Understanding Water Footprint of Nursery Production

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Water **Footprint**

Footprint -> **IMPACT**

Similar in basic concept to a Carbon Footprint / Ecological Footprint

Water Footprint

"Consumptive Use" of water is defined by *impact*.

Water used for one purpose cannot be used for another purpose at the same time.

Ex. Captured rainfall runoff that has evaporated behind a dam cannot flow downstream and provide habitat.

Water Footprint

Relevant or Competitive uses of water…

- Irrigation
- Drinking water
- Ecological Requirements
  - Dilution of pollutants
  - Habitat support

    ex. aquatic animals, vegetation

Is All Consumptive Water Use Equal?

(mostly) **No!**

Critical Factors:

- Location
- Time of Year

BUT, comparisons between geographic locations should include unweighted Water Footprint volumes.

A **Water Scarcity Index** is a ratio equal to

$$\frac{\textbf{CONSUMPTIVE WATER USE}}{\textbf{AVAILABILITY}}$$

State	January	February	March	April	May	June	July	August	September	October	November	December	Annual Average	Representative Drainage	Population
Virginia	0.014181	0.01832	0.018219	0.025763	0.038401	0.063774	0.117747	0.186882	0.208571	0.155023	0.059899	0.026471	0.077771	James River (163)	909,948
South Carolina	0.019746	0.0189	0.018254	0.031089	0.063785	0.116685	0.201934	0.351206	0.225242	0.221579	0.127507	0.052044	0.120664	Savannah River (181)	1,169,380
New Jersey	0.098284	0.20119	0.039736	0.072174	0.095669	0.177733	0.264605	0.306618	0.283452	0.213289	0.114869	0.124629	0.166021	Delaware River (147)	6,415,590
Maryland	0.063034	0.07346	0.050191	0.063696	0.094937	0.150985	0.267116	0.399776	0.49382	0.409168	0.218213	0.113635	0.199836	Potomac River (156)	3,494,420
South Carolina	0.098463	0.09975	0.105906	0.167028	0.298493	0.466598	0.566113	0.583447	0.61985	0.669924	0.532555	0.200463	0.367383	Santee River (175)	3,126,590
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Selected Water Scarcity Indices (2011)

Purpose of Water Footprint Analysis

International Standard

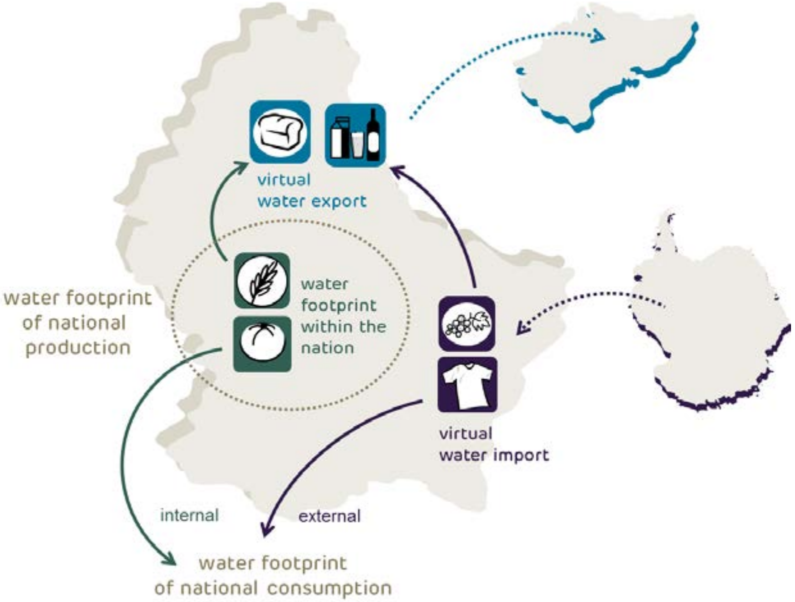
&

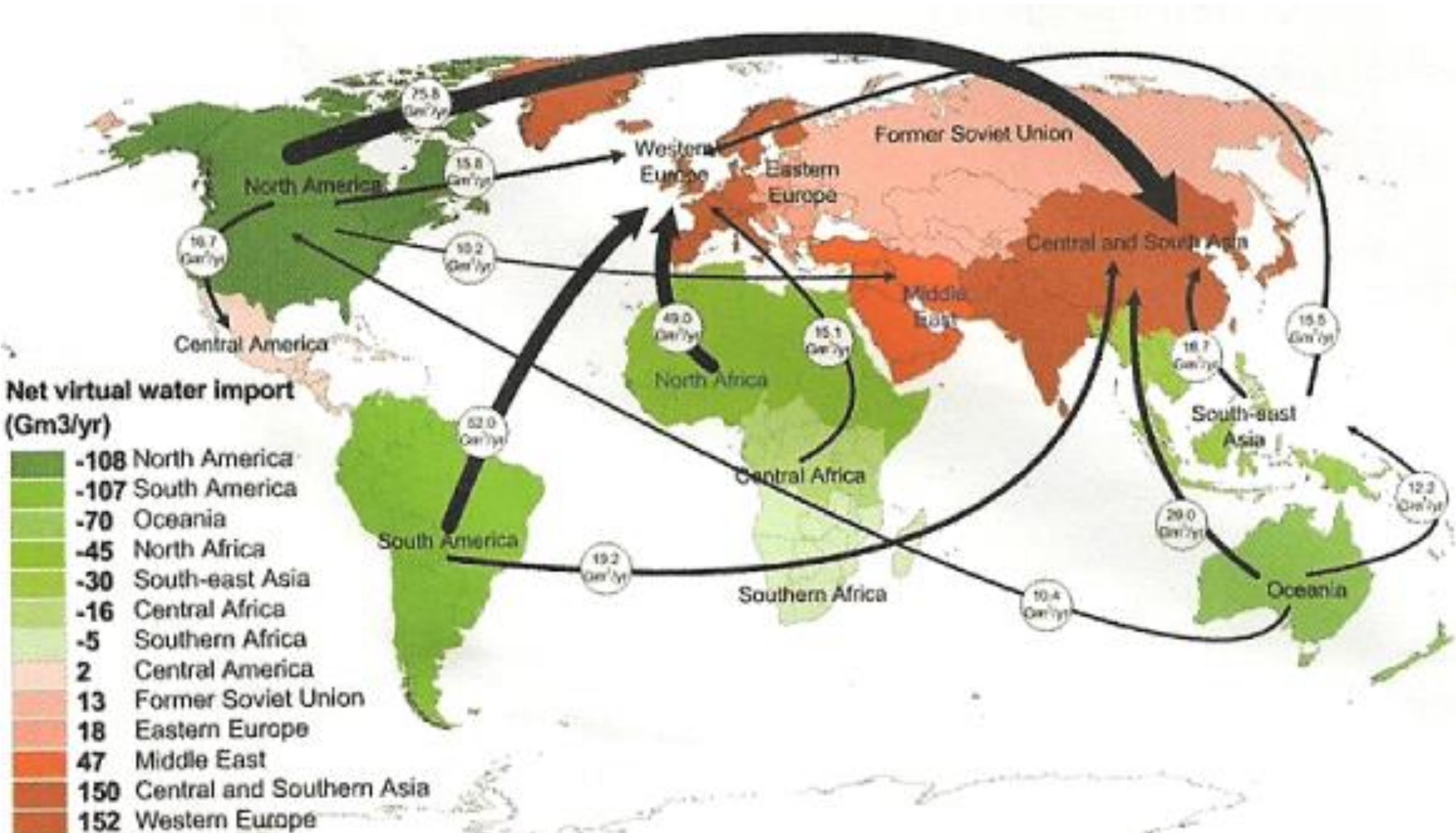
Broad Application

Purpose of Water Footprint Analysis

International Standard

Due to international trade, freshwater is becoming a **global resource**.
&
Consumers are **spatially disconnected** from water resources.





Virtual water balance per country and direction of gross virtual water flows related to **trade in agricultural and industrial products over the period 1996-2005**. Only the biggest gross flows (> 15 Gm3 /yr) are shown; the fatter the arrow, the bigger the virtual water flow.

Purpose of Water Footprint Analysis

International Standard

Not a stick to beat on water by consumers or producers, but rather **a method to analyze consumptive water** use and ultimately **make practical improvements**.

Purpose of Water Footprint Analysis

Broad Application

Water footprint can allow comparisons

- Companies
- Products
- Commodities
- Communities
- Individuals

Comparing Water Footprint	
Smartphone	240 gallons
Cotton T-shirt	26 gallons
Cup of Coffee	35 gallons
Direct Consumption per day -washing, cleaning, etc.	27 gallons
Plastic Bottle (1 pint)	1.4 gallons

Illustrating water ~~conservation from recycling…~~

Water Volume requirement to **produce** new packaging expressed in volume of Empire State Building.

1 million cubic meters
= 1 empire state building

How it works…

Basic Water Footprint Calculation in Nursery Production

Embodied WF

Green WF

Grey WF

+ Blue WF

Total Water Footprint

How it works…

Basic Water Footprint Calculation in **Nursery Production**

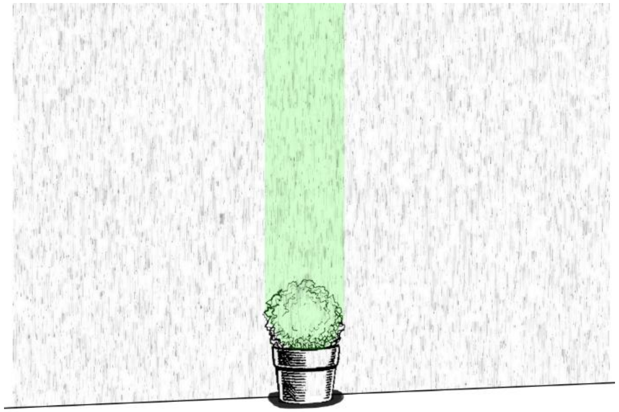
Embodied WF = Weighted volume of water required for fabrication of inputs

Ex. for field production phase of holly in a #3 container…

Injection molded HDPE plastic container
= 0.534 Gallons (weighted)
Herbicides (total)
= 0.262 Gallons (weighted)
….
Total Embodied WF
= ~ 4.2 Gallons (weighted)

Basic Water Footprint

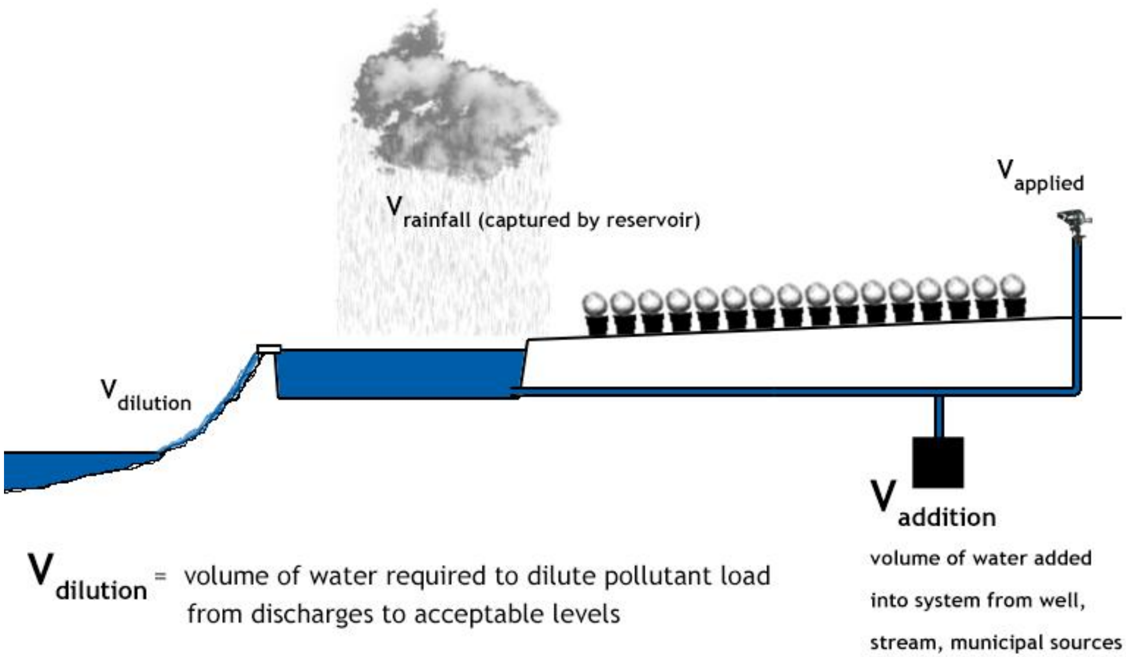
Green WF = water used ***directly*** during atmospheric events



Calculated as **Volume** of irrigation events *avoided* due to precipitation

$$WF_{blue} = V_{rainfall} + V_{addition}$$

$$WF_{grey} = V_{dilution}$$



$V_{dilution}$ = volume of water required to dilute pollutant load from discharges to acceptable levels

Grey WF is "simple": Measure or estimate volume and pollutant load of discharges

Aside from metered additions, **Blue WF** is complex:
How much rainfall runoff is there to capture?

How? – Calculating WF

- ❑ **Interview Grower**
- ❑ Complete Checklist
- ❑ Get Climate Data (30-Y normals)
- ❑ **Calculate Green WF**
- ❑ **Calculate Grey WF**
- ❑ **Model Captured Rainfall Runoff**
- ❑ **Calculate Blue WF**

Water Footprint Data Checklist

Nursery Name

Physical Address

CRITICAL INFORMATION

Irrigation

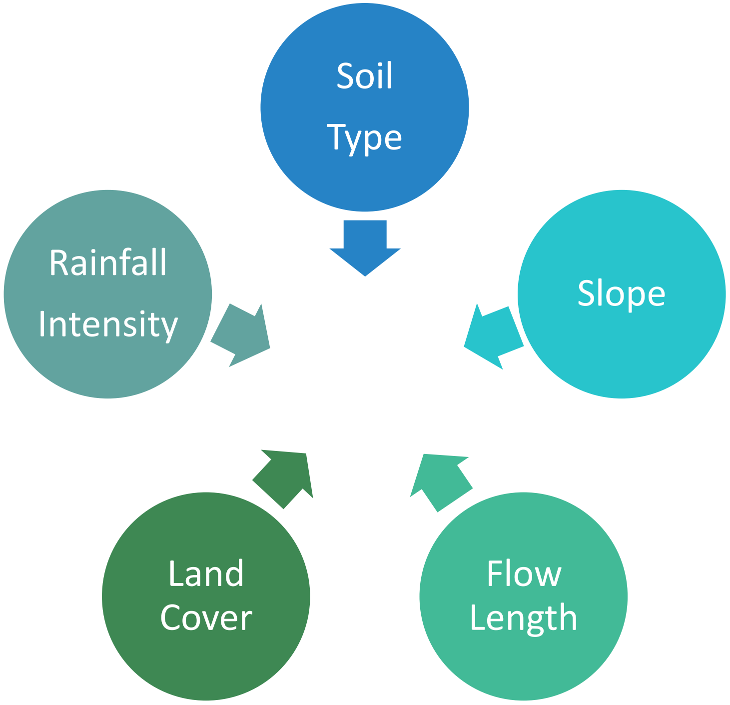
Total Area Irrigated		Area Under Cover		Area NOT Under Cover	
Irrigation Method A	Overhead	Drip	Mist	Ebb/Flood	Other
Area of Irrigation A			□ Covered		□ Uncovered
Estimated % Irrigation Applied Returning to Reservoir					
Irrigation Method B	Overhead	Drip	Mist	Ebb/Flood	Other
Area of Irrigation B			□ Covered		□ Uncovered
Estimated % Irrigation Applied Returning to Reservoir					
Irrigation Method C	Overhead	Drip	Mist	Ebb/Flood	Other
Area of Irrigation C			□ Covered		□ Uncovered
Estimated % Irrigation Applied Returning to Reservoir					

Monthly Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Irrigation Method A												
frequency (per week)												
amount per event												
Irrigation Method B												
frequency (per week)												
amount per event												
Irrigation Method C												
frequency (per week)												
amount per event												
Water Additions (gallons)												
stream (price $____per____)												
well (price $____per____)												
municipal (price $____per____)												
other (price $____per____)												
Water Discharges												
Volume (gallons)												
Pollutant Loads												
N (specify unit)												
P (specify unit)												
(specify unit)												
(specify unit)												
(specify unit)												
Water Storage Capacity												
Average Depth of Reservoir (empty)												

Other Water Storage (describe)

How? – Calculating Water Footprint

How much of typical rainfall is caught?



Calculating Blue WF

FIND LOCATION

Physical address

or

GPS Coordinates

How? – Calculating WF

Define production / irrigated area

- *Models tell us how much runoff can be expected from given rainfall and irrigation*

How? – Calculating WF

Define water reservoirs

- 100% of rainfall captured in reservoir

How? – Calculating WF

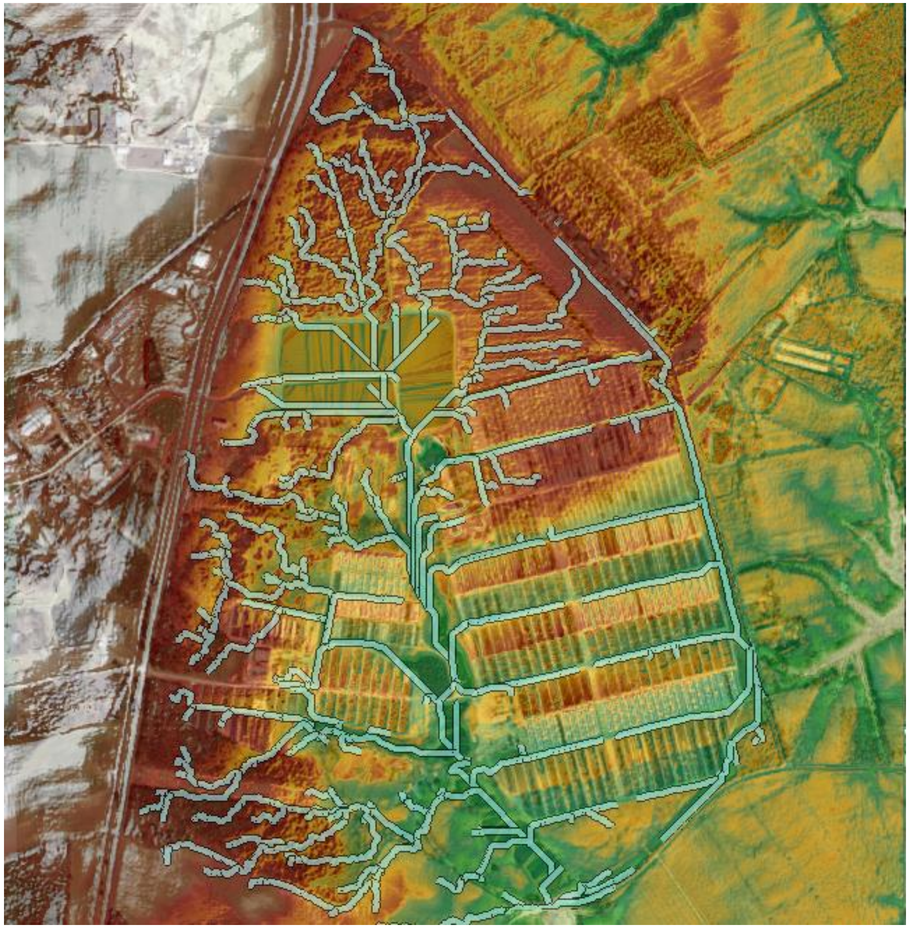
Find boundaries of catchment

1. **Elevation map**
2. Find Flows
3. Boundaries

How? – Calculating WF

Find boundaries of catchment

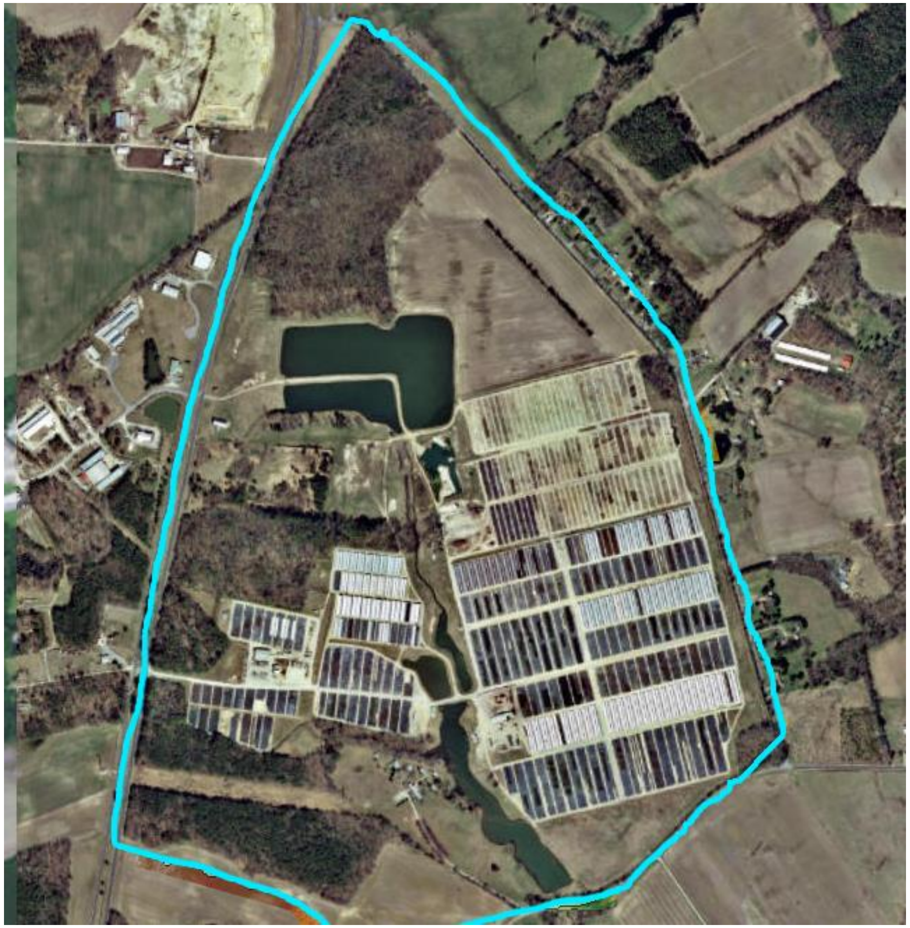
1. Elevation map
2. **Find Flows**
3. Boundaries



How? – Calculating WF

Find boundaries of catchment

1. Elevation map
2. Find Flows
3. **Boundaries**

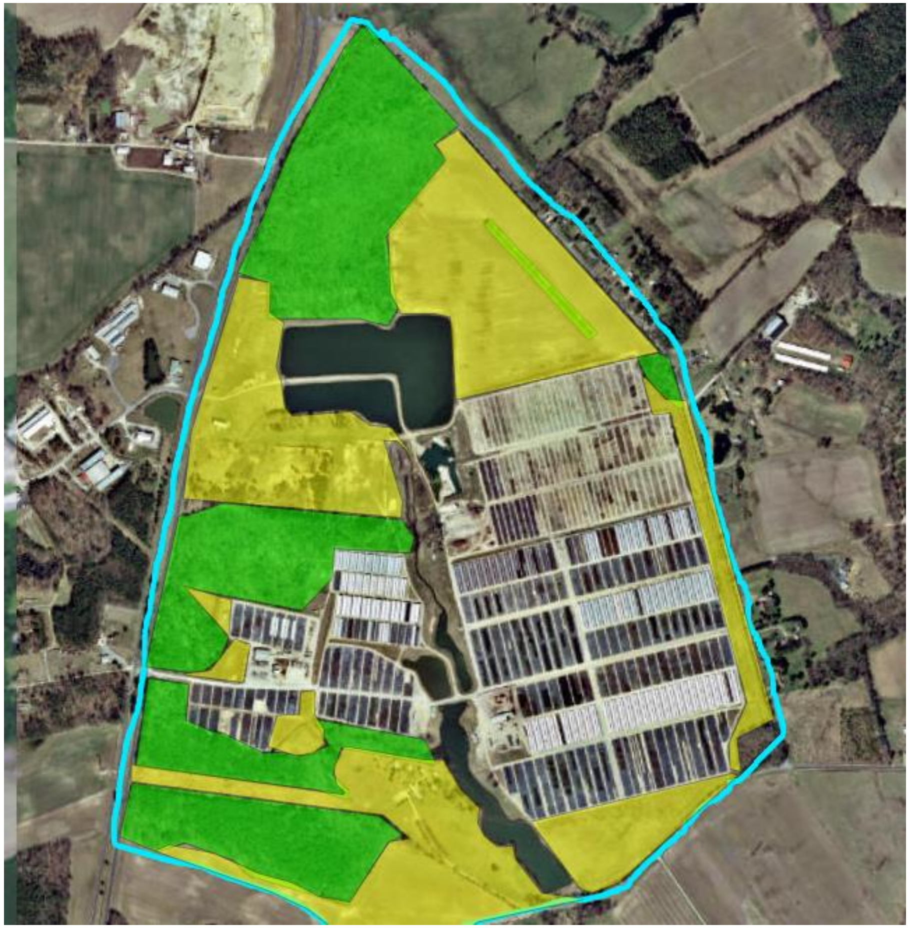


How? – Calculating WF

Define land cover*

Trees/woods, grasses

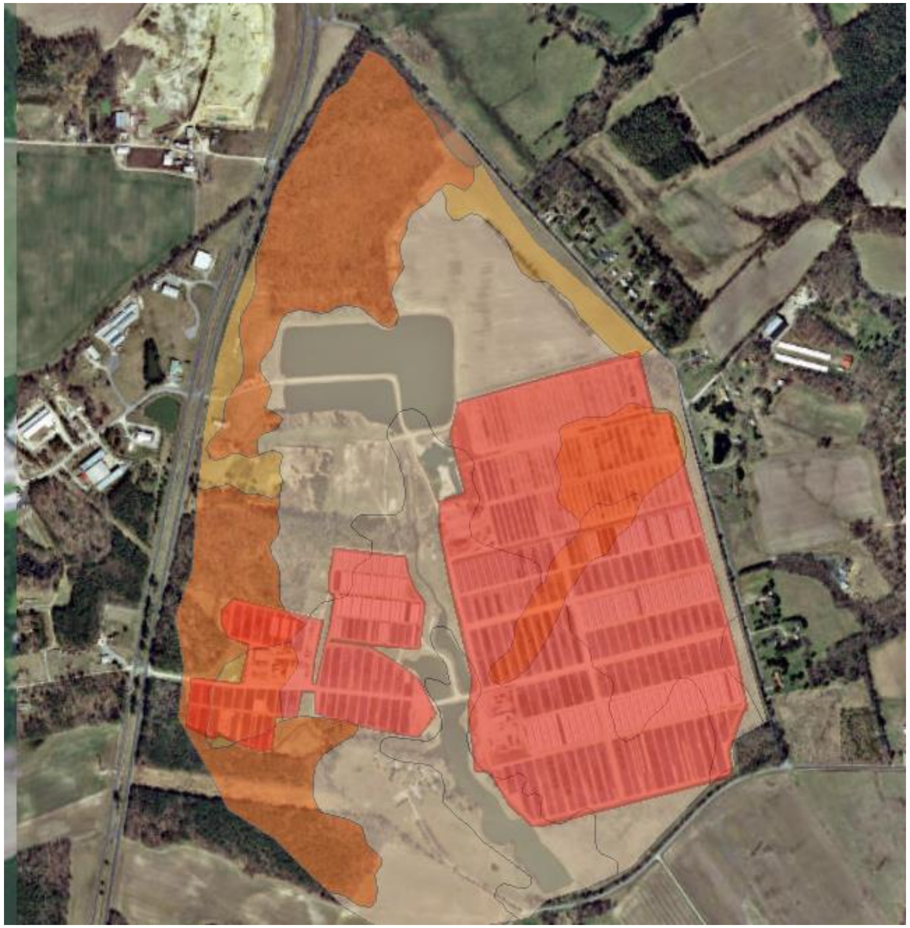
**only necessary for unengineered areas*



How? – Calculating WF

Find soil drainage types*

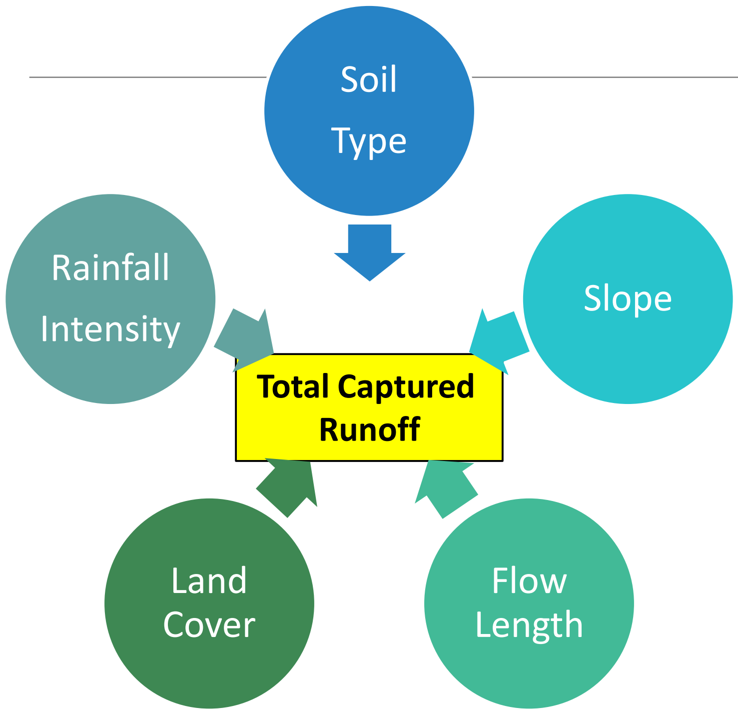
**only necessary for unengineered areas*



Rainfall Intensity (monthly)

Rainfall intensity estimated from 30-year normals (1981 – 2010)

	Jan	Feb
Rainfall (inches) 30-yr average	3.33	3.01
Rainfall events => 1 inches	0.8	0.9
Rainfall events => 0.5 inches	2.6	2.4
Rainfall events => 0.1 inches	6.5	5.9
Rainfall events => 0.01 inches	10.1	9.6

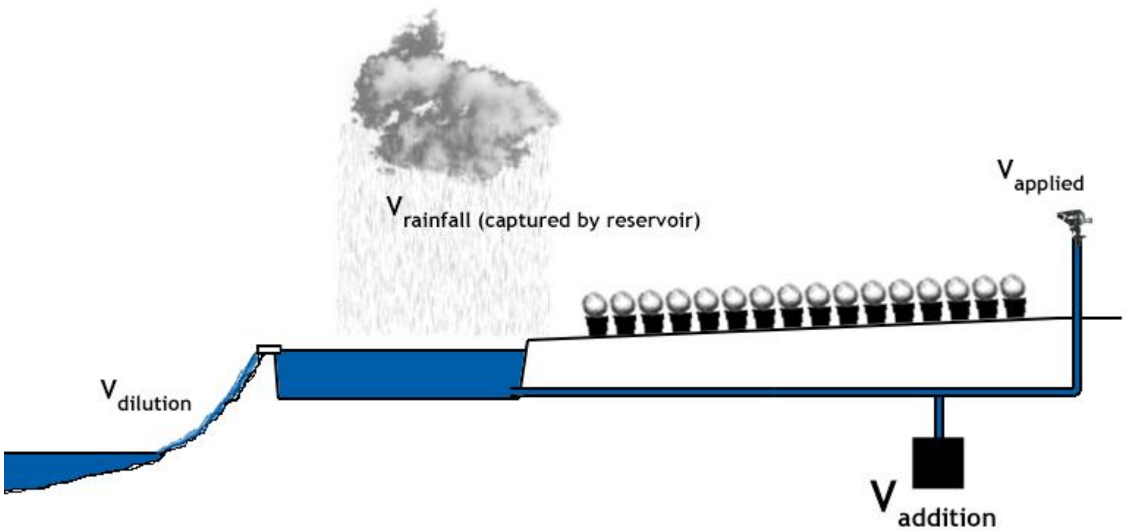


Total Captured Runoff is compared with **Reservoir Capacity** and estimated losses to evaporation (monthly)…

You can only capture what you can use or hold!

$$WF_{blue} = V_{rainfall} + V_{addition}$$

$$WF_{grey} = V_{dilution}$$



$V_{dilution}$ = volume of water required to dilute pollutant load from discharges to acceptable levels

volume of water added into system from well, stream, municipal sources

Captured Rainfall

+ Additions

Blue Water

Example Estimated Calculations

Green Water Volume	30 m gallons / yr
Grey Water Volume	50 m gallons / yr
+ Blue Water Volume	300 m gallons / yr
Total Water Volume	380 m gallons / yr

For entire catchment area!

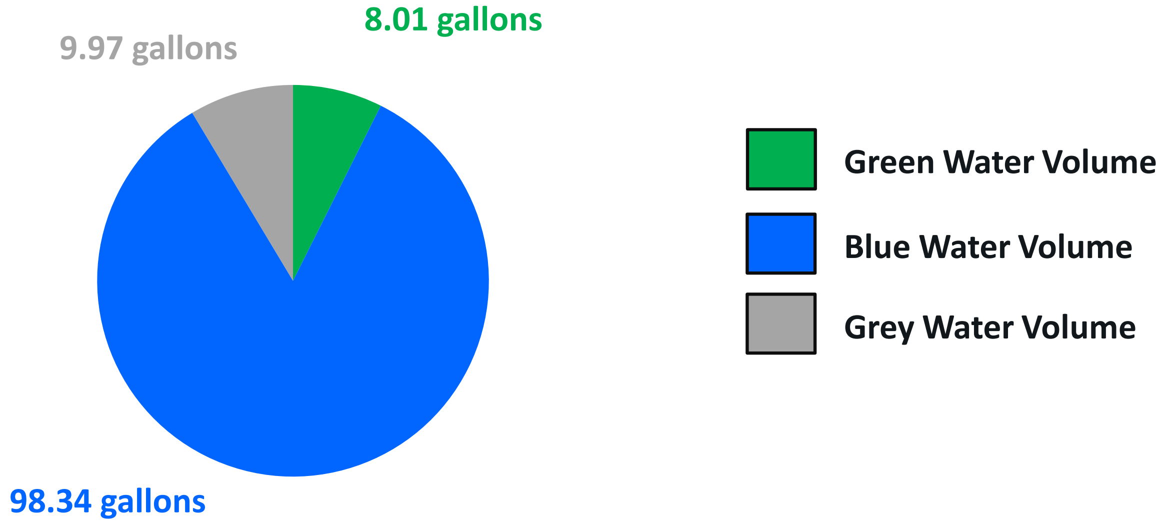
From Total Water Volume

=> Per Plant Consumptive Water Use:

$$\frac{\text{(Total Water Volume per year)(Length of Production Cycle)}}{\text{(Plant Density) (Total Production Area)}}$$

Ex. #3 Container *Buxus*

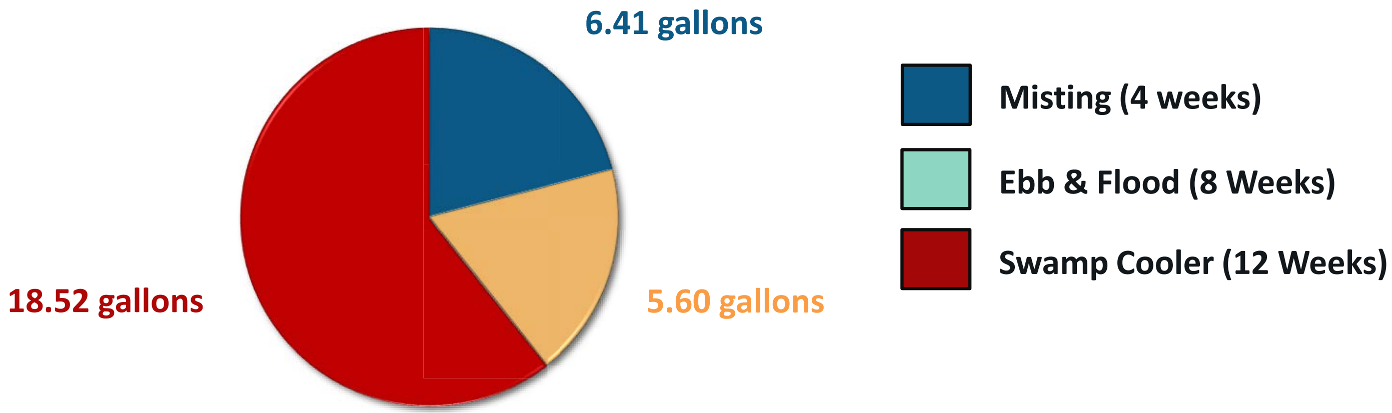
Water Volume of Consumptive Use Characterized by Water Type



Total = 116.32 gallons

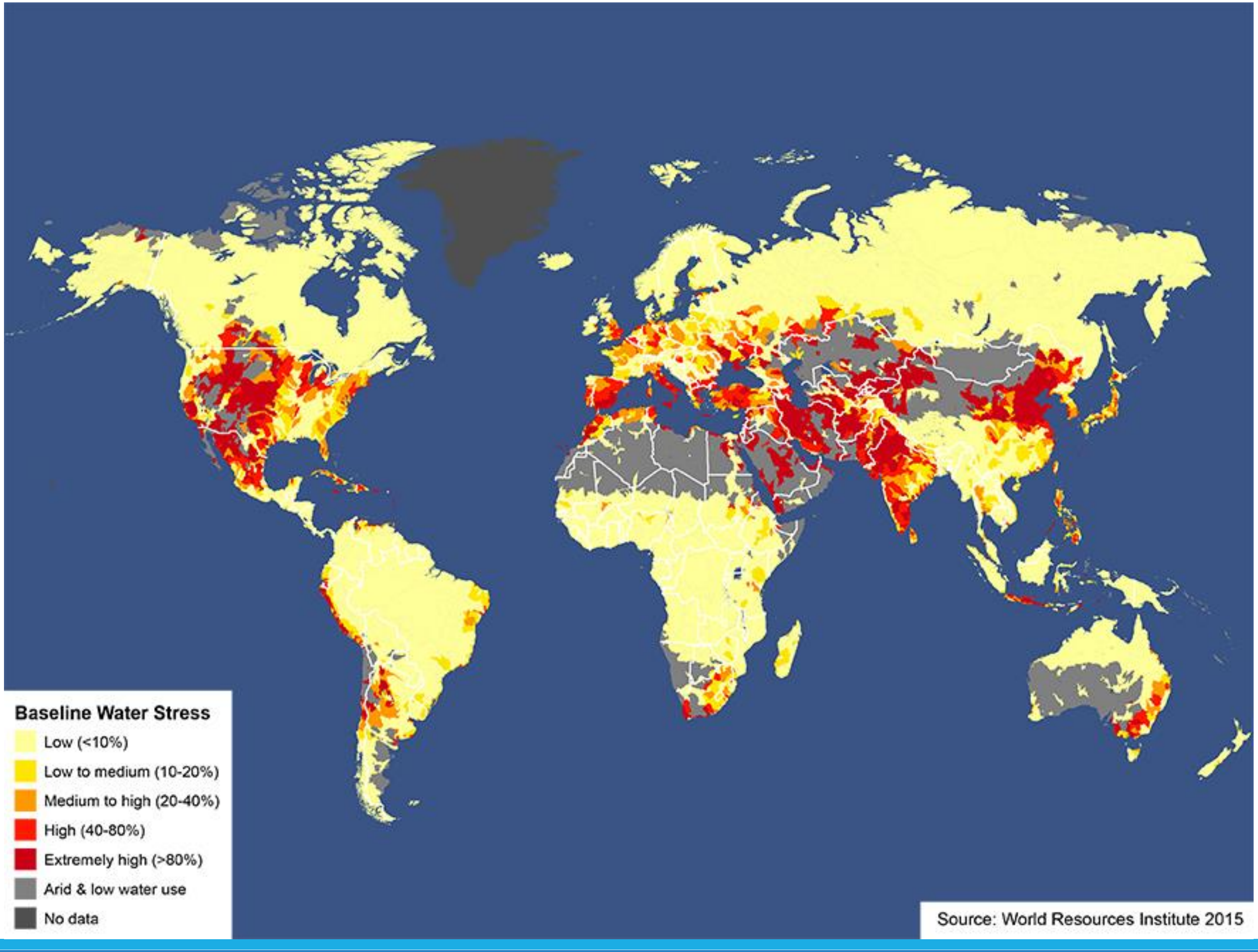
Ex. Greenhouse 72 Cell Tray

Water Volume of Consumptive Use Characterized by Production Use



Total = 30.53 gallons

What about scarcity?



Water Volume vs. Weighted Water Volume

- Appropriate for **comparing** changes in water use efficiency from **system changes**
  - irrigation schedule
  - recycling techniques
- Appropriate for **comparing system efficiencies** among similar systems with **variable water scarcity**.

- Appropriate for **comparing environmental impacts** across systems with variable water scarcity.
- Appropriate for **quantifying** e**nvironmental impact** to location throughout year.
- **Moving Target!** … Changes with shifting climate (availability) and use changes.

How is scarcity calculated?

Multiple methods, attempting to answer the question

“What is the potential to deprive another freshwater user—human or ecosystem—by consuming freshwater in this region?”

Generally expressed as in range between .01 and 100.

How is scarcity calculated?

Generally expressed as in range between

.01 -- 100

Low scarcity
(water abundance)

High scarcity
(water limited)

Calculation Methods

Withdrawal-to-Availability ratio (WTA) ~2008 (early)
Consumption-to-Availability ratio (CTA) ~2012 (common)
Inverse of Availability minus Demand (AWARE) ~2017 (new)

Selected Water Scarcity Indices (CTA Method) (2011)

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1.0 = All Available Water is Being Used

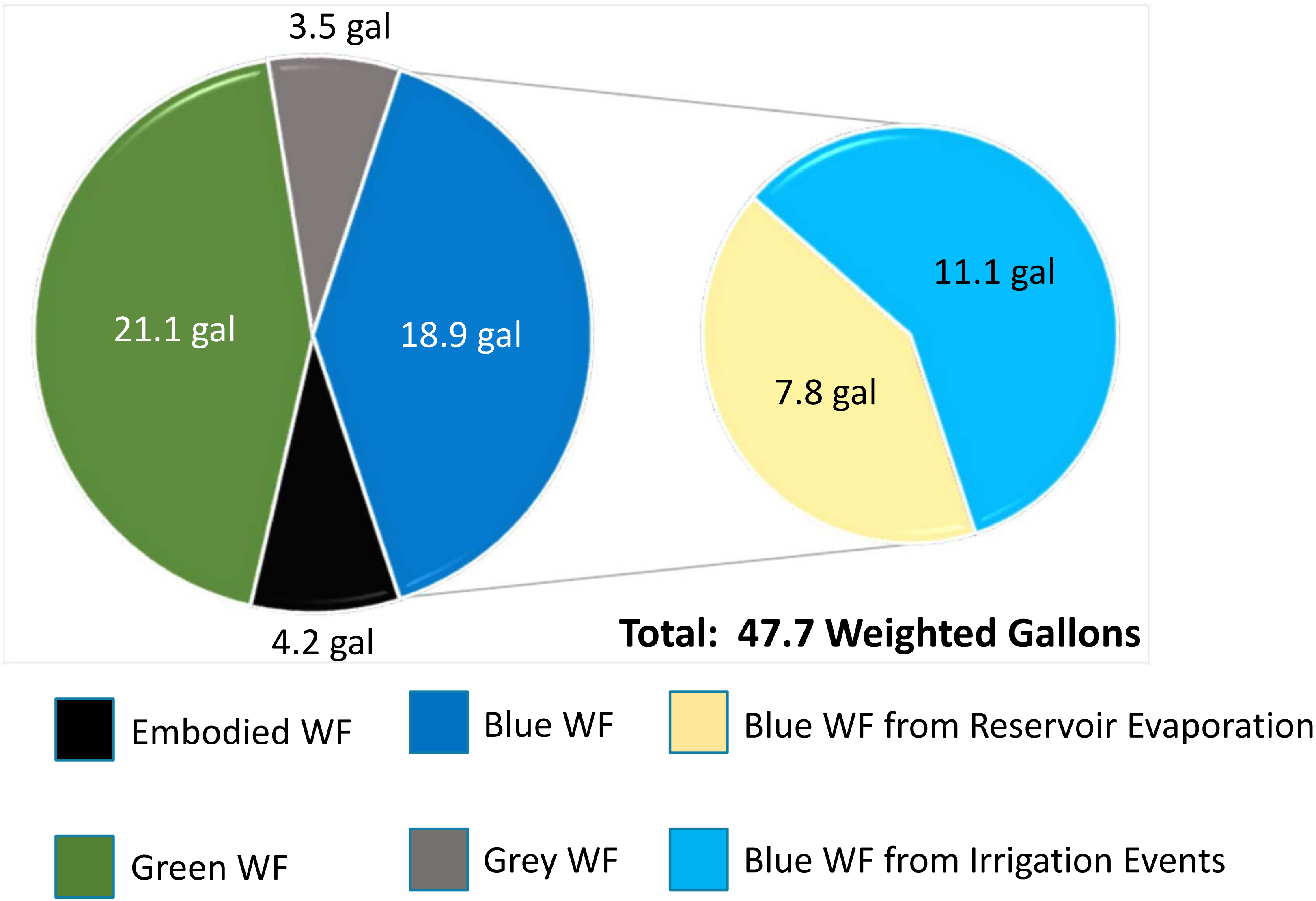
Weighted Water Footprint =

$$\sum\left(\frac{\text{Monthly Water Volume (Blue + Grey)}}{\text{Marketable Plants in Production Area}} \times \text{Monthly Scarcity Index}\right)$$

$$+$$

$$\frac{\text{Green Water Volume}}{\textbf{Marketable Plants in Production Area}}$$

Example: ***Preliminary*** **WF of a single, marketable #3 Container Holly, East Coast U.S.**



CLEAN WATER³
REDUCE•REMEDIATE•RECYCLE

WEAH

http://cleanwater3.org/

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