

ESTIMATING WATER AND NUTRIENT RETENTION OF PAYMENT FOR WATER SERVICES PROGRAMS ON SOUTH FLORIDA RANCLANDS



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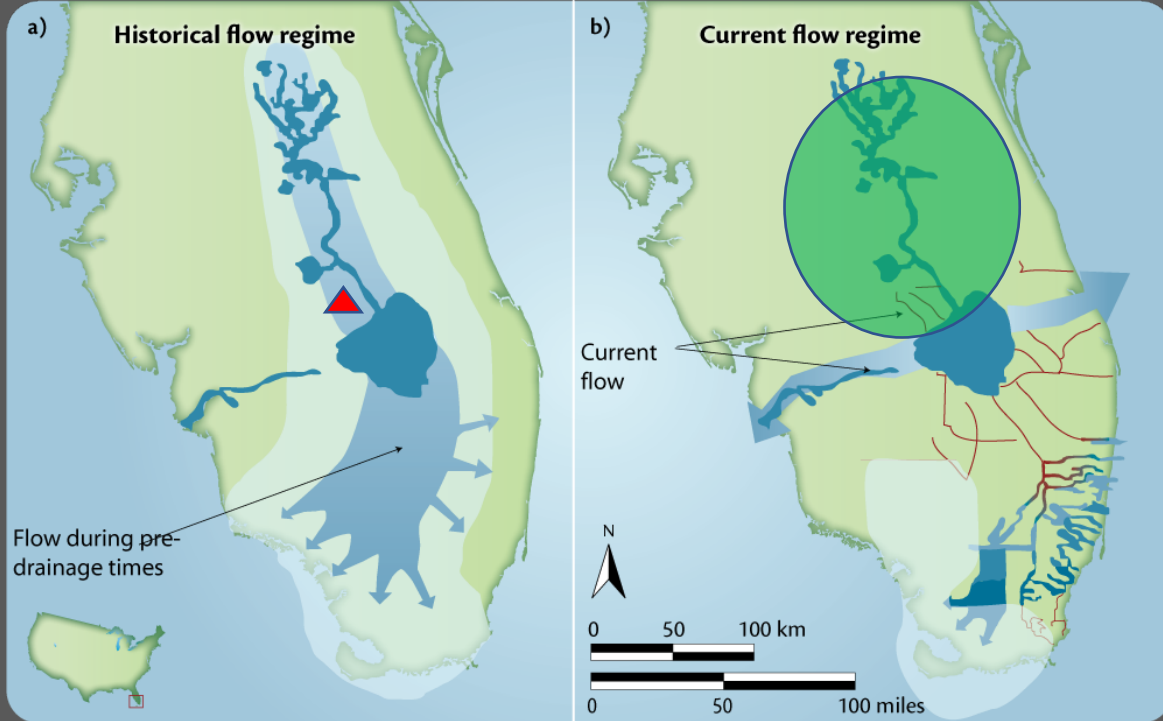
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²South Florida Water Management District, FL. Retired.

³Dispersed Water LLC, Jupiter, FL.



The **Biggest Environmental Issue** in South Florida: **Water**



Conceptual diagram illustrating the current versus the historical flow regimes through the everglade wetlands, showing how water that once flowed south into the Everglades is now directed east and west. Based on information provided by the South Florida Water Management District, www.evergladesplan.org/doc/fs/_fi_bay_feas_study.pdf.

Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Longstaff, B.J., T.J.B. Carruthers, W.C. Dennison, T.R. Lookingbill, J.M. Hawkey, J.E. Thomas, E.C. Wicks, and J. Woerner (eds) (2010) Integrating and applying science: A handbook for effective coastal ecosystem assessment. IAN Press, Cambridge, Maryland.

1. Water Quantity

- Lake Okeechobee, Caloosahatchee and St Lucie estuaries- **TOO MUCH** in wet season
- Everglades National Park – **TOO LITTLE** in dry season → seawater intrusion

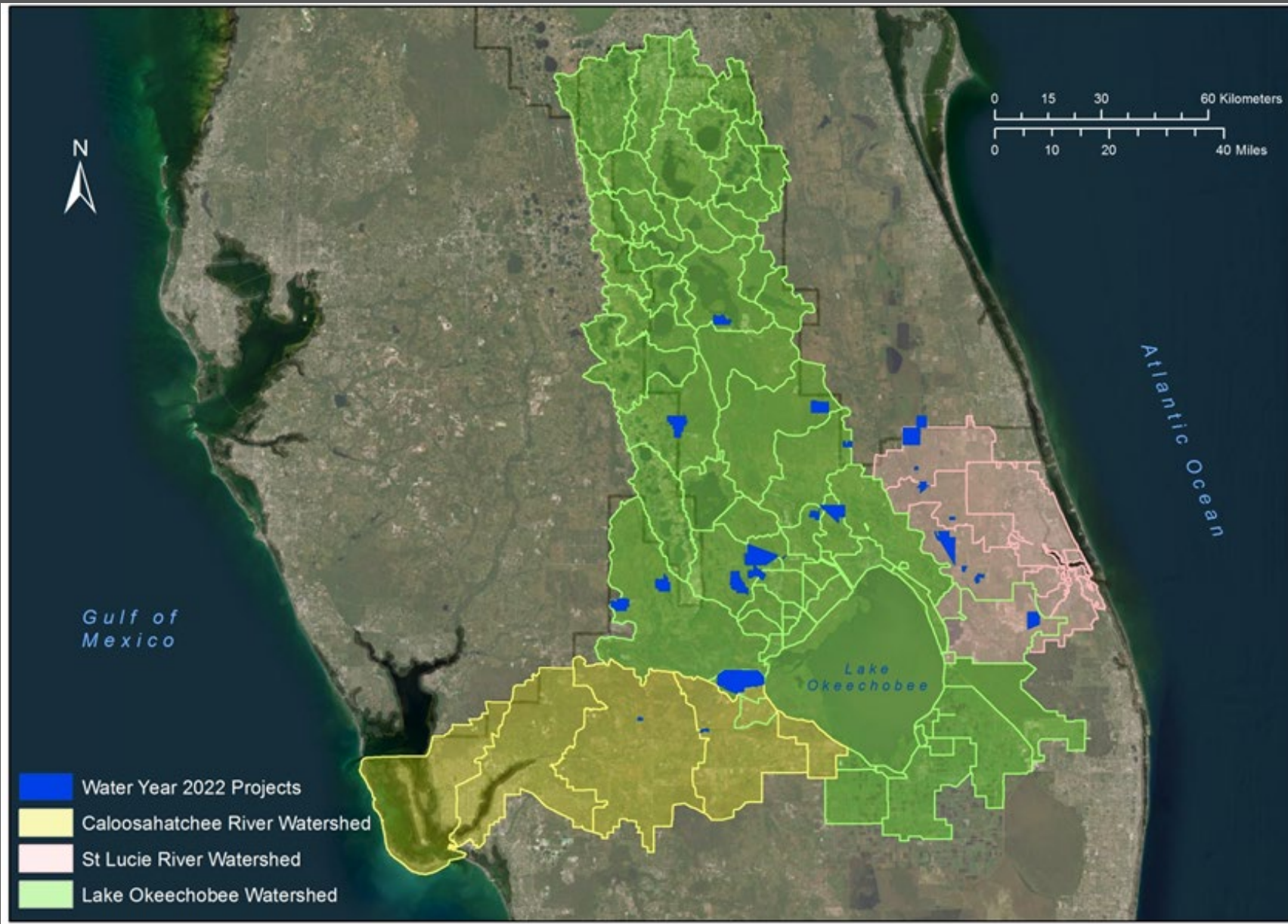
2. Water Quality

Fertilizer + Urban Runoff → Algal Blooms

Solution: Hold back water on land upstream of Lake Okeechobee.

Dispersed Water Management Program

Northern Everglades Payment for Environmental Services (**NE_PES**) Project



Dispersed Water Management/ Northern Everglades Payment for Ecosystem Services (NE-PES)

Holding back water:

67 sites on 13 ranches and 5
SFWMD properties

Archbold Biological Station

is the independent third-party
organization in charge of
monitoring water storage and
water quality sampling
for nutrient retention estimates

Challenges in measuring water retention

- Flat landscapes in Florida – a hydrologist's nightmare !
- Water management (gates, pumps) changes flow direction in canals, affects groundwater
- Spatially variable rainfall, sandy soils – seepage, variable ET with plant communities



So initially, retention was estimated by modelling.

Now we have 10 yrs data, so are using two independent methods to calculate retention



Objectives of this talk:

For the NE-PES program,

1. Describe METHODS to estimate WATER retention on ranches
2. Describe METHODS to estimate NUTRIENT retention/removal
3. Show RESULTS for
 - one water retention project
 - one nutrient retention project, and
 - one nutrient removal project

How is water held back on ranches ?

Answer: Weirs (wooden boards) placed in culvert risers.

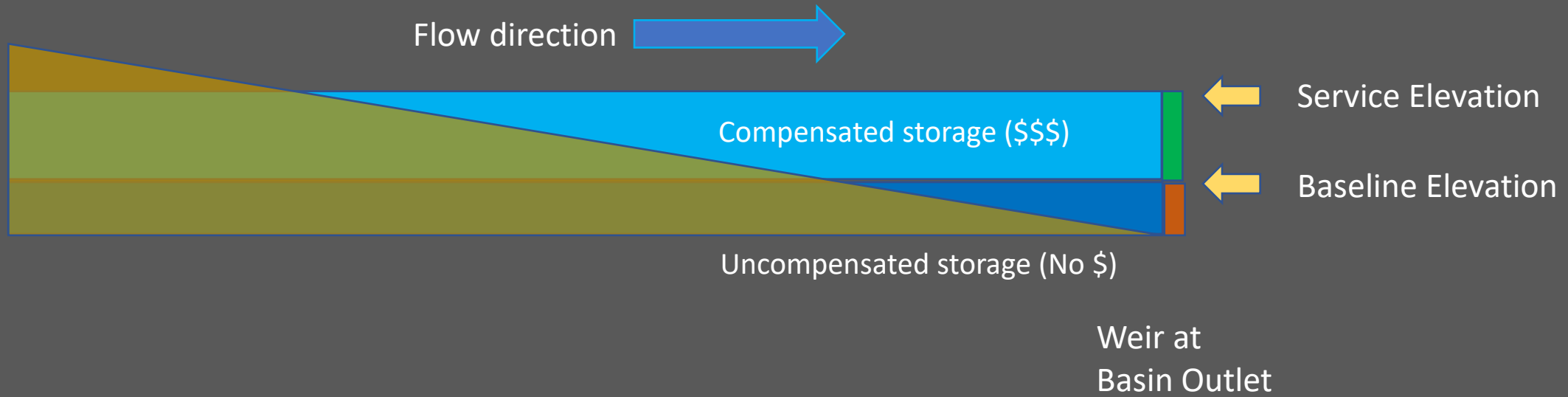




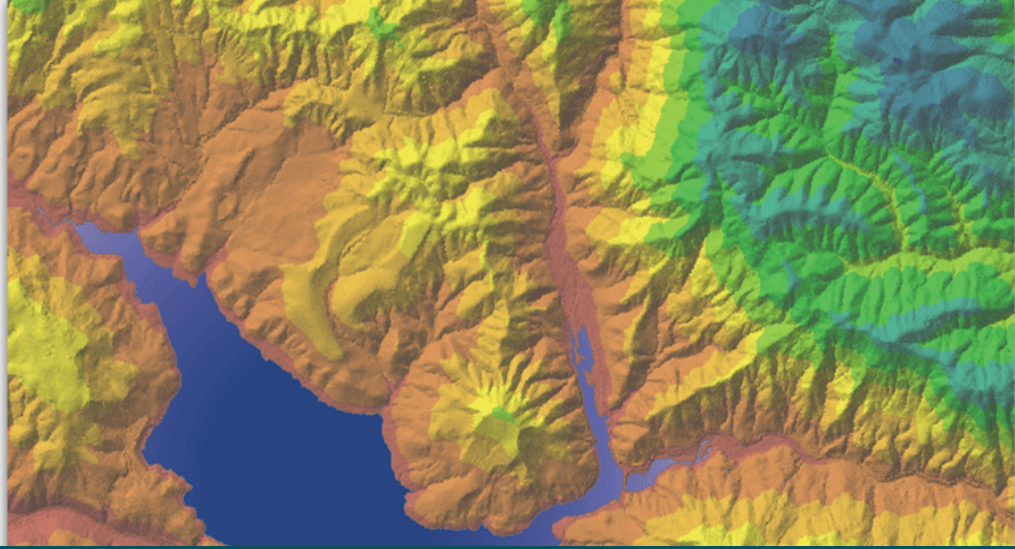
Weir Service Elevation

Weir Baseline Elevation

NE-PES Water Retention Terminology - Elevations



ESTIMATION of **WATER HELD BACK**:
2 Independent Methods



**Geographic
Information
System**



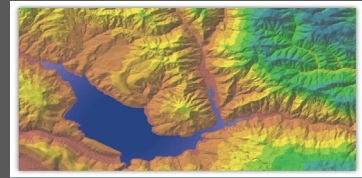
Modelling - Surface + Groundwater
storage CAPACITY



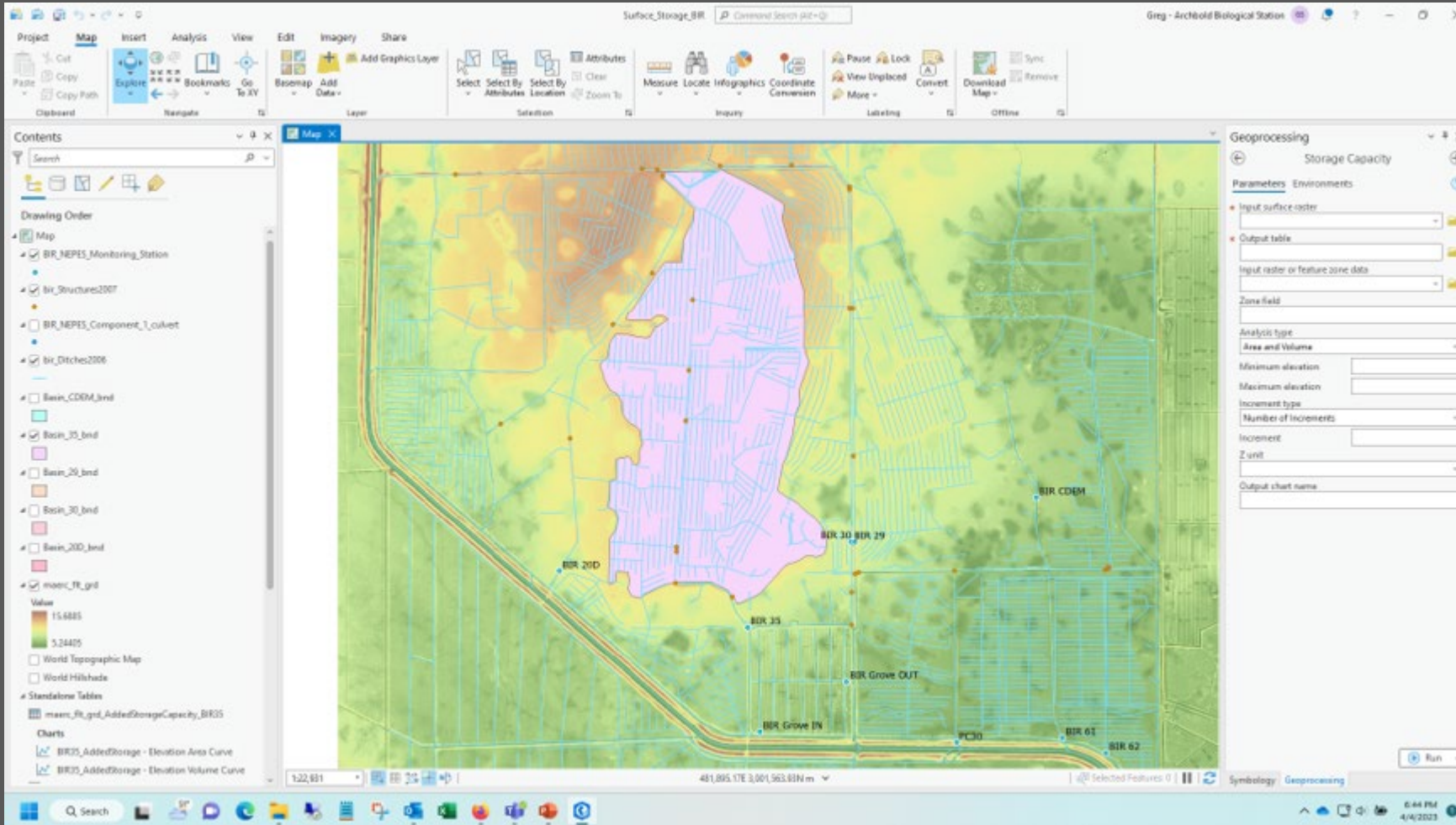
**Rainfall Summation
over Basin**

Based on Actual Rainfall data

Method 1: Part 1 -- Surfacewater storage capacity



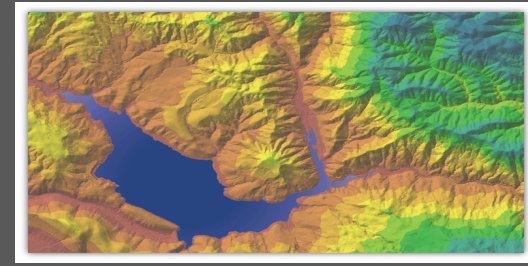
ArcGIS Pro -> Spatial Analyst -> Hydrology -> Storage Capacity



Inputs:

- Digital Elevation Model
- Basin Delineation Shapefile
- Minimum elevation – baseline
- Max elevation - service

Method 1: Part 2 - Groundwater storage capacity

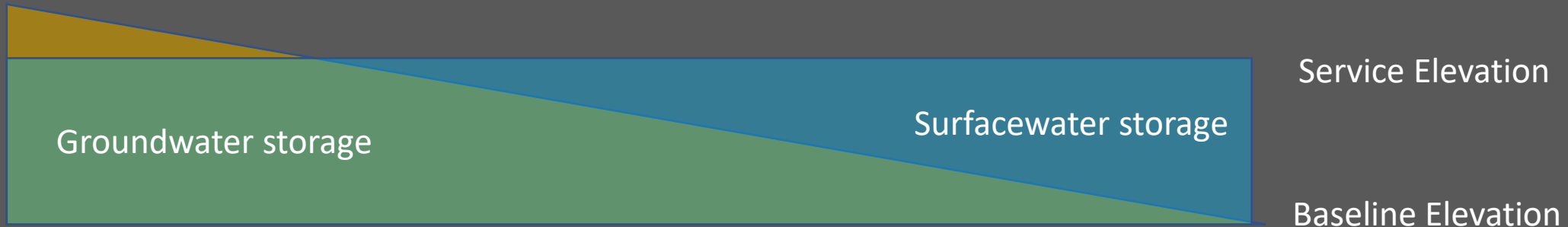


Groundwater storage capacity = Subsurface Volume of Basin * Soil Porosity

Where

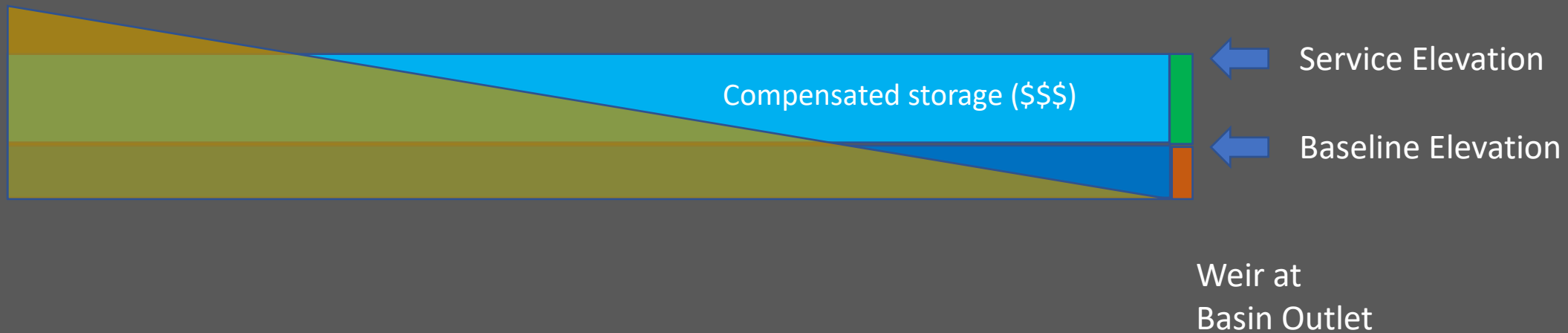
0.40 – 0.46

- Subsurface Volume of Basin = Total basin volume – Surface volume (calculated by GIS)
- Total Basin volume = Basin Area * (Service - Baseline elevations)

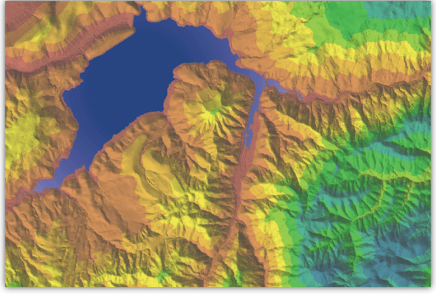



Method 2: Rainfall summation over Basin

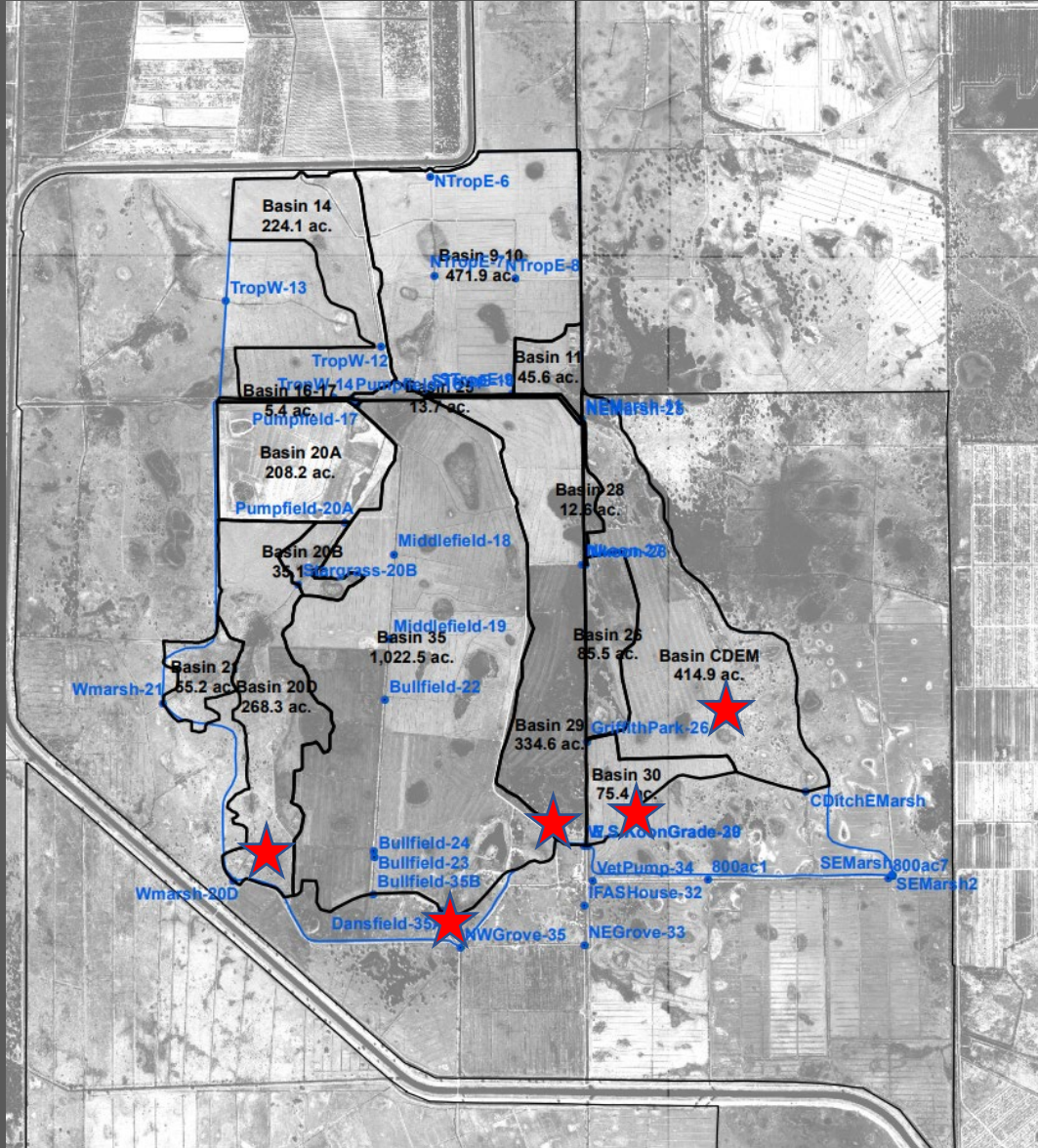
1. Sum of rainfall
for all days
When water level BETWEEN baseline and service elevations
2. $(\text{Rainfall sum} * \text{Basin Area}/12)$ acre-ft



Caveats and assumptions of each water retention calculation method

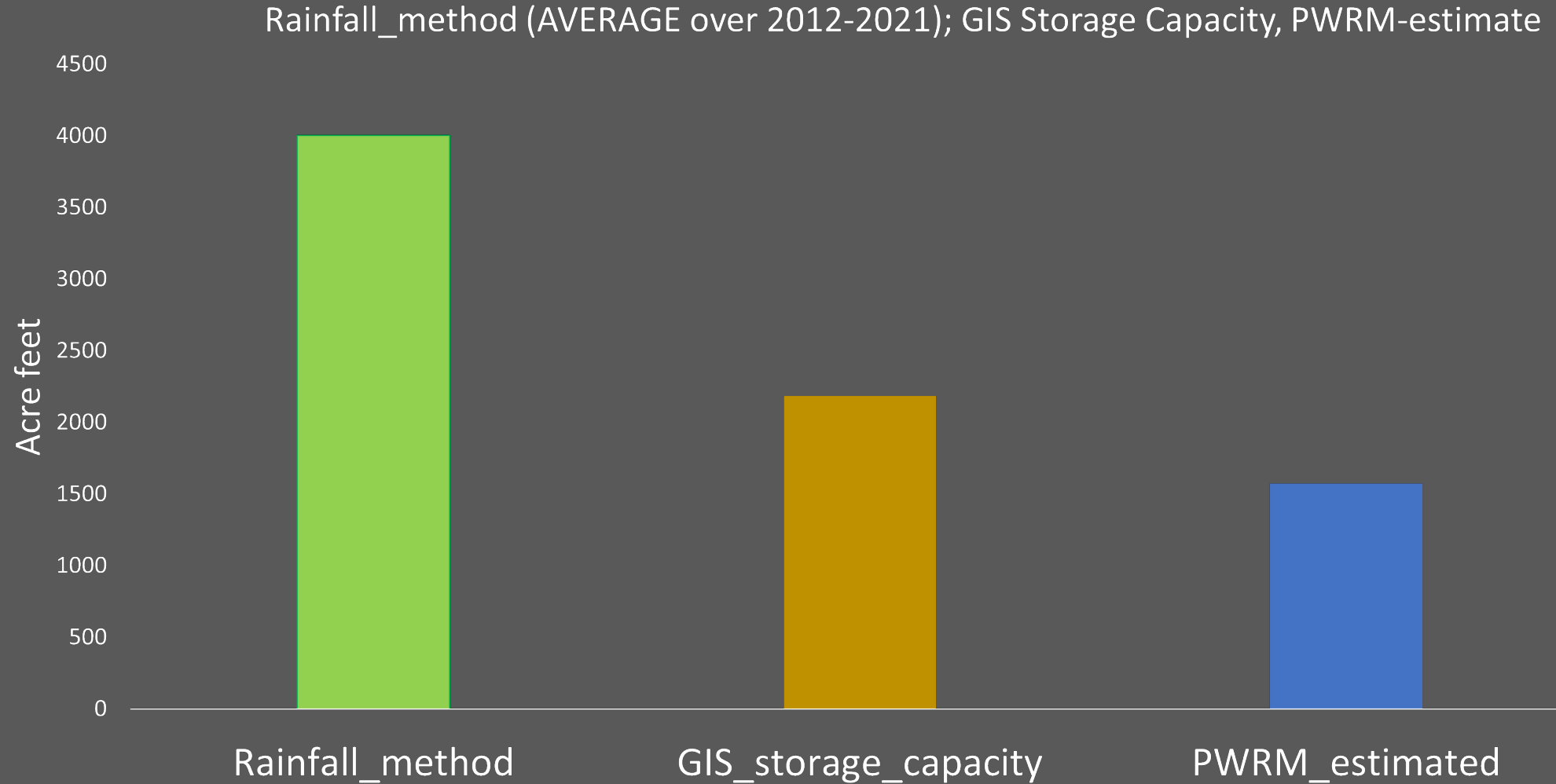
Method	Advantages	Limitations
 <p>Geographic Information System</p>	<ul style="list-style-type: none">• Accurate storage capacity volumes determined.	<ul style="list-style-type: none">• Storage capacity, not total amount stored over a year• Requires accurate Digital Elevation Model, GIS license and knowledge• Modelling, not actual data
 <p>Rainfall Summation over Basin</p>	<ul style="list-style-type: none">• Actual data used• Observe interannual variability in water retention• Easy to calculate, needs just rainfall data	<ul style="list-style-type: none">• Evapotranspiration losses and lateral Groundwater inflow gains not considered

Results: Holding back water at Buck Island Ranch

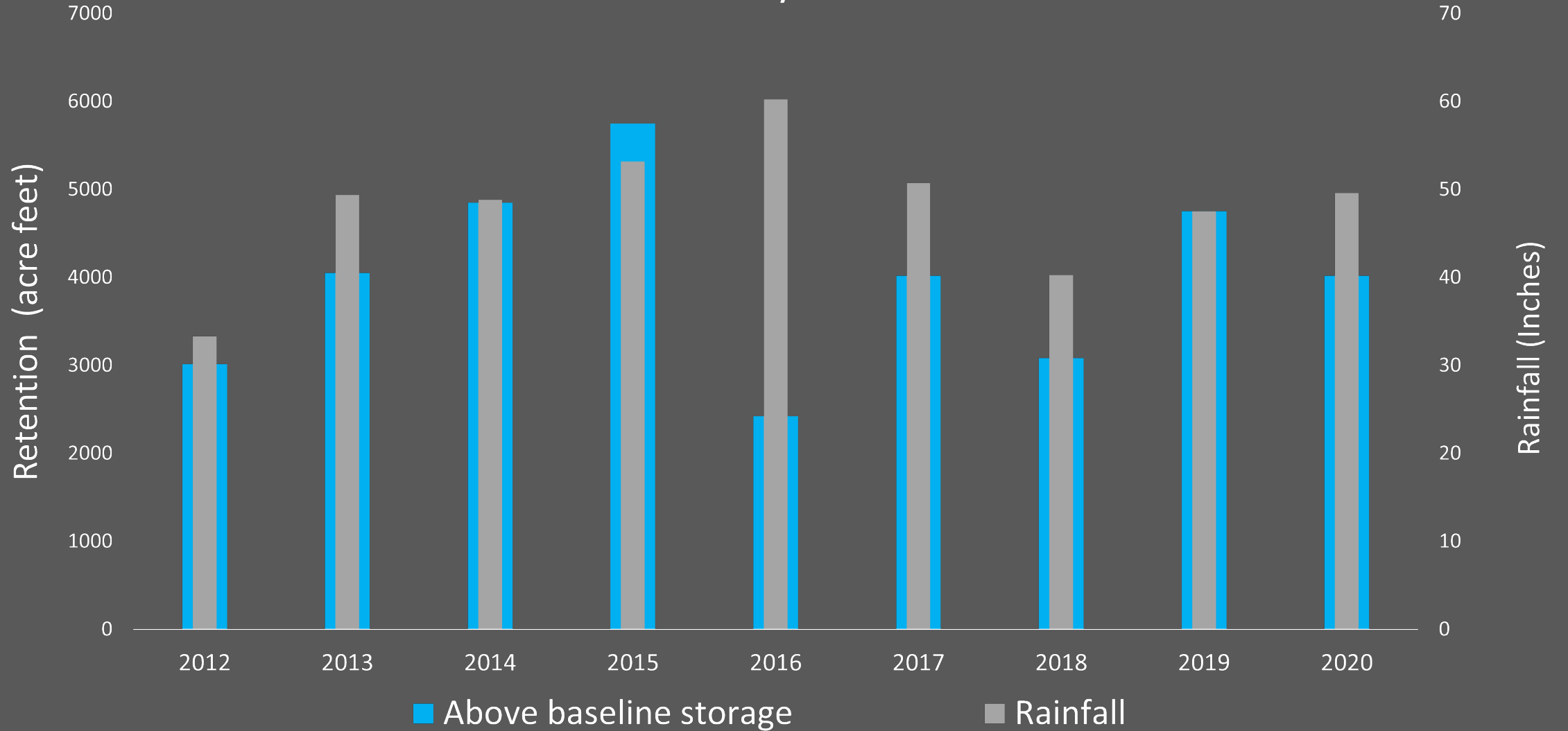



★ indicates basin outlets with water level monitoring stations

Results: Water retention by two methods and the initial PWRM estimate



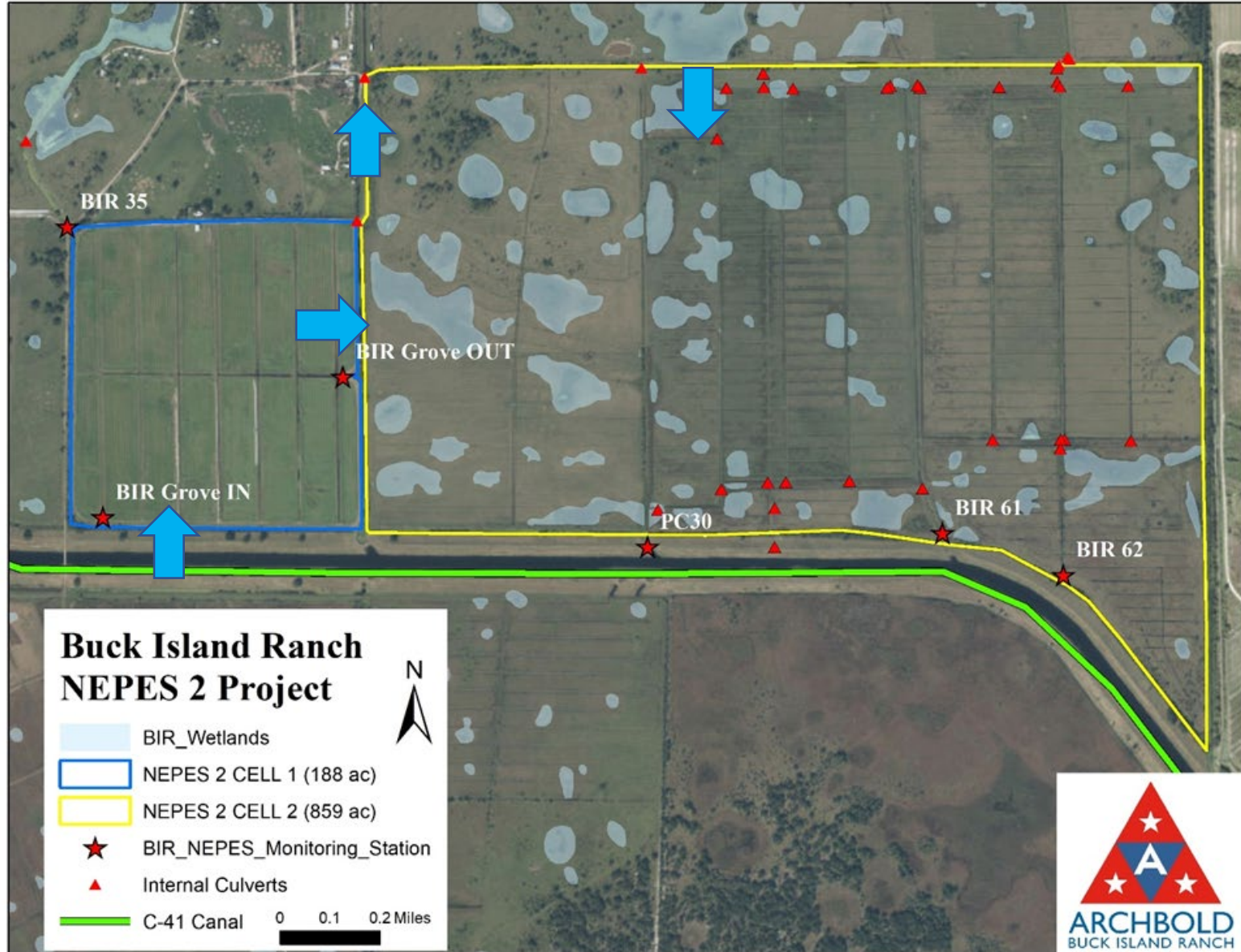
Annual water retention at BIR by RAINFALL summation method



A photograph of a lush green field of plants, likely a wetland or marsh, with a body of water visible in the background. The plants are tall and have long, narrow leaves. The water is calm and reflects the sky. The overall scene is bright and natural.

Nutrient Removal Project – Buck Island Ranch
Nutrient Retention Project – Lykes West Water Hole

Nutrient Removal Project - Buck Island Ranch

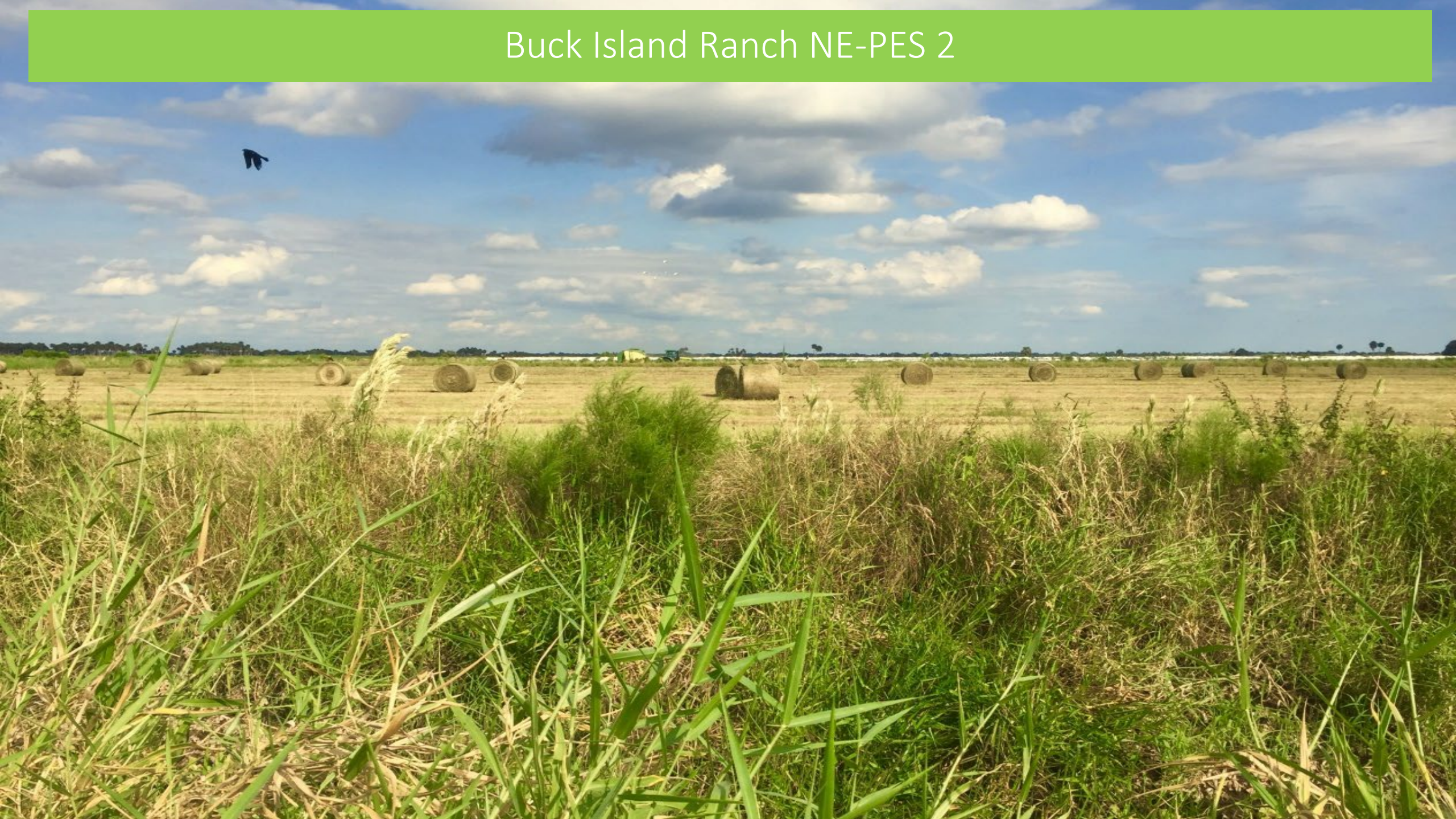


Using P-rich canal water to grow grass: nutrient uptake from water

Tracking

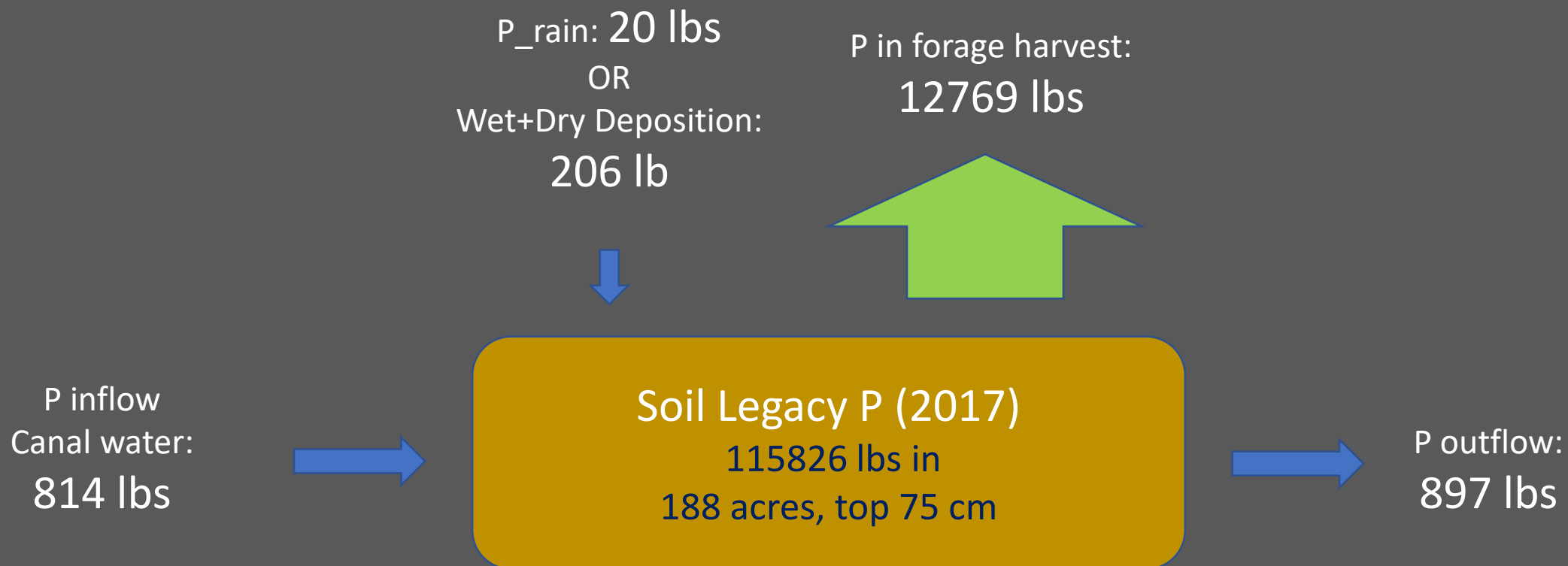
1. Water + nutrients pumped in
2. Water + nutrients pumped out
3. Nutrients harvested in forage

Buck Island Ranch NE-PES 2



Phosphorus Budget (2018-2022)

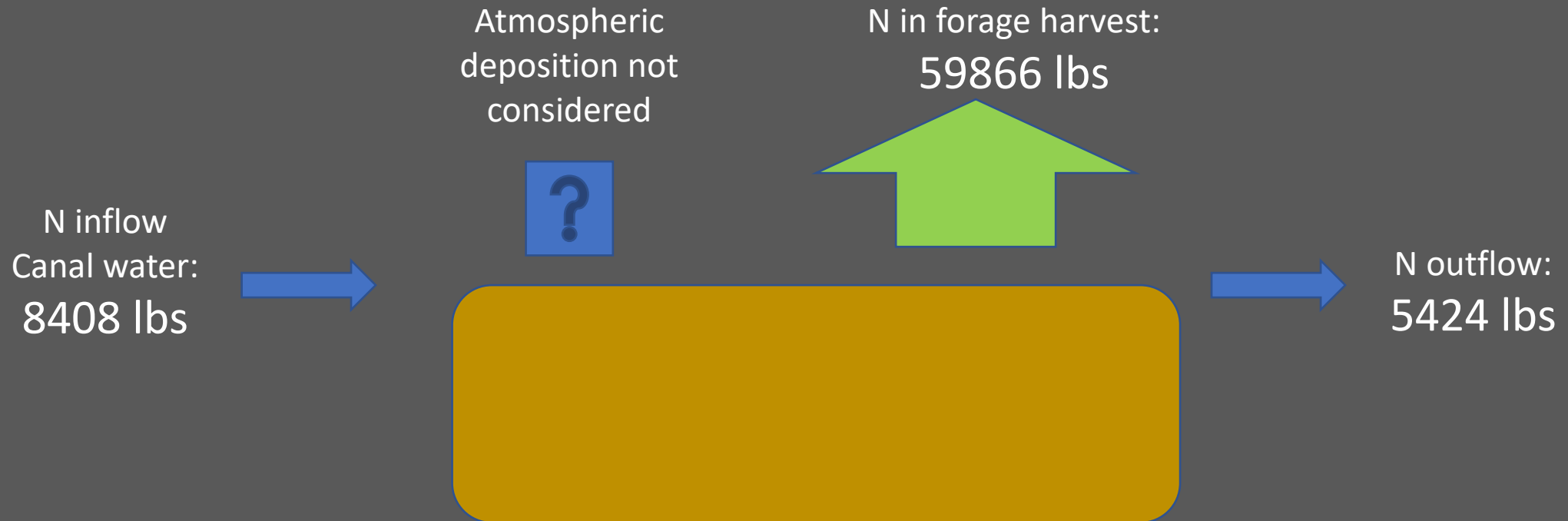
Buck Island Ranch Nutrient Removal Project



P removal by forage harvest: 18 lbs P / acre per year

Nitrogen Budget (2018-2022)

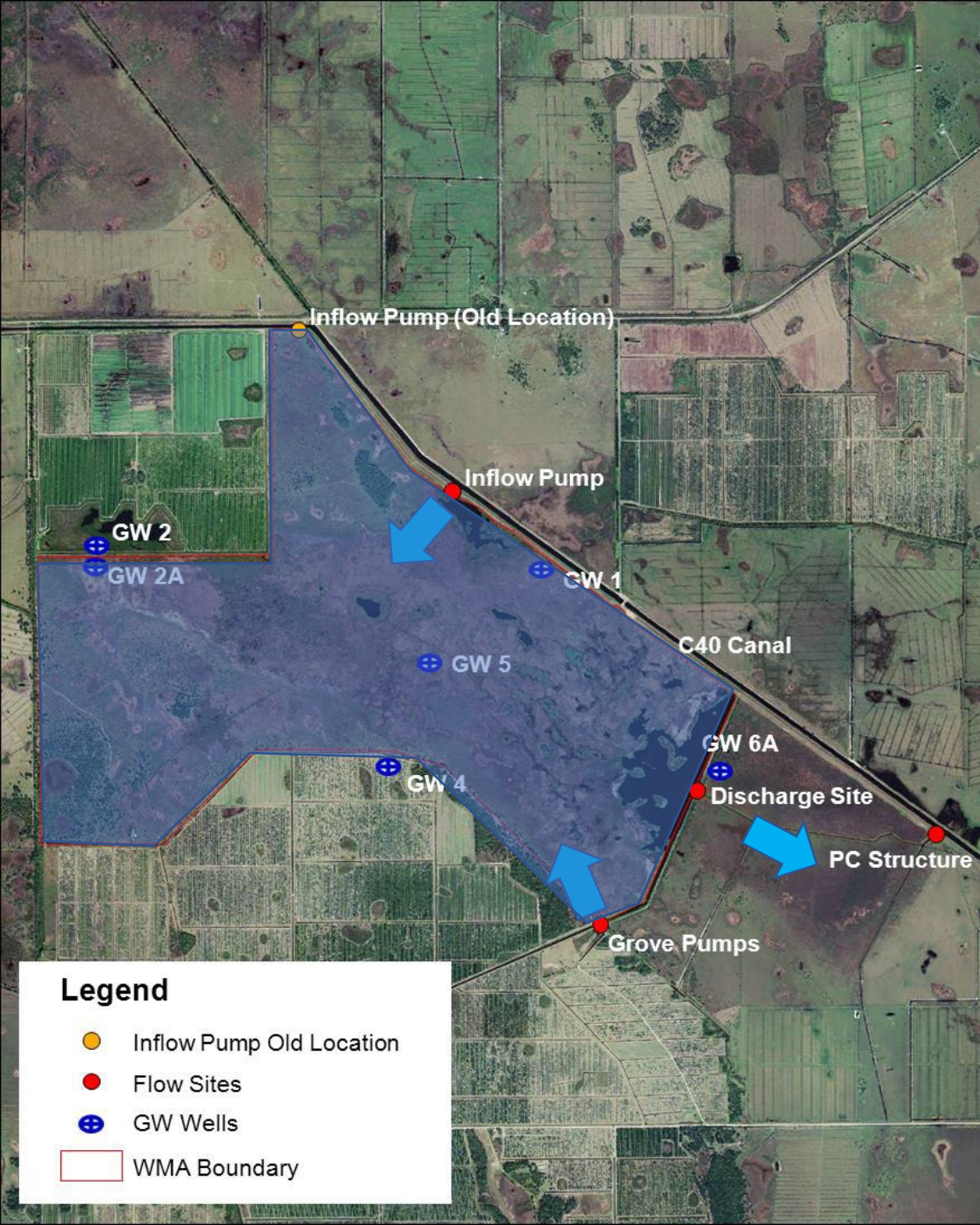
Buck Island Ranch Nutrient Removal Project



N removal by forage harvest: 84 lbs N / acre per year

Lykes West Waterhole Nutrient Retention Project

- 2008 - on going
- 2370 acres reservoir
- Nutrient uptake by plants and settling to soil



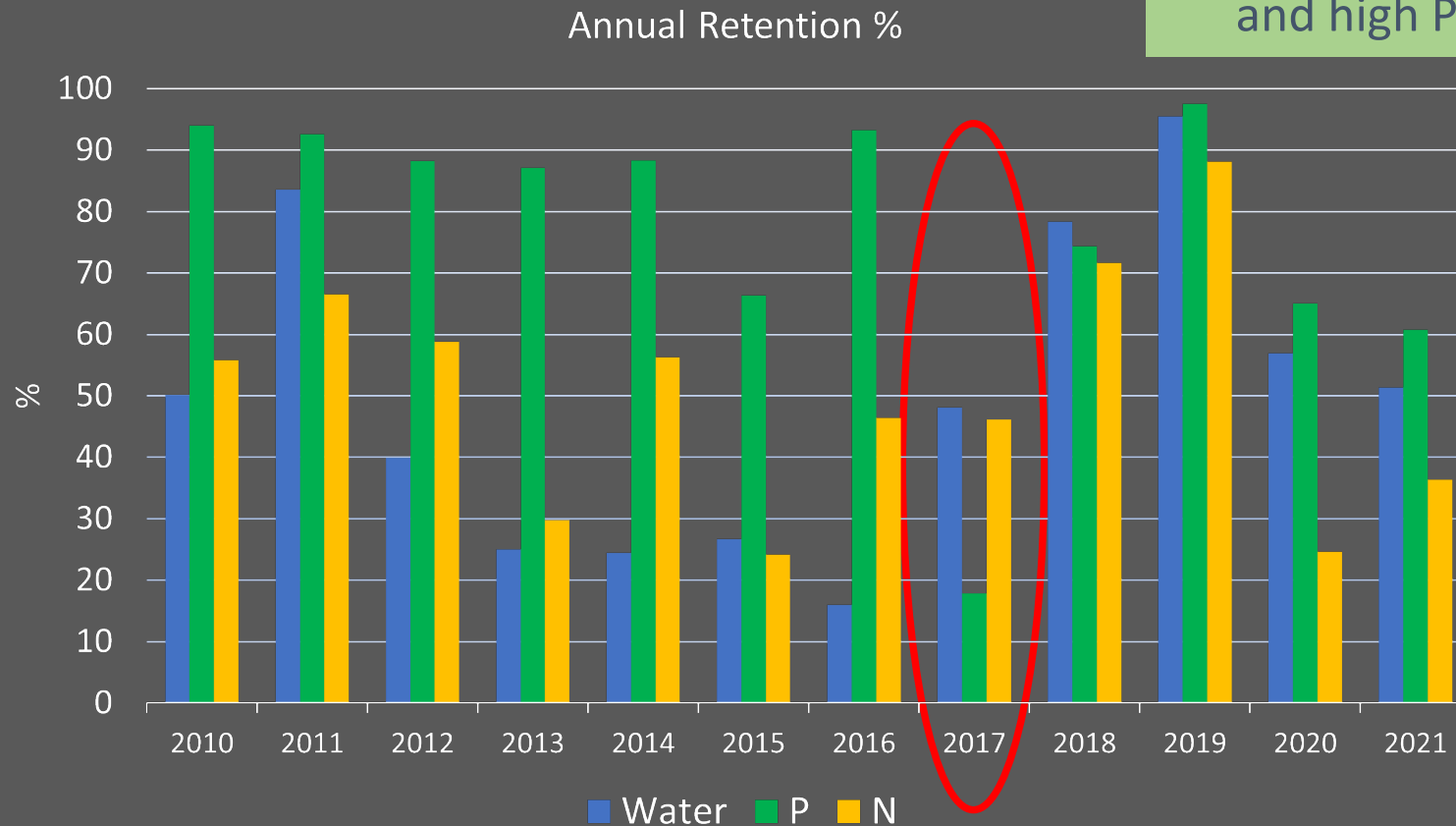
Results: Nutrient Retention (2010-2021) at Lykes West Waterhole

75% of P in water pumped into the reservoir is retained in plants + soil

47% of N in water pumped into the reservoir is retained in plants + soil

Considerable Interannual variation depending on rainfall and pumping

- Drought 2016-2017 dry season
- Reservoir dried
- 2017 rain, reservoir re-flooded and high P in discharge



Conclusions:

The projects demonstrated success in retaining both water and nutrients

Each method of measuring/estimate water retention has its own caveats and assumptions. Still, both methods yielded estimates higher than the original model

Nutrient removal projects have more straightforward calculations of the amount of nutrients removed/sequestered.

Acknowledgements:

South Florida Water Management District

Ranchers from Alderman, Buck Island, Dixie, Eagle Haven, Lykes, La Hamaca, Mudge, Triple A, Willaway, Bull Hammock, Rafter-T, XL, Adams

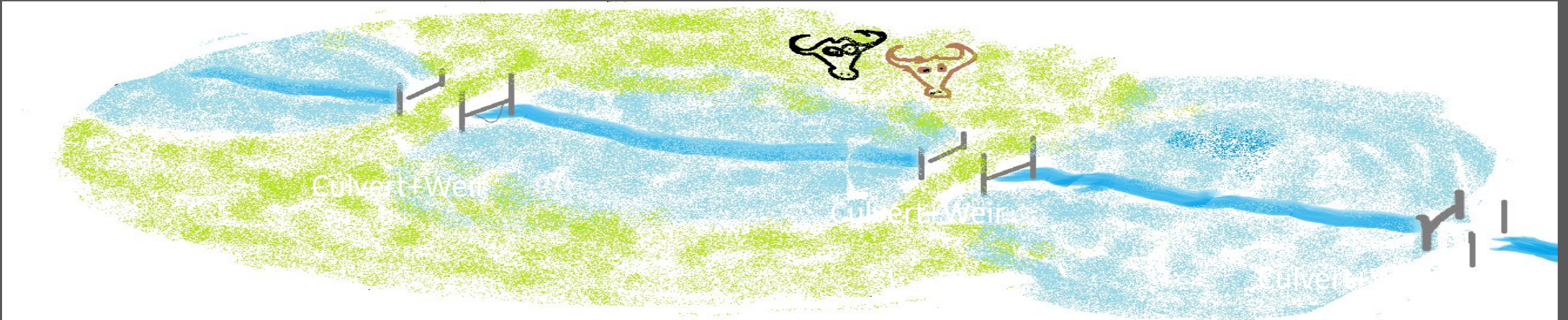
Staff from Archbold Biological Station


A photograph of a flooded field with a fence and palm trees in the background under a cloudy sky. The water is dark and reflects the sky and the surrounding vegetation. A wooden fence runs across the middle ground, and a corrugated metal structure is visible in the foreground on the right. The background features a line of palm trees and other vegetation under a heavy, overcast sky.

Questions/Discussion

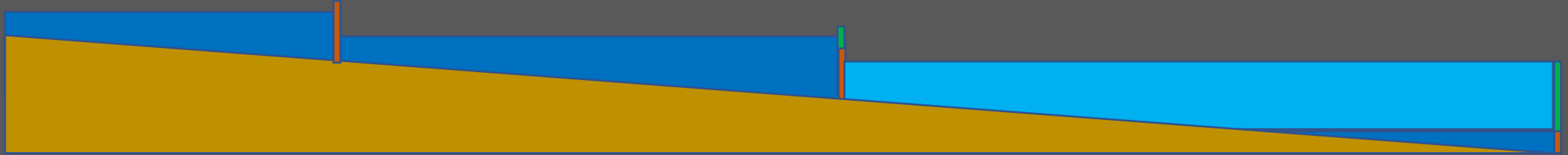
asaha@archbold-station.org

Holding Back Water



Flow direction 

Basin Outlet





Storage from Baseline to Service elevation

Compensated storage (\$\$\$)

Storage upto Baseline elevation

Uncompensated storage (No \$)

 Culvert Weir elevations (board elevations)
 Baseline Storage Elevation

Dispersed Water Management/ Northern Everglades Payment for Ecosystem Services (NE-PES)

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