Water and Irrigation

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What do we hope to learn about water and irrigation?

To Better Understand:

- How water interacts with our environment
- How plants utilize water
- How, when, and where to irrigate plants
Molecular Structure of Water

- One oxygen atom
- Two hydrogen atoms
- $\text{H}_2\text{O}$
- Not symmetrical
- Electrons spend more time near the oxygen and less near the hydrogen
- Water molecule is polar
Hydrogen Bonding

- + attracted to -
- Each H₂O is bonded to its nearest neighbor

2.02 Å

109.47°
Physical States

Ice → Melting → Water

Vapor
Solvent Properties

- Interacts with other polar compounds
- Is repelled by non-polar compounds
- Small size allows it to saturate areas
- Can convey other substances in solutions
Sodium Chloride in Solution

Water molecules

Chloride ion (Cl\(^{-}\))

Sodium ion (Na\(^{+}\))

Undissolved sodium chloride
Cohesion

- The attraction of water to itself – H bonds
Adhesion

- The attraction of water to other surfaces/substances
Surface Tension

- Interaction between hydrogen bonding and the earth’s gravitational pull
Capillary Action

- “Wettable” surfaces cause a film of water to partially pull away from other water molecules and cling to the surface.

- Capillary action is important in soil and plant/water relations.
Useful Constants/Conversions

- Weight: 62.416 pounds per cubic foot at 32°F
- Weight: 8.33 pounds/gallon, 0.036 pounds/cubic inch
- Density: 1 gram per cubic centimeter (cc) at 39.2°F
- 1 gallon = 4 quarts = 8 pints = 128 ounces = 231 cubic inches
- 1 liter = 0.2642 gallons = 1.0568 quart = 61.02 cubic inches
- 1 Acre-Foot = 325,851 gallons = 43,560 cubic feet
Diffusion

- The tendency of substances to move from areas of high concentration to areas of low concentration
- At equilibrium, they remain as far apart as possible
Osmosis

- Osmosis is the net movement of water across a selectively permeable membrane driven by a difference in solute concentrations on the two sides of the membrane.
- The water moves from the area of higher solute concentration to the area of lower solute concentration until equilibrium is reached.
Osmosis

Low Solute Concentration

High Solute Concentration

higher water

less water

less solute

more solute

Semi-Permeable Membrane

H₂O

Osmosis is the net movement of solvent (water) from an area of lower solute concentration to an area of higher solute concentration through a semi-permeable membrane.
**pH: Alkalinity/Acidity**

- The measurement of the H+ ions found in that particular substance
- The scale goes from 0 to 14
- 7 is neutral
- Below 7 is acidic
- Above 7 is alkaline (or basic)
- One pH unit represents a ten-fold change in H+ concentration
The pH Scale

- Lye
- Milk of magnesia
- Alkaline soil (above 7)
- Average seawater
- Neutral
- Theoretical pH of rain (5.5–6.5)
- Acidic soil
- Most acidic rainfall recorded in U.S.
- Vinegar
- Battery acid
- Lemon juice
- Apples
- Tomato juice
- Milk
- Baking soda
- Human blood
- Ammonia
Plant/Water Relations

- **Transpiration** is the water vapor given off by plants.
- **Evaporation** is the water vapor lost from the soil.
- **Evapotranspiration** is the sum of both (Et).
Transpiration—Cohesion Hypothesis

Evaporation (the driving force)
The lower water potential of air causes evaporation from cell walls.
This lowers the water potential in cell walls and in cytoplasm.

Cohesion (in xylem)
Cohesion holds water columns together in capillary-sized xylem elements.
Air bubbles block movement of water to next element.

Water uptake (from soil)
Lower water potential in root cells draws water from soil.
The absorptive surface increases with the production of more root hairs.
Water moves through endodermis by osmosis.
Transpiration Animation

- Start
Et Prediction

- air temperature
- relative humidity
- soil temperature
- solar radiation
- precipitation
- wind speed
- wind direction

AZMET Station
Irrigation

- Art and Science of providing to proper quantity of water to plant roots when it is needed
- Plants and irrigation techniques should be suited to:
  - Climate (macro and micro)
  - Topography
  - Soil
  - Available water (quality and quantity)
Shrub and Tree Root Systems

In the arid southwest, tree roots can extend horizontally 3 to 5 times the height of the tree.
Terry Mikel’s Law of Pizza

- $A = \pi r^2$
- 10” pizza = 79 in²
- 12” pizza = 113 in²
- 20” pizza = 314 in²
- As the radius of the root system doubles, the area of the root system increases by four times
Weight of water on/in soil

- Table is 3’ x 6’ (36 ft²)
- 1 inch of water on that table weighs...
- 187 lbs
- 6 inches of water = 1,122 lbs
- Soil compaction can occur during flood irrigation
- Water also displaces air potentially leading to plant stress
Lysimeters are used to measure actual water use.
How does water behave in soil?

1. Gravity moves it in (infiltration)
2. Gravity + Capillary Action moves it down and horizontally (percolation)
3. Evaporation and transpiration removes water from soil
4. Capillary action moves it upward
5. Diurnal effect
   - Day - dries
   - Night - equilibrates
Irrigation Principles

- 1 inch of water will:
  - Go 12” deep in a sandy loam
  - 8-10” deep in a loam
  - 4-6” deep in a clay loam

- To irrigate each soil to a three foot depth, you need to apply:
  - 3” on a sandy loam
  - 4” on a loam
  - 6” on a clay loam
More Irrigation Principles

- 1 gallon of water will irrigate roughly 1 ft$^3$ of soil
One, Two, Three Rule - I
Irrigate plants to the proper depth and check with a probe
Allow plants to utilize the water until the soil surface dries to a depth of (early morning):

- Annual or Perennial Shrub
- Tree

<table>
<thead>
<tr>
<th>1 inch</th>
<th>2 inches</th>
<th>3 inches</th>
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One, Two, Three Rule - IV

This is the irrigation frequency for that soil at that time of year!

Annual or Perennial

Shrub

Tree
Irrigation Methods-Drip

- Easy to install, but does not keep up with growth on large woody plants.
- You can use multiport heads for these situations.
- I think of it as a “disposable system” which works for some natives (i.e. by the time the system disintegrates, natives may be able to survive on natural precipitation.)
Irrigation Methods-Spray heads

- Excellent for turf and ground covers
- Not as good for trees and shrubs
- Need a good design (consider hiring a professional to design the system)
- Still need repair and maintenance
- Do not mix and match incompatible nozzles and head types or brands.
Irrigation Methods - Bubblers

- Great for shrubs and trees in basins
- Need to have level ground and a berm
- Do not put on same station (valve) as turf or drip
Irrigation Methods - Automatic Timers

- Reset times for different times of year
- Check system periodically to make sure it is working correctly
- Turn off after rains
Soaker hoses work great for trees, shrubs, vegetables, and annuals.

Oscillating sprinklers can work well for those on a budget, but there will be dry spots.

Good, old fashioned hose spraying works well for natives that only need periodic watering during drought.
Irrigation Wrap-Up

- Do not overwater or fertilize native and/or drought tolerant plants and cause them to grow too much
- Do not assume that just because a plant is native and/or drought tolerant that it does not need irrigation
- Plants need some water in winter, evergreens also need adequate water in winter