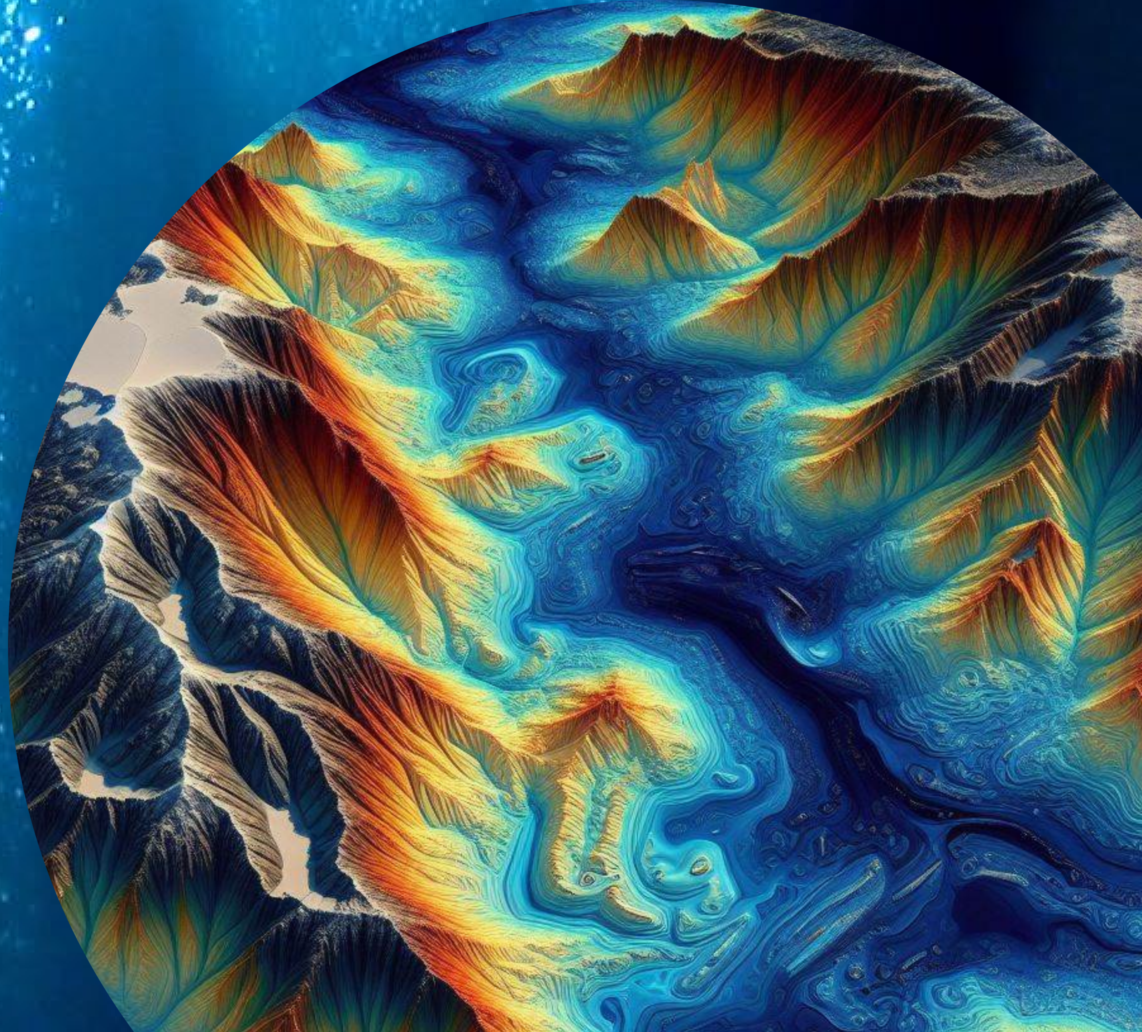
BENEATH THE SURFACE

UNVEILING HIDDEN DEPTHS OF FLOOD RESILIENCE

with USGS 3DNTM

Tyson James, PE, CFM
Hope Morgan NCPLS, CFM, GISP

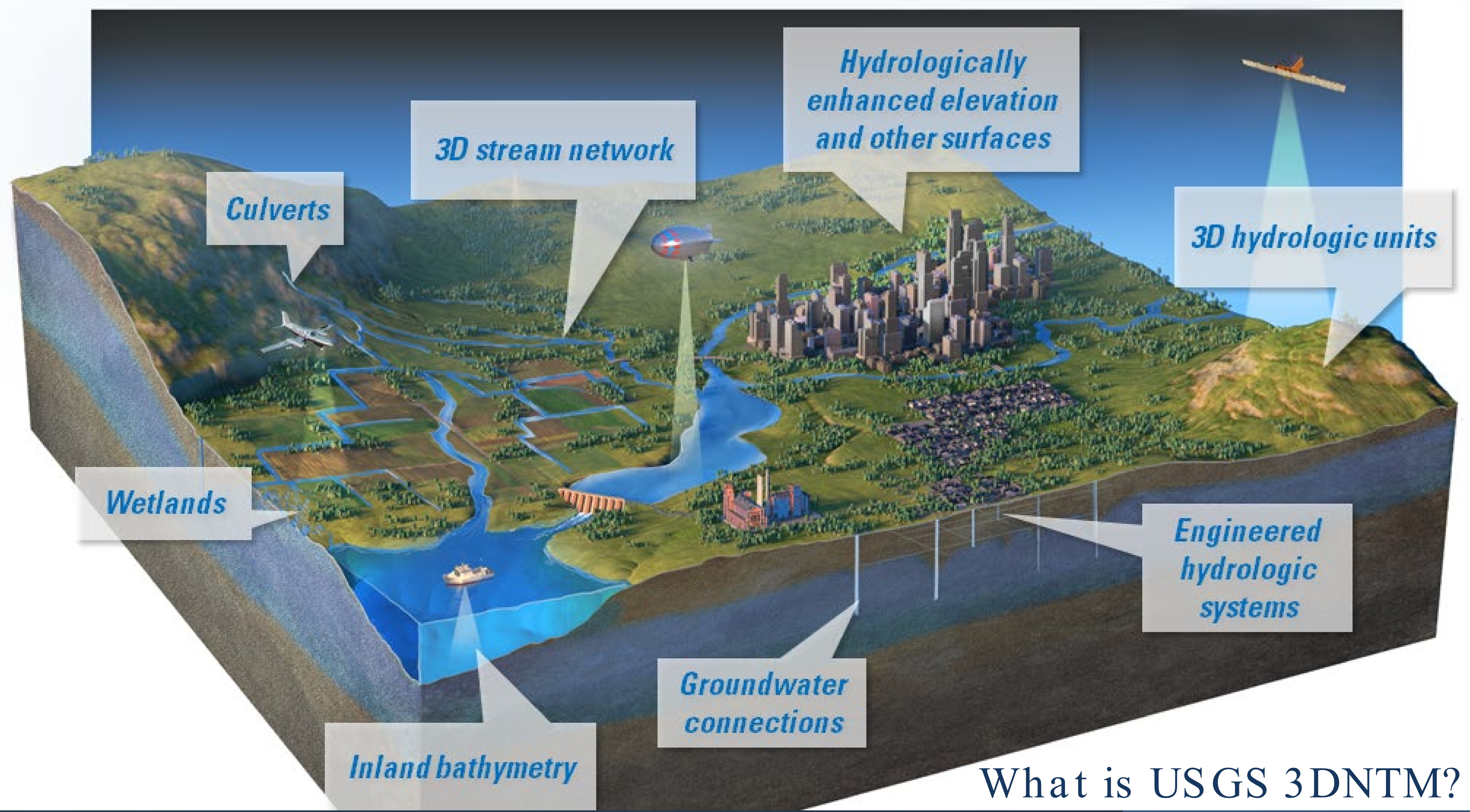


What is

USGS 3D National Topography Model (3DNTM)?

- National vision to provide a continuous elevation surface from the depths of our waters to the peaks of our mountains
  - Joint study in 2022 3D Nation Elevation Requirements and Benefits Study (3D Nation Study)
    - USGS - terrestrial perspective,
    - NOAA - coastal perspective
  - Estimated the benefits of improved topographic and inland bathymetry data at upwards of $10.8 billion/year

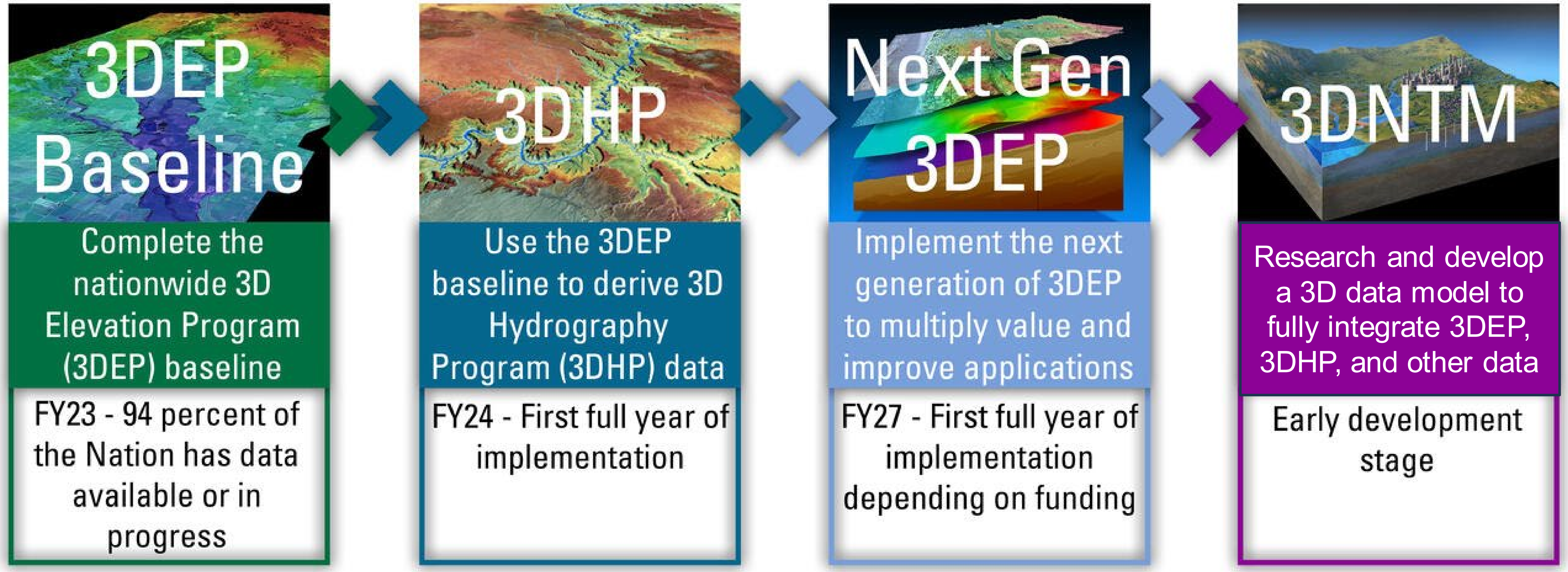
https://www.usgs.gov/3d-elevation-program/3d-nation-elevation-requirements-and-benefits-study



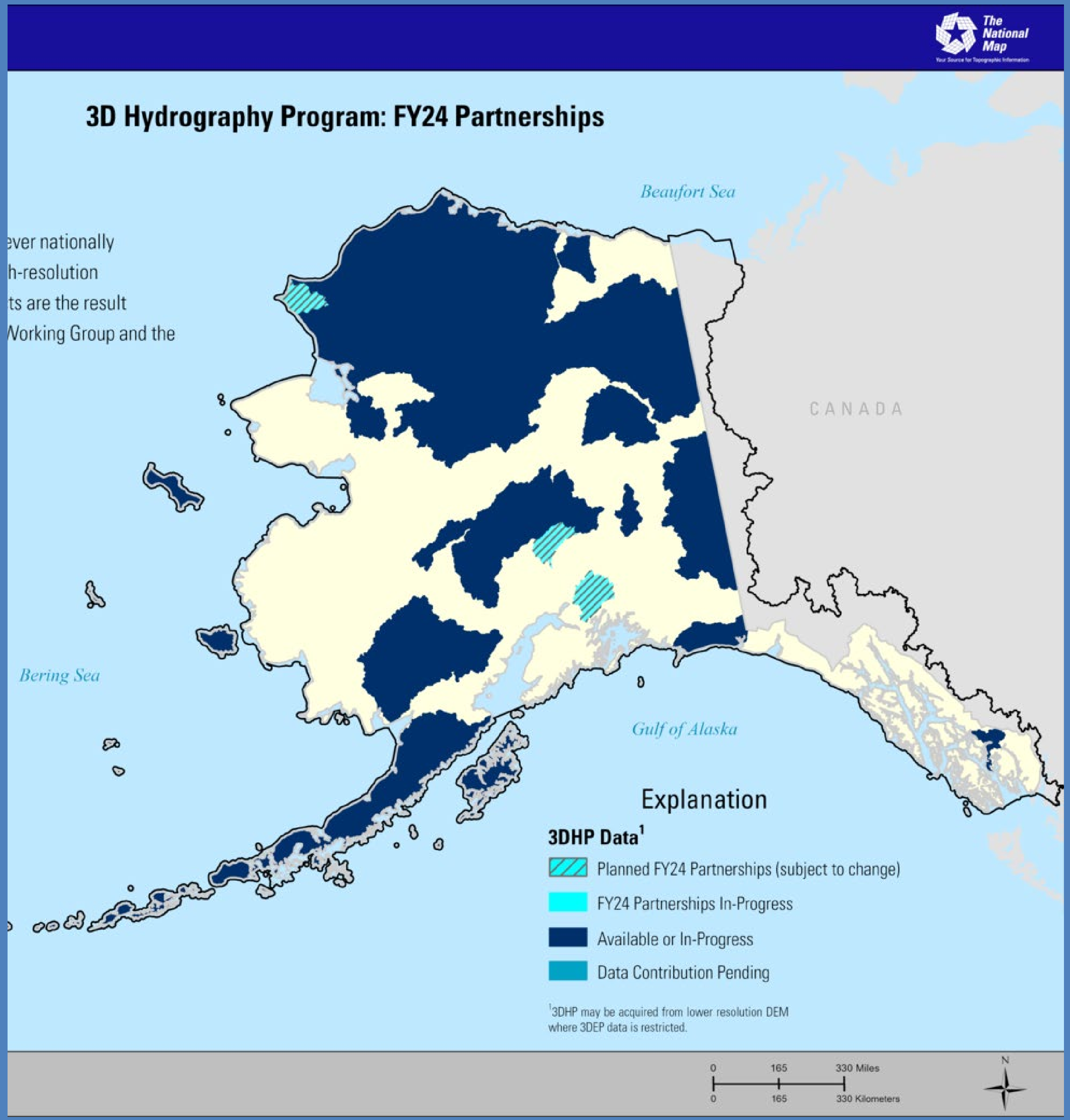
What is USGS 3DNTM?

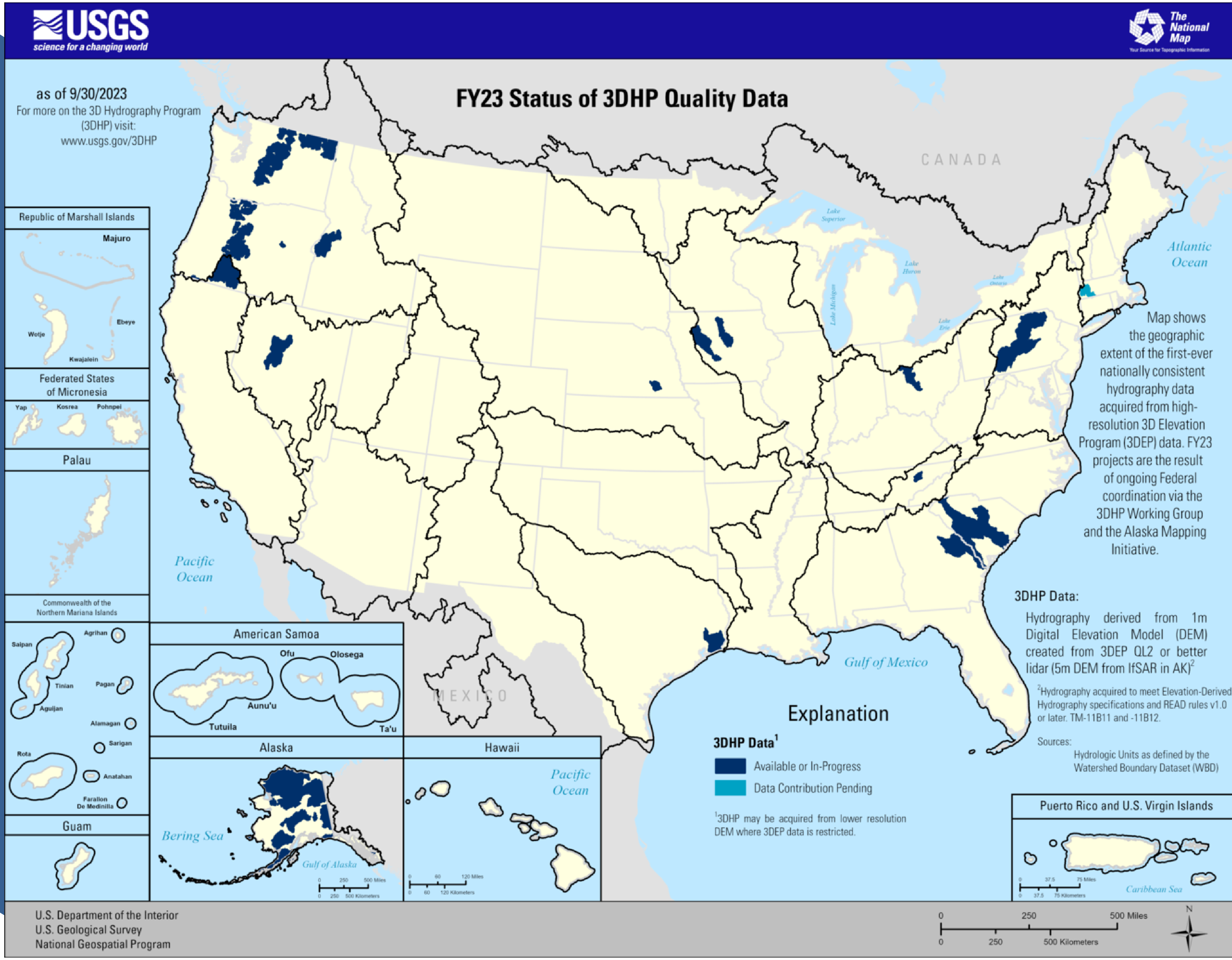
https://www.usgs.gov/media/images/3dhp-figure-3-3d-national-topography-model-visualization

What USGS 3DNTM Includes



SourceCredit: [3D National Topography Model | U.S. Geological Survey (usgs.gov)]


The National Map
3D Hydrography Program: FY24 Partnerships
ever nationally
h-resolution
ts are the result
Working Group and the
Beaufort Sea
CANADA
Bering Sea
Gulf of Alaska
Explanation
3DHP Data[1]
Planned FY24 Partnerships (subject to change)
FY24 Partnerships In-Progress
Available or In-Progress
Data Contribution Pending
[1]3DHP may be acquired from lower resolution DEM where 3DEP data is restricted.
0 165 330 Miles
0 165 330 Kilometers
N


USGS
science for a changing world
The National Map
as of 9/30/2023
For more on the 3D Hydrography Program (3DHP) visit:
www.usgs.gov/3DHP
FY23 Status of 3DHP Quality Data
CANADA
Atlantic Ocean
Pacific Ocean
Gulf of Mexico
MEXICO
Map shows the geographic extent of the first-ever nationally consistent hydrography data acquired from high-resolution 3D Elevation Program (3DEP) data. FY23 projects are the result of ongoing Federal coordination via the 3DHP Working Group and the Alaska Mapping Initiative.
3DHP Data:
Hydrography derived from 1m Digital Elevation Model (DEM) created from 3DEP QL2 or better lidar (5m DEM from IfSAR in AK)[2]
[2]Hydrography acquired to meet Elevation-Derived Hydrography specifications and READ rules v1.0 or later. TM-11B11 and -11B12.
Sources:
Hydrologic Units as defined by the Watershed Boundary Dataset (WBD)
Explanation
3DHP Data[1]
Available or In-Progress
Data Contribution Pending
[1]3DHP may be acquired from lower resolution DEM where 3DEP data is restricted.
Republic of Marshall Islands
Majuro
Wotje
Ebeye
Kwajalein
Federated States of Micronesia
Yap
Kosrea
Pohnpei
Palau
Commonwealth of the Northern Mariana Islands
Saipan
Agrihan
Tinian
Pagan
Aguijan
Alamagan
Sarigan
Rota
Anatahan
Farallon De Medinilla
Guam
American Samoa
Ofu
Olosega
Aunu'u
Tutuila
Ta'u
Alaska
Bering Sea
Gulf of Alaska
Hawaii
Pacific Ocean
Puerto Rico and U.S. Virgin Islands
Caribbean Sea
U.S. Department of the Interior
U.S. Geological Survey
National Geospatial Program
0 250 500 Miles
0 250 500 Kilometers
N

Bathymetry Classifications

Topo-Bathymetry (topobathy)

Accurate high-resolution digital elevation models (DEMs) that show both land topography and submerged topography (bathymetry)

Inland Topography

refers to data collected on land, may include exposed land surface, features and objects such as building structures, vegetation, as well as bare earth

Typically includes the beach area, as far as Mean Lower Low Water (MLLW), if tidal conditions permit, to map all land areas that are not submerged.

Inland Bathymetry

refers to data collected on the bottoms of lakes, reservoirs, and rivers and may include submerged features such as structures, objects, or vegetation.

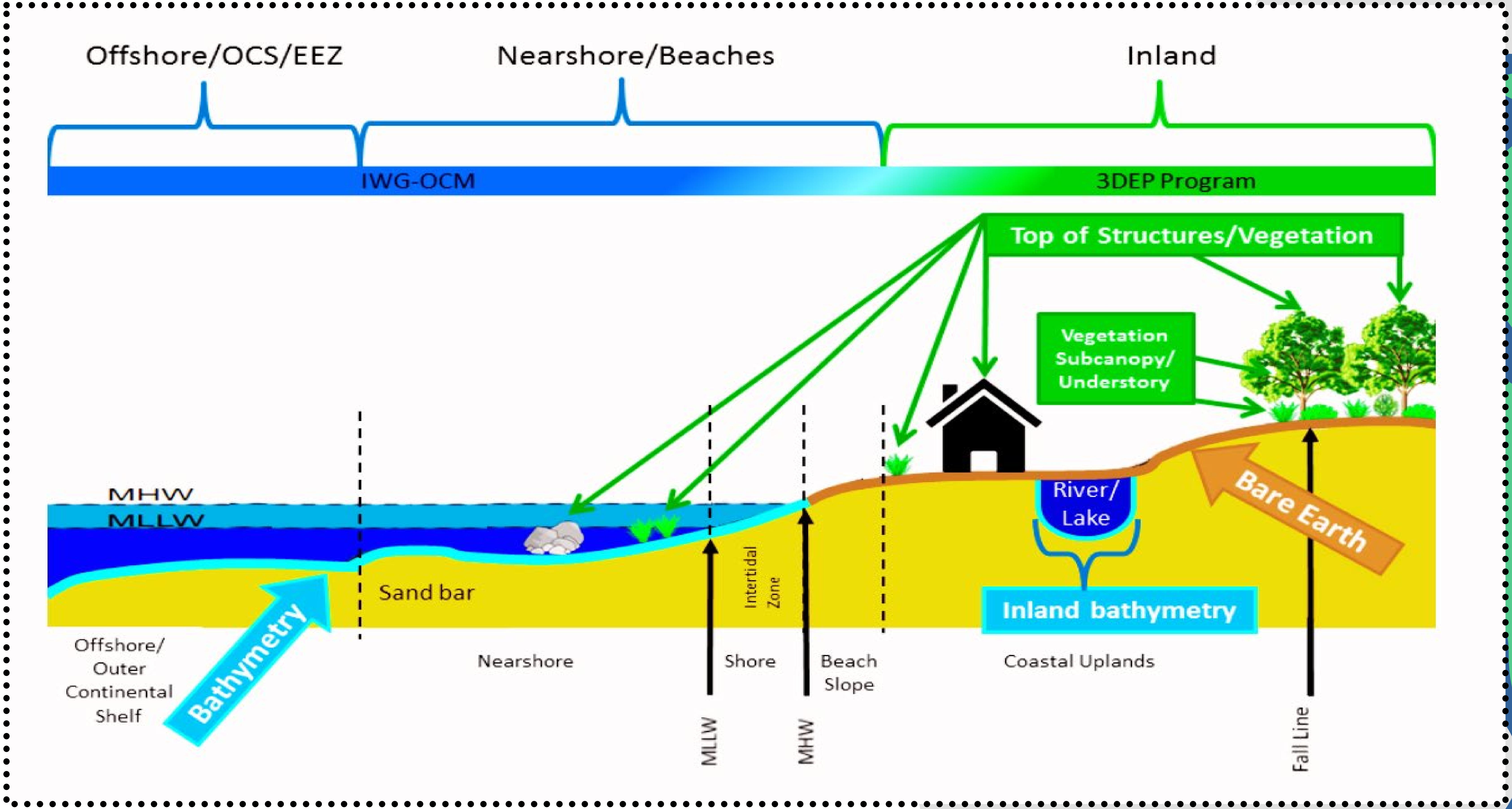
Nearshore Bathymetry

For the 3D nation study, nearshore bathymetry pertains to coastal areas to a water depth of about 10 meters (20 meters in the Florida Keys and elsewhere where waters are exceptionally clear).

Offshore Bathymetry

For the 3D nation study, offshore bathymetry pertains to areas deeper than 10 meters under water including the Great Lakes

Bathymetry Classifications



Bathymetric Role

Bathymetric data, which includes information about the depths and shapes of underwater terrain,

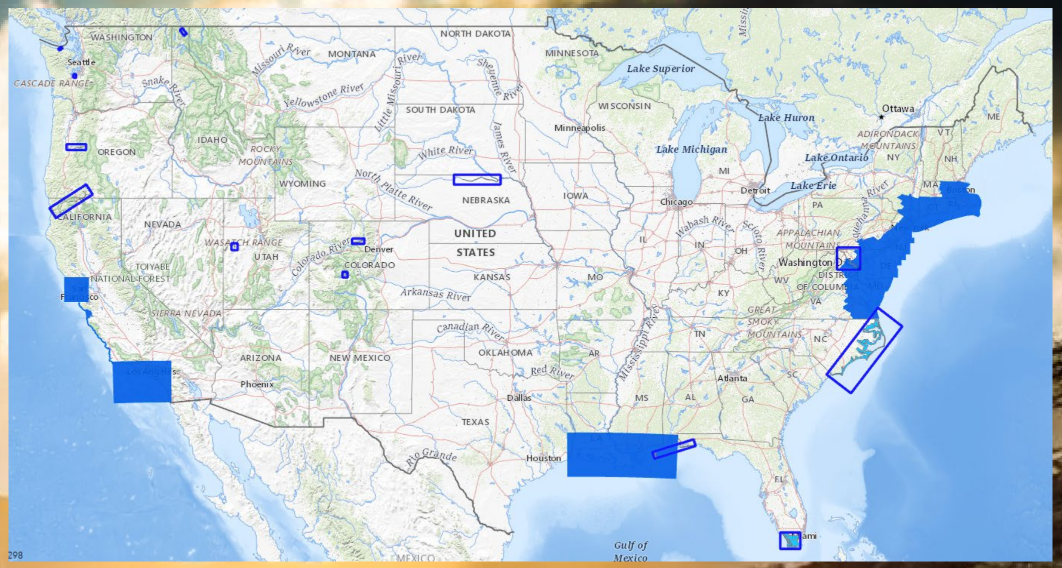
Coastal

- Nautical charts
- Erosion
- Subsidence
- Calculate currents\tides
- Water temperature
- Salinity
- Study of marine habitats

Riverine

- flood inundation
- contour of streams and reservoirs
- Scour and stabilization
- Hydrodynamic modeling
- Simulating flow dynamics
- Forecasting flood hazards
- Sediment transport
- Instream habitat modeling

Where do I get bathymetric data?



Hydrographic surveys

- NOAA
- USACE-

Topo-bathy lidar

- NOAA Digital Coast
- Joint Airborne Lidar Bathymetry Technical Center of Expertise

Vertical Datums/Conversion Factors

Ellipsoidal Datums:
NAD83(HARN), WGS84

Orthometric Datums:
NAVD88, NGVD29, EGM2008, EGM1996, EGM1984

Tidal Datums:
Mean Low Water (MLW), Mean Lower Low Water (MLLW)

NOAA-
https://www.ncei.noaa.gov/maps/bathymetry/

JALBTCX-
https://jalbtcx.usace.army.mil/

GMRT- Global Multi-Resolution Topography (GMRT)
https://www.gmrt.org/contributors/index.php

USGS Topobathy
https://apps.nationalmap.gov/viewer

Collection Methods

Lidar

- Ephemeral
- Shallow
- Clear

Sonar

- Single or Multibeam EchoSounder
- Navigation Charts

Emerging Tech

- Hyperspectral Imaging
- Machine Learning
- Underwater ROV
- Citizen Science

Inland Bathymetry Concerns

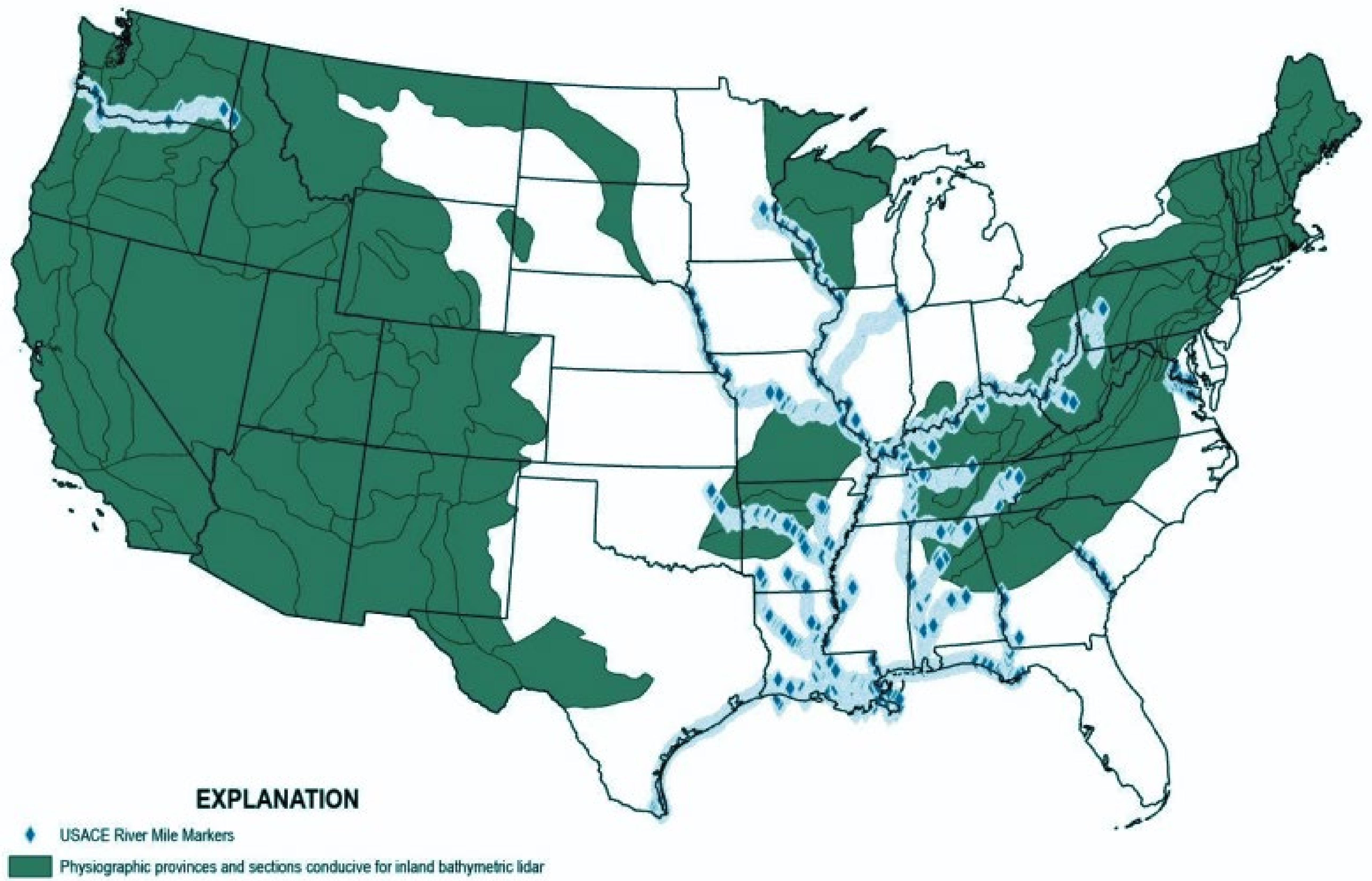
<u>User concerns with Bathymetry</u>

- Lack of Existing Inland Bathymetric Data
- Stakeholders cannot envision
- Lack of understanding of feasibility
- Lack of Testing

<u>Collection concerns with Bathymetry</u>

- Difficult to collect:
  - Water clarity
  - Turbidity
  - Depth
  - Bottom reflectivity
  - Steep banks
  - Vegetation

Method Cost of Bathymetry



- Areas Conducive to collection $5.7k per sq mile vs
- Areas <u>Not</u> Conducive to collection $12 - 90k per sq mile

3D Nation Study Final Report

IS INLAND BATHYMETRY WORTH IT?

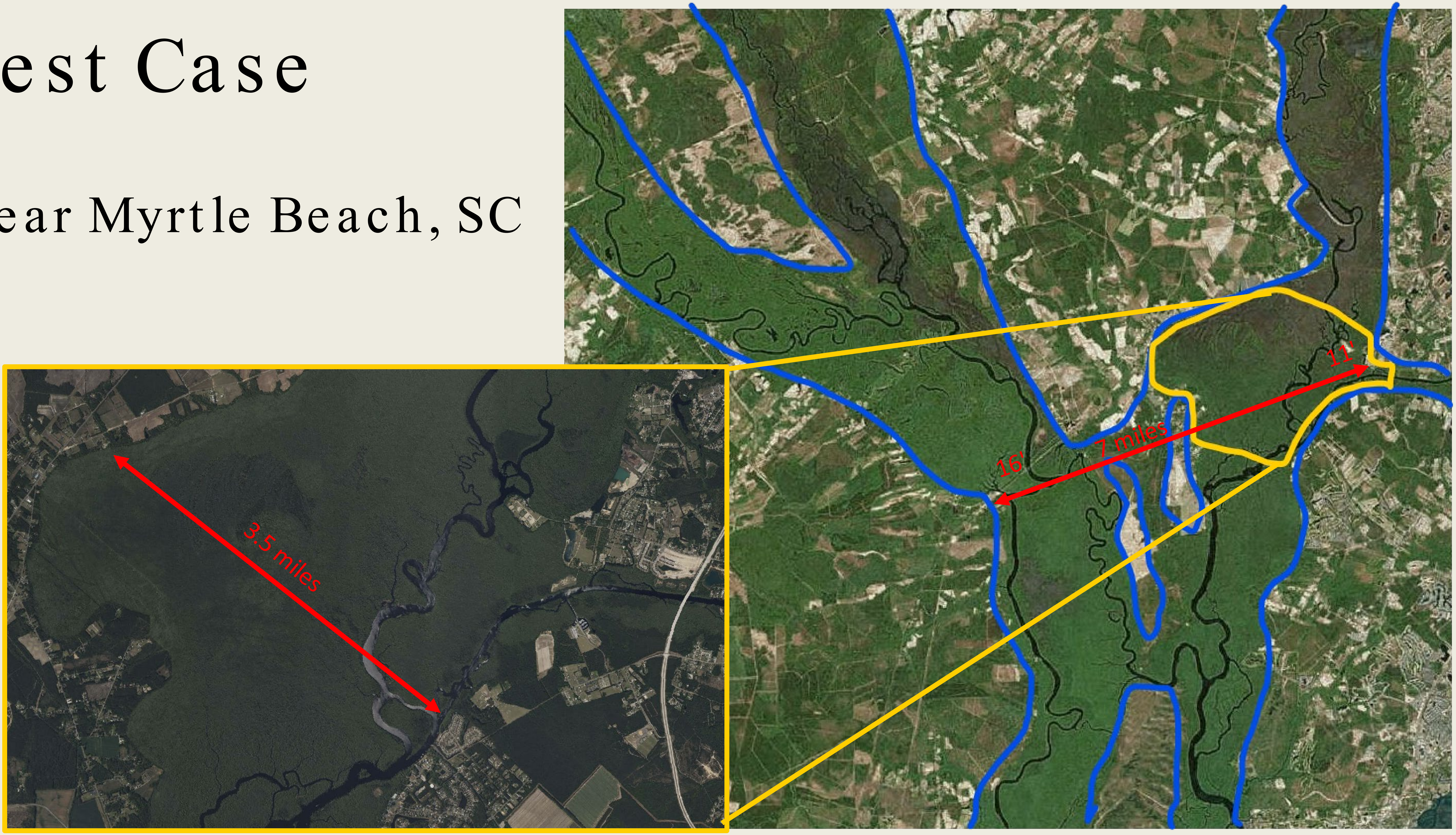
five reasons

Reason 1 :

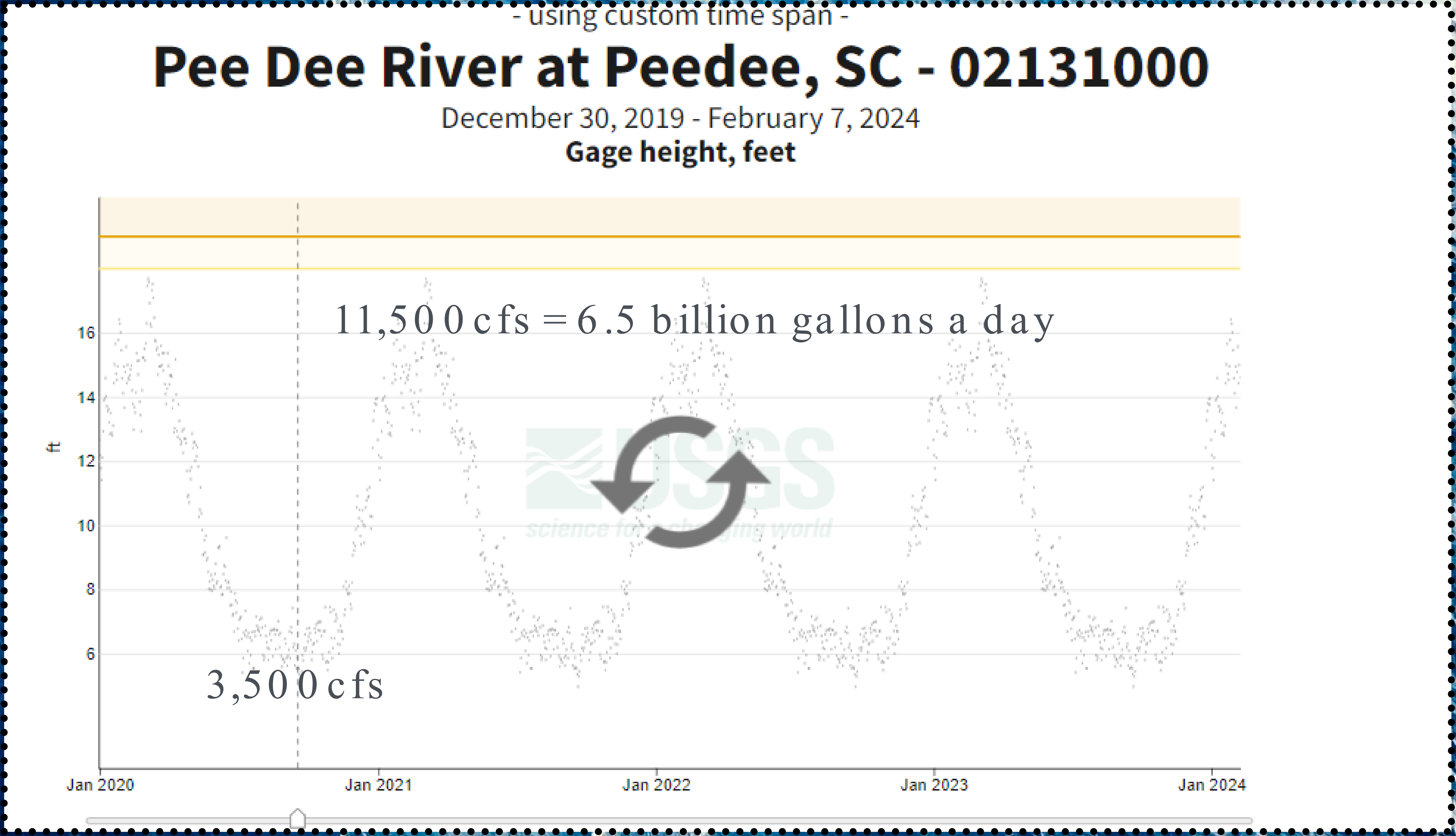
Storage Accounting

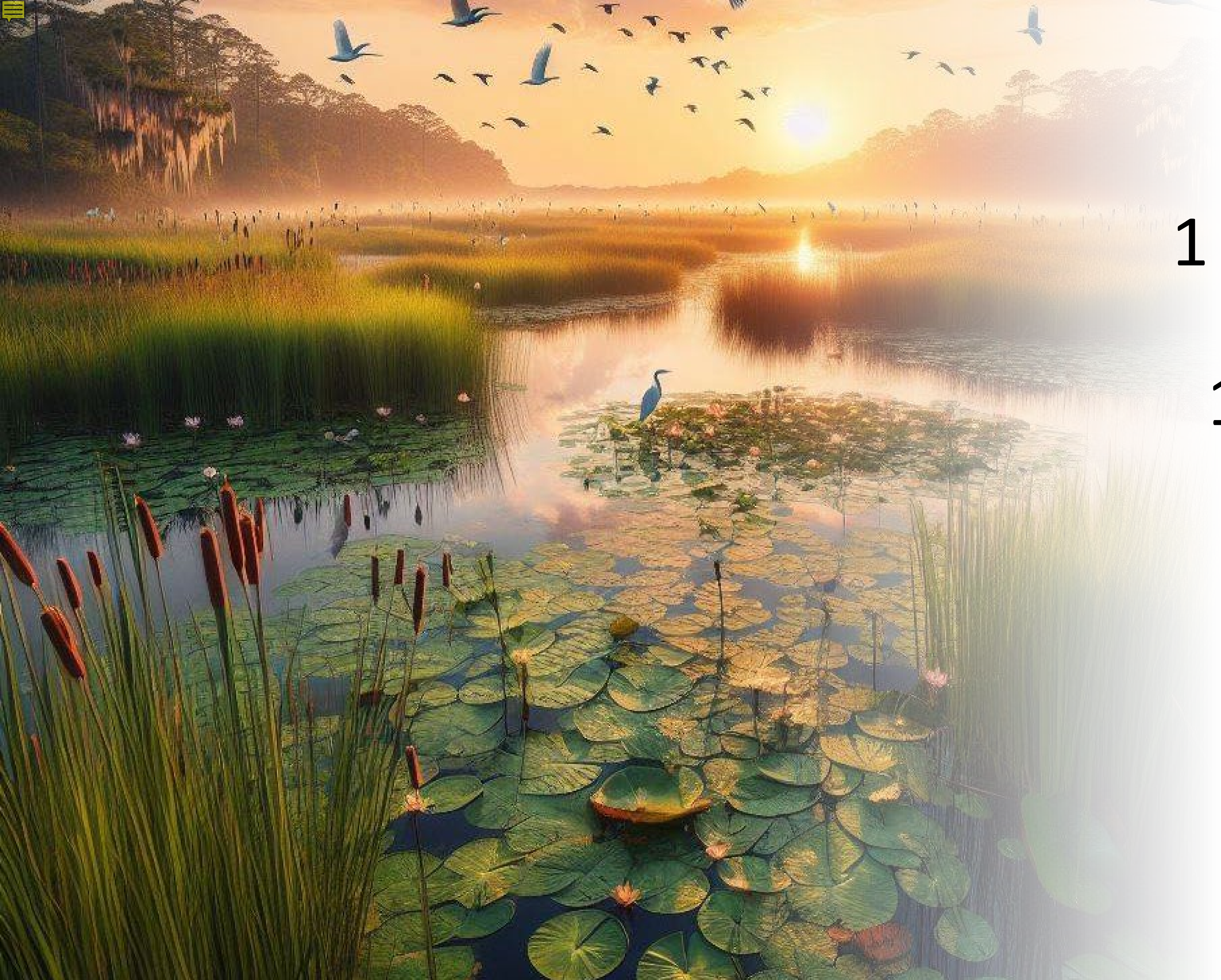
Test Case

Near Myrtle Beach, SC



Seasonal Patterns #1





1 acre of wetland
=
1 to 1.5 million gallons

(EPA)

- Bathymetry
    - Tide
    - Seasonal
    - Drought
- Sponge Wetlands
    - Surface Retention
    - Infiltration
- Vegetation
    - Transpiration

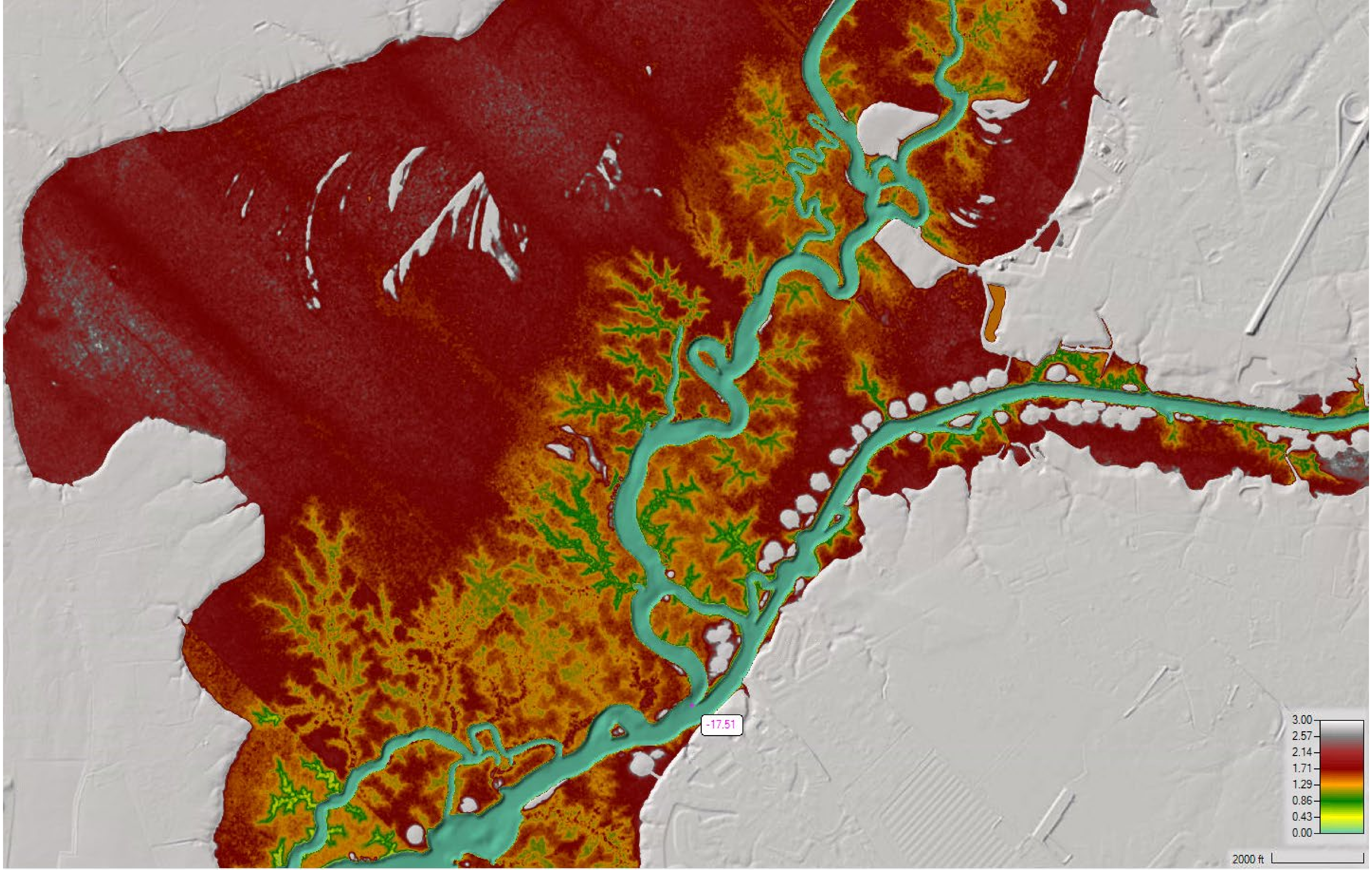
Seasonal Pattern #2

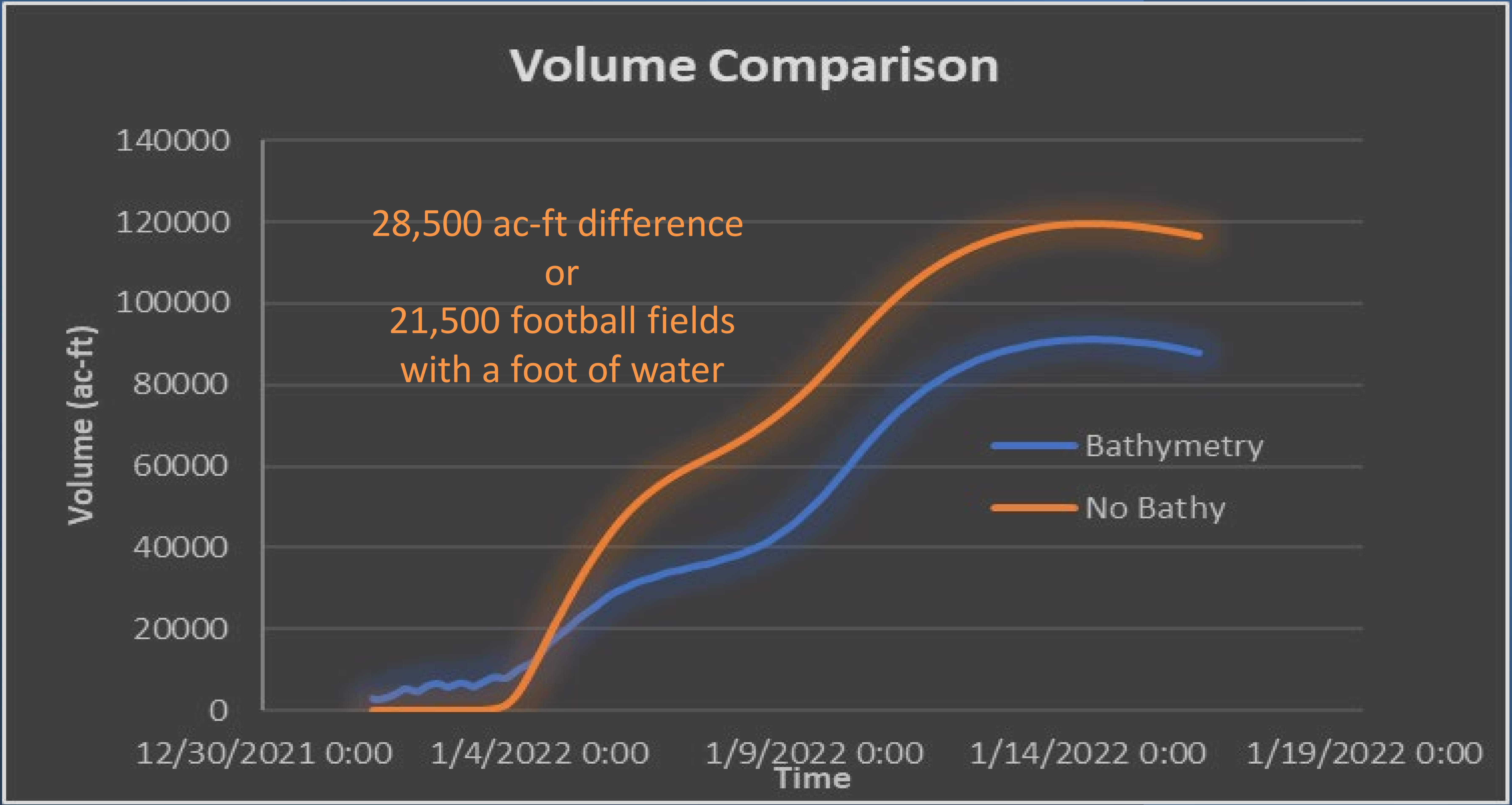
PeeDee, SC

Water Year	Date	Gage Height (feet)	Streamflow (cfs)
1945	1945-09-22	33.30	220,000[6]
2018	2018-09-21	31.83	132,000[6]
1979	1979-03-02	29.03	103,000[6]
2003	2003-04-15	29.46[2]	101,000[6]
1987	1987-03-07	29.06	96,500[6]
1975	1975-03-20	27.81	85,300[6]
2020	2020-02-12	29.11	85,300[6]
1973	1973-04-06	26.97	74,600[6]
1960	1960-04-10	26.28	70,400[6]
1978	1978-02-01	26.58	70,000[6]
1948	1948-02-19	26.23[6]	69,300[6]
2021	2020-11-18	27.85	68,700[6]
1939	1939-03-06	25.61	66,700[6]
1984	1984-04-04	26.55	65,200[6]
1952	1952-03-10	25.95	62,600[6]
1965	1964-10-23	26.01	62,100[6]

Major Flood Stage

Moderate Flood Stage

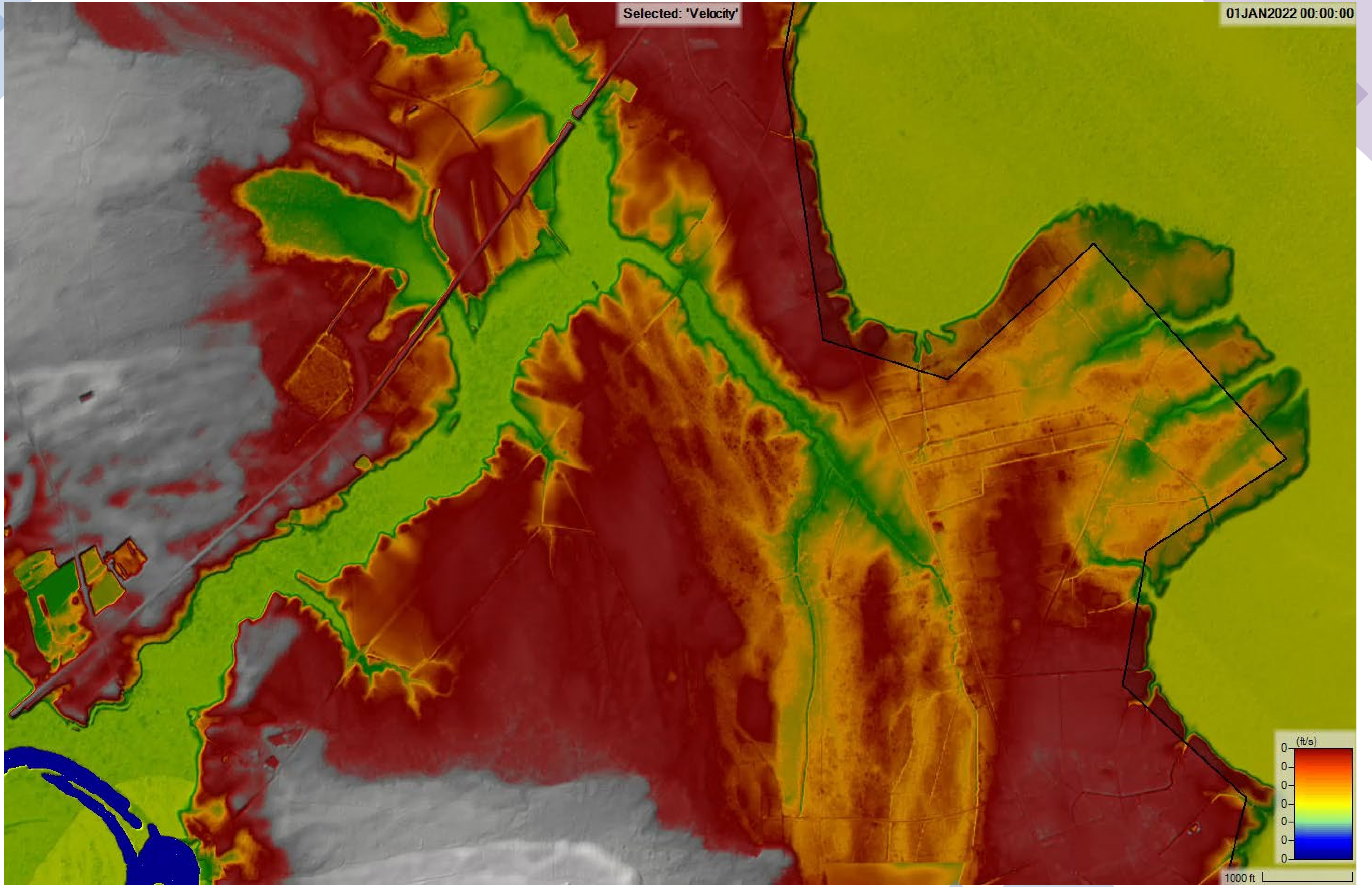

-17.51
3.00
2.57
2.14
1.71
1.29
0.86
0.43
0.00
2000 ft



Volume Comparison
28,500 ac-ft difference
or
21,500 football fields
with a foot of water
140000
120000
100000
80000
60000
40000
20000
0
Volume (ac-ft)
12/30/2021 0:00
1/4/2022 0:00
1/9/2022 0:00
1/14/2022 0:00
1/19/2022 0:00
Time
Bathymetry
No Bathy

Reason 2 :

Flooding Driving Force



Selected: 'Velocity'
01JAN2022 00:00:00
(ft/s)
0
0
0
0
0
0
0
1000 ft

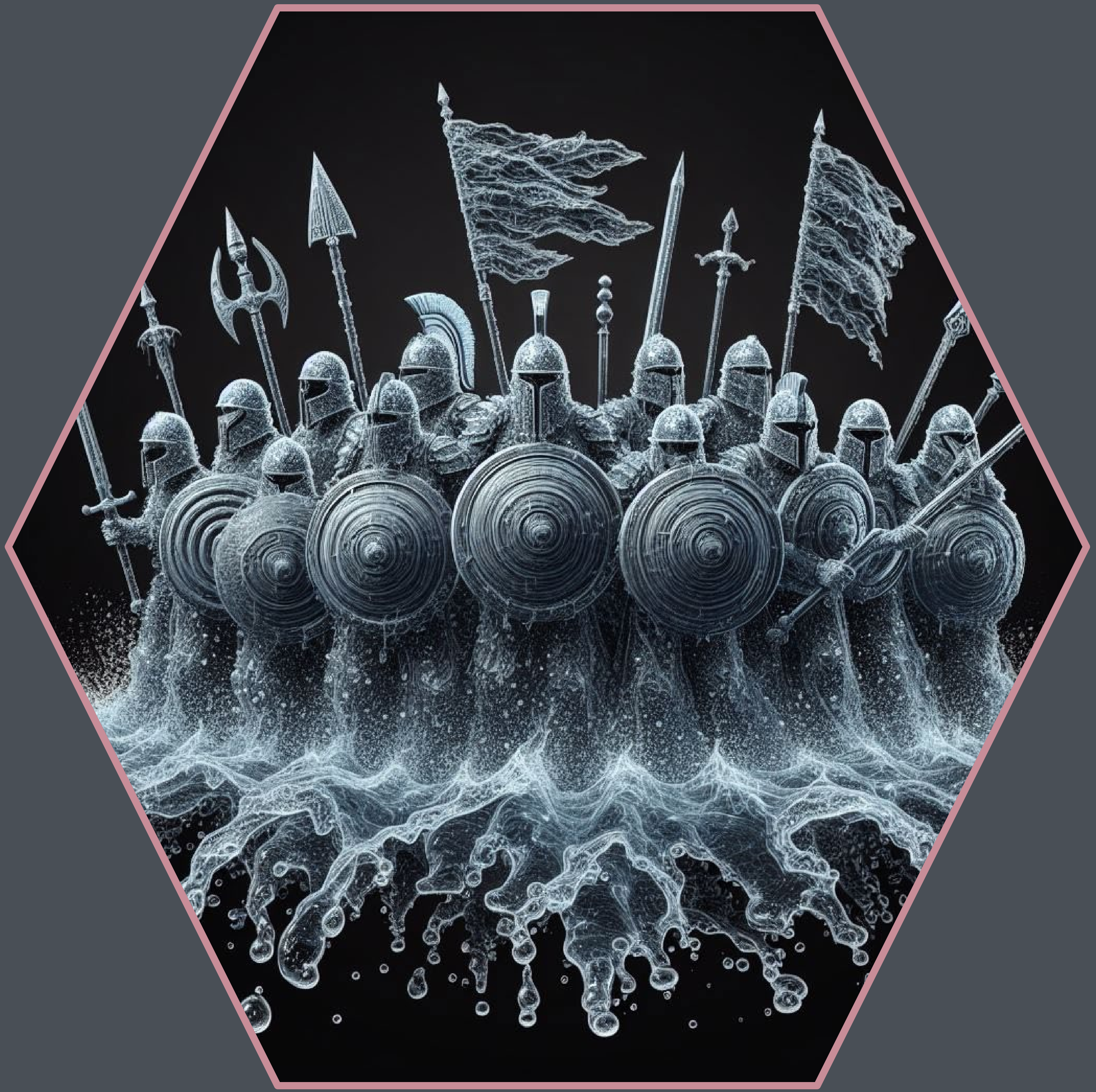
Table 2. Peak flooding associated with Hurricane Florence(September 14–17, 2018). Peak stage, discharge, and water surface slope as based on river distance. Slopes of peaks of low flow before the storm (September 10) are included.

Station	Distance from Ocean and River Valley Miles		Peak stage (ft NAVD88)	Location Figure 1 Number	Peak discharge (cubic feet per second)	Downstream slope during flood peak (ft/10 miles)	Downstream slope September 10 high tide (ft/10miles)
Ocean	0		3.57				
Georgetown	14.9	14.5	4.14	10		0.38	-0.61
Hagley Landing	22	21.7	5.21	16		1.51	0.61
Pawleys	27.1	26.4	6.82	15		3.16	-1.33
Pee Dee near Bucksport	38.8	37.8	16.07	9	137,000	7.91	-0.07
Pee Dee at Hwy 378	80.8	62.8	38.4	5		5.32	2.66
Pee Dee below Pee Dee	103.8	82.6	51.25	4	139,000	5.59	6.56
Pee Dee at Pee Dee	108.0	85.2	53.25	3	134,000	4.76	3.93
Pee Dee near Florence	117.7	93.7	61.0	2		7.99	4.19
Pee Dee near Bennettsville	161.6	126.6	93.07	1	191,000	7.26	4.44
Waccamaw at Bucksport	39.4	37.6	11.41	14		3.73	-0.16
Waccamaw at Conway	57.1	49.9	15.06	13	49,000	2.06	-0.23
Waccamaw above Conway	73.3	59.3	19.81	12	44,500	2.93	-0.05
Waccamaw near Longs	108.1	71.9	24.45	11	57,500	1.33	1.29

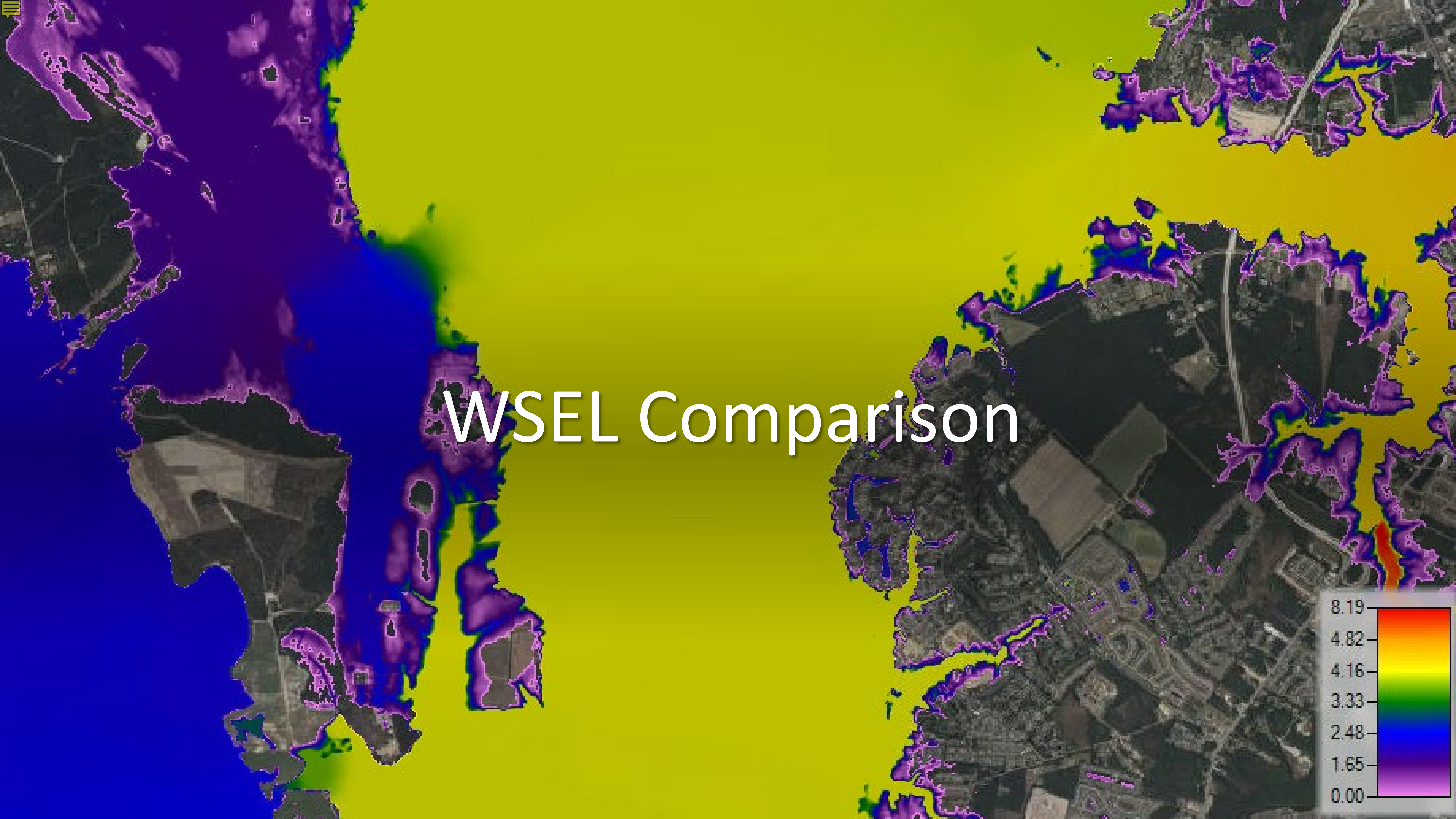
Williams, T. M., Hitchcock, D., Song, B., & O'Halloran, T. (2019). *Hurricane Florence Flooding in Georgetown County: A Qualitative Explanation of the Interactions of Estuary and Tidal River*Journal of South Carolina Water Resources, 6(1), 36–451.

Force

Backwater
Confluence
Storm Surge
Debris Jam

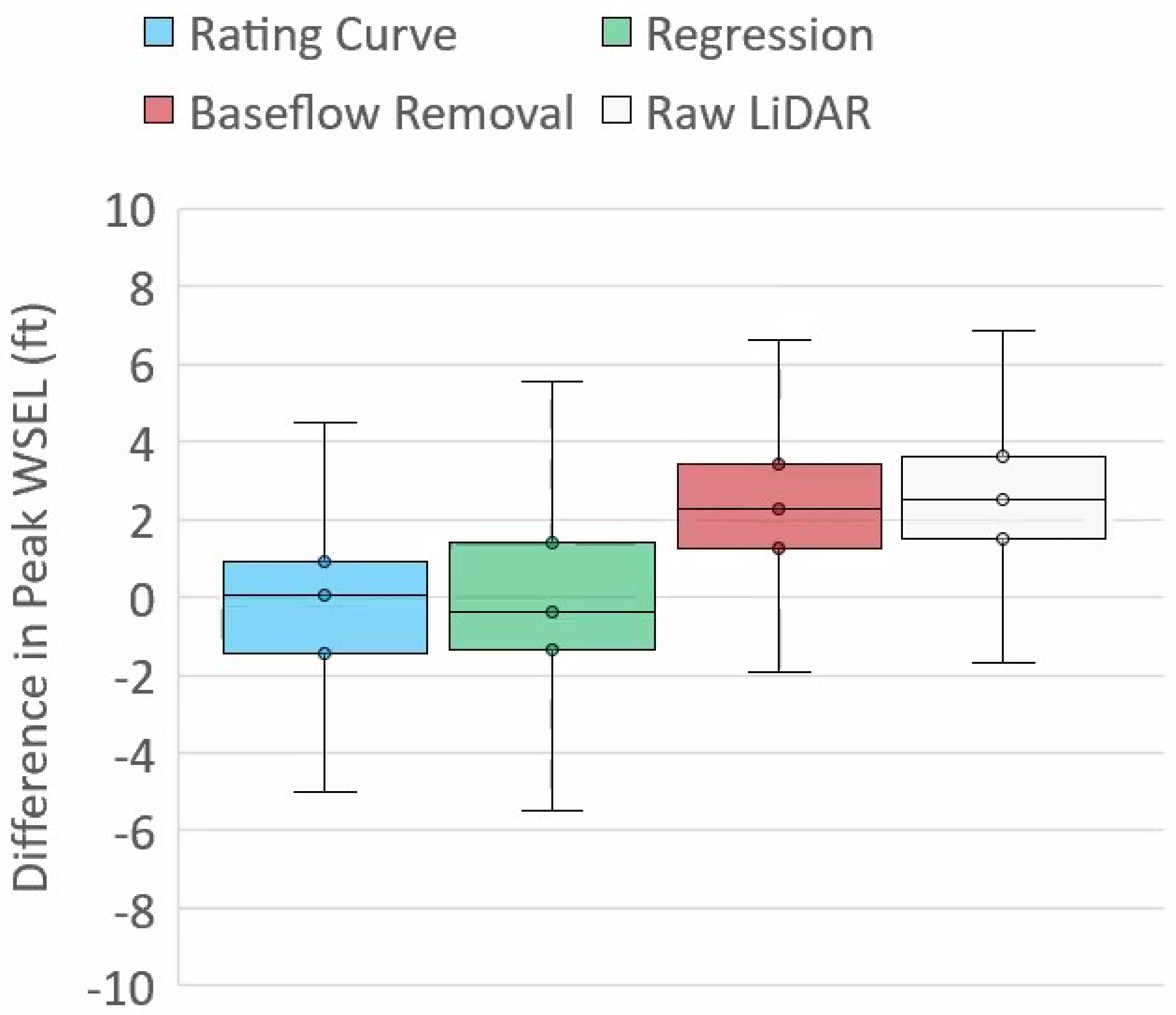


WSEL Comparison

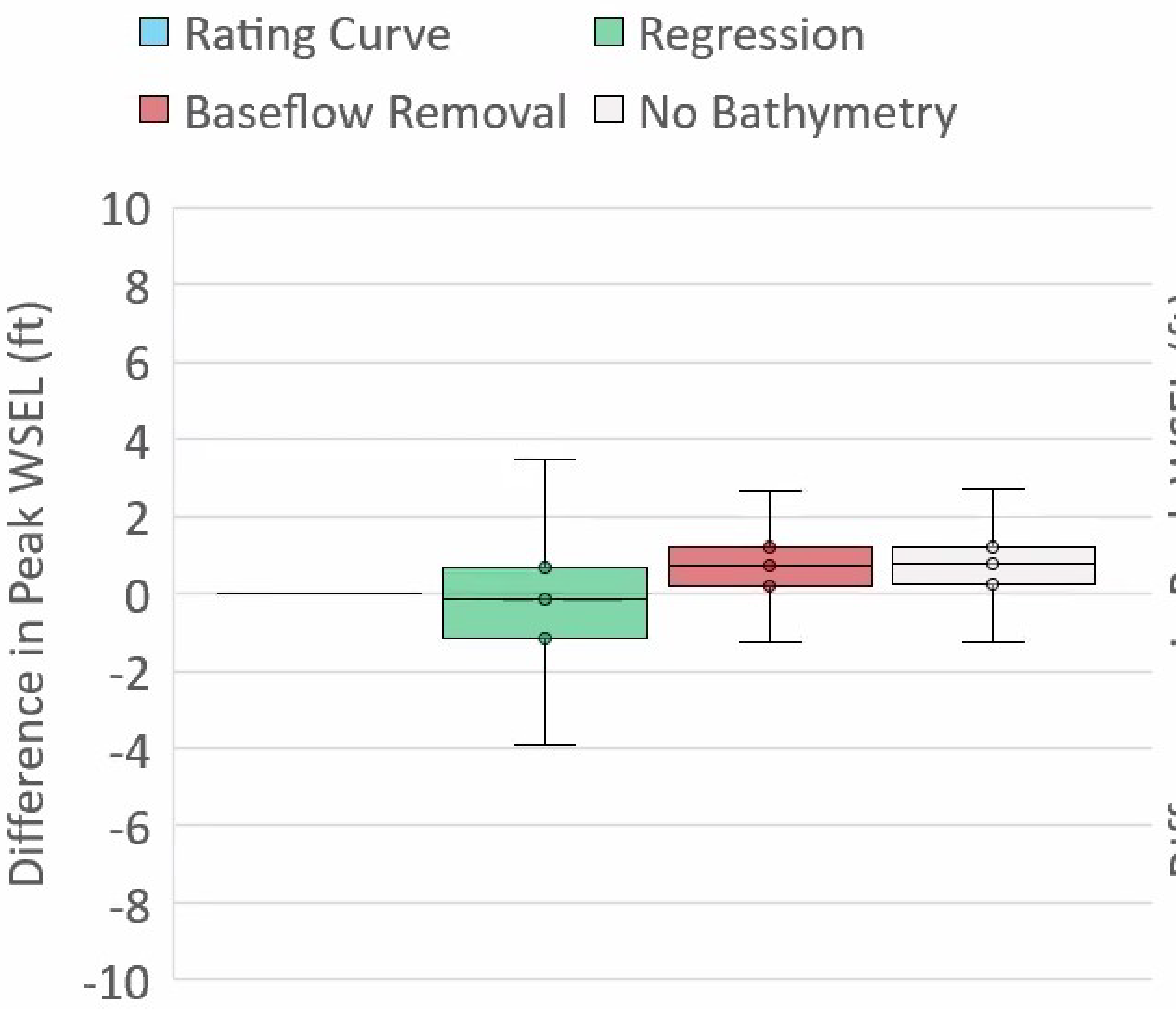


WSEL Differences | High Flow | All Study Areas | All Approaches

Kanawha Elk Middle

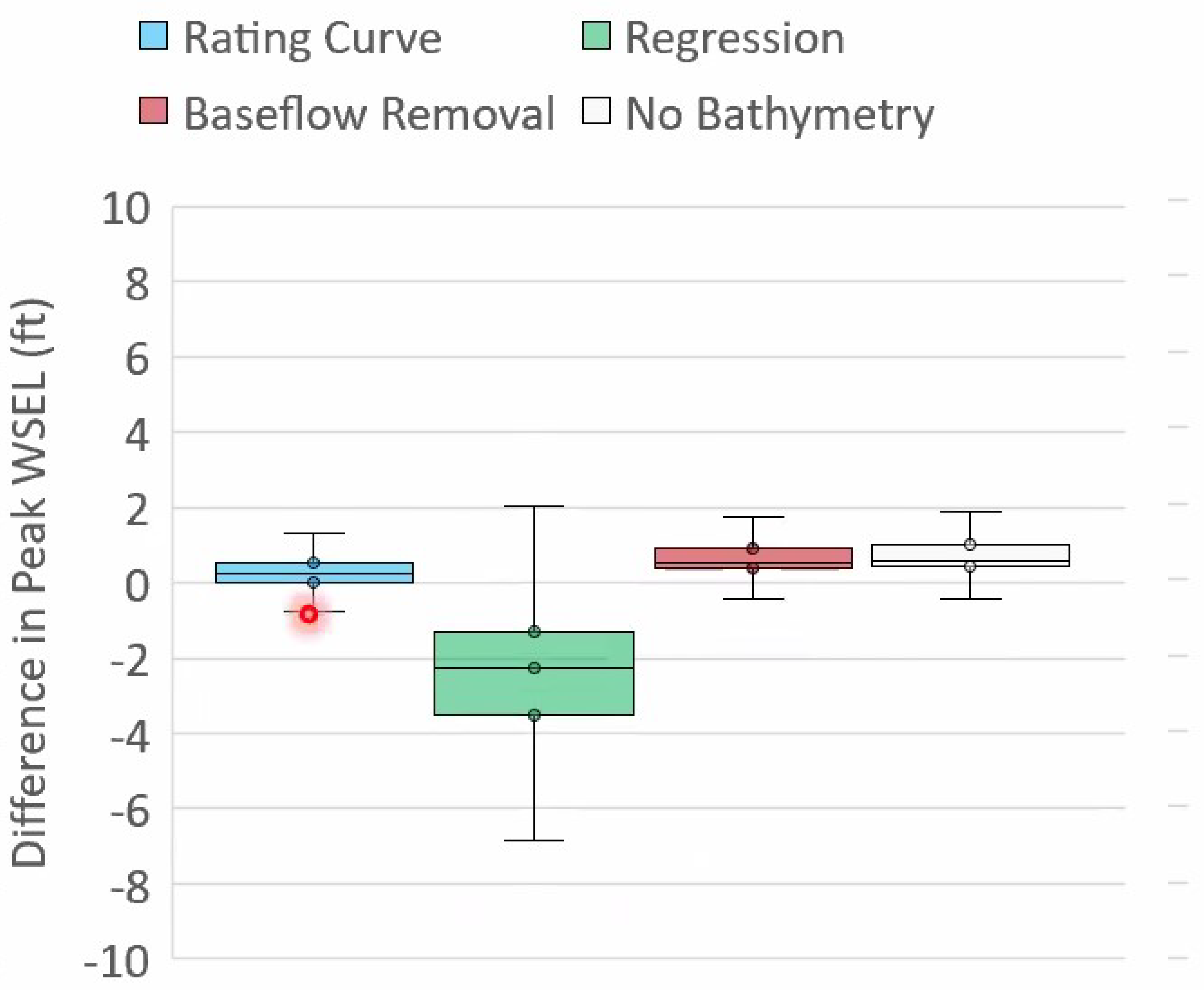


Kanawha Gauley at Summersville*



*No surveyed bathymetry available, rating curve used as base approach for comparison

Brazos River



Reason 3:

Will the real Depth, please stand up?

Depth

Floodway

Hazard

Boat Navigation

Development

Irrigation

D*V
2D Floodway Comparison

Reason 4:

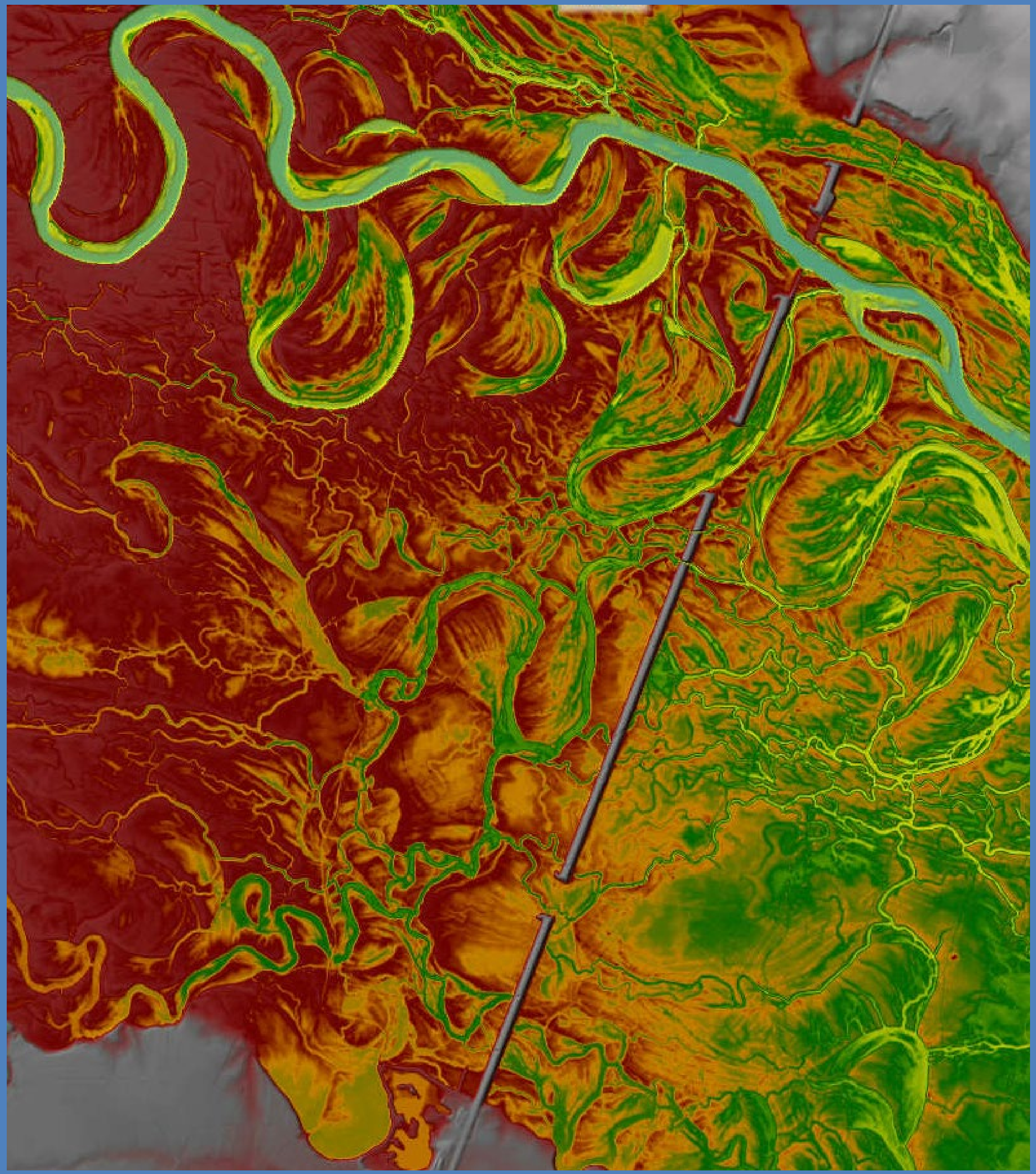
Scour & Sediment

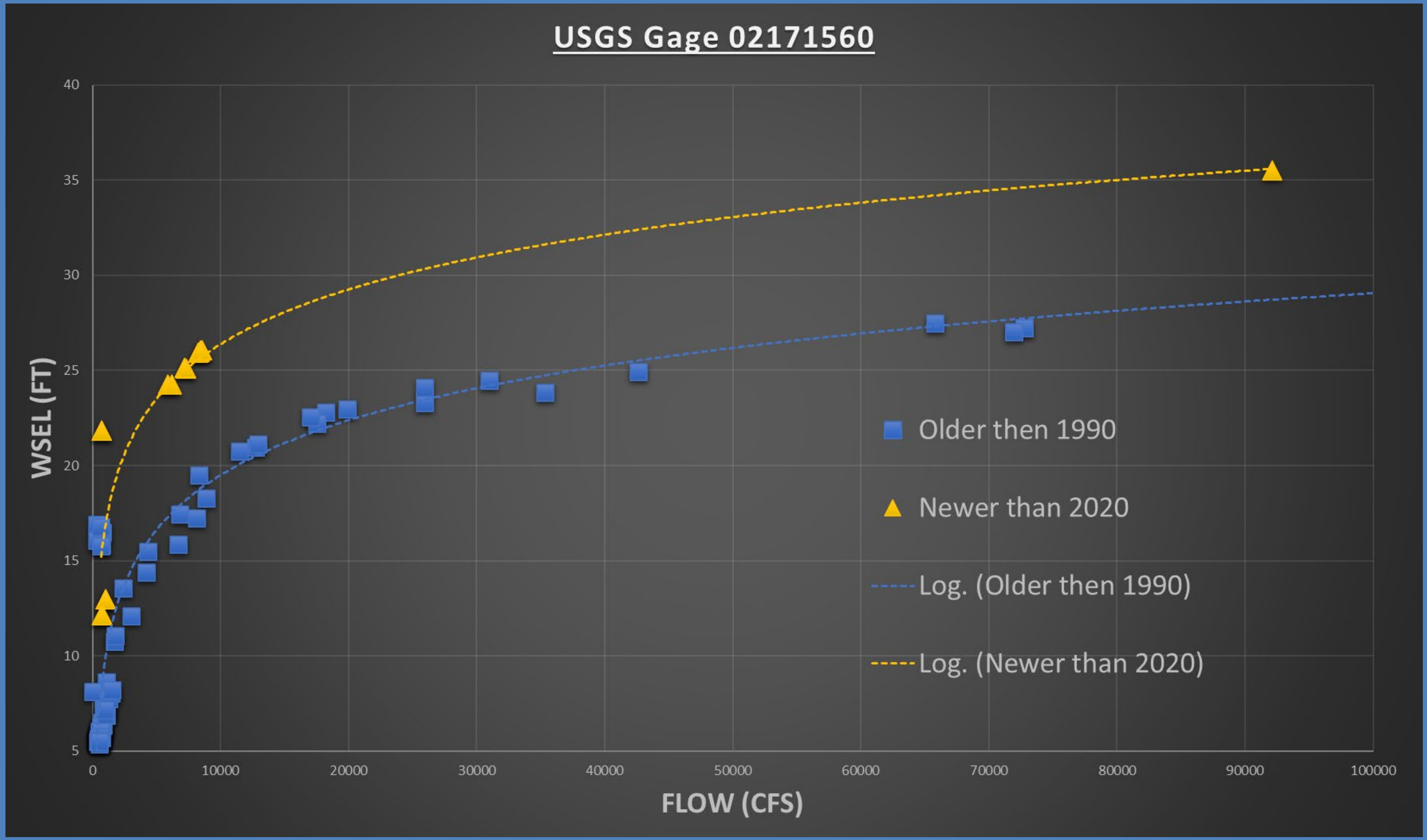
SCOUR

- Piers & Footings
- Road Washouts
- Reservoirs / Levee
- Landslide
- Sinkholes

Sediment Deposition

- Efficiency of Structures & Storage
- Flow Path
- Water Quality
- Nutrients/ Pollution Studies
- Fish Habitat
- Dam Removal




USGS Gage 02171560
WSEL (FT)
40
35
30
25
20
15
10
5
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
FLOW (CFS)
Older then 1990
Newer than 2020
Log. (Older then 1990)
Log. (Newer than 2020)

Reason 5: Hydrologic & Hydraulic Expense

Expenses

- DEM
  - Compile Sources
  - Datum Conversion
  - Formatting Type
  - Mosaic
  - Smoothing
  - Estimating
- Hydrology/ Hydraulics
  - Baseflow
  - Season
  - Double Counting
  - Calibration
  - Quality
- Digital Twin
  - 99% time it will be low flow
  - Agility

How can Bathymetry elevate your Flood Resilience?

Thank You

Tyson James PE, CFM
Hope Morgan NCPLS, CFM, GISP

AECOM

2024