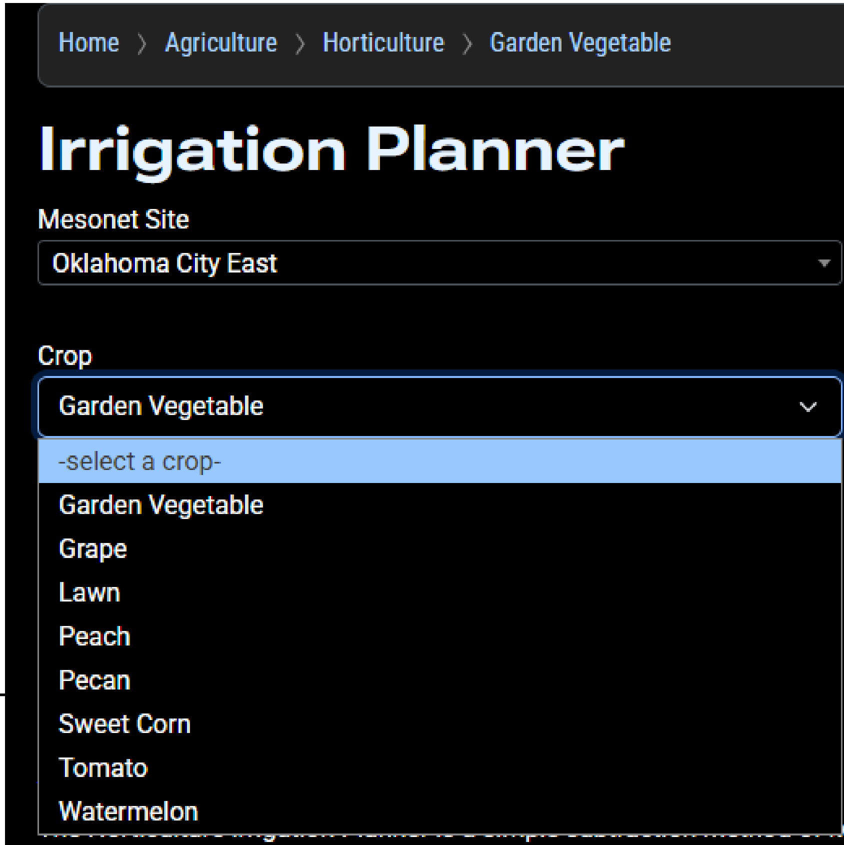
- https://content.prod.mesonet.org/learn/ag/tools_documentation/horticulture-irrigation-planner-tool-202210-tagged.pdf

ET vs. Accumulated ET

- ET is the daily estimate of water loss from plants and soil
- Accumulated ET is the total ET starting at planting date

Rainfall vs. Accumulated Rainfall

- Rainfall is the amount of precipitation in a specific day
- Accumulated rainfall is the total rainfall starting at planting date

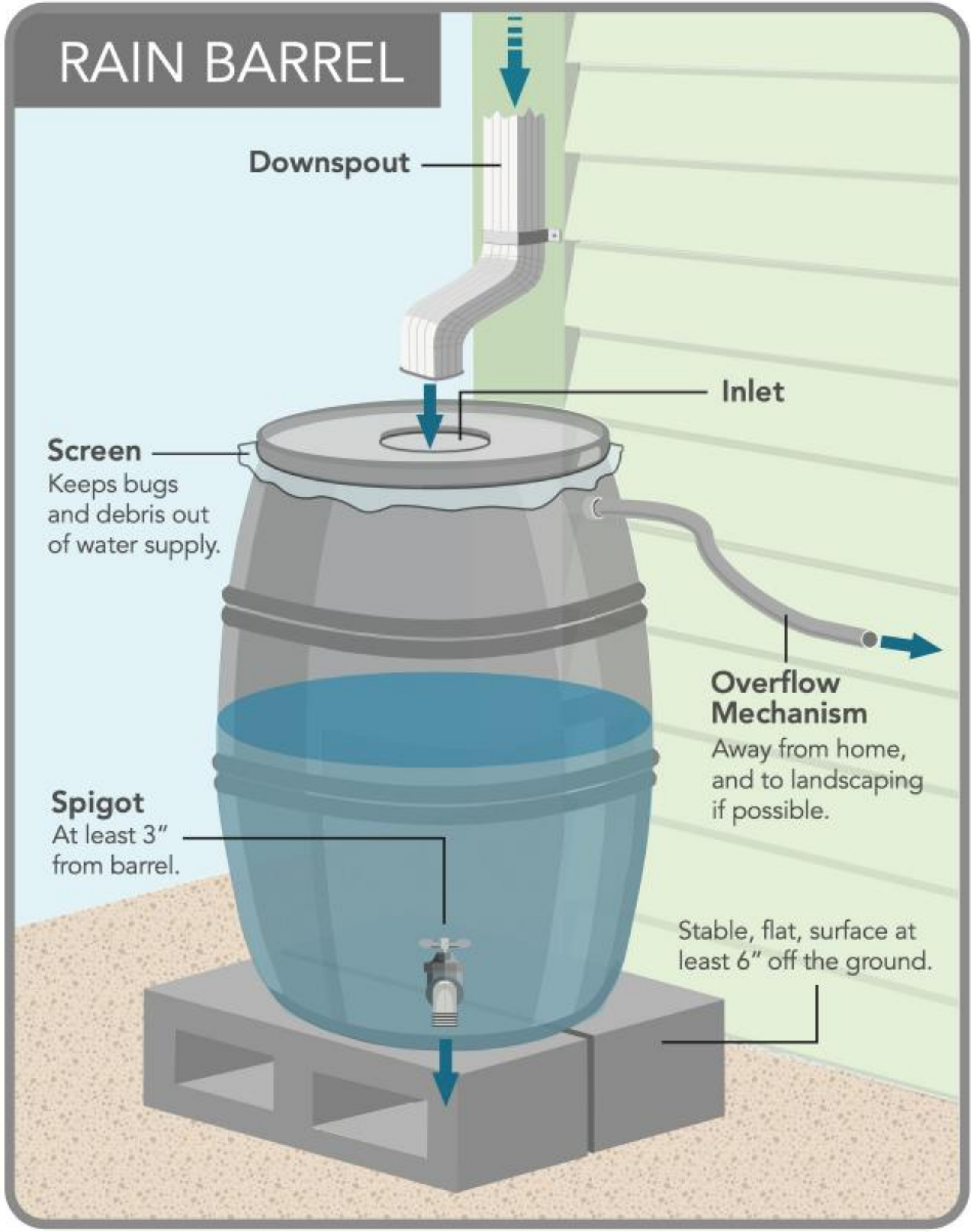


Rainwater Harvesting:

- **The process of collecting and storing rainwater from rooftops or impervious surfaces for later use.**

- **Often used for:**
  - **Irrigation**
  - **Car wash**
  - **Cleaning**

- **Benefits:**
  - **Reducing municipal water demand**
  - **Lowering water bill**
  - **Managing stormwater runoff**
  - **Enhancing landscape resilience during drought**




Rain barrel assembly
Downspout elbows
Downspout adapter
Drill 1¼-in. holes for ventilation
Trace base of downspou adapter and cut hole for a snug fit
Fiberglass window screen
Overflow hose
4-in. hose clamp
Female hose connector
#8 ½-in. sheet-metal screw
Drill 1-in. hole for hose bibb
1-in. conduit hanger
1-in. fender washer
¾-in. hose bibb

IRRIGATION SCHEDULING AND WATER BUDGETING

Irrigation Schedule

- **Base Run Time**
- **Scheduling Multiplier**
- **Adjusted Run Time**
- **Irrigation Events per Reference Period**
- **Total Run Time per Irrigation Event**
- **Maximum Run Time per Cycle**
- **Cycles per Irrigation Event**
- **Run Time Per Cycle**

Site Name:
Site Address:
Prepared By: Date:
E-Mail Address: Phone:
Zone Description:

Landscape Water Requirement				
1	Plant Material	Landscape Plan or Site Visit		
2	Reference Month			
3	Reference Period			Days
4	Reference Evapotranspiration Rate (ETo)	Multiple Sources		Inches
5	Landscape Coefficient (K_L)(Ks____Kd____Kmc____	Landscape Coefficient Charts		
6	Landscape Water Requirement for Reference Period	Line 4 * Line 5		Inches
Irrigation System Performance				
7	Precipitation Rate (PR) (Theoretical / Actual)	Product Catalog or Formula		In./Hr.
8	Distribution Uniformity (DU) (Estimate / Actual)	Chart or Formula	0.________	
Soil Properties				
9	Root Zone Soil Type	Site Visit		
10	Available Water Storage Capacity	Chart		In./Inch
11	Average Plant Root Depth	Site Visit		Inches
12	Allowed Depletion	Line 10 * Line 11 * 0.50		Inches
Irrigation Schedule				
13	Base Run Time	Line 6 / Line 7 * 60		Minutes
14	Scheduling Multiplier	Chart		
15	Adjusted Run Time	Line 13 * Line 14		Minutes
16	Calculated Irrigation Events per Reference Period	Line 6 / Line 12		
17	Irrigation Day Restrictions	Self Imposed or Municipality		
18	Actual Irrigation Events per Reference Period	Adjust for Watering Restrictions		
19	Total Run Time per Irrigation Event	Line 15 / (Line 16 or Line 18)		Minutes
20	Maximum Run Time per Cycle	Observation		Minutes
21	Cycles per Irrigation Event	Line 19 / Line 20 or Mgt Decision		
22	Run Time per Cycle	Line 19 / Line 21		Minutes
Schedule Summary				
23	Irrigation Events per Reference Period	Line 18		
24	Cycles per Irrigation Event	Line 21		
25	Run Time per Cycle	Line 22		Minutes

Water Measurement Units and Conversion Factors

Saleh Taghvaeian
Assistant Extension Specialist

Irrigation water management begins with knowing the quantity of water available. The purpose of this publication is to provide basic information on water measurement units and convenient conversion factors. Sometimes one will want to know only the volume of water used; while, at other times one will want to know the rate of flow. Conversion factors simplify changing from one unit of measurement to another.

Water Measurement Units

There are two conditions under which water is measured—water at rest and water in motion. Water at rest is measured in units of volume. Water in motion is measured in units of flow— unit of volume for a convenient time unit. It is important that the difference between a unit of volume and a unit of flow be kept in mind.

Volume Units

Water at rest; i.e., ponds, lakes, reservoirs, and in the soil, is measured in units of volume — gallon, cubic foot, acre-inch, and acre-foot.

Cubic Foot - The volume of water that would be held in a container one foot wide by one foot long by one foot deep.
Acre-Inch - The volume of water that would cover one acre (43,560 square feet) one inch deep.
Acre-Foot - The volume of water that would cover one acre one foot deep.

Flow Units

Water in motion; i.e., flowing in streams, canals, pipelines, and ditches, is measured in units of volume per unit of time—gallons per minute (gpm), cubic feet per second (cfs), acre-inches per hour and acre feet per day. Cubic feet per second, sometimes written second-feet (sec. ft. or cusec) is most commonly used for measuring flow of irrigation water moving by gravity from streams and reservoirs. Gallons per minute is most commonly used for measuring flow from pumps.

Cubic foot per second - The quantity of water equivalent to a stream one foot wide by one foot deep flowing with a velocity of one foot per second.
Gallon per minute - The quantity of water equivalent to a stream which will fill a gallon measure once each minute.

A flow of one cfs is approximately equal to either 450 gpm, one acre-inch per hour, or two acre-feet per day (24 hours).

Oklahoma Cooperative Extension Fact Sheets are also available on our website at:
http://osufacts.okstate.edu

Conversion Factors

The following equivalents are useful for converting from one unit to another and for calculating volumes from flow units.

Volume Units

One gallon
= 231 cubic inches
= 0.13368 cubic foot weighs approximately 8.33 pounds

One cubic foot
= 1,728 cubic inches
= 7.481 gallons (7.5 for ordinary calculations) weights 62.4 pounds (62.5 for ordinary calculations)

One acre-inch
= 3,630 cubic feet
= 27,154 gallons (27,200 for ordinary calculations)
= $^{1}/_{12}$ acre-foot weighs approximately 113.1 tons

One acre-foot
= 43,560 cubic feet
= 325,851 gallons
= 12 acre-inches weighs approximately 1,357 tons

Flow Units

One gallon per minute
= 0.00223 (approximately $^{1}/_{450}$) cubic foot per second
= 0.00221 acre-inch per hour
= 0.00442 acre-foot per (24 hour) day
= 1 acre-inch in 452.6 hours (450 for ordinary calculations)
= 1 acre-foot in 226.3 days

One cubic foot per second
= 448.83 gallons per minute (450 for ordinary calculations)
= 1 acre-inch in 1 hour and 30 seconds (1 hour for ordinary calculations)
= 1 acre-foot in 12 hours and 6 minutes (12 hours for ordinary calculations)
= 1.984 acre-feet per (24 hours) day (2 acre-feet for ordinary calculations)

Million gallons per day (mgd)
= 694.4 gallons per minute (695 for ordinary calculations)
= 1.547 cubic feet per second (1.5 for ordinary calculations)

Example 1. The average daily crop water use during the month of June was 0.45 inches at a 60-acre corn field in Oklahoma Panhandle. What is the total volume of water used up by this field in June?

Step 1. The total depth of water use during June was 0.45 × 30 (days) = 13.5 inches.

Step 2. The total volume of water use was 13.5 × 60 (acres) = 810 acre-in.

Step 3. This volume is equal to 2,940,300 cubic-ft (row 2 in conversion table) or 22,052,250 gallons (row 1 in conversion table).

Example 2. How many hours a well yielding 400 gpm should operate to fill an irrigation pond that is 150 ft long, 100 ft wide, and 10 ft deep?

Step 1. The volume of this pond is 150 × 100 × 10 = 150,000 cubic-ft. This volume is equal to 1,125,000 gallons (row 1 in conversion table).

Step 2. A well with 400 gpm should operate 2,813 minutes (1,125,000 ÷ 400) to fill the pond. This period of time is equal to about 47 hours (two days).

* In this example the seepage from the pond is ignored. Longer times will be required depending on the magnitude of seepage.

Cultural Values

- **Beyond its functional roles, the water cycle enriches human life by sustaining natural landscapes and recreational opportunities. Rivers, lakes, and wetlands support activities such as fishing, boating, and birdwatching, contributing to local economies and enhancing quality of life.**
- **Cultural traditions and practices in many communities are deeply tied to water, emphasizing its spiritual and symbolic significance.**

Bangladeshi commuters use boats to cross the Buriganga River in the capital Dhaka in 2018. In July, Bangladesh's top court granted all the country's rivers the same legal rights as humans.
Munir Uz Zaman/AFP/Getty Images

In early July, Bangladesh became the first country to grant all of its rivers the same legal status as humans. From now on, its rivers will be treated as living entities in a court of law. The landmark ruling by the Bangladeshi Supreme Court is meant to protect the world's largest delta from further degradation from pollution, illegal dredging and human intrusion.

New Zealand: ground-breaking in respect of indigenous law

The Whanganui on the North Island is New Zealand's third longest river. For the Māori who have lived along the river for 700 years, the Whanganui is more than just a river. They regard the river as an ancestor from whom humans are descended. It has also been an important source of food through fishing, especially for eel.

Over time, the construction of a hydropower plant in a neighbouring watercourse and run-off from agriculture have impaired the water quality and resulted in less water flow in the river. Fish stocks have also declined. Māori living along the river have been in talks with the authorities on the management of the river for many years.

"The Act that gives the Whanganui River the status of a legal person is in practice a recognition of Māori claims that go back at least 150 years," Borchgrevink explains.

Since the introduction of the Act, the local Māori population has regained some of the control they had over the area before Great Britain colonised the country in 1840. According to the Act, all councils and committees that make management plans for the river must include representatives of the Māoris. The Māoris must always be involved in discussions when construction projects and other developments are proposed that might lead to possible interventions in nature.

In recent years, many rivers—including the Amazon (pictured here), which flows through several countries in South America—have been granted legal rights in order to provide concrete protections.
PHOTOGRAPH BY MARCIA KEBBON, NAT GEO IMAGE COLLECTION

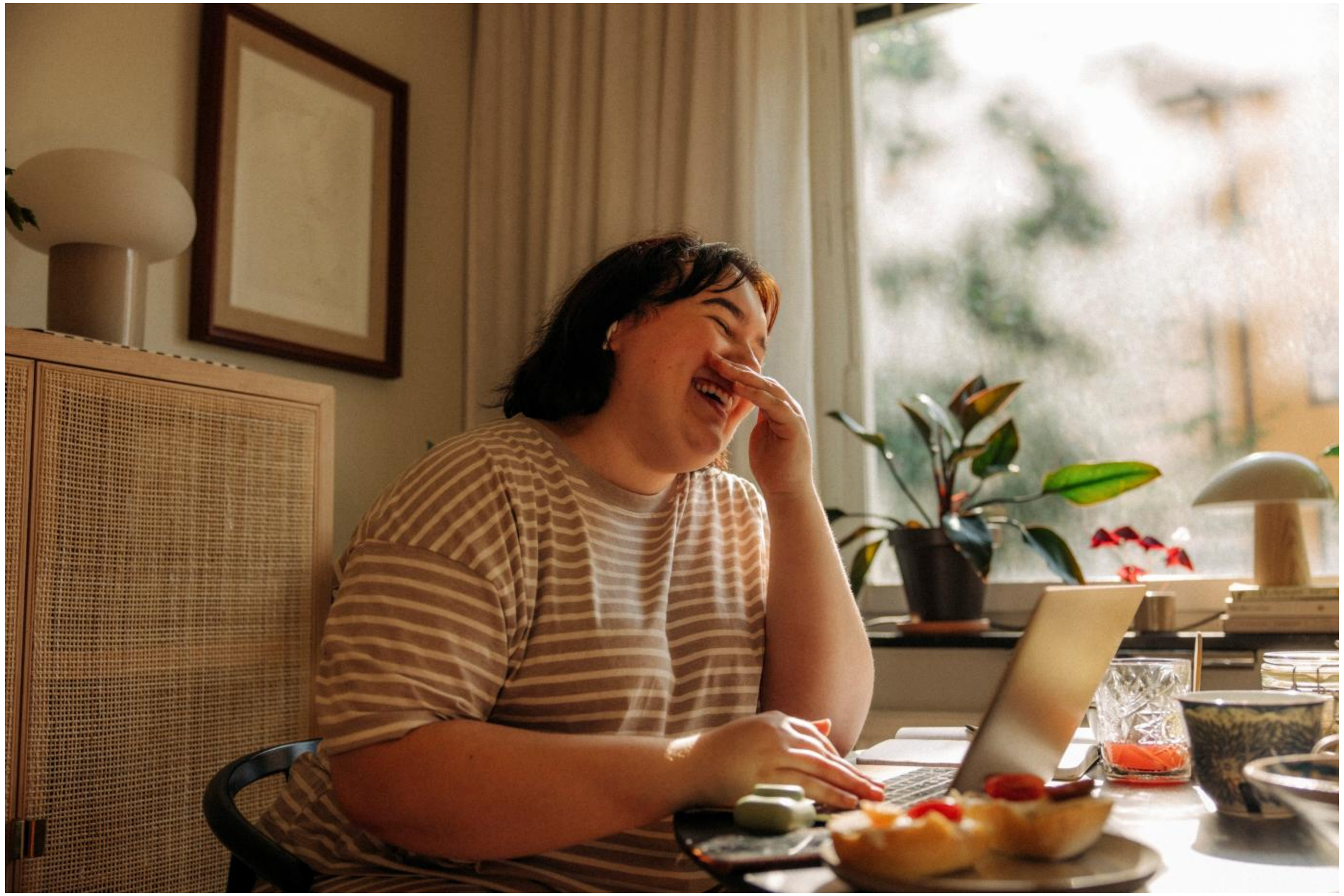
TRAVEL | EARTH DAY

This Canadian river is now legally a person. It's not the only one.

From the Amazon to the Klamath, granting rivers legal rights is part of Indigenous-led efforts to protect them.

By Chloe Berge
April 15, 2022 • 10 min read

IRRIGATION IS JUST THAT SIMPLE, RIGHT?



Classes > Certified Fertigator

https://www.itrc.org/classes/fertigation.htm

Certified Fertigator

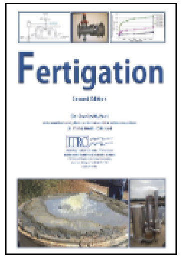
Register for Free Online Class Now

The class covers new techniques in the control and application of fertilizers through irrigation systems and strategies to conform with the intent of the new nitrogen regulations in California. Other topics include nitrogen fertilizers, challenges with phosphorus and potassium applications, growth enhancers, and organic-compliant ways to keep drip systems clean. Increasing yields per acre-foot of evapotranspiration (ET) through better fertility management, will also be discussed – a key topic for California growers.

Use the link above to register for the free class now that you can go through on your own time, at your own pace. Your registration in the online course will be good for 90 days from date of enrollment. A certificate of completion will be available for download for participants who pass the exam at the end of the course with a score of 70% or higher.

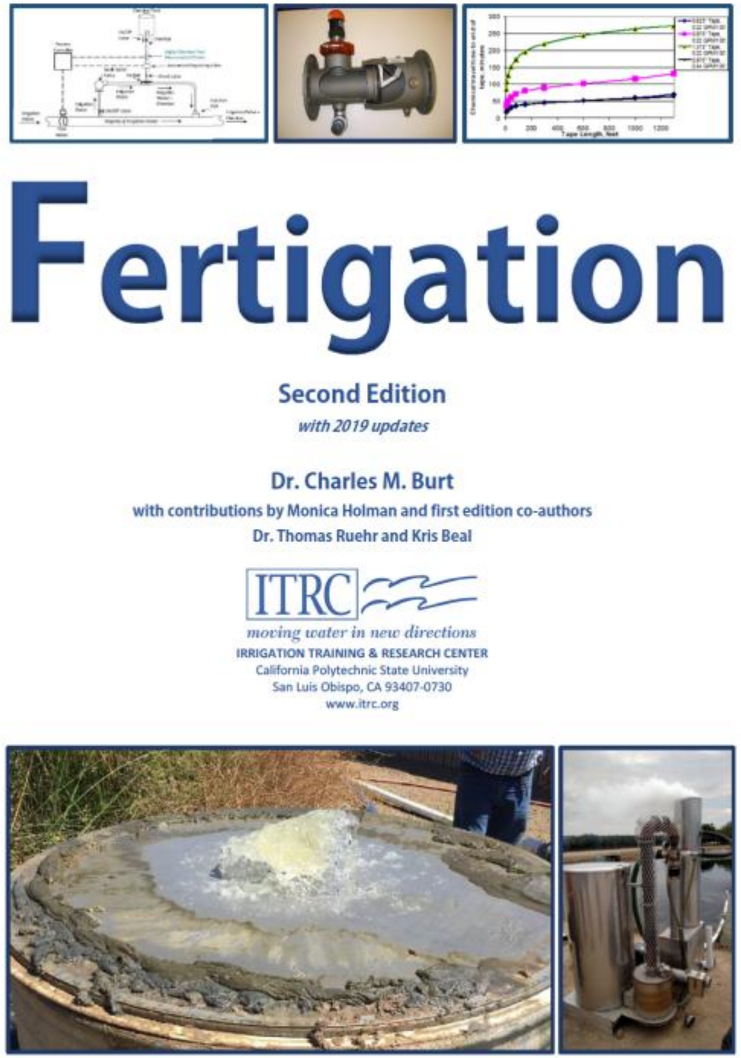
This course will soon also be available in Spanish. Until the Spanish certification is ready, feel free to utilize our **Spanish fertigation video playlist on our YouTube channel**.

Fertigation, 2nd Ed. Now Available!



Sponsor: CDFA/FREP
The second edition of the groundbreaking *Fertigation* manual is now available. The new edition contains hundreds of updates, including detailed descriptions of injection hardware and techniques, back flow prevention, N, P, K and injection, drip system maintenance, gypsum injection, and specifications for various irrigation methods.

Online Download: Free through this form



Podcast

Urban Gardener Podcast

OK County OSU Extension

New Podcast Episode

Episode 46: Holding On to Every Drop

Urban Gardener Podcast

Podcast Episode

Episode 45: Spring Cleaning

Urban Gardener Podcast

Podcast Episode

Episode 44: Water Conservation in Oklahoma County

Urban Gardener Podcast

Podcast Episode

Episode 34: Secrets of the Soil

Urban Gardener Podcast

Spotify

United States	89.3%
Germany	1.2%
Australia	1.1%
Canada	1%
United Kingdom	<1%
The Netherlands	<1%
South Africa	<1%

OKLAHOMA COUNTY EXTENSION

THINKWATER
OSU Extension

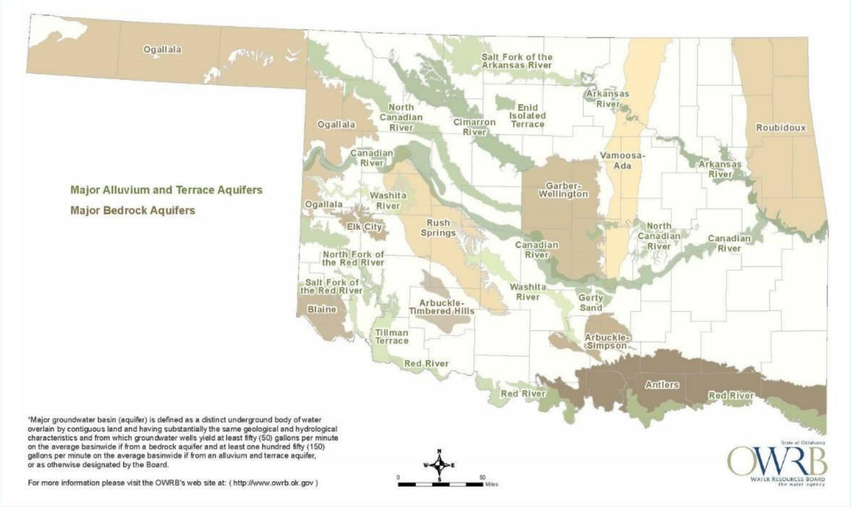
What is groundwater? What is an aquifer? What's the big deal?

Join us for this FREE workshop to learn more about this hidden water and the importance of groundwater for Oklahomans.

The first 50 samples of well water brought to the workshop will be tested for FREE by the Oklahoma Well Owner Network (OWON)! To accommodate as many people as possible, only one well water sample per person will be accepted.

March 30th from 12:00pm-3:00pm

Oklahoma County OSU Extension Office
2500 N.E. 63rd St., Oklahoma City, OK 73111



Persons with disabilities who require alternative means for communications, program information or reasonable accommodations, need to contact Andrew Fleet at the OSU Extension Office at 405-713-1125 at least two weeks prior to the event.

6th PFAS and Emerging Contaminants Workshop Biosolids, Water & Wastewater, Air, and Waste

May 6-7, 2026 | 9:00 AM-6:00 PM CDT

Hamm Energy Institute, OKC and Online

Join us to learn about PFAS and other emerging contaminants regulations, health effects, assessment, remediation, research, and legal aspects. Attend free in person

What We'll Cover:

- Status of federal PFAS/Emerging Contaminant regulations for water, waste, biosolids, and contaminated sites
- Oklahoma regulations and perspectives
- Legal aspects of PFAS management
- Human health and environmental impacts of PFAS exposure
- Methods for PFAS characterization and compliance monitoring
- Remediation technologies/strategies for treating emerging contaminants
- PFAS presence and management in biosolids research
- Microplastics

OKLAHOMA COOPERATIVE EXTENSION SERVICE

Trihydro

Can Oklahoma really support resource-heavy data centers? The potential impact isn't clear

Jeff Elkins and Steve Lackmeyer The Oklahoman
Nov. 12, 2025, 5:40 a.m. CT

YUKON, Okla. — Yukon city leaders are considering adding reclaimed water capabilities to their treatment facilities to support a proposed data center near Frisco Road and Vandament Avenue, owned by Beltline Energy, but the plan has drawn criticism from nearby residents concerned about costs and potential rate increases.

LOCAL

Cherokee Nation launches task force on impact of data centers

by: Terré Gables/KFOR
Posted: Feb 25, 2026 / 11:59 AM CST
Updated: Feb 25, 2026 / 12:26 PM CST

Clinton studies impact of data center expansion on Oklahoma's water resources and power grid

Oct 22, 2025

THE FRONTIER

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As data centers boom in Oklahoma, so does water demand

February 23, 2026

From Pryor to Stillwater and Muskogee, local officials say supplies are sufficient, even as Google alone used more than 1.1 billion gallons in a single year.

Data centers, utility bills and water among subjects of Oklahoma lawmakers this year

StateImpact Oklahoma | By Chloe Bennett-Steele
Published January 27, 2026 at 3:40 PM CST

Data centers are eyeing Oklahoma communities. Residents and officials are worried about water.

By Graycen Wheeler | KOSU
November 18, 2025

Facebook X LinkedIn Email

Stay tuned!

OSU Data Center Research Committee

Water Resources Specialists	Energy Specialist	Agricultural Economics Specialists	Mechanical and Aerospace Engineering Specialist	Waste Management Specialist

Fact sheets are under construction

First one will be a list of specific questions for residents to ask during town/city hall meetings; relating to water, energy, land use, etc.

Oklahoma Water Resources Center

The Oklahoma Water Resources Center provides informative resources and specialists for producers in need of water expertise in many different areas such as: animal care and production, environment and recreation, and crop production.

PROGRAM DETAILS

Water Topics:

- Animal Care & Production Water Issues
- Crop Production Water Issues
- Groundwater
- Home & Garden Water Issues
- Industrial & Commercial Uses of Water
- Irrigation
- Municipalities & Infrastructure Water
- Pollution, Hazardous Materials & Contamination
- Water & Environmental Issues

https://extension.okstate.edu/topics/environment-and-natural-resources/water/

Water Conservation Program Development, Year 2

PLEASE FILL OUT THIS SURVEY!

THANK YOU FOR YOUR TIME & ATTENTION

QUESTIONS?

COMMENTS?

CONCERNS?