Species Effects Analysis & Take Methods

GBRA Guadalupe River Habitat Conservation Plan

Fifth Public Stakeholder Meeting

July 30, 2025

GBRA
Guadalupe-Blanco River Authority

Guadalupe-Blanco River Authority

- Created by Texas Legislature in 1933 to develop, conserve, and protect the water resources of 10-county statutory district

- Operations include water supply, wastewater, hydroelectric, engineering, environmental and stewardship

- Funded by revenues, not taxes

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What is a "Habitat Conservation Plan?"

- **Endangered Species Act (ESA)** - Administered by the U.S. Fish and Wildlife Service (USFWS), this law protects species from development impacts.
  - **Incidental Take Permit (ITP)** - federal permit allowing entities to continue lawful operations that impact endangered species.
    - **Habitat Conservation Plan (HCP) -** required for federal Incidental Take Permit.
      - Identifies and quantifies adverse impacts.
      - Commits conservation measures to benefit covered species
      - Proactive – applicant's plan and heads off enforcement/litigation.

GRHCP Covered Species

Guadalupe fatmucket

Guadalupe orb

Guadalupe darter

Whooping crane

Eastern black rail

False spike

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Arrows denote species distribution from headwaters to the estuary.

GRHCP Covered Activities – Participants' Operations

Diversion of surface water

Discharge of treated wastewater

Hydrogeneration

Impoundments

Participant Covered Activities Included in Water Quantity Modeling

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Entity	Surface Water Diversion	On-channel Impoundments
GBRA	✓	✓
Kerr County		✓
City of Kerrville	✓	✓
New Braunfels Utilities (NBU)	✓	
Canyon Regional Water Authority (CRWA)	✓	
City of Gonzales	✓	✓
INVISTA	✓	
Dow	✓*	

*Includes only diversions authorized under water rights located at Saltwater Barrier (Certificates of Adjudication 18-5177 and 18-5178).

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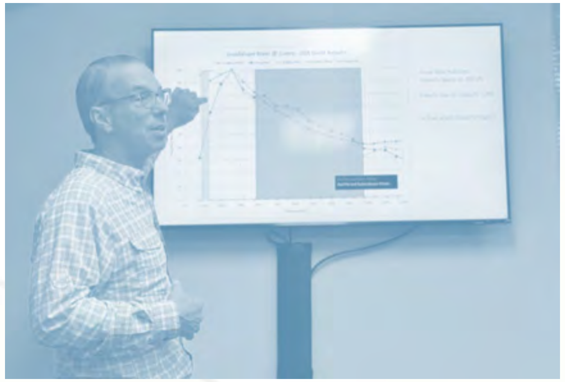
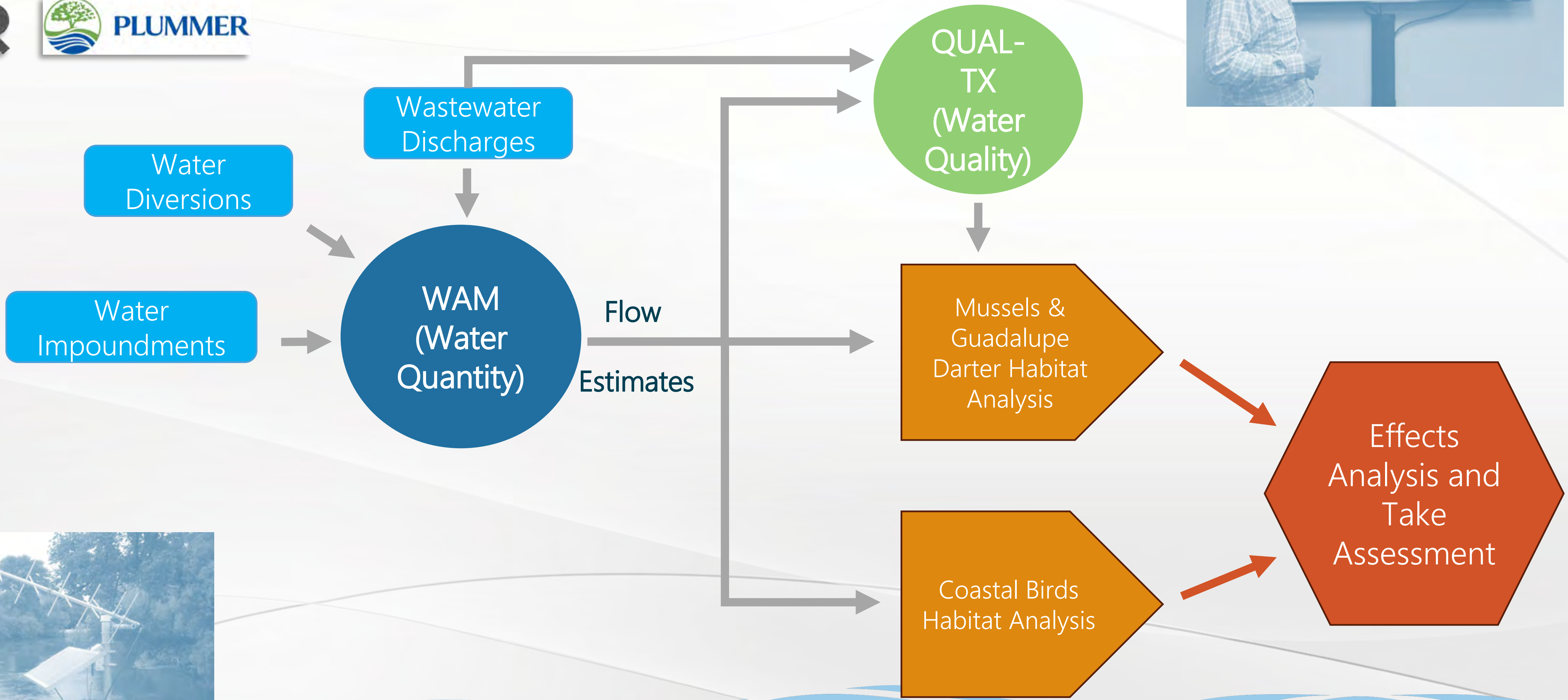
Hydrologic Impacts Modeling

HDR PLUMMER





Effects Analysis and Take Methods:

Water Quantity Modeling

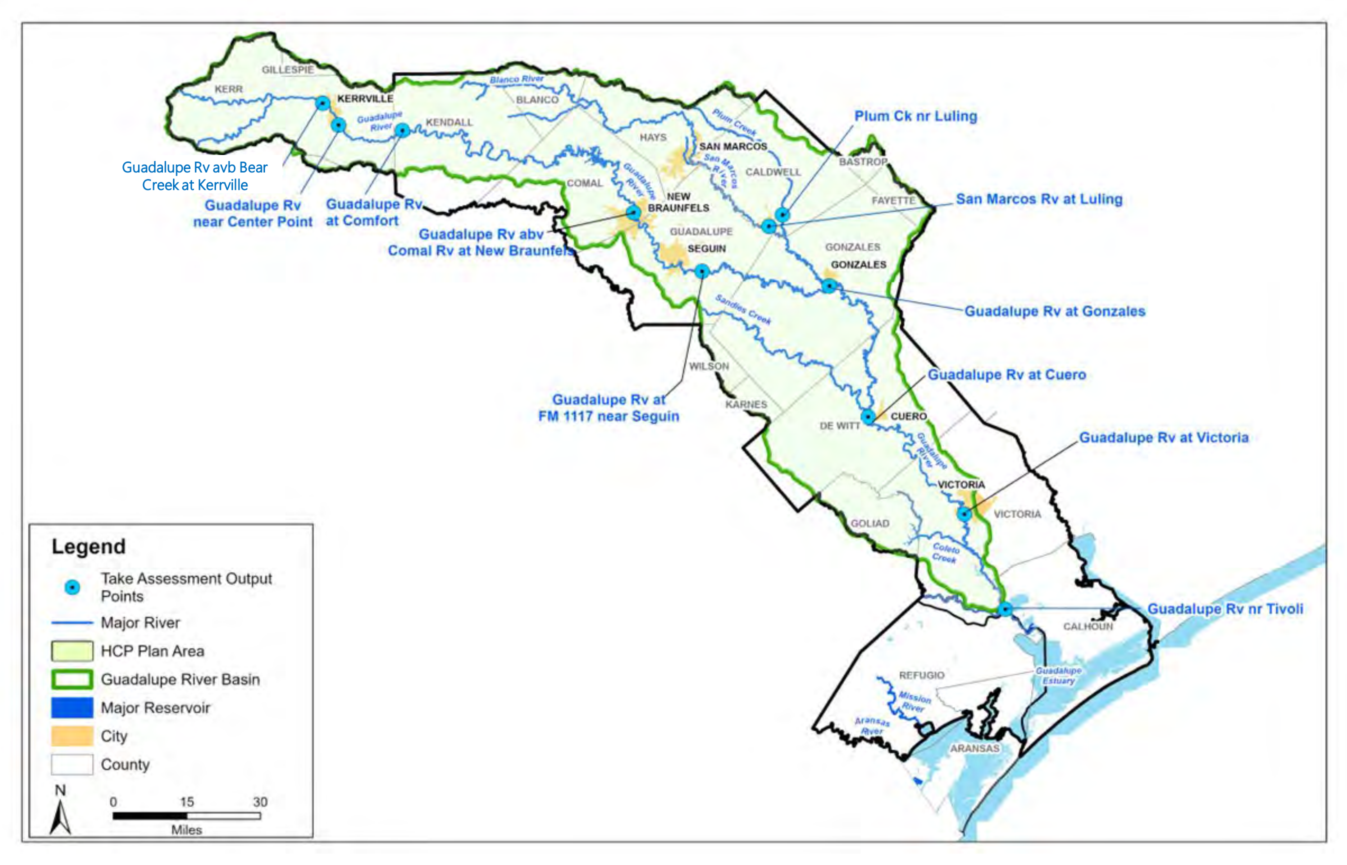
Water Quantity Modeling for the GRHCP

- Water availability modeling informs effects analysis for:
  - **mussels and darter** (habitat/flow),

  - **whooping crane** (salinity), and

  - **Eastern black rail** (inundation)

WAM Nodes within the Guadalupe River Basin



Location	USGS Gage No.
Guadalupe River above Bear Creek at Kerrville	08166140
Guadalupe River near Center Point	08166250
Guadalupe River at Comfort	08167000
Guadalupe River above Comal River at New Braunfels	08168500
Guadalupe River at FM 1117 near Seguin[a]	08169792
San Marcos River at Luling	08172000
Plum Creek near Luling	08173000
Guadalupe River at Gonzales	08173900
Guadalupe River at Cuero	08175800
Guadalupe River at Victoria	08176500
Guadalupe River near Tivoli	08188800
Guadalupe Estuary	---

[a]Control point added to WAM

Water Quantity Modeling Overview

- **Modeling considers streamflow impacts by GRHCP Participant and Non-Participant activities**
- **Water quantity activities include:**
  - Surface water diversions
  - Impoundments
  - Reduction in major springflows from Edwards Aquifer pumping with current Edwards Aquifer HCP in place
  - Surface water/groundwater interactions from Carrizo and Trinity aquifer pumping
- **Return flows are considered a conservation measure (if dedicated to stream) and not included in impacts analysis**

Surface Water Quantity Modeling Approach

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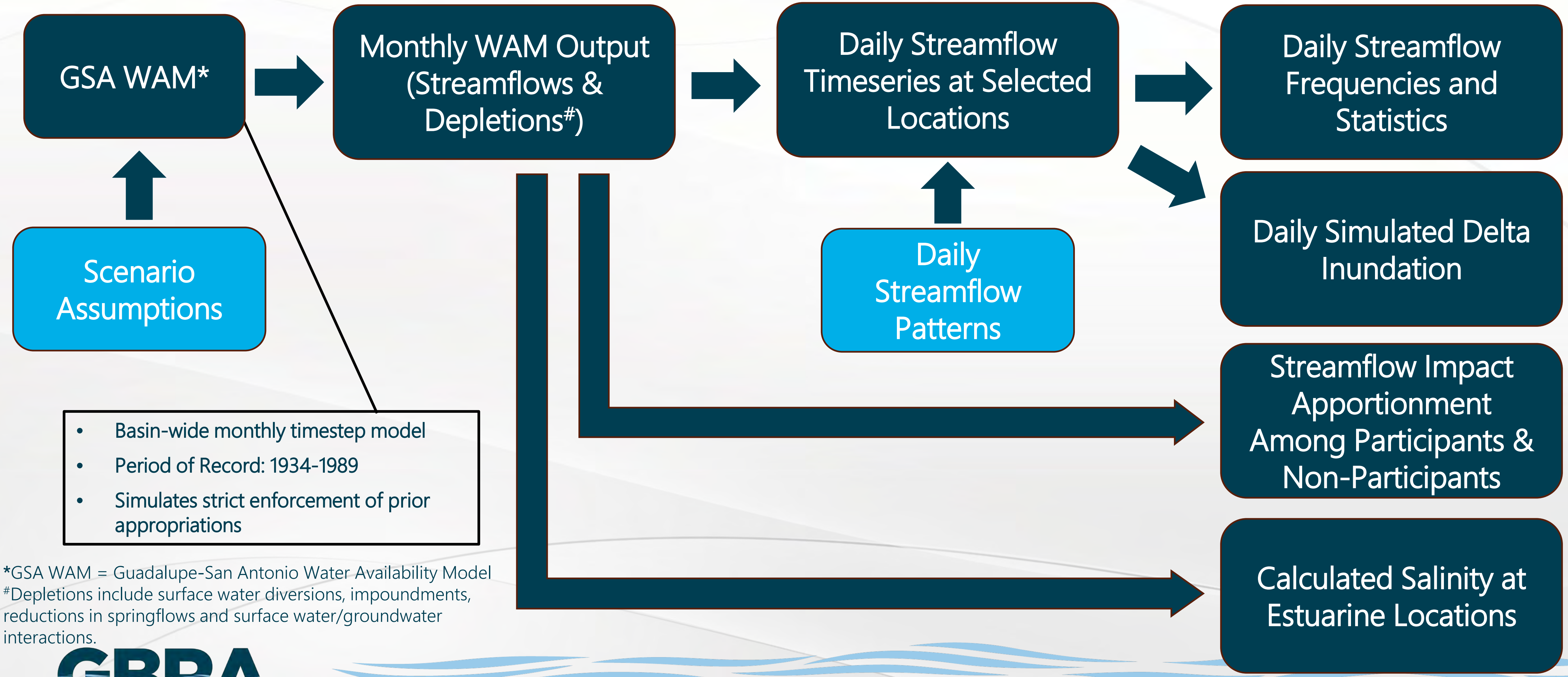

*GSA WAM = Guadalupe-San Antonio Water Availability Model
#Depletions include surface water diversions, impoundments, reductions in springflows and surface water/groundwater interactions.

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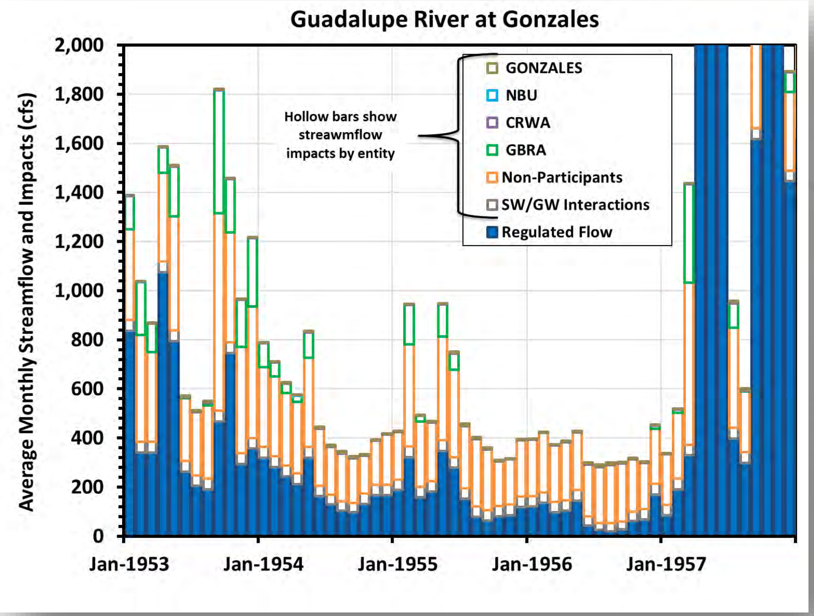
Impacts Analysis –Scenarios & Assumptions

Scenario	Scenario Purpose	Flow and Related Attributes	Participant Covered Activities		Non-Participant Activities		Large Dams or Other Existing Infrastructure/ Sediment Conditions	Conservation Measures	Climate Change
			Water Use & Operations	Return Flows	Water Use & Operations	Return Flows			
New Reference (Natural Flow)	Point of comparison for impacts of all entities (Participants and Non-Participants)	No water management in the basin and no Edwards Aquifer pumping (Natural Conditions)	No	No	No	No	No	No	No
New Covered Activities	Determine streamflow impacts from Participants and Non-Participants by comparing to Reference Scenario	Future water management in the basin with future Participant Covered Activities (full water rights)	Yes/Full Permit	No	Yes/Full Permit	No	Yes/Future Sediment Conditions for all Large Reservoir	No	No

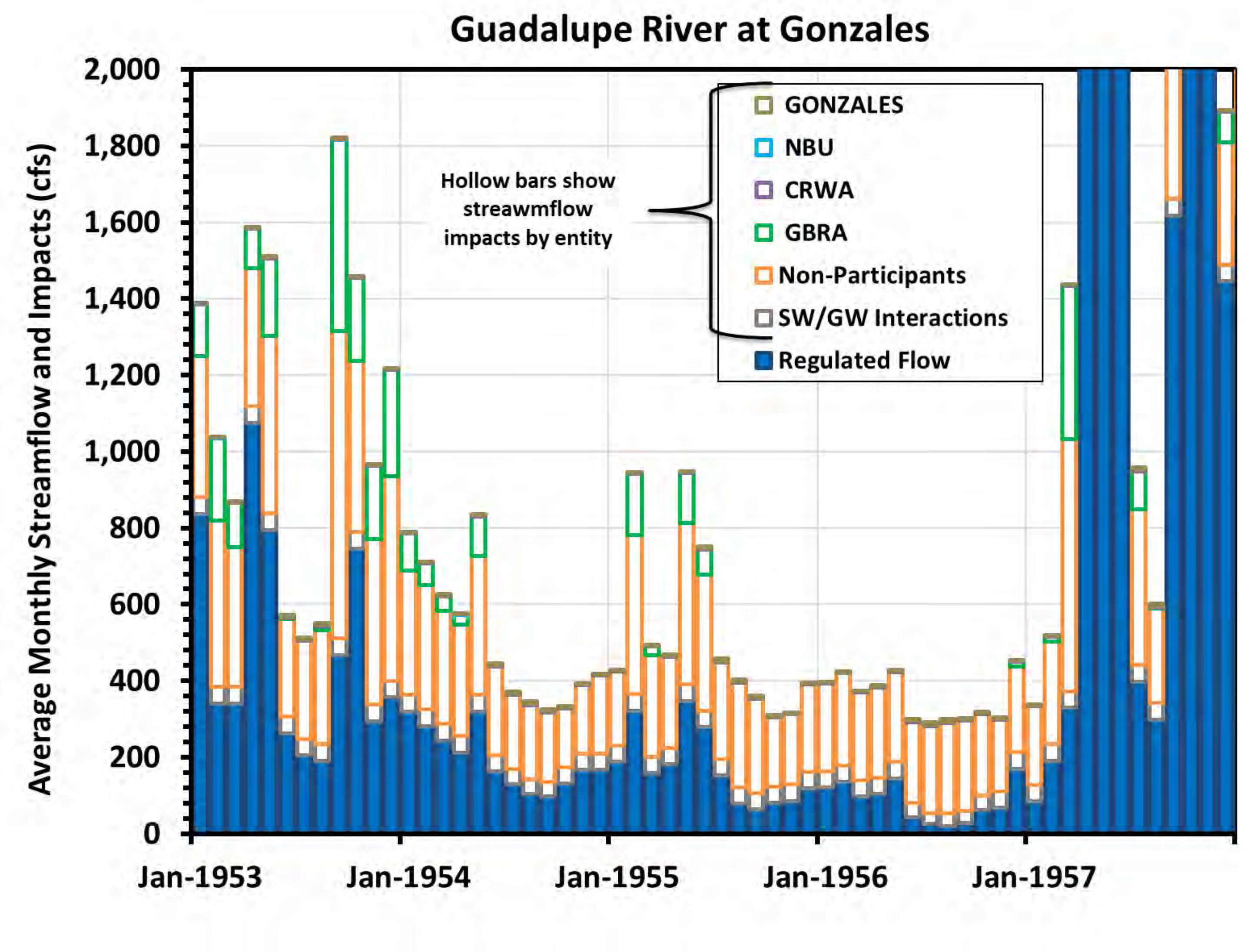
- Comparison of Reference and Covered Activities scenarios considers Participant and Non-Participant impacts and allows for apportionment of take to Non-Participant activities.
- **Assumes the most conservative, worst-case scenario to evaluate outer limit of potential impacts to species, thereby providing a foundation for a robust conservation strategy.**

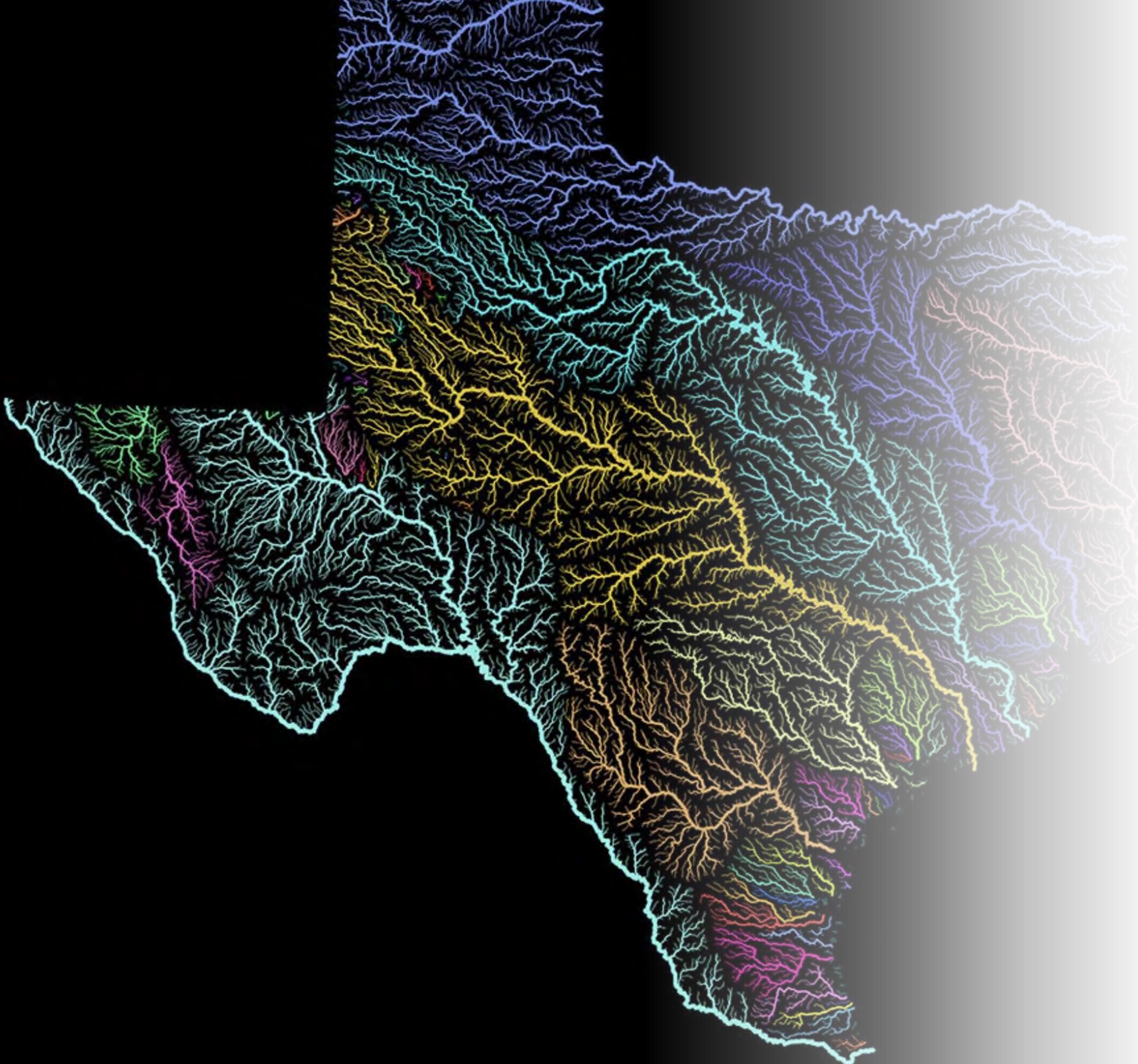
Apportionment of Streamflow Impacts

- Allows for determining proportion of impacts from water diversions attributable to each GRHCP Participant versus non-participants
- Ensures mitigation is proportional to each Participant's contribution to take
- Based on streamflow impact modeling at selected locations and the estuary using WAM outputs



Apportionment of Streamflow Impacts Example





Q&A

Effects Analysis & Take Methods:

Technical Advisory Group Update

Technical Advisory Group

Dan Opdyke
Chair of Committee
Anchor QEA
Water quality and hydromodeling

Cindy Loeffler
Retired TPWD
Texas Water Policy and HCPs

Webster Mangham
Trinity River Authority
Mussel Policy and River Authority operations

Ryan Smith
Texas Nature Conservancy
Texas water and ecosystems

Activities Since Last Public Meeting

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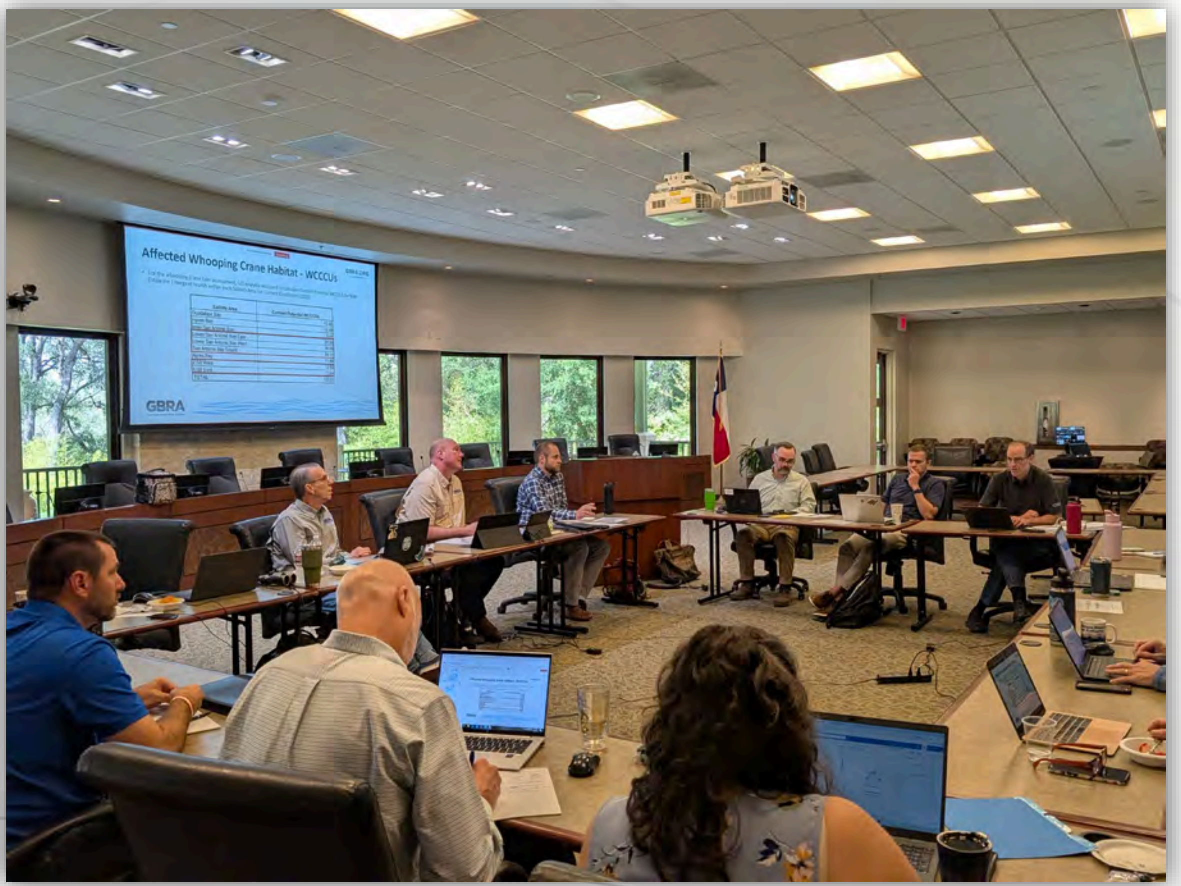
- Met with HCP team
  - August 15, 2024
    - Water quantity modeling updates
    - Water quality modeling updates
    - Coastal birds take assessment methods
    - Mussels task assessment methods
  - October 29, 2024
    - Mussels conservation strategy
  - November 19, 2024
    - Mussels update
  - April 29, 2025
    - Coastal birds take assessment and conservation strategy



Overall Comments

- TAG members continue to be appreciative of the thoroughness and openness of the discussions we've had with GBRA, consultants, and USFWS
- TAG members appreciate refinements and improvements to methodologies resulting from comments
- The following slides document concepts that the TAG is focusing on. The questions are not meant to imply that GBRA has not, or will not, answer them. Rather, they are the concepts that we feel require careful consideration.

Key Concepts of Interest to the TAG

- Mussels
  - Comments related to the methods for using flow-habitat curves for estimation of take
    - We don't want to lose sight of the many assumptions underpinning the flow-habitat analysis from the BBEST work because that work forms the foundation for the take methodology.
      - One key assumption is that curves are transferable to other sites and the full extent of the river reach for which they are being used to estimate take.
        - Consider a flow trigger on habitat impacts and differentiation of habitat curves between reaches; i.e., one trigger or curve may not be applicable to a separate reach.
      - Another assumption is that the cross-sections used to develop a representative reach picture at the time of the BBEST work are still relevant. Has there been channel change in the study sites in the last 15 or so years that could challenge this assumption?
      - Another assumption is that the mesohabitat/fish-based Habitat Suitability Index (HSI) from the BBEST is applicable to mussels. For example, what are the HSI criteria used to define riffles in this analysis and do those ranges in hydraulic variables adequately represent suitable Guadalupe Orb and False Spike habitats?
    - Consider using habitat quality as well (e.g., see Nueces BBEST) to look at how area of good habitat (e.g., combined HSI score of at least 0.5 out of 1) changes over the range of flows as opposed to just using total habitat, which includes significant suboptimal habitat.

Key Concepts of Interest to the TAG

- Mussels (cont.)
  - Comments related to the methods for using flow-habitat curves for estimation of take (cont.)
    - Provide documentation of the basis for SB3 habitat curves, WAM curves, and water quality modeling in the HCP.
    - Provide a map showing the extents of each mussel take analysis reach (i.e., how these are bound upstream and downstream around the gages) and, if possible, the locations of the study sites for BBEST WUA curves being used for the mussels analysis, in the HCP.
    - Obtain transect data underlying flow curves, if available, and consider appropriateness of flow curves used in relation to site-specific data.
  - Data on percent occupancy from surveys is dependent on habitat available at the time of the survey. For example, if the survey was performed during a drought, that may bias low the habitat available during normal times.
    - Recommendation is to consider these effects in the analysis.
  - Consider ways to refine the estimation of mussel baseline for take estimate.
    - CPUE likely higher in upper vs. lower basin due to lower turbidity and depth.
    - May provide a basis for a correction factor.

Key Concepts of Interest to the TAG

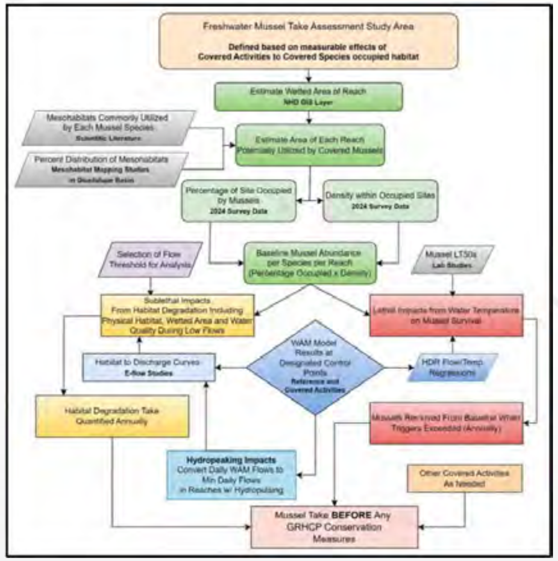
- Mussels (cont.)
  - Temperature
    - Daily average flow is used to evaluate lethal impacts in the temperature assessment. This does not consider variability associated with shorter timeframes, but it uses the available data in a reasonable way.
  - Lethality and sublethality
    - Consider partitioning lethal and sublethal effects that can occur in temperature or habitat to avoid double counting effects
    - Ensure that temperature and habitat assumptions are clearly explained.
  - How will the different analyses of take be combined to generate one estimate?
    - Consider a way to combine the take estimation methods, e.g., by developing a composite measure, as appropriate.
    - Try to reduce or explain the disparity between available mussels for take in lethal versus sublethal methods.

Key Concepts of Interest to the TAG

- Mussels (cont.)
  - Consider applicability of host fish and limited understanding of the dynamic between host fish and mussels as a potential issue for adaptive management (e.g., if there is a large change to certain host fish population or if understanding changes).

Key Concepts of Interest to the TAG

- Birds
  - TAG appreciates that GBRP revised the whooping crane methodology (in response to previous TAG comments) to expand the analysis area.
    - This expanded area has significant crane habitat, but is also less strongly influenced by GBRA's activities
  - Recommend building flow charts to describe different analyses
    - Mussel chart is helpful.
    - Whooping Crane chart could provide more detail
    - Consider a similar chart for eastern black rail analysis
  - Consider the time scale of vegetation response to salinity so as not to mask impacts on vegetation that would happen on a different time scale, or to acknowledge associated limitations.
  - Recommend carefully explaining the limitations of using Metzger 2020 data to represent existing conditions for whooping crane in the take assessment methods in the HCP.



Overall Concepts of Interest to the TAG

- Explain level of uncertainty and assumptions
- Balance the precision of the results with the level of uncertainty in the data
  - Consider adding more details to regression analysis slides

GBRA TAG Acknowledgement

- **Recognition** of time, commitment, and value of input
- Review process has been **interactive**
- Comments **fall into different categories**:
    1. Comments that have ***informed effects analysis and take methods***
    2. Comments ***beyond scope*** of the HCP; e.g., for policy reasons
    3. Comments related to ***assumptions inherent in modeling****, especially given limited information*

Effects Analysis & Take Methods:

Freshwater Mussels & Guadalupe Darter

Mussel Take Estimation

ABUNDANCE of Mussels

Wetted Habitat
(NHD – m^2)

Available Habitat
(% of wetted area – m^2)

Occupied Habitat
(% of available – m^2)

Density
(mussels/m^2)

Abundance
(# of mussels)

Reference – Covered Activities = # of Impacted Mussels

Estimated Wetted Habitat

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- Estimates of available habitat by species and reach based on aerial imagery; aerial datasets refined to more accurately reflect suitable habitat

OLD

NEW

Estimated Available Habitat

- Preferred habitat occurrence based on empirical data (BIO-WEST 2015, 2017)
- Guadalupe Orb and False Spike
  - Riffle habitat occurrence – 26%
- Guadalupe Fatmucket
  - Shallow Run, Deep Run, Shallow Pool – 90%

Mussel Distribution & Abundance

- **Large gaps in mussel survey data** existed at beginning of GRHCP process
    - **GBRA and USFWS** performed additional surveys in 2022
    - **GBRA further expanded on these efforts** in 2023 and 2024 (BIO-WEST 2022; BIO-WEST 2023; BIO-WEST 2024; Salcido 2022).
- These recent surveys **significantly improved understanding of the distribution and relative abundance of the covered mussel species within the basin** and serve as the basis for defining current distribution.

Estimated Occupancy

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GRHCP Assessment Reach	Proportional Occurrence		
	Guadalupe Fatmucket	Guadalupe Orb	False Spike
Kerrville	0.04	0.13	-
Centerpoint	0.06	0.13	-
Comfort	-	0.01	-
New Braunfels	-	0.01	-
Seguin	-	0.10	0.03
Gonzales	-	0.18	0.04
Cuero	-	0.31	0.06
Victoria	-	0.17	0.03
Plum Creek	-	0.01	-
San Marcos River	-	0.13	-

Estimated Density

GRHCP Assessment Reach	Density		
	Guadalupe Fatmucket	Guadalupe Orb	False Spike
Kerrville	0.10	0.12	-
Centerpoint	0.16	0.11	-
Comfort	-	0.10	-
New Braunfels	-	0.10	-
Seguin	-	0.14	0.10
Gonzales	-	0.25	0.20
Cuero	-	0.27	0.25
Victoria	-	0.48	0.10
Plum Creek	-	0.10	-
San Marcos River	-	0.24	-

Mussel Baseline Population Estimate

Guadalupe Orb – Seguin Reach

Wetted Habitat (NHD – m^2) → **Available Habitat** (% of wetted area – m^2) → **Occupied Habitat** (% of available – m^2) →

2,380,933 m^2 x 0.26 = 619,043 m^2 x 0.10 = 61,904 m^2

0.26 → Riffle occurrence %

0.10 → Occurrence proportion

→ **Density** (mussels/m^2) → **Abundance** (# of mussels)

61,904 m^2 x 0.14 mussel/m2 = 8,667 Guadalupe Orb

Habitat Impact Assessment

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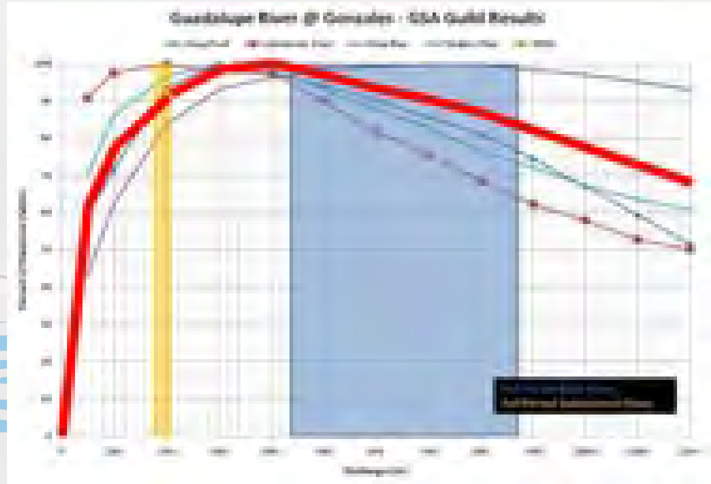
- BBEST Habitat curves represent the fundamental niche (i.e., depth, velocity, and substrate) for a particular species and life stage or guild (i.e. represent physical characteristics of habitat).

- Habitat curves used based on known habitat associations – i.e. Guad Orb and False Spike associated with riffle habitat curves, and Fatmucket associated with deep run habitats.

- Habitat curves do not exist for all control points



Habitat Assessment Triggers

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Assessment Reach	Reach Description	Habitat Take Assessment Trigger (cfs)*
Kerrville	Upstream occurrence in each fork to Nimitz Lake Dam	11.55
Centerpoint	Nimitz Dam to High St in Comfort TX	10.9
Comfort	High St. in Comfort, TX to Canyon Lake	9.38
New Braunfels	Canyon Dam to Comal River confluence	52
Seguin	Meadow Lake Dam to upper extent of Gonzales Hydro influence	106
Gonzales	Gonzales hydro dam to SH72 near Cuero	191
Cuero	SH 72 near Cuero to FM 447 near Nursery	176
Victoria	FM 447 near Nursery to Business SH 77 in Victoria	166
San Marco River	Old Martindale Rd to upper extent of Gonzales Hydro influence	83
Plum Creek	Lower three miles above San Marcos River confluence	2

*5th percentile flow from last 20 years of USGS streamflow data

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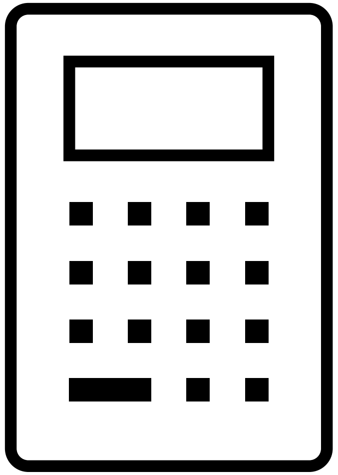
Habitat Take Calculation Example



Habitat Take Example

Guadalupe Orb at Gonzales

Trigger = 191.15 cfs

Year X Reference

- Min flow in Reference = 150 cfs

Year X Covered Activities Run

- Min flow = 100 cfs

Habitat Take Example
Guadalupe Orb at Gonzales

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Trigger = 191.15 cfs   Occupied Habitat = 164,455 m2   Baseline # of Guad Orbs = 41,114

Year X Reference

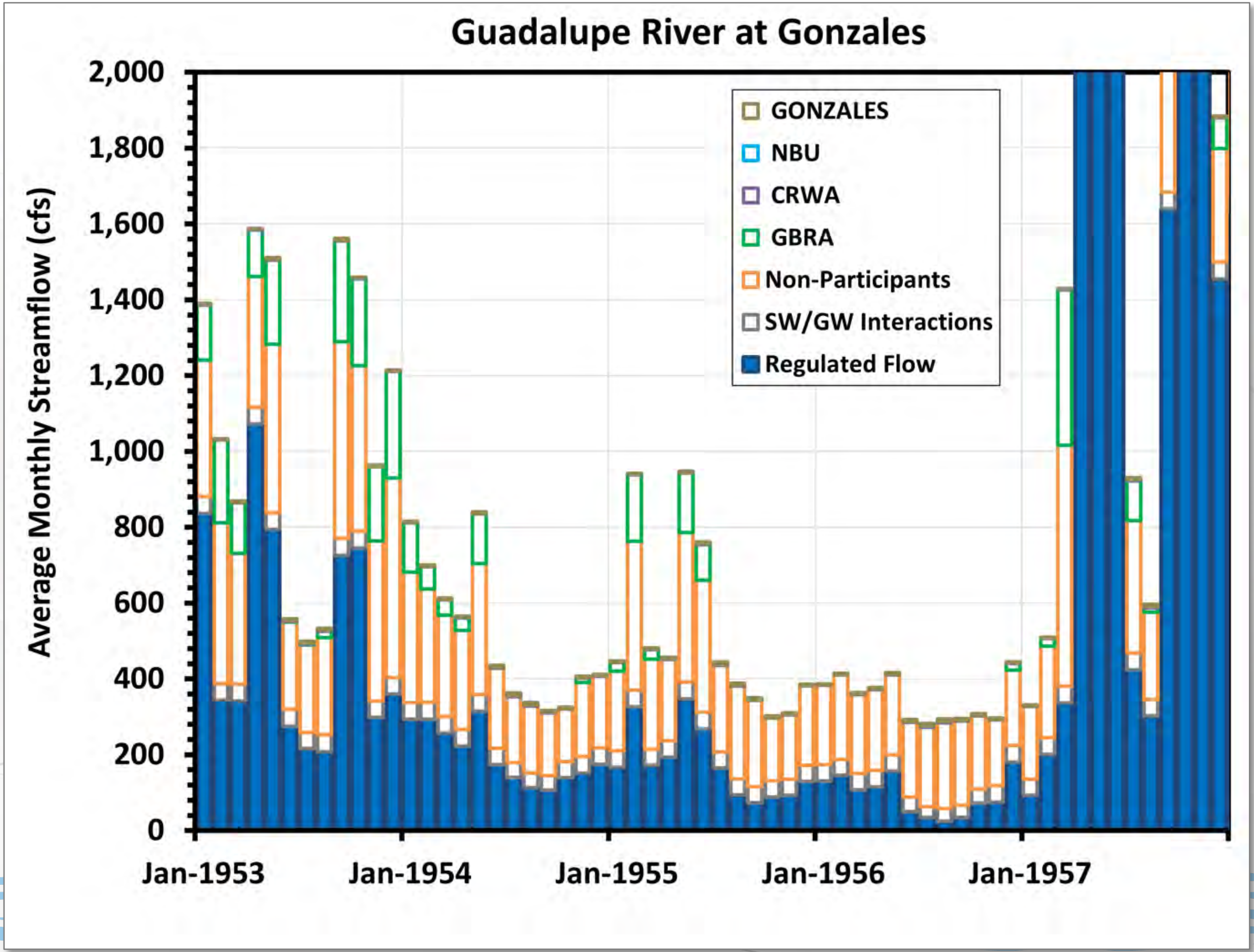
- Min flow in Reference = 150 cfs
- 84% of riffle/run habitat available
- 138,142 m^2 x 0.25 mussels/m^2
- 34,535 Guad Orb

Year X Covered Activities

- Min flow in CA Run = 100 cfs
- 77% of riffle/run habitat available
- 126,630 m^2 x 0.25 mussels/m^2
- 31,657 Guad Orb

Year X Take = 34,535 – 31,657 = 2,878 Guadalupe Orb

Apportionment of Habitat Impacts from Diversions



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Temperature Impact Assessment

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- Assessing impacts from temperature problematic
  - Very limited surface thermal data
  - Regressions developed based on flow – poor relationships
    - R^2 values ranged from 0.11 to 0.52 (most b/w 0.30-0.35)
  - Lab LT's not representative of spatial and temporal variation of real-world thermal regime

Temp Estimates at Flow Triggers

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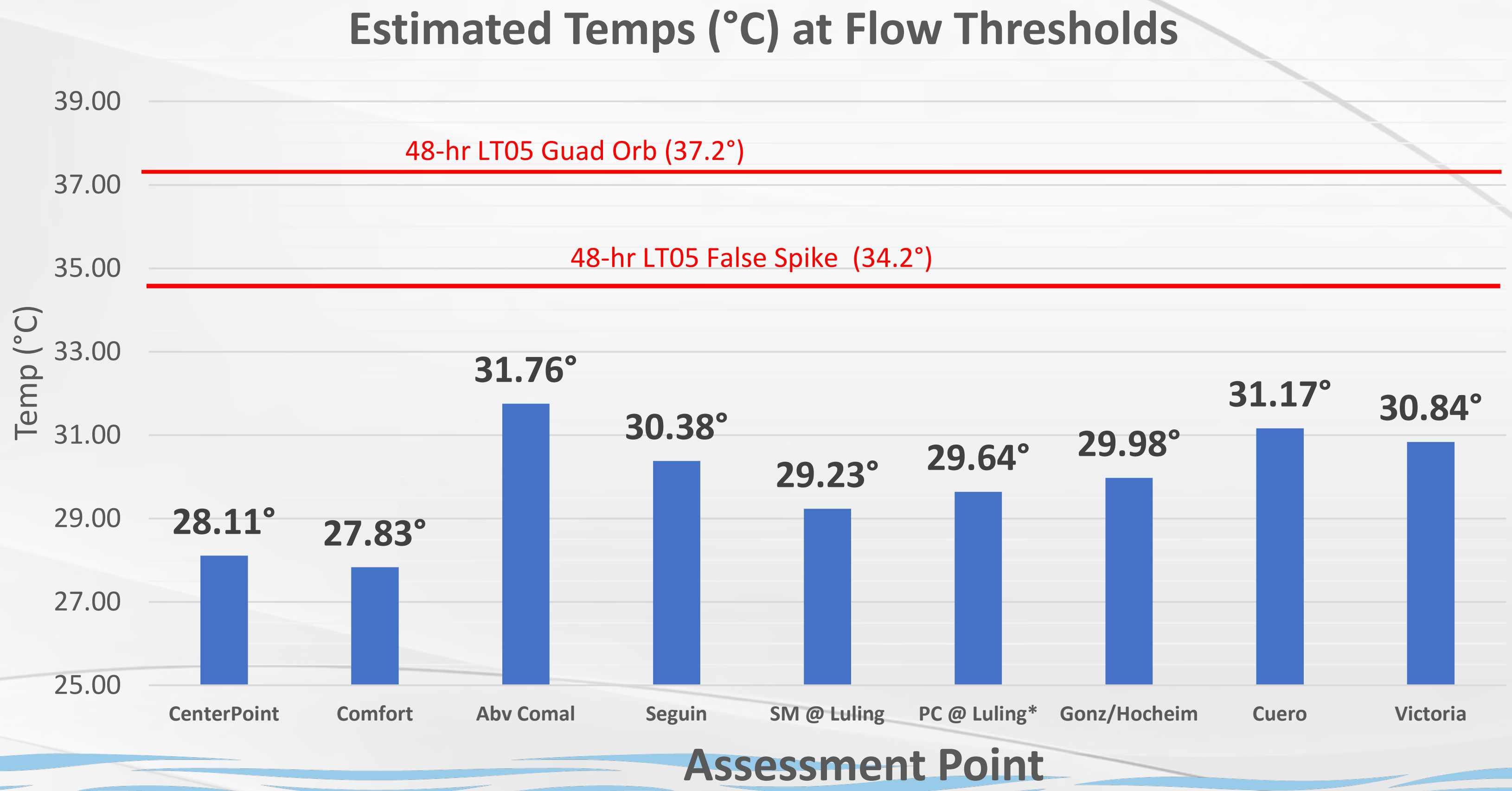
- Habitat impacts triggered earlier and more often at every site

- False Spike 48-hr LT05 (34.2°C) exceeded (based on regression):
  - Seguin at 8 cfs
  - Cuero at 9 cfs
  - Victoria at 3 cfs



Temp Effects Accounted for in Habitat Assessment

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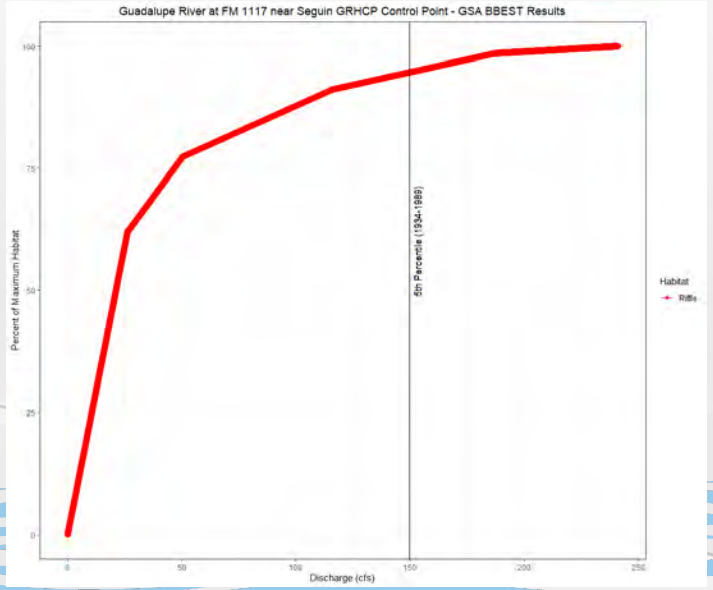
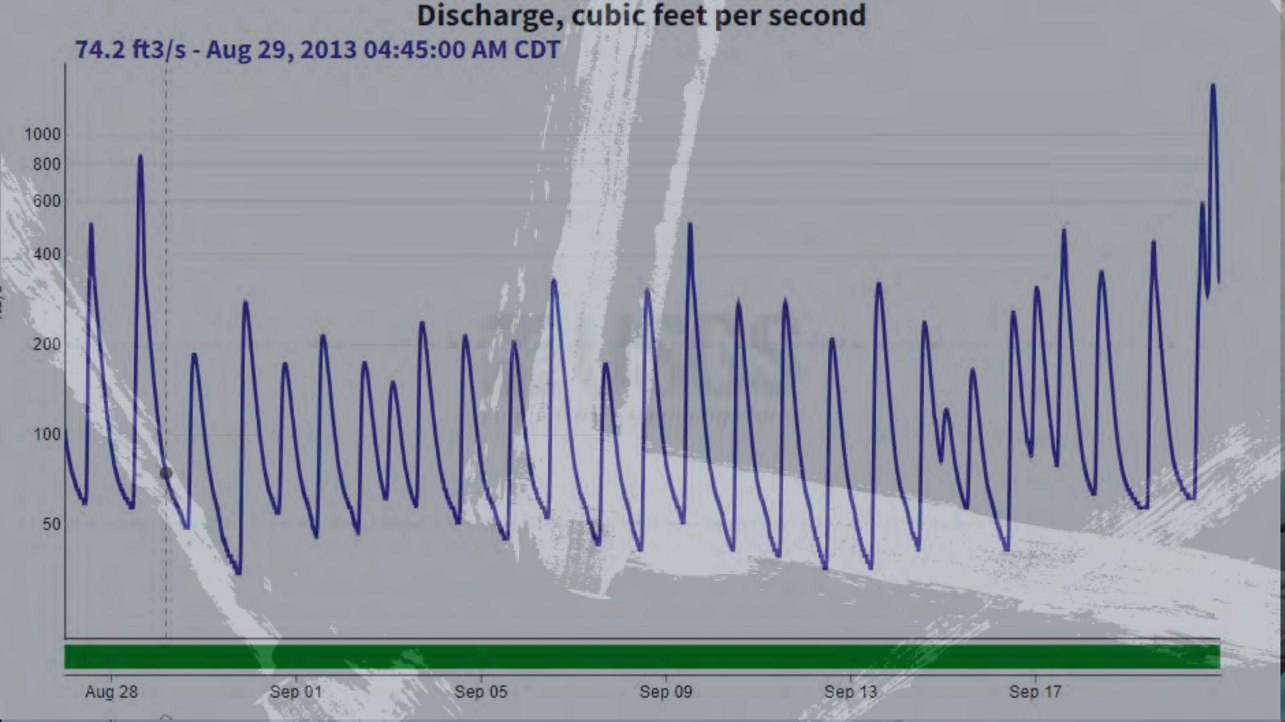
- Habitat curve methodology accounts for interrelated and compounding effects of temperature and flow on mussels
- Curves produce greater take per cfs as flows decline
  - Extending curves to zero habitat at zero flow is conservative approach
  - i.e., rate of take increase as flows decrease
- Adding temp impacts on top of habitat impacts results in double counting and overestimation of take





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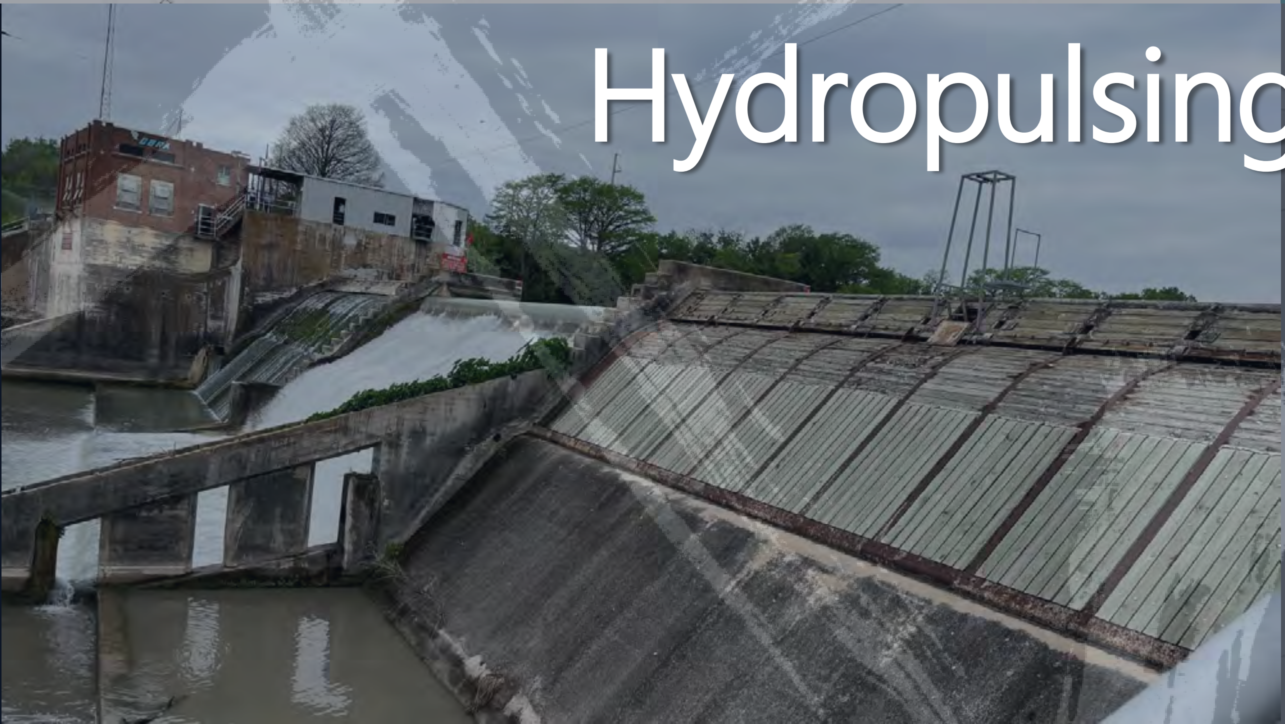
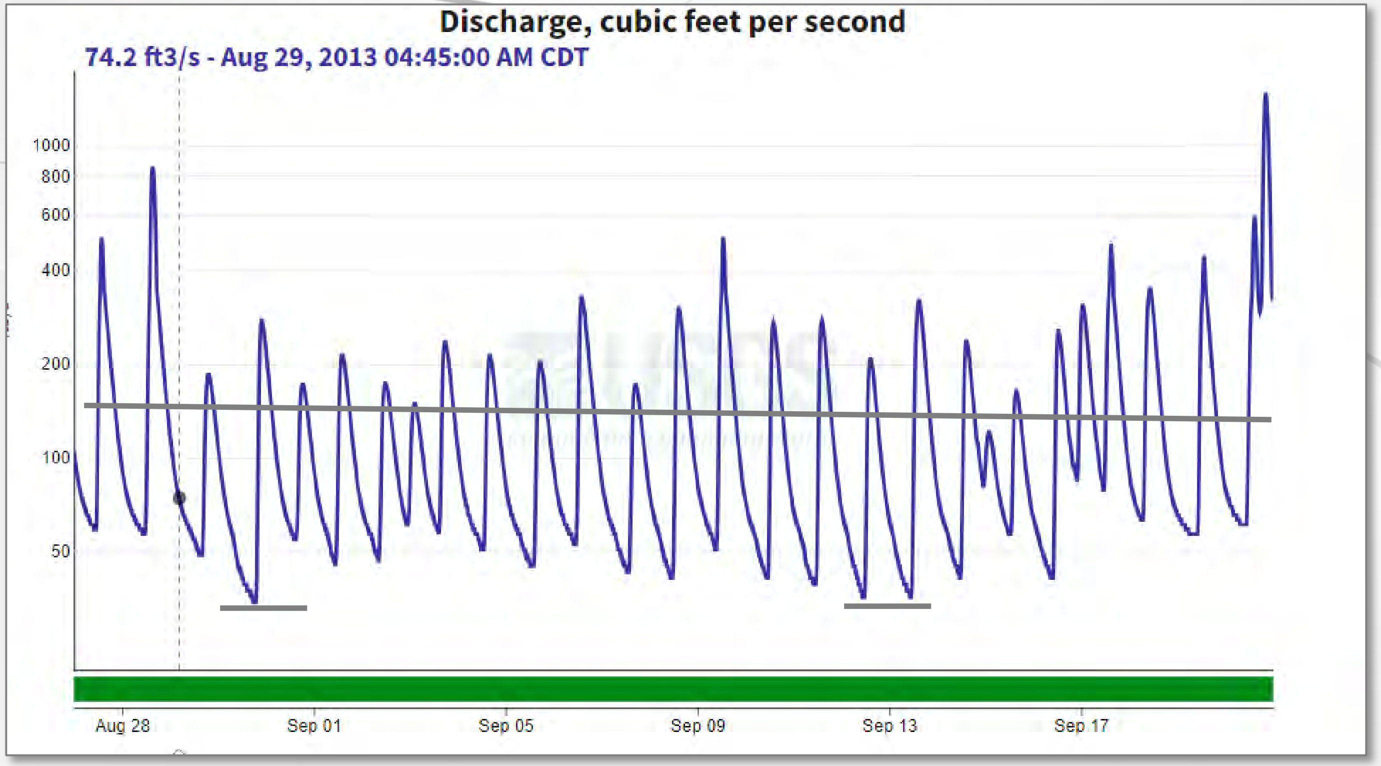


Hydropulsing Assessment

Hydropulsing Assessment

- Daily mean from WAM doesn't accurately reflect hydropulsing impacts
- Daily min is most important stat from mussel habitat/take perspective
- Need method for estimating daily min from daily mean
- How often does it happen?



GBRA Hydrolakes:

- GBRA Hydro pools water in Dunlap <550 cfs – cascades to downstream lakes
- Guadalupe at FM 1117 nearest USGS gaging station
- Daily occurrence except for occasional maintenance, etc.

Hydropulsing Assessment - GBRA

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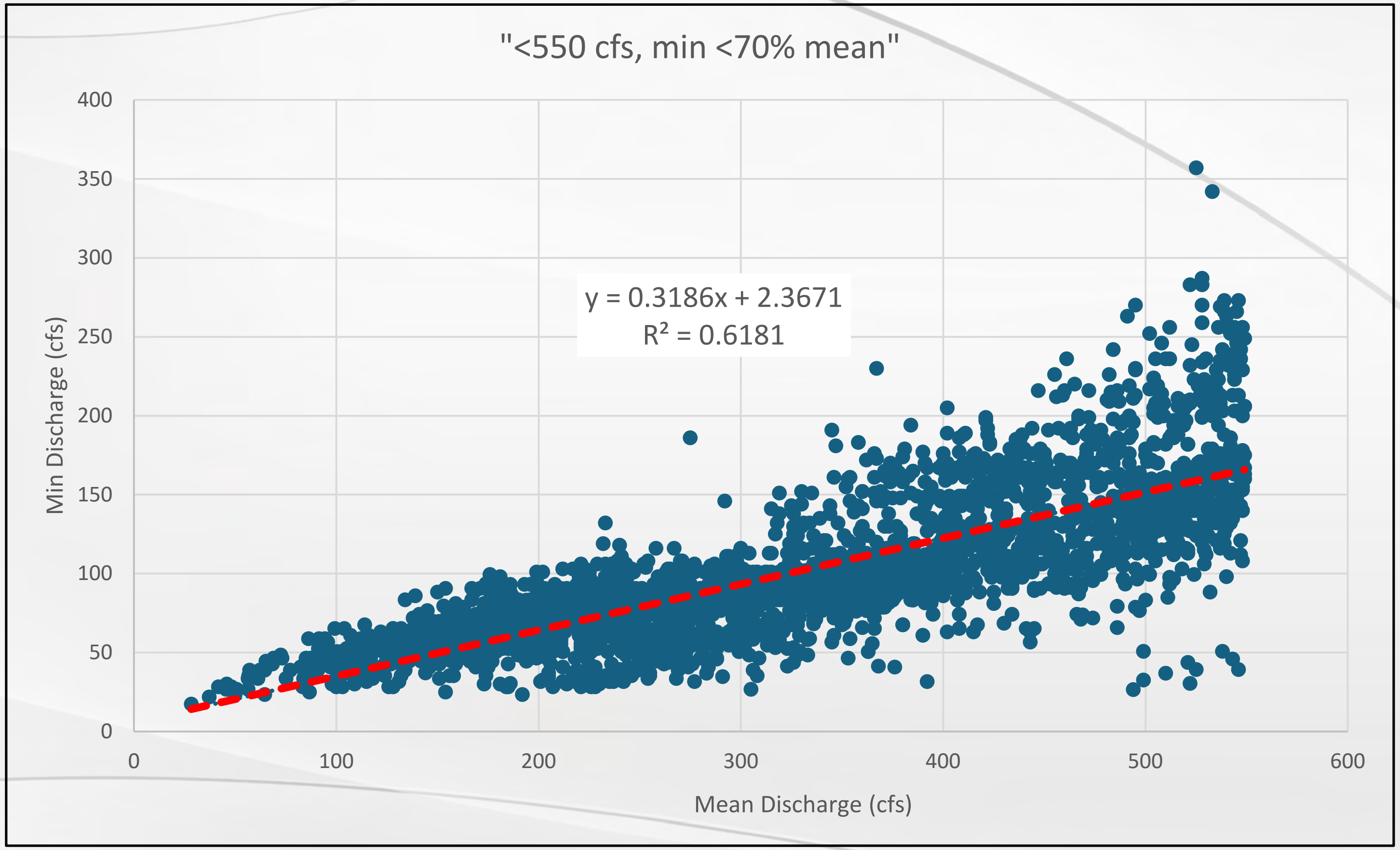
- Hydropulsing appears to occur about 98% of time when below 550 cfs
  - 2005-2019 POR at FM 1117 (prior to Dunlap failure)
- Apply this equation to estimate min daily habitat conditions 100% of time at flows below 550 cfs @ FM 1117



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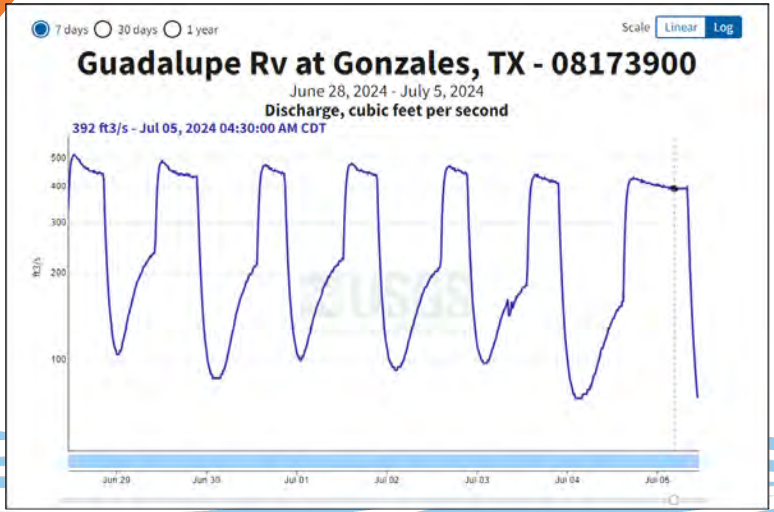
Hydropulsing Take Calculation Example



Hydropulsing Take Example

Guadalupe Orb at FM 1117

Trigger = 106 cfs

Year X Reference

- WAM Min Daily Mean = 432 cfs
- Min flow estimate = 140 cfs

Year X Hydro Run

- WAM Min Daily Mean = 250
- Min flow estimate = 82 cfs

Estimated Min Using Regression of WAM Mean

Y= 0.3186x + 2.3671

Hydropulsing Take Example

Guadalupe Orb at FM 1117

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Trigger = 106 cfs

Occupied Habitat = 61,904 m2

Baseline # of Guad Orbs = 8,677

Year X Reference

- Min flow in Reference = 140 cfs
- 94% of riffle/run habitat available
- 58,189 m^2 x 0.14 mussels/m^2
- 8,146 Guad Orb

Year X Covered Activities

- Min flow in CA Run = 82 cfs
- 84% of riffle/run habitat available
- 51,999 m^2 x 0.14 mussels/m^2
- 7,279 Guad Orb

Year X Hydro Take = 8,146 – 7,279 = 867 Guadalupe Orb

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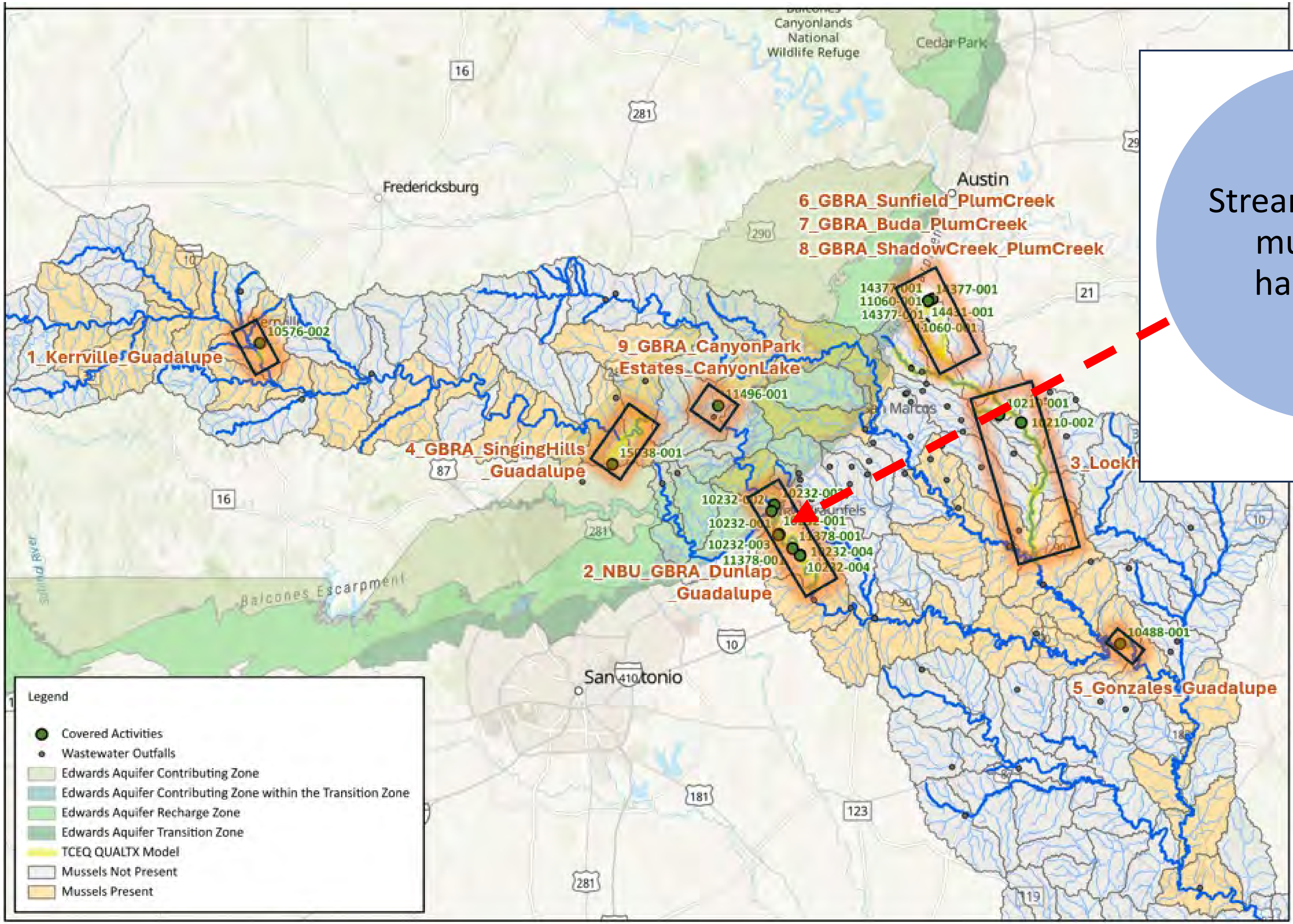
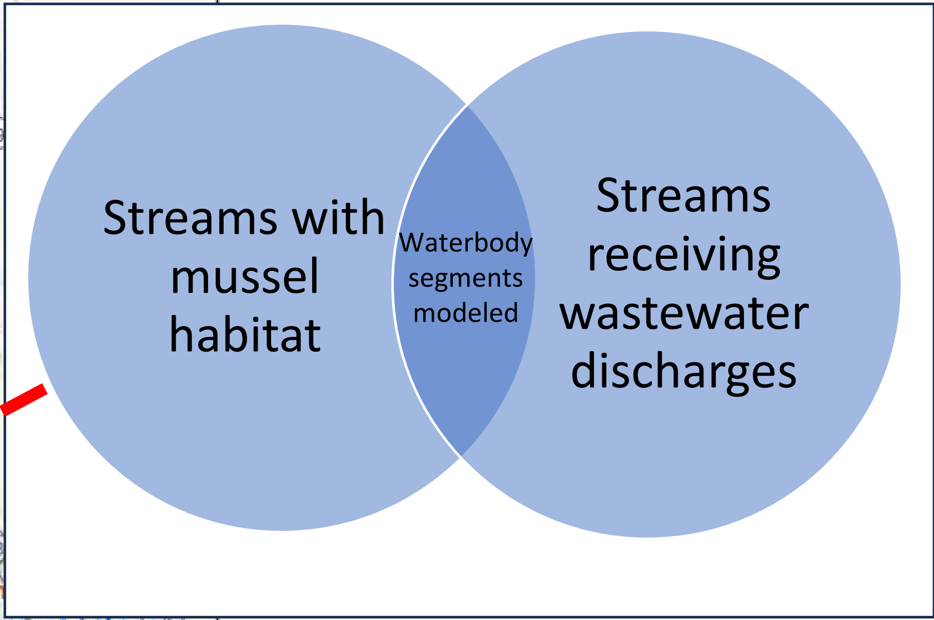
Wastewater Treatment Facility Impact Assessment





Streams that have mussel habitat & are impacted by Covered Activities wastewater treatment plants can be evaluated with TCEQ QUAL-TX models.

QUAL-TX Modeling Results: Guad at Lake Dunlap

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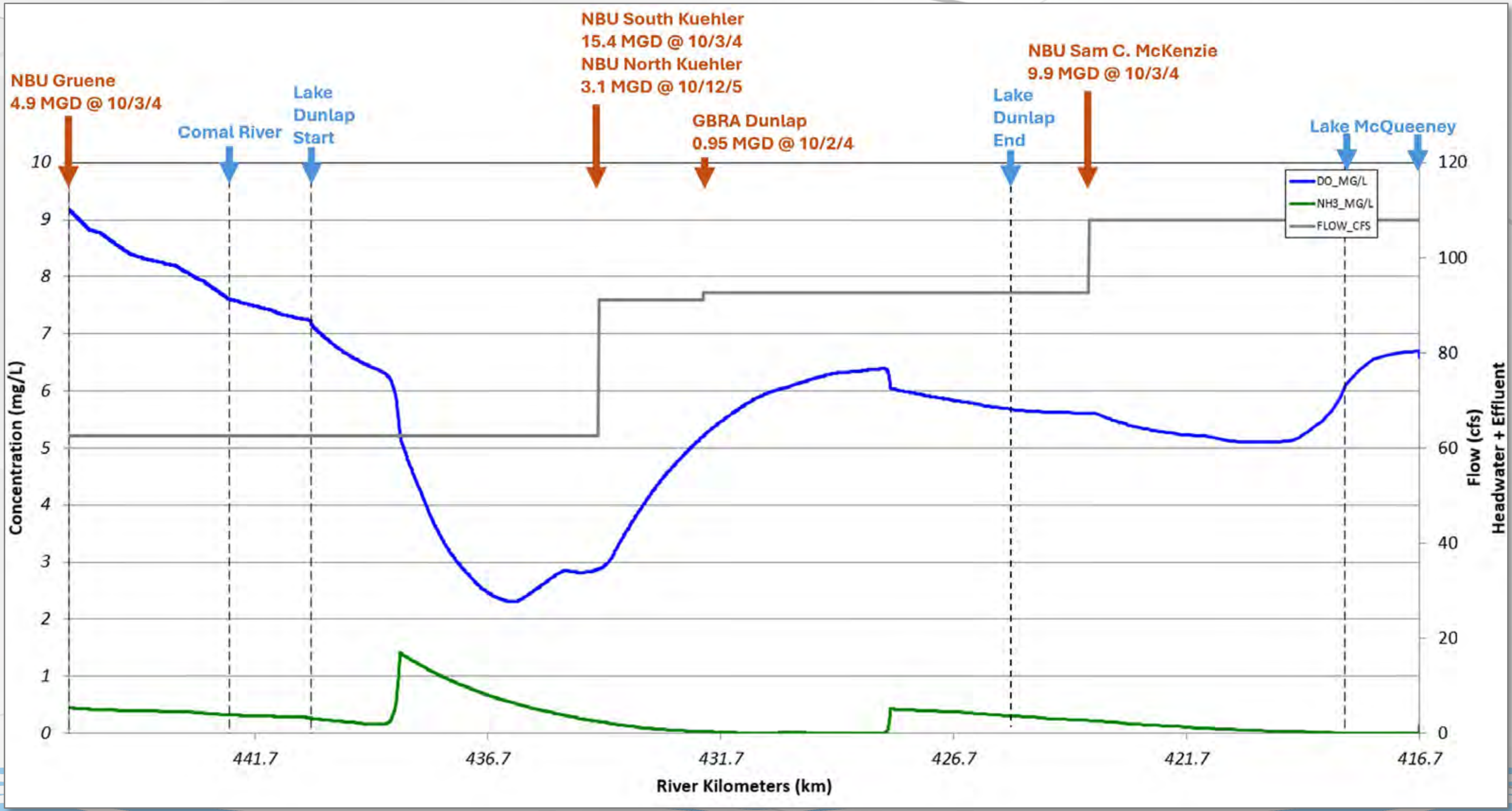

Wastewater Treatment Facility Assessment

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- Distance upstream static at 100 ft (30.5m) (TAC §307.8)
- Distance downstream starts at 300 ft (91.5 m) and increases by 10% for each range of discharge (TAC §307.8)
- Intermittent or unnamed - Assumed 5m wide
- Named tributary - Assumed 10 m wide
- Guadalupe River - Width estimated using Google Earth
- Lake Dunlap and Flat Rock Lake - 100 ft radius used (TAC §307.8)

Effluent Volume (MGD)	Distance upstream from Q point (m)	Distance downstream from Q point (m)
0-1	30.5	91.5
1-5	30.5	100.7
2-10	30.5	110.8
10-25	30.5	121.9
25-50	30.5	134.1
50-100	30.5	147.5
>100	30.5	162.3

WWTF Assessment Example

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- Example calculation: Lockhart #2 WWTF – Guadalupe Orb
  - total area = 1,312 m^2 x .26 (habitat occurrence) = 341.1 m^2 available habitat
  - Occupied habitat = 341.1 m^2 x 0.01 (species occurrence) = 3.41 m^2
  - Take estimate = 3.41 m^2 x 0.10 (species density) = 0.34 Guadalupe Orb taken/year


Q&A

Effects Analysis & Take Methods:

Whooping Crane

Overview of Take Assessment Approach

Freshwater Inflow → Salinity → Vegetative Productivity → Whooping Crane Crane Carrying Capacity Units → Whooping Crane Take in WCCCUs

General Overview of Approach

- Hydrology and Hydrodynamic Modeling to calculate salinity based on fresh water inflow (FWI) at numerous locations throughout the Guadalupe Estuary – establish relationship

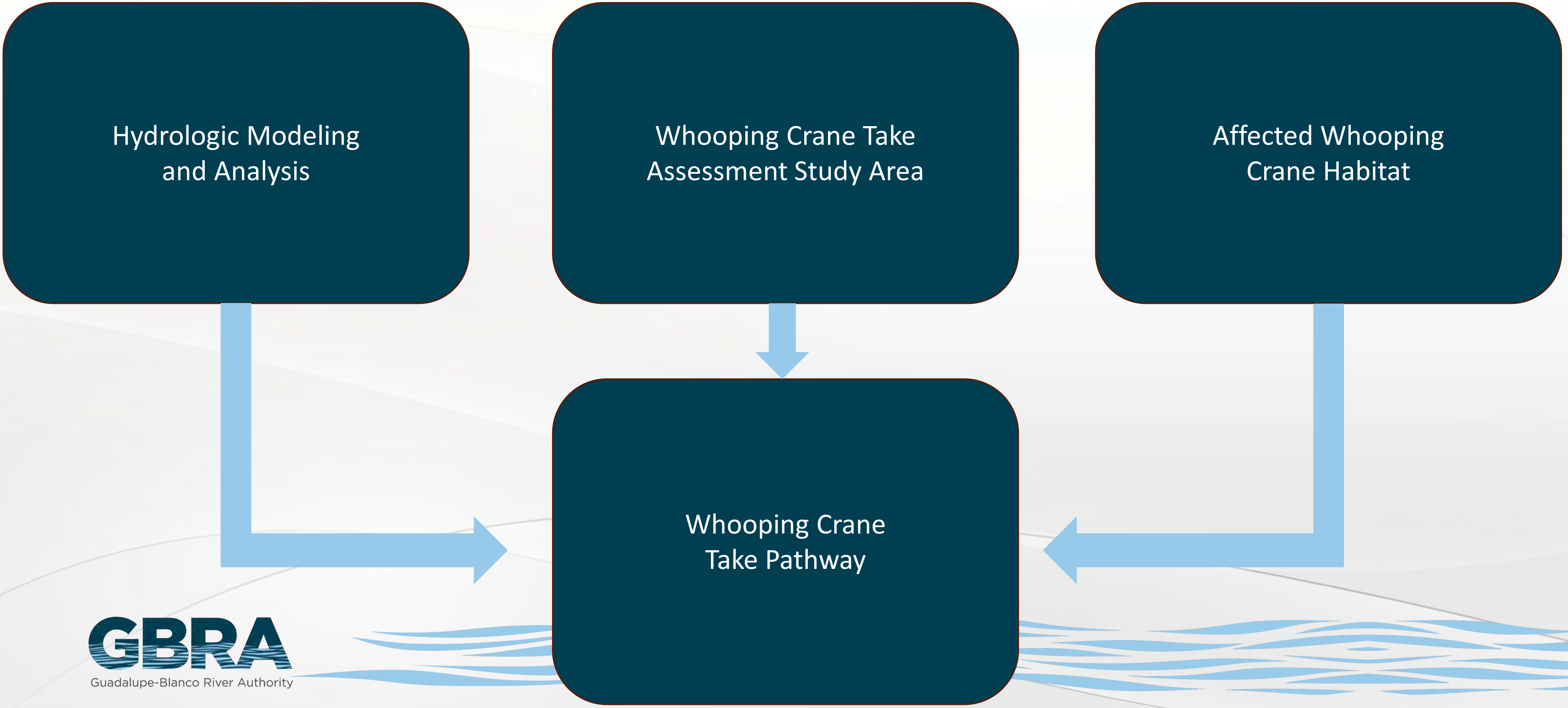
- Define Area of Effect to Whooping Crane Habitat as National Wetlands Inventory (NWI) Estuarine Emergent Marsh in the Guadalupe Estuary

- Establish Baseline Whooping Crane Habitat Conditions – Current (2020) Potential Whooping Crane Carrying Capacity Units (WCCCUs) for NWI Estuarine Emergent Marsh (Metzger et al. 2020)

- Use Vegetative Productivity Regression to Calculate Reduction in Saline Marsh Productivity between Natural Flow and Activities Model Scenarios

- Take Calculated as the reduction in WCCCUs in the Guadalupe Estuary over Permit Term due to decreased saline marsh productivity – to be Apportioned

Summary: Components of the Effects Analysis



Hydrologic Modeling and Analysis

- Estuary WAM (1934-1989): NatFlow and Activities Scenarios
- BBEST and Extrap. TxBLEND Salinity Nodes
- Salinity Regressions

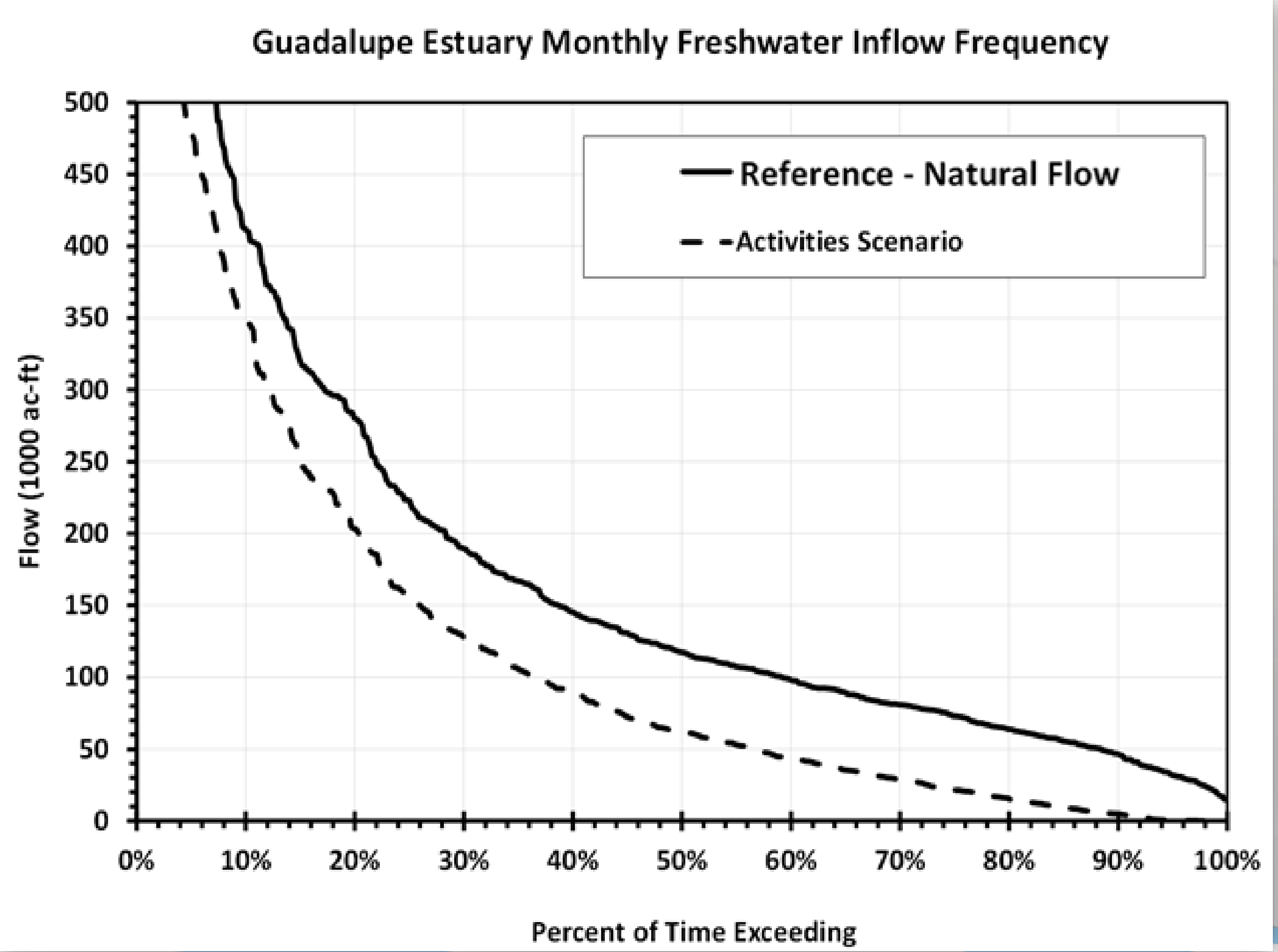
Whooping Crane Take Assessment Study Area

Affected Whooping Crane Habitat

Whooping Crane Take Pathway

Hydrologic Modeling and Analysis - WAM

- Model Period 1934-1989
- FWI combination of gauged and ungauged inflow estimates, plus corrections for diversions of water and wastewater returns below gauges
- Reference Scenario: Natural Streamflow (NatFlow)
- Activities Scenario (Activities): Includes fully authorized use of GRHCP participants and non-participants and no return flows.



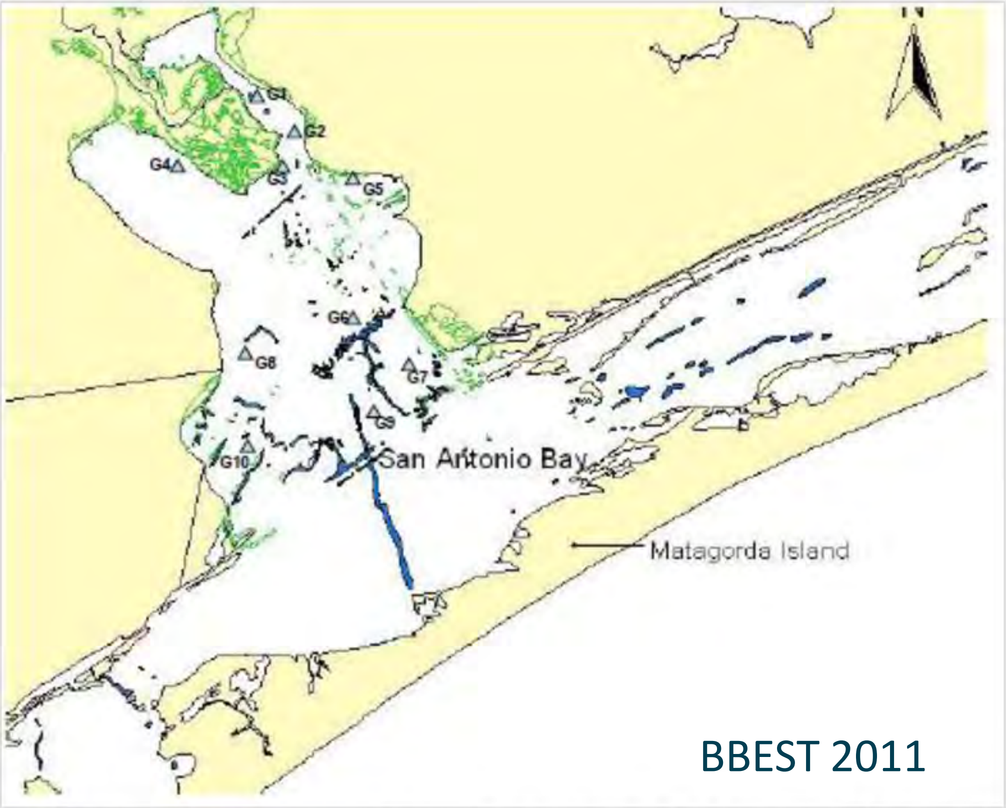
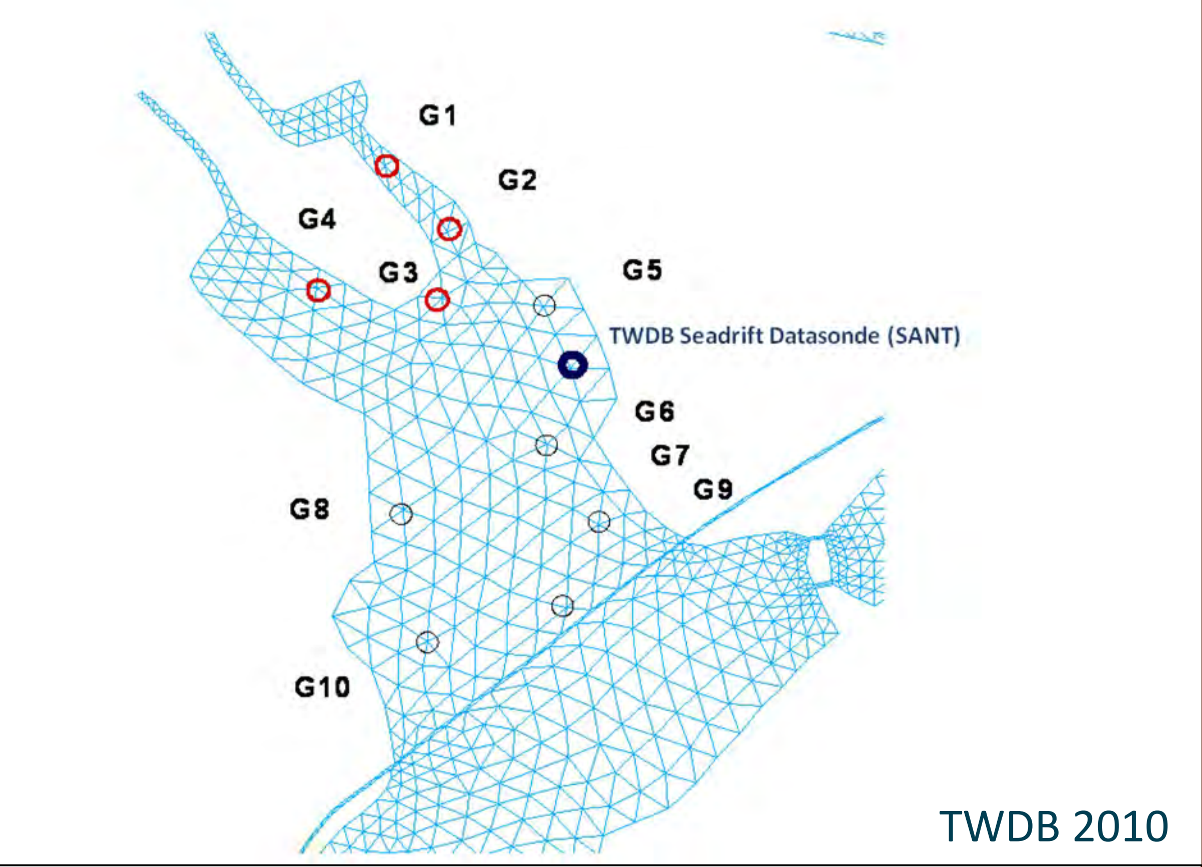


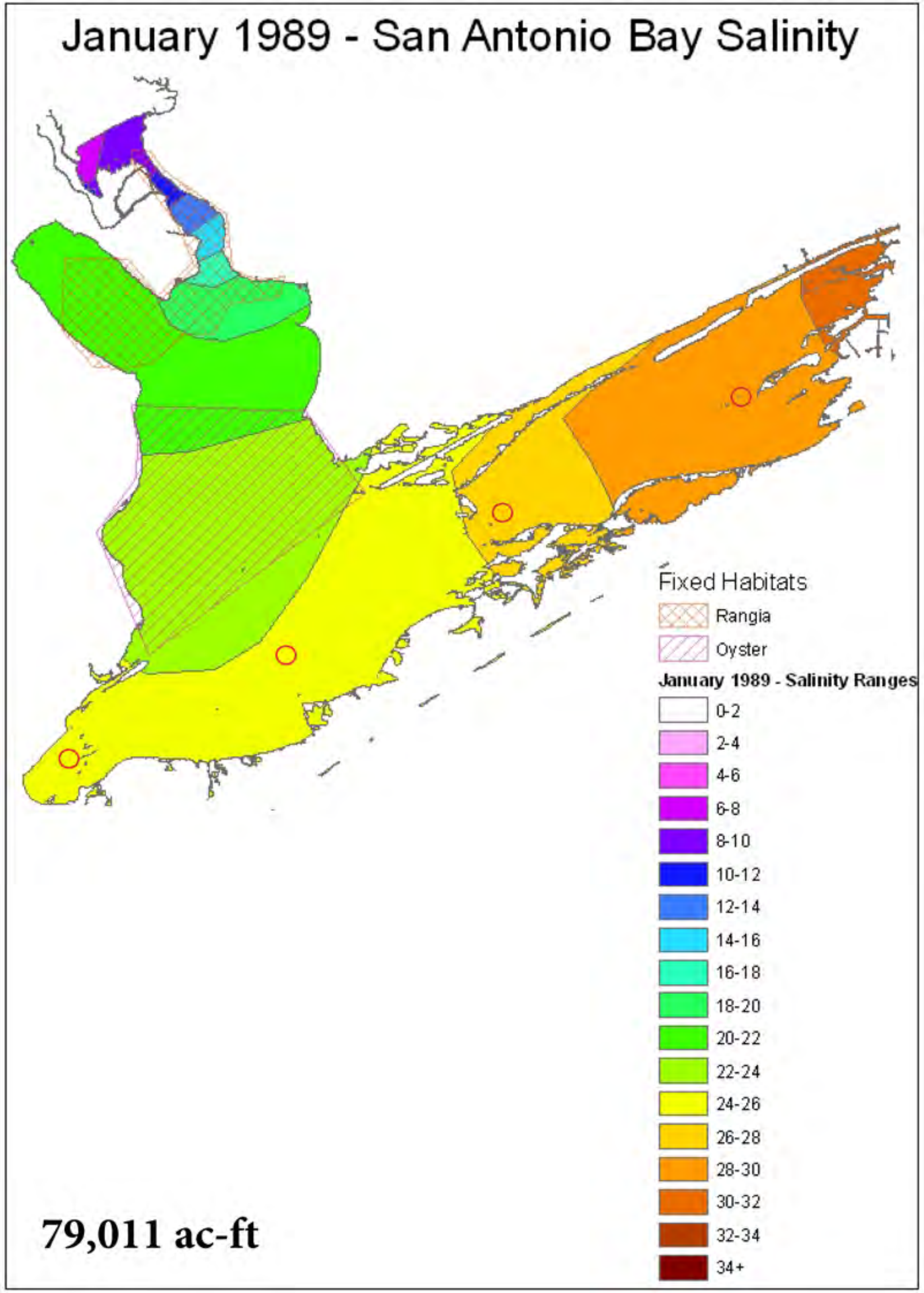
Figure 4.2-8. The initial suite of specific points (triangles) in the Guadalupe Estuary utilized by the GSA BBEST to track salinity through time as predicted by the TxBlend model.



- Monthly average salinity gradients throughout the estuary based on FWI from TxBLEND model
- BBEST (2011) developed regression equations for monthly average salinity based on current and preceding month FWI for 10 nodes (G1 – G10).
- Nodes missing for San Antonio Bay Sound, Ayres Bay, and Espiritu Santo Bay

Extrapolated Salinity Nodes

- Follows BBEST (2011) approach – regression based on monthly TxBLEND salinity output with current and preceding month FWI dependents
- Nodes digitized in Ayres Bay, San Antonio Bay Sound, and Espiritu Santo Bay (west and east)
- Four years of monthly average salinity output: 1989, 1993, 2001, and 2005
- FWI from data provided by HDR (Table A-2, TWDB 2010)
- Max salinity set to 40 ppt and assumptions on minimum salinity based on salinity gradients and trends



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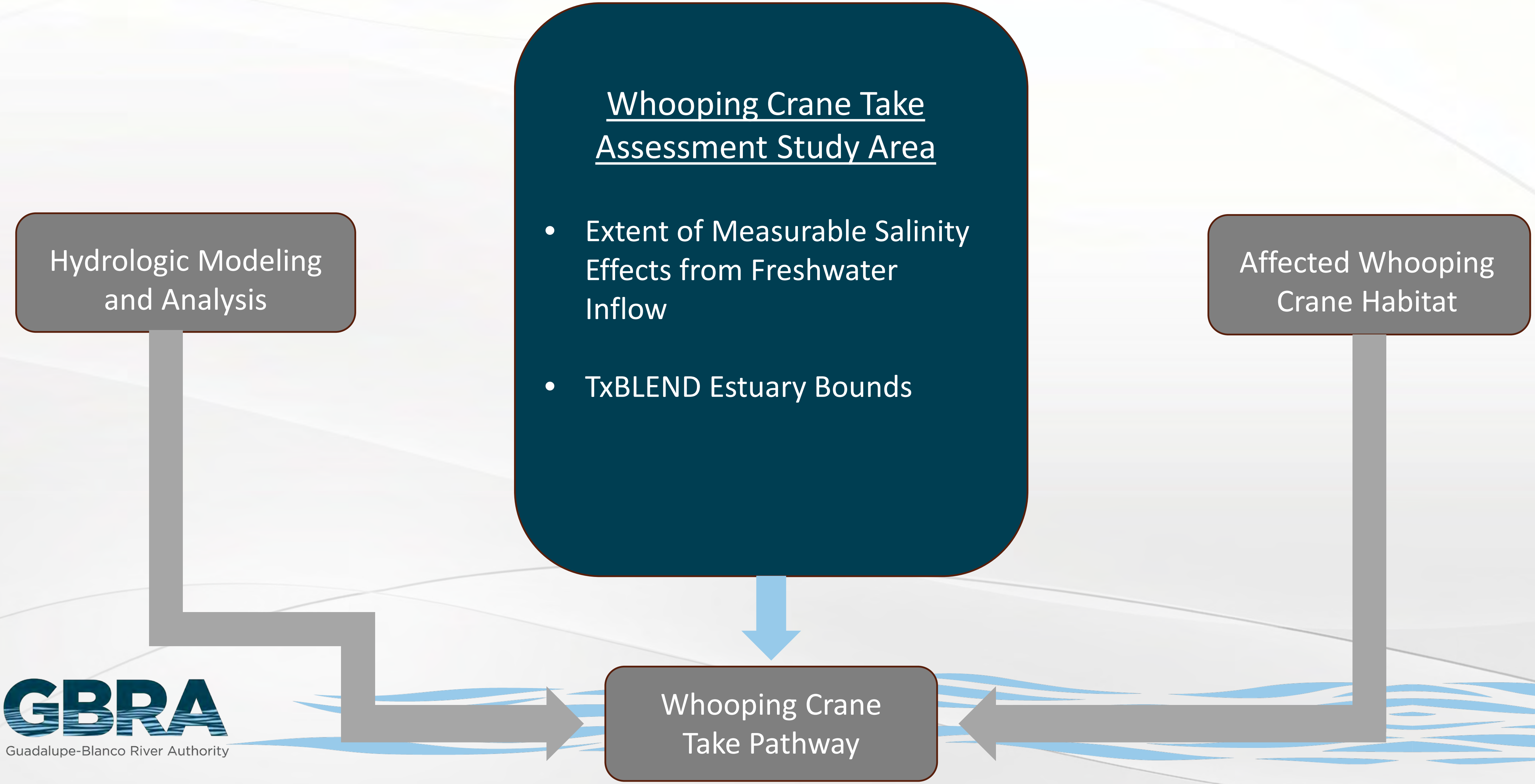
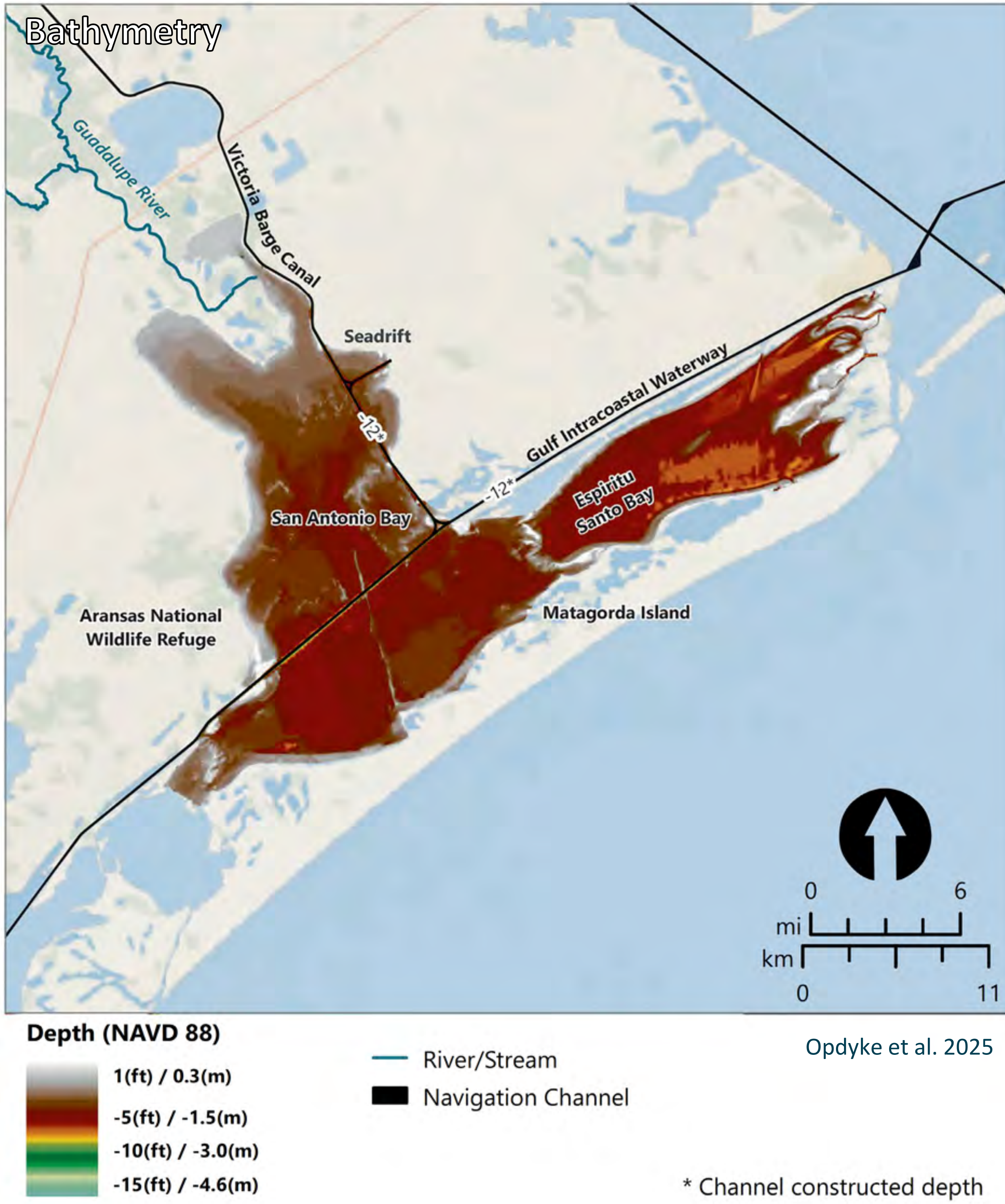
Overview of Take Assessment Approach



Study Area

- Essential to bound the Study Area by the anticipated area of effects to whooping cranes
- Effects pathway driven by changes to salinity in the Guadalupe Estuary between NatFlow and Activities Scenarios according to FWI
- Spatial extent of anticipated changes in salinity must be defined by understanding salinity gradients in the estuary, circulation patterns, and hydrologic modeling
- Guadalupe Estuary is an extremely shallow system lacking a deep draft channel and with muted tidal connection to the Gulf of Mexico through Pass Cavallo and Cedar Pass



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Defining the Study Area

- Whooping Crane take assessment Study Area was based on evaluation of the relationship between FWI and salinity throughout the Guadalupe Estuary
- Upper boundary established as State Highway 35 – above Mission Lake
- Lower boundary includes the entirety of the Guadalupe Estuary as defined by TxBLEND model limits

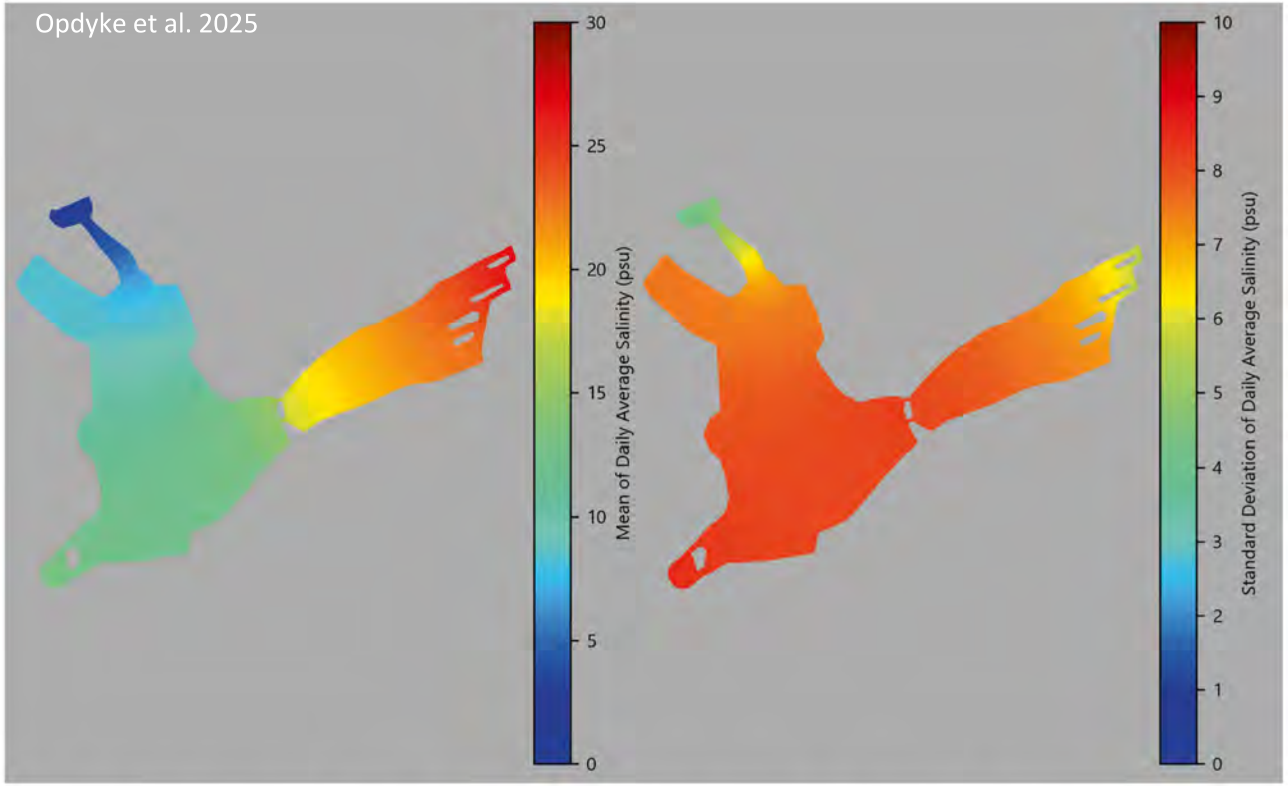
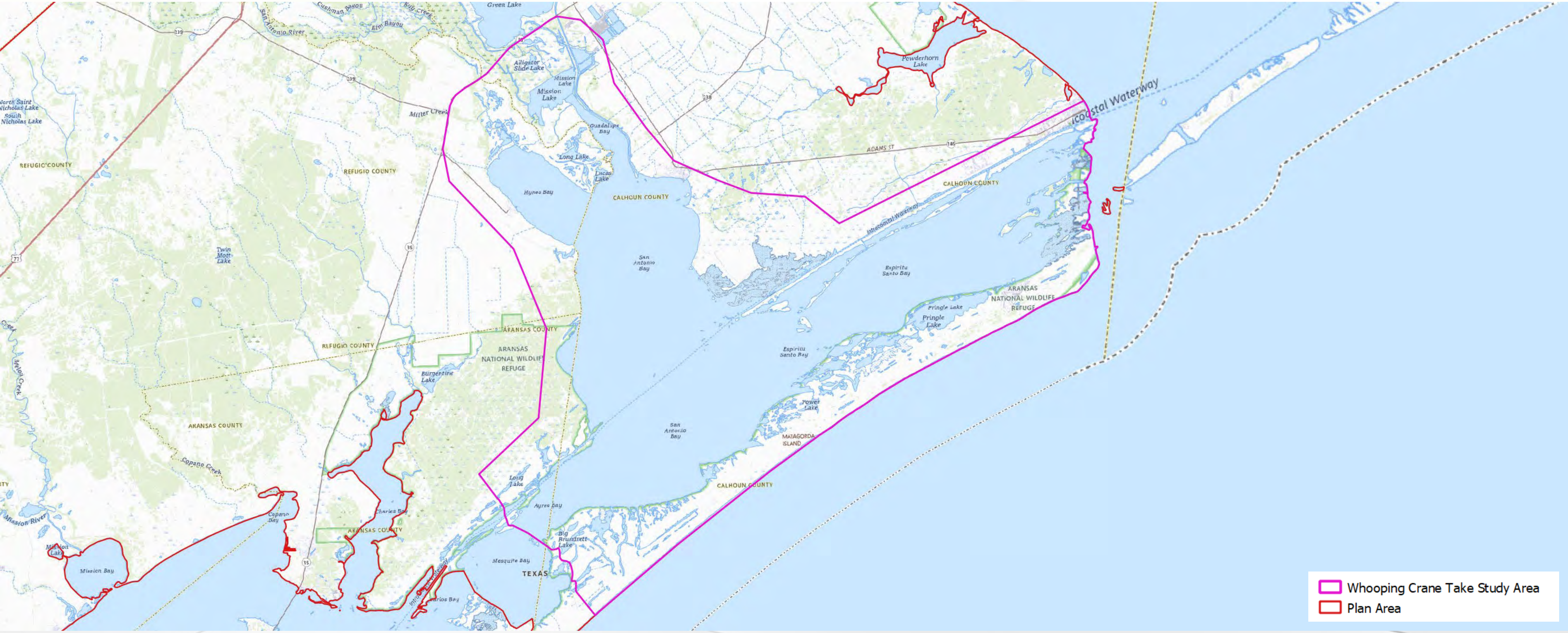


Fig. 57 Salinity for the Guadalupe Estuary, the long-term average of daily average salinity values on the left, and the standard deviation of the daily average on the right



Whooping Crane Take Study Area
Plan Area
Intracoastal Waterway
Powderhorn Lake
Green Lake
San Antonio River
Cushman Bayou
Elm Bayou
Alligator Slide Lake
Mission Lake
Guadalupe Bay
Long Lake
Lucas Lake
Hynes Bay
Miller Creek
North Saint Nicholas Lake
South Nicholas Lake
REFUGIO COUNTY
CALHOUN COUNTY
ADAMS ST
San Antonio Bay
Espiritu Santo Bay
Twin Mott Lake
ARANSAS COUNTY
ARANSAS NATIONAL WILDLIFE REFUGE
Burgentine Lake
Pringle Lake
Power Lake
MATAGORDA ISLAND
Copano Creek
Copano Bay
Charles Bay
Mission River
Mission Lake
Mission Bay
Ayres Bay
Big Brundrett Lake
Mesquite Bay
TEXAS

Overview of Take Assessment Approach

Hydrologic Modeling and Analysis

Whooping Crane Take Assessment Study Area

Whooping Crane Take Pathway

Affected Whooping Crane Habitat

- NWI Estuarine Emergent Marsh
- Current Potential WC Carrying Capacity Units (Metzger et al. 2020)
- Salinity Segmentation and Node Assign.

Affected Whooping Crane Habitat

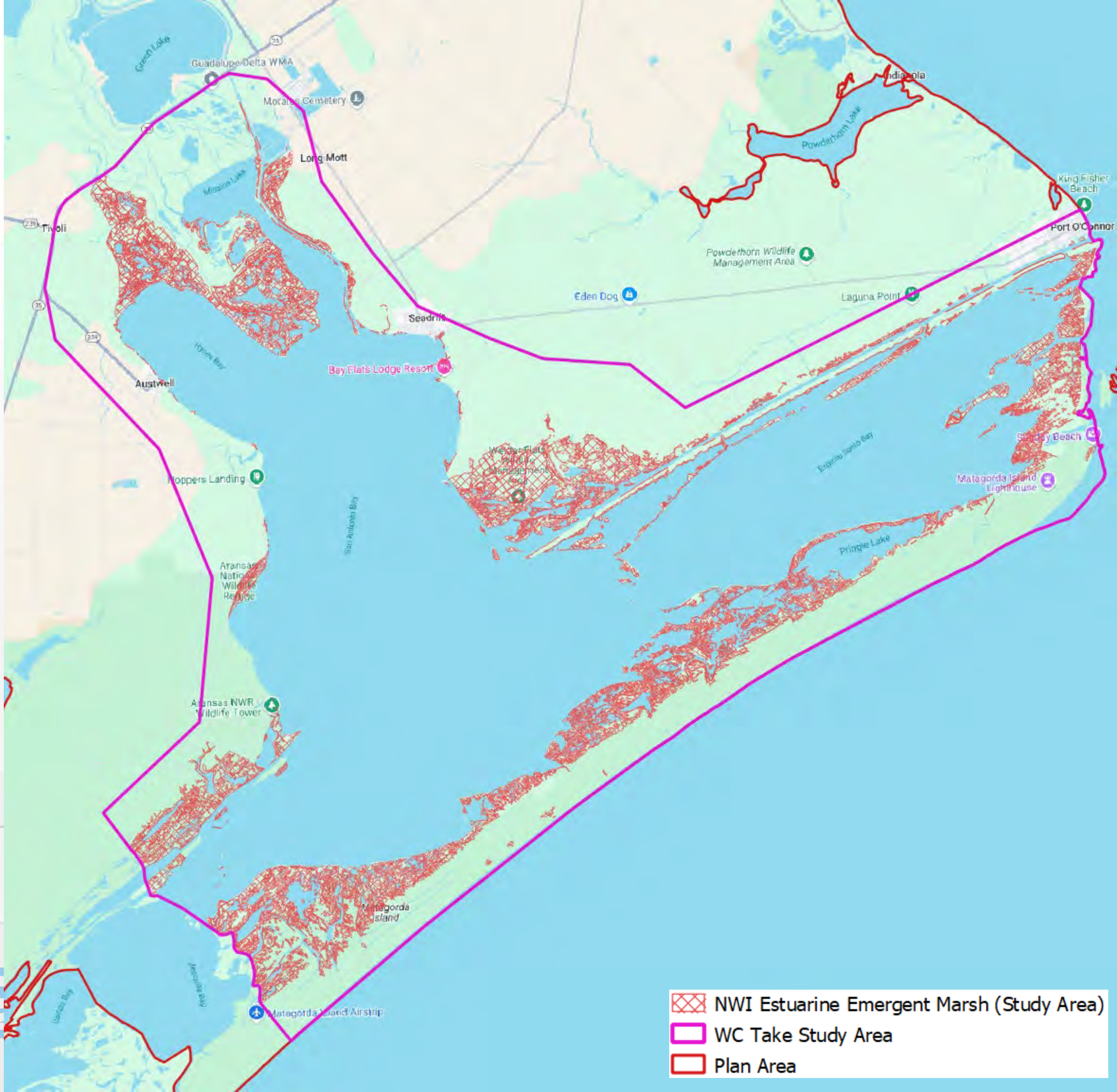
- Sought to spatially define whooping crane habitats within the Study Area that would be **measurably affected** by changes in salinity from covered activities

- Whooping cranes primarily use salt marsh habitats on their wintering grounds (e.g., Chavez-Ramirez 1996)

- Key importance of salt marsh supported by winter habitat use and suitability studies (e.g., Metzger et al. 2020, Golden et al. 2022, Lehnen et al. 2024)

Affected Whooping Crane Habitat

- National Wetlands Inventory (NWI) data (USFWS 2008) acquired and clipped to the Study Area in GIS
- Extracted NWI features classified as Estuarine Emergent Marsh
  - Includes regularly flooded and irregularly flooded classes
  - Synonymous with categories used by Metzger et al. (2020)
- Delineates tidally influenced marshes – landward extent of "where bay water goes"
- Referenced DEMs and tidal datums



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Establish Affected Whooping Crane Habitat Conditions – Potential Carrying Capacity Units (WCCCUs)

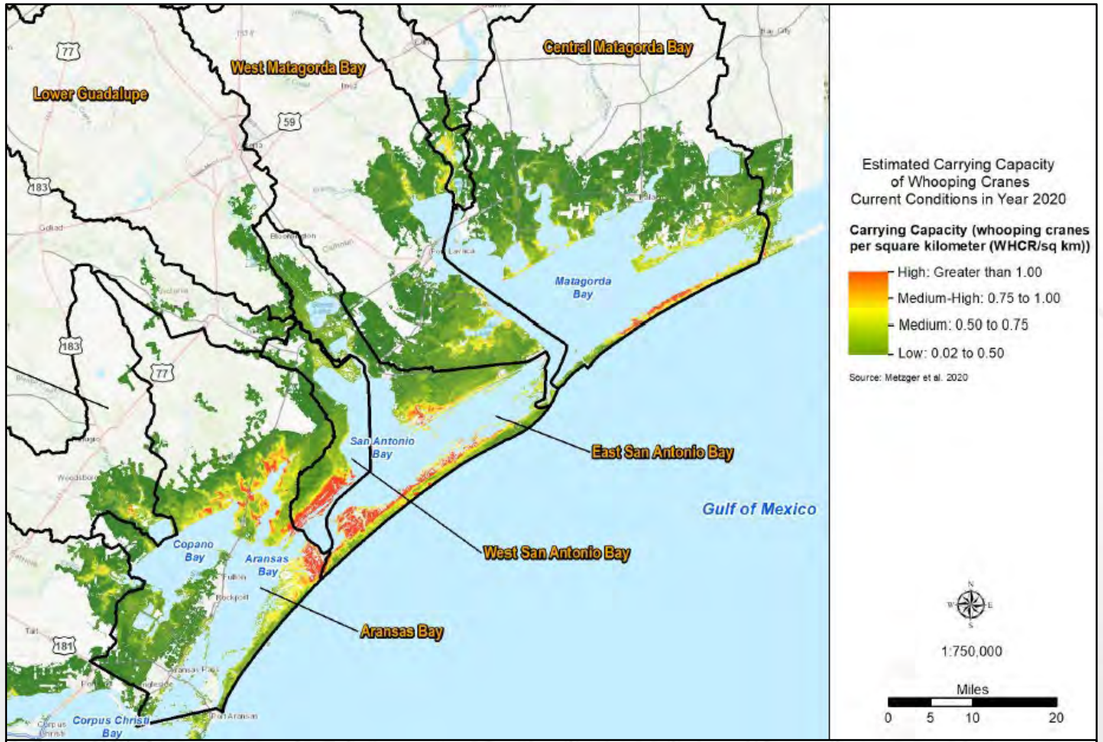
- Metzger et al. (2020) used whooping crane density data and habitat selection models to calculate and map whooping crane habitat suitability and potential carrying capacity units (WCCCUs) for Current Conditions (2020)

- For our take assessment, GIS analysis was used to assign Current Potential WCCCUs for NWI Estuarine Emergent Marsh based on overlap

Table 2

Output from random forest model. Variable importance is defined as percent increase Mean Squared Error (MSE). The higher the percent increase MSE, the more important the variable was to the final model.

Variable	% increase MSE
Salt marsh	1.03
Distance to Estuarine water	0.83
Irregularly flooded marsh	0.62
Estuarine beach	0.52
Distance to inland open	0.42
Dry undeveloped	0.30
Inland fresh marsh	0.23
Tidal flats	0.08
Density of development	0.06



Identifying sustainable winter habitat for whooping cranes

Kristine L. Metzger [a,*], Sarah E. Lehnen [a], Steven E. Sesnie [a], Matthew J. Butler [a], Aaron T. Pearse [b], Grant Harris [a]

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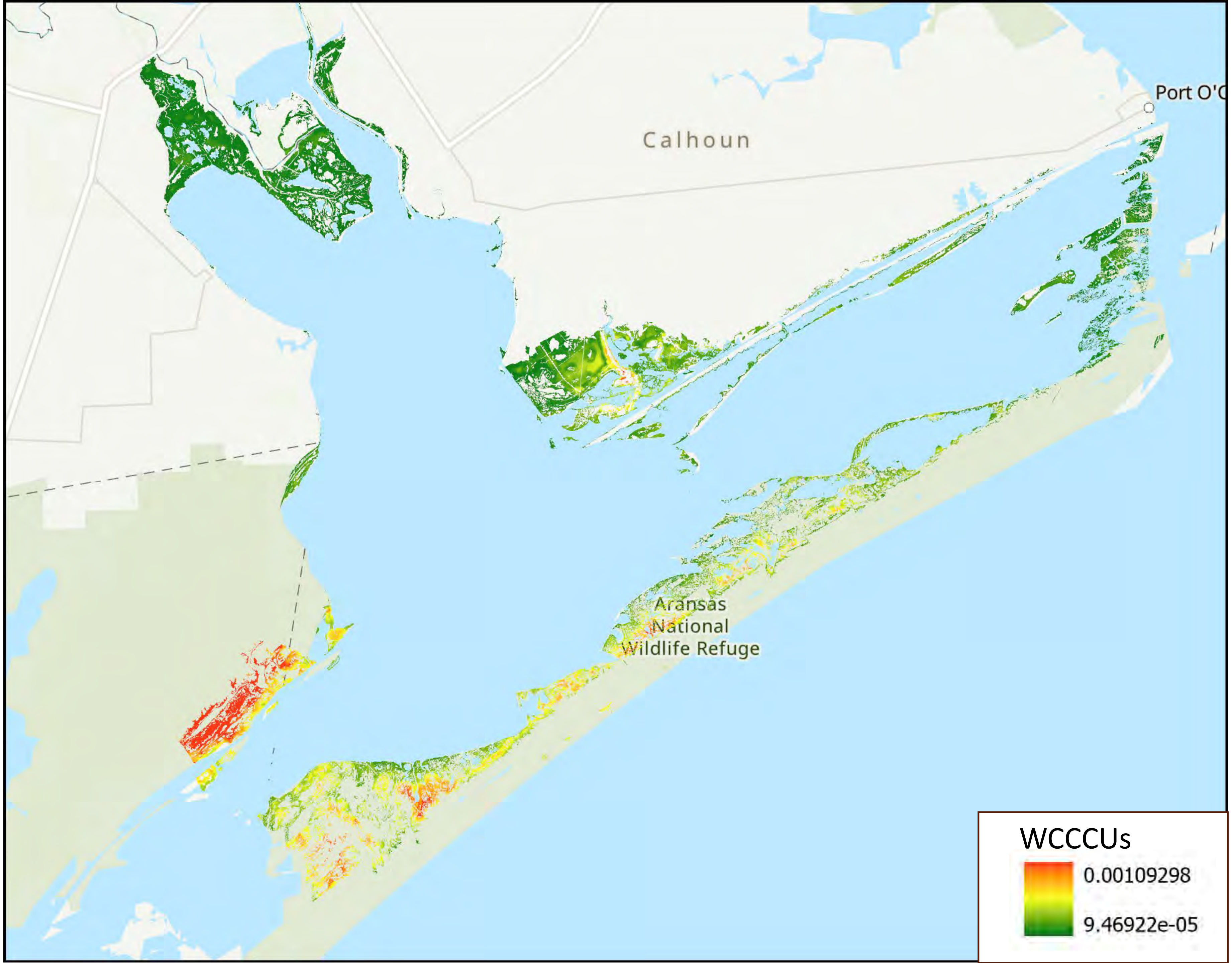
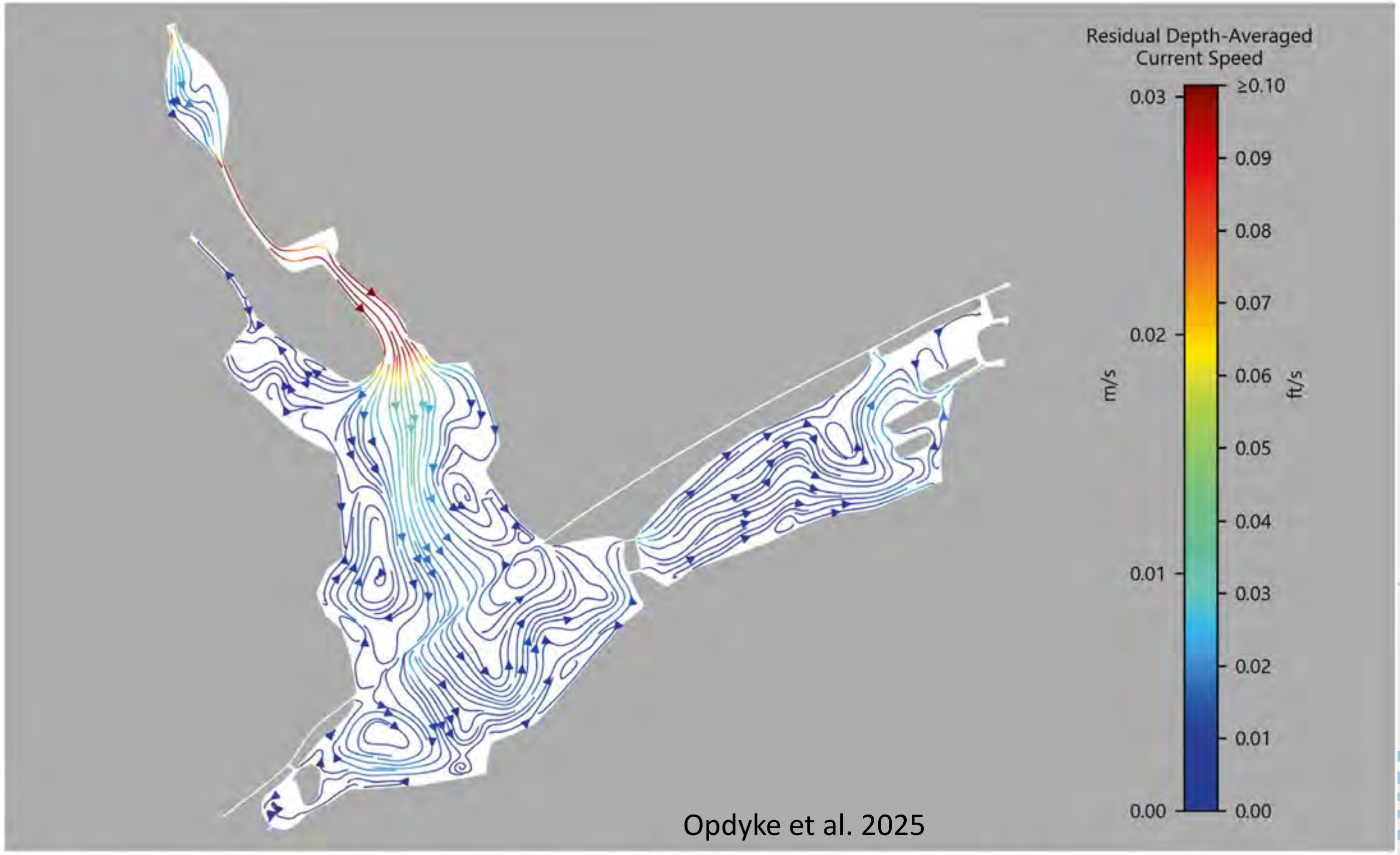

Port O'C
Calhoun
Aransas
National
Wildlife Refuge
WCCCUs
0.00109298
9.46922e-05

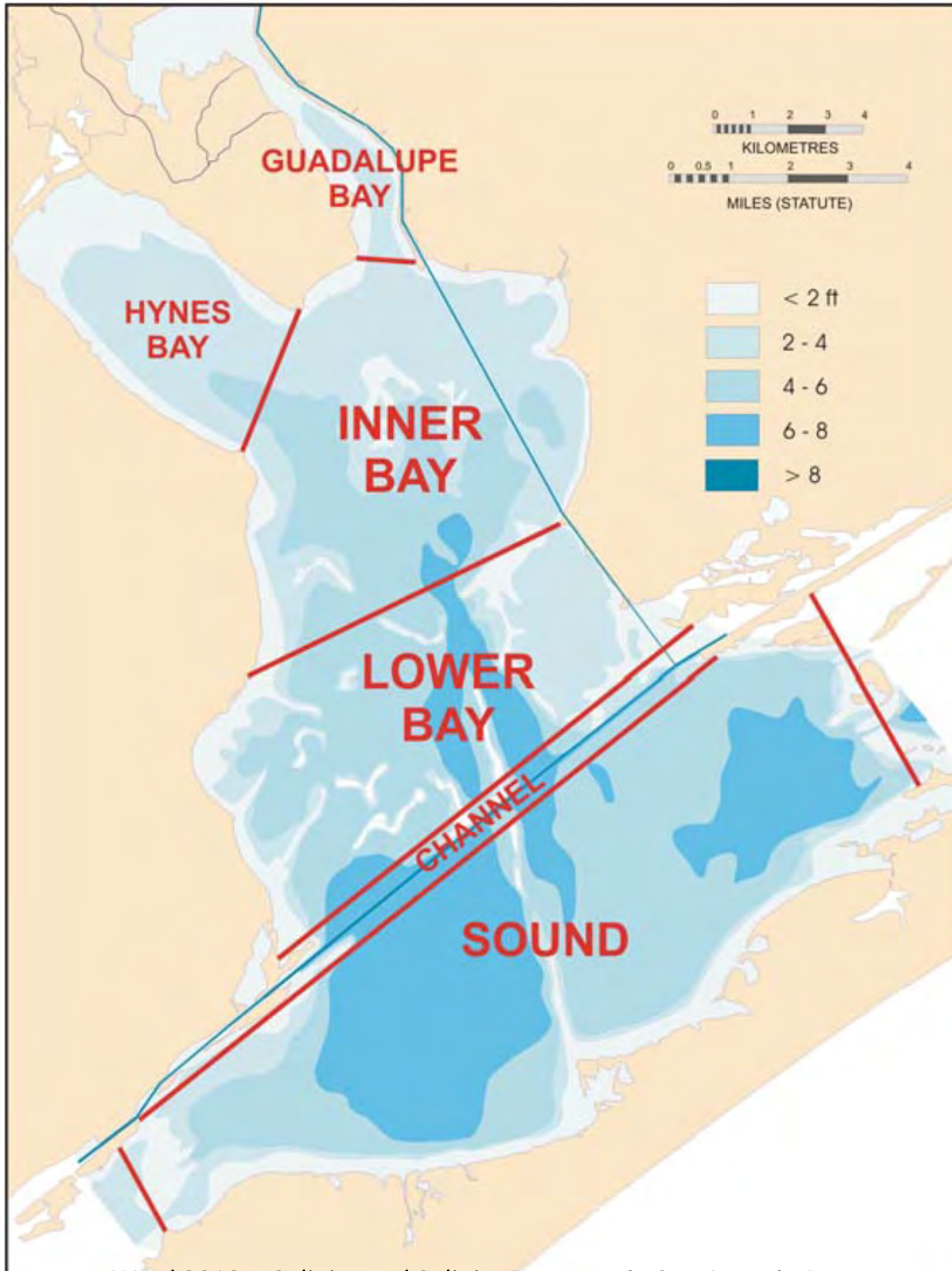
Assignment of Salinity Nodes to Effect Areas

- Based on available research
- Examined studies on flow, circulation, and salinity in the Guadalupe Estuary



Opdyke et al. 2025

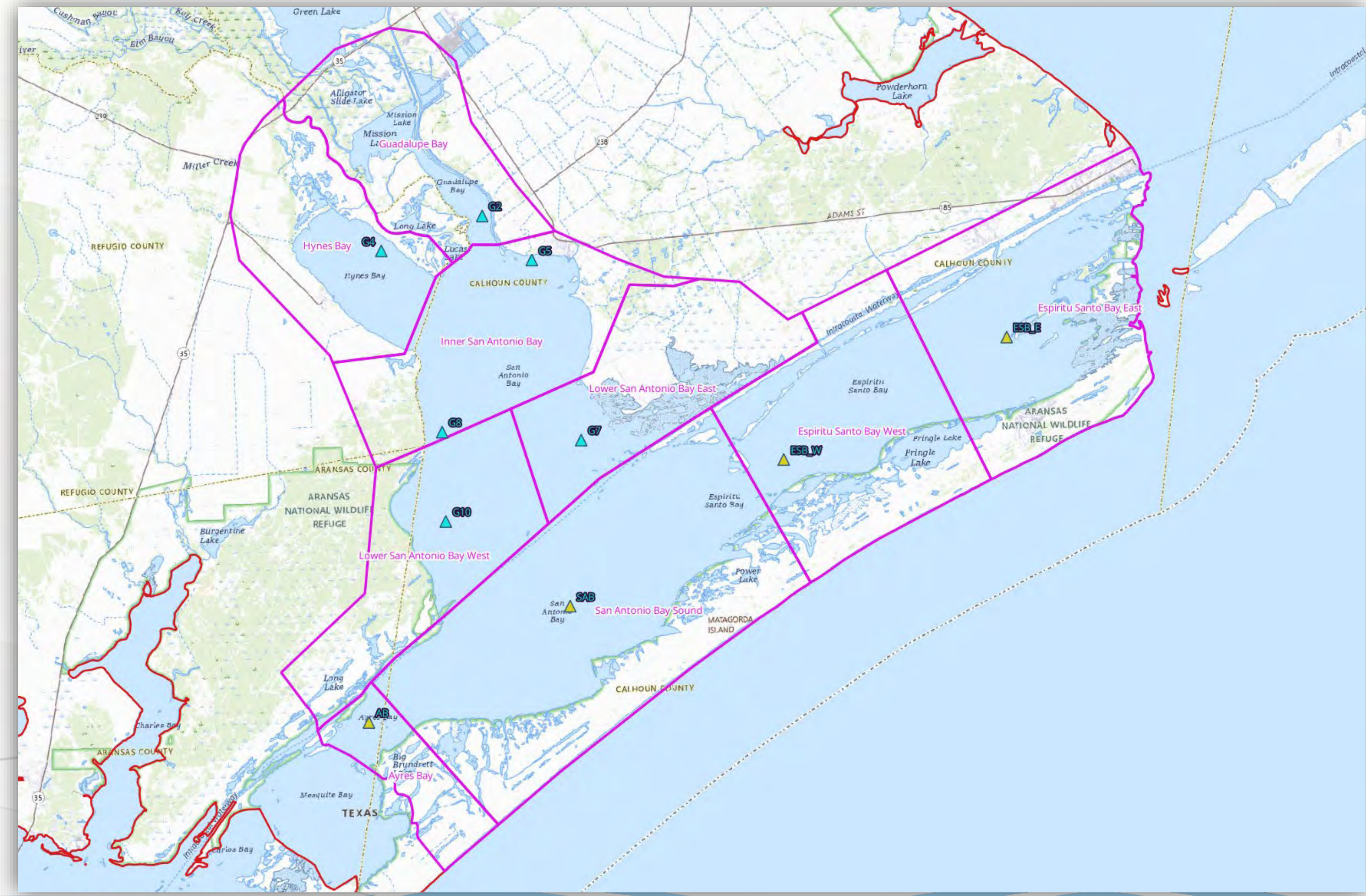
Fig. 40 Average net velocity flowlines for the Guadalupe Estuary. Flowlines color-scaled to the average net velocity



Ward 2013 – *Salinity and Salinity Response in San Antonio Bay*

Assignment of Nodes to Salinity Areas

- Guadalupe Bay: G2
- Hynes Bay: G4
- Inner San Antonio Bay: mean G5 and G8
- Lower San Antonio Bay East: G7
- Lower San Antonio Bay West: G10
- San Antonio Bay Sound: SAB
- Ayres Bay: AB
- Espiritu Santo Bay West: ESB_W
- Espiritu Santo Bay East: ESB_E



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Overview of Take Assessment Approach

Whooping Crane Take Assessment Study Area

Hydrologic Modeling and Analysis

Affected Whooping Crane Habitat

Whooping Crane Take Pathway

- Mean Annual Salinity (WAM & Salinity Regressions)
- Saline Marsh % Productivity by Salinity Regression (Visser et al. 2004)
- Change in WCCCUs for Study Area

Overview of Take Assessment Approach

Freshwater Inflow → Salinity → Vegetative Productivity → Whooping Crane Crane Carrying Capacity Units → Whooping Crane Take in WCCCUs

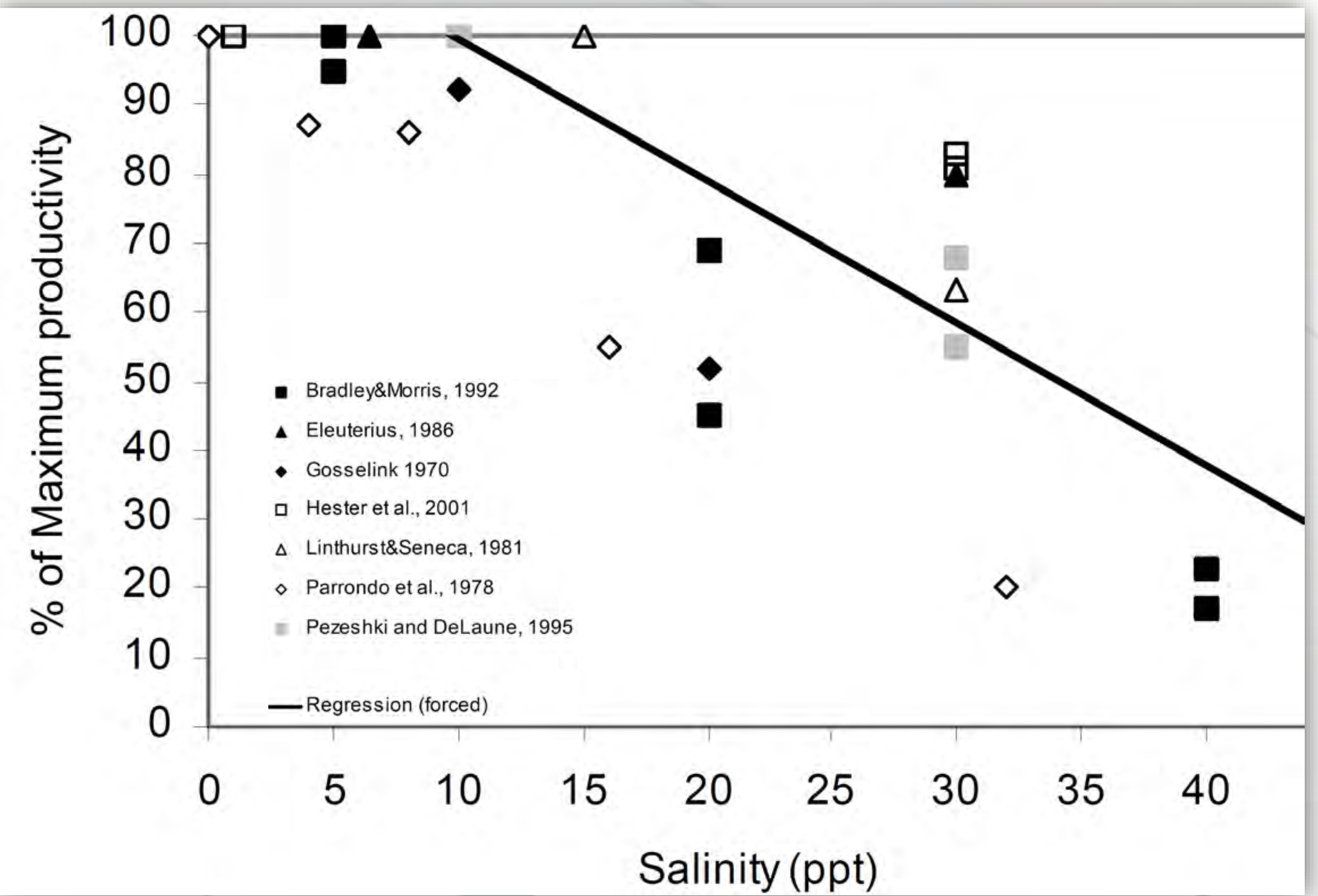
Whooping Crane Take Pathway

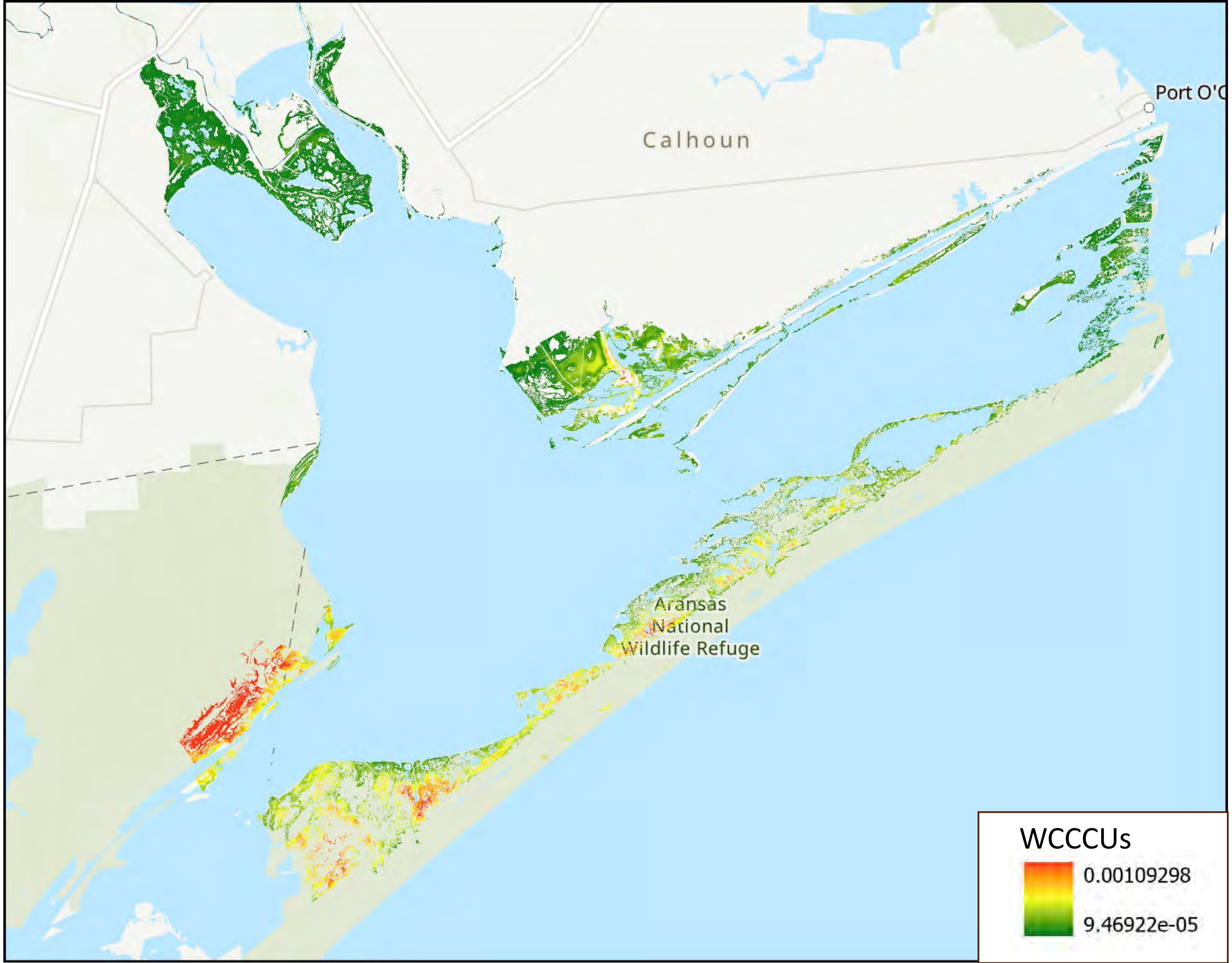
- Meta-analysis by Visser et al. (2004) developed regression for percent maximum veg. productivity of saline marsh dependent on <u>**mean annual salinity**</u>

<u>For Saline Marsh Mean Annual Salinity</u>:
if $\geq$ 10 ppt

% Maximum Productivity = 100 – (2.1*(Salinity - 10))

- Allows for continuous calculation of anticipated effects on vegetative productivity across salinities based on empirical data





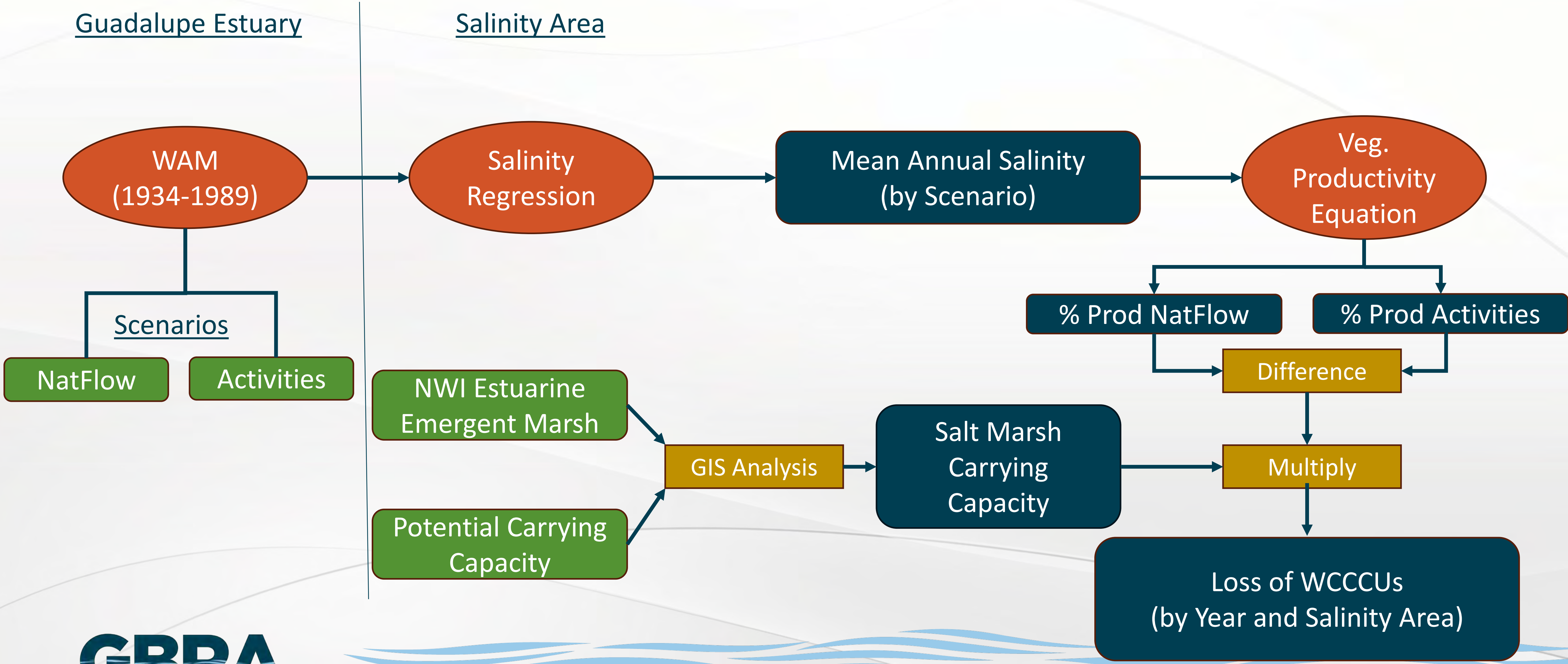
Port O'C
Calhoun
Aransas
National
Wildlife Refuge
WCCCUs
0.00109298
9.46922e-05

Affected Whooping Crane Habitat - WCCCUs

- For the whooping crane take assessment, GIS analysis was used to calculate Current Potential WCCCUs for NWI Estuarine Emergent Marsh within each Salinity Area for Current Conditions (2020)

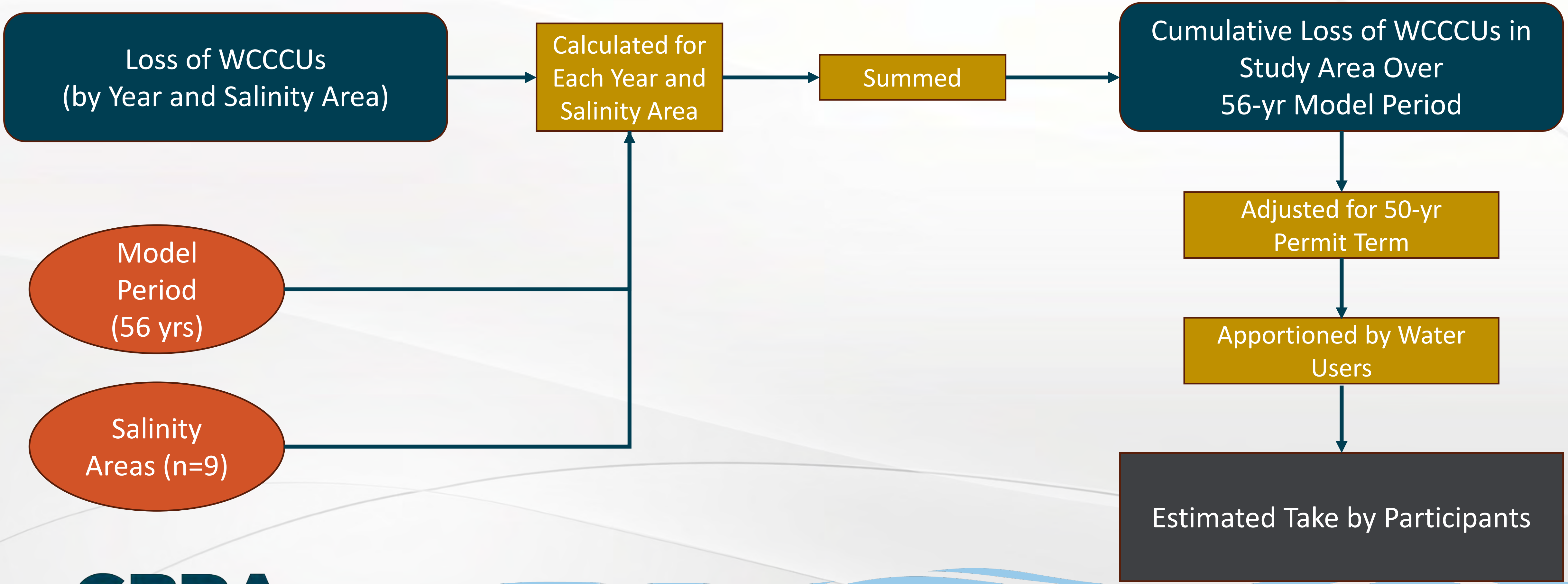
Salinity Area	Current Potential WCCCUs
Guadalupe Bay	12.92
Hynes Bay	16.49
Inner San Antonio Bay	0.44
Lower San Antonio Bay East	24.60
Lower San Antonio Bay West	26.09
San Antonio Bay Sound	34.11
Ayres Bay	11.89
ESB West	12.83
ESB East	13.64
TOTAL	153.01

Whooping Crane Take Pathway (Generalized)

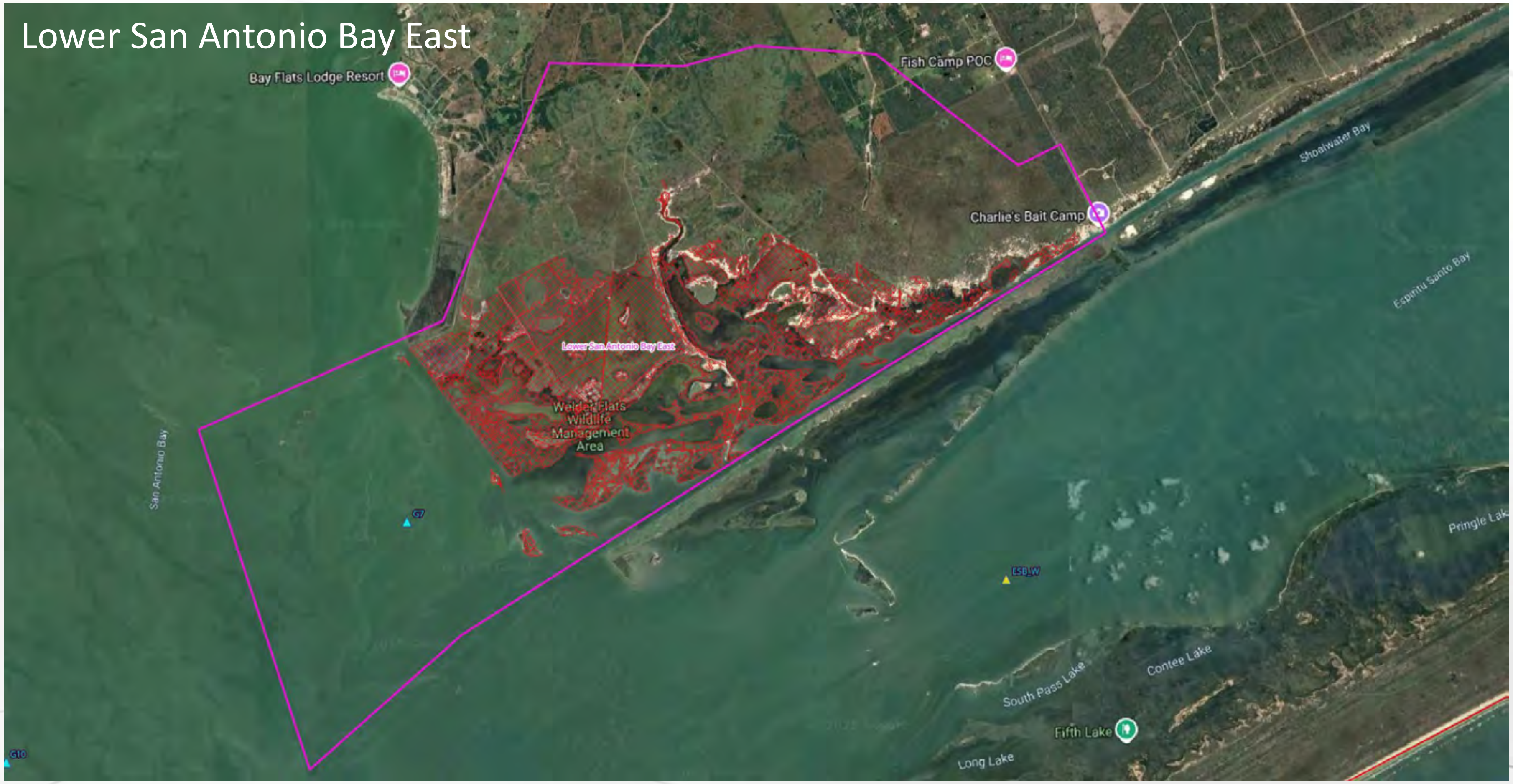


Whooping Crane Take Pathway (Generalized)

Guadalupe Estuary



Example Whooping Crane Take Calculation



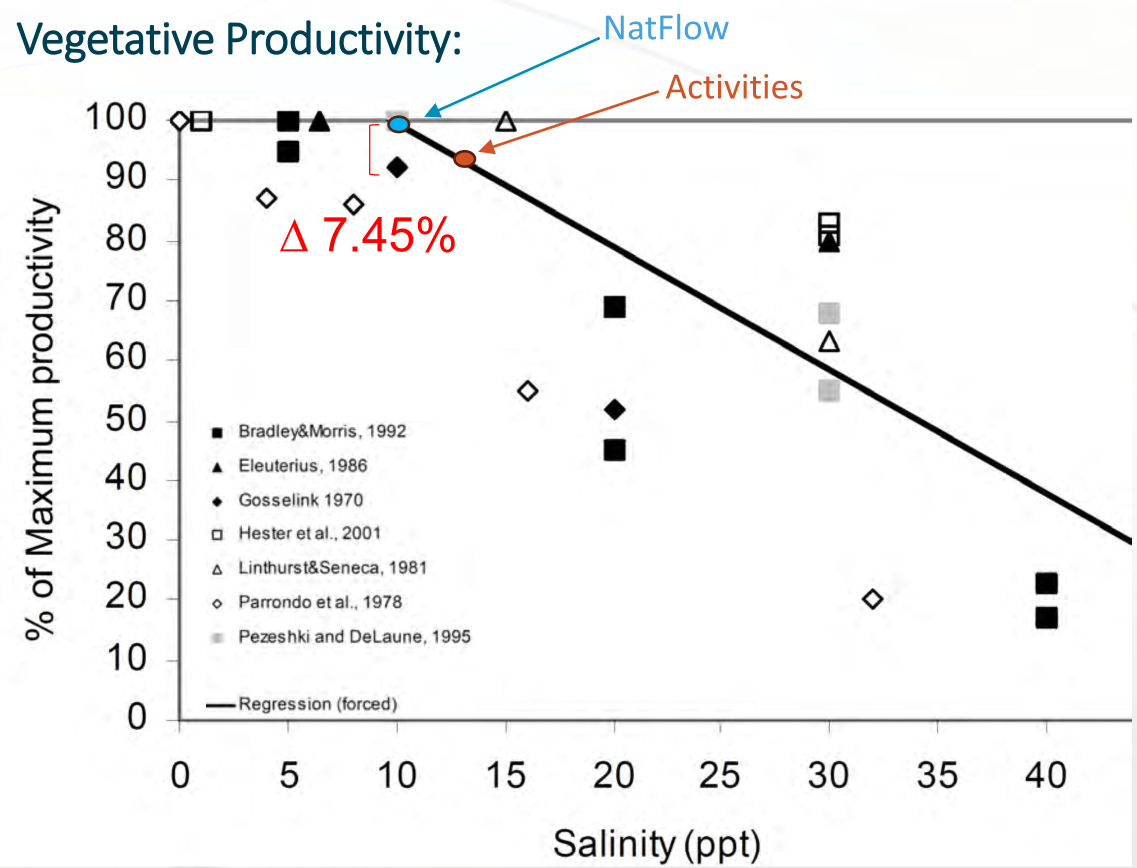
Example: Whooping Crane Take Pathway

Salinity Area: Lower San Antonio Bay East (G7)
Year: 1974

WAM Modeling of Monthly Salinity

Salinity (ppt)			
Year	**Month**	**NatFlow**	**Activities**
1974	1	8.69	10.99
1974	2	8.59	11.33
1974	3	10.99	14.39
1974	4	12.95	17.06
1974	5	11.58	15.35
1974	6	8.84	11.73
1974	7	14.63	21.59
1974	8	15.54	24.16
1974	9	9.13	12.08
1974	10	7.21	9.01
1974	11	8.17	10.09
1974	12	4.83	6.00
Mean Annual Salinity		10.10	13.65

Vegetative Productivity:



% Maximum Productivity = 100 – (2.1(Salinity - 10))*

NatFlow = 100 – (2.1*(10.10-10)) = 99.79%
Activities = 100 – (2.1*(13.65-10)) = 92.34%

Example: Whooping Crane Take Pathway

Salinity Area: Lower San Antonio Bay East (G7)
Year: 1974

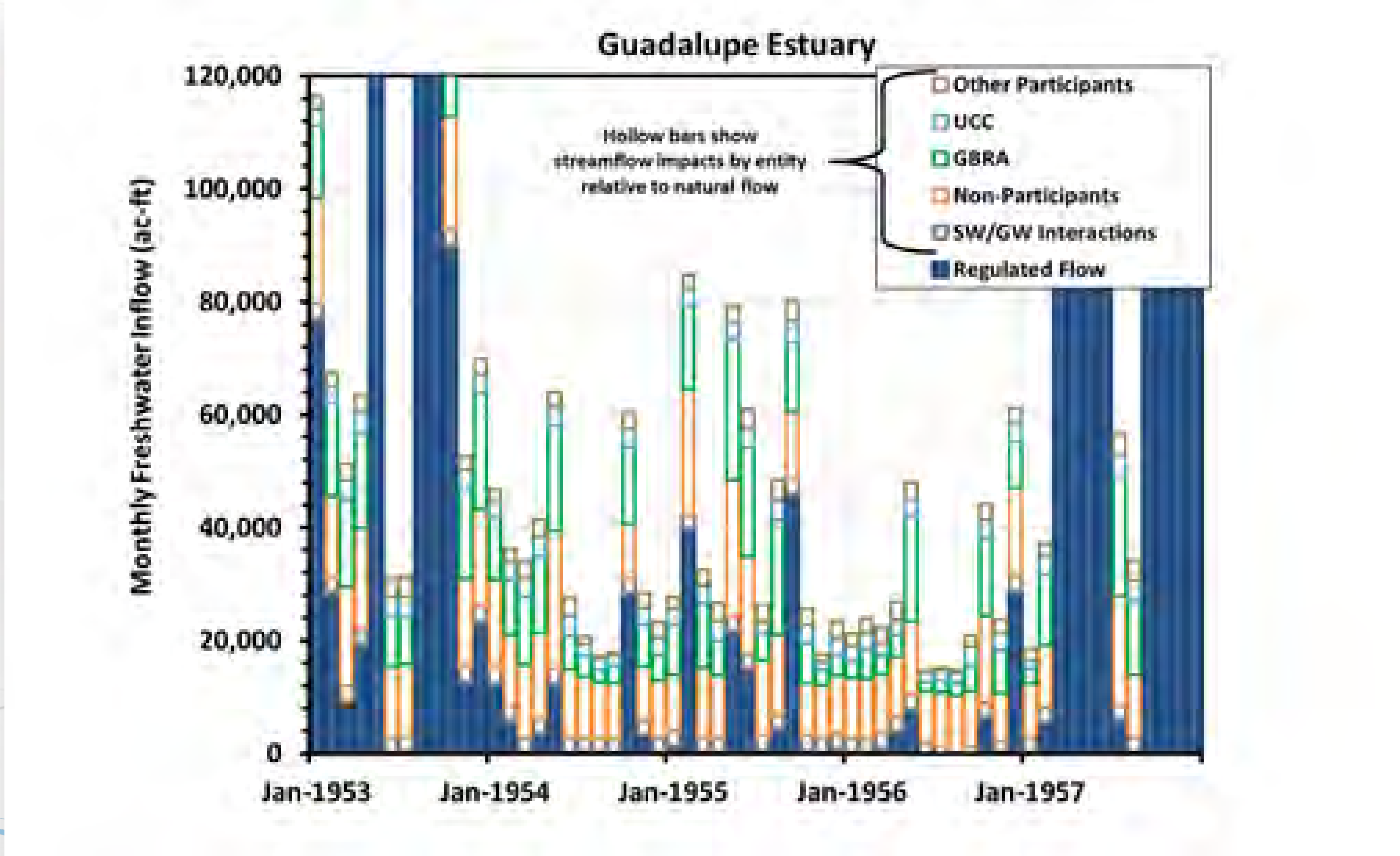
Vegetative Productivity Reduction = 7.45%

Saline Marsh Current WCCCUs in LSB_E: 24.60

Whooping Crane Take for Lower San Antonio Bay East (G7) in 1974:

24.60 WCCCUs x 7.45% = 1.83 WCCCUs

Apportionment of Streamflow Impacts Example



Drinking Water

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Summary

- Difficulty numerically equating salinity with take from Covered Activities (e.g., energetic costs, predation risk, foraging efficiency)
- Metzger et al. (2020) habitat suitability and potential carrying capacity units inherently capture dietary drinking water and prey abundance in whooping crane home range calculations for GPS-tracked birds (i.e., habitat use)
- Rather than address drinking water as a separate take pathway, it is generally incorporated into use of the Vegetation Productivity Take Surrogate and WCCCU loss
- GBRA is considering inclusion of providing drinking water for whooping cranes in the Conservation Strategy


Q&A

Effects Analysis & Take Methods:

Eastern Black Rail

Effects Analysis Overview – Eastern Black Rail

Habitat Needs

- Requires dense overhead perennial herbaceous cover with underlying soils that are moist to saturated interspersed with or adjacent to very shallow water (typically ≤ 3 cm)

- Transition zones (ecotone) between emergent wetlands and upland grasslands with cover.

Effects Analysis Overview – Eastern Black Rail

Effects Methods

- Defined suitable habitat
- Used habitat acres as surrogate for take
- Modeled changes to inundation from covered activities scenario compared to reference scenario
- Evaluated potential maintenance disturbance from covered activities

Eastern Black Rail Suitable Habitat Layer

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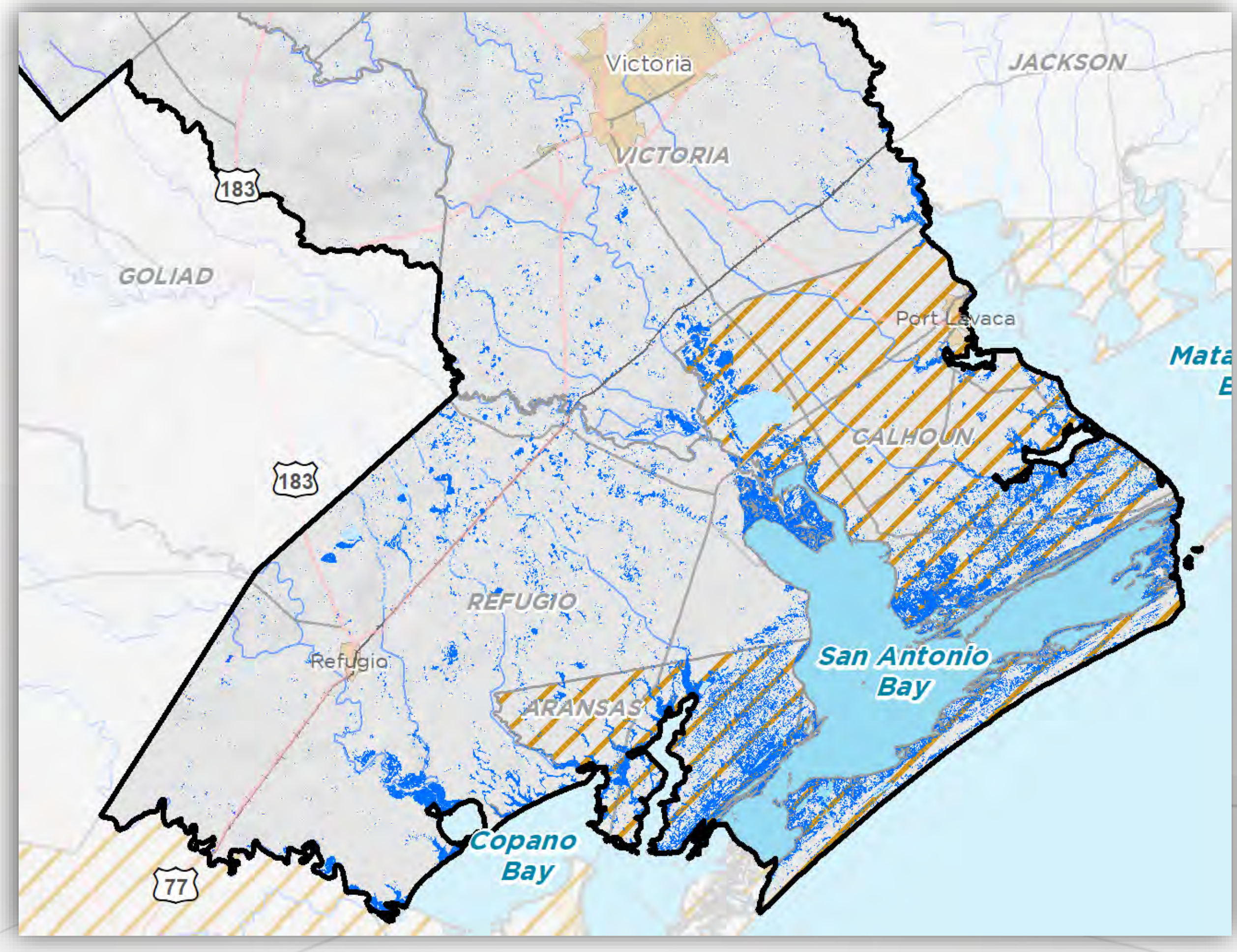

Objective: Define habitat suitability data layer by incorporating various spatial datasets and refining the habitat suitability criteria to better inform effects analysis.

- **Primary Spatial Datasets:**
  - TPWD EMST for Western Gulf Coastal Plains (WGCP_EMS_DATA)
  - National Wetland Inventory (NWI)
- **Process:**
  - Clipped and analyzed vegetation class GIS files
  - Removed unsuitable vegetation classes based on literature (18 vegetation classes determined to be unsuitable habitat)
  - Removed patches less than 1.26 acres (minimum EBR home range size)
  - Calculated new acres for suitable habitat for the Plan Area and inundation model extent.

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Eastern Black Rail Take Considerations

- Habitat acres as a surrogate for take
- Primary threats to Eastern black rail (USFWS SSA 2019)
  - Habitat fragmentation and conversion,
  - Altered plant communities,
  - **Altered hydrology,**
  - Land management,
  - Effects of climate change,
  - Environmental contaminants and chemical spills,
  - Disease,
  - Altered food webs and predation, and
  - Human disturbance.

Inundation Effects Analysis Methods

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1. **Model inundation: none,** > **0 to ≤ 3cm**, **> 3 cm**
2. **Evaluate change in averaged monthly acres from all activities for no inundation** (=0 cm), >0 – 3 cm, and > 3 cm from natural scenario.
3. **Evaluate amount of time increase during non-inundation**.
4. **Incorporate historic precipitation into analysis of inundation effects to EBR habitat**.
   1. Inundation model based on WAM output – does not account for local precipitation
   2. Calculated average monthly rainfall over the model period (1934-1989)
   3. Months with greater than average precipitation excluded from average of daily differences in non-inundated acreage between Natural and Activities scenarios
5. **Apportion take (acres of habitat) between GRHCP participants and non-participants**.

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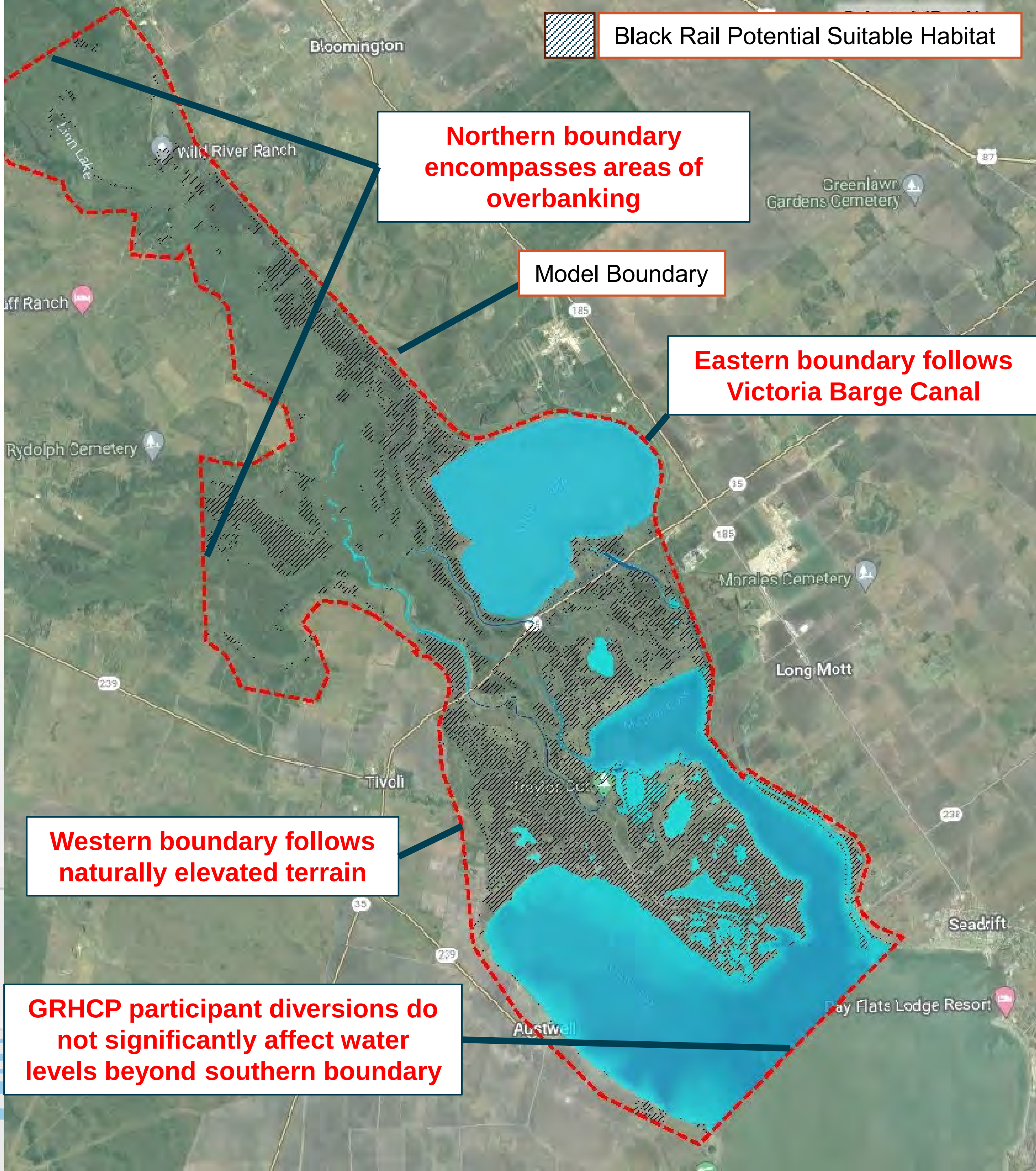
Modeling Hydrologic Effects

Where can effects from covered activities occur?

- Inundation model extent:
    - Northern extent begins just downstream of Bloomington gage
    - San Antonio River segment included just upstream of confluence with Guadalupe River
    - Ends at San Antonio Bay near Seadrift, TX
- 10,868 acres of EBR Suitable Habitat Area within model extent



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Interpreting Results

- GBRA operates the SWB and gates to maintain water in diversion system and reduce saltwater intrusion while minimizing overbanking.
- Greatest difference between Natural and Activities scenarios is in acreage not inundated (=0 cm).
- Average time between inundation by streamflow increased from 21 to 44 days.
- Water withdrawals = less inundation to support black rail habitat conditions.
  - The difference between all activities and natural flow reference for non-inundated monthly averages are between 69 to 199 acres with consideration of rainfall.
  - Maximum averaged monthly difference is in March = 199 acres.

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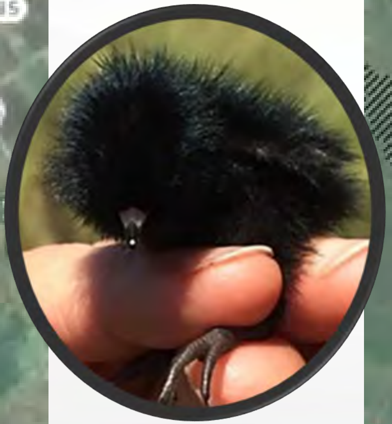
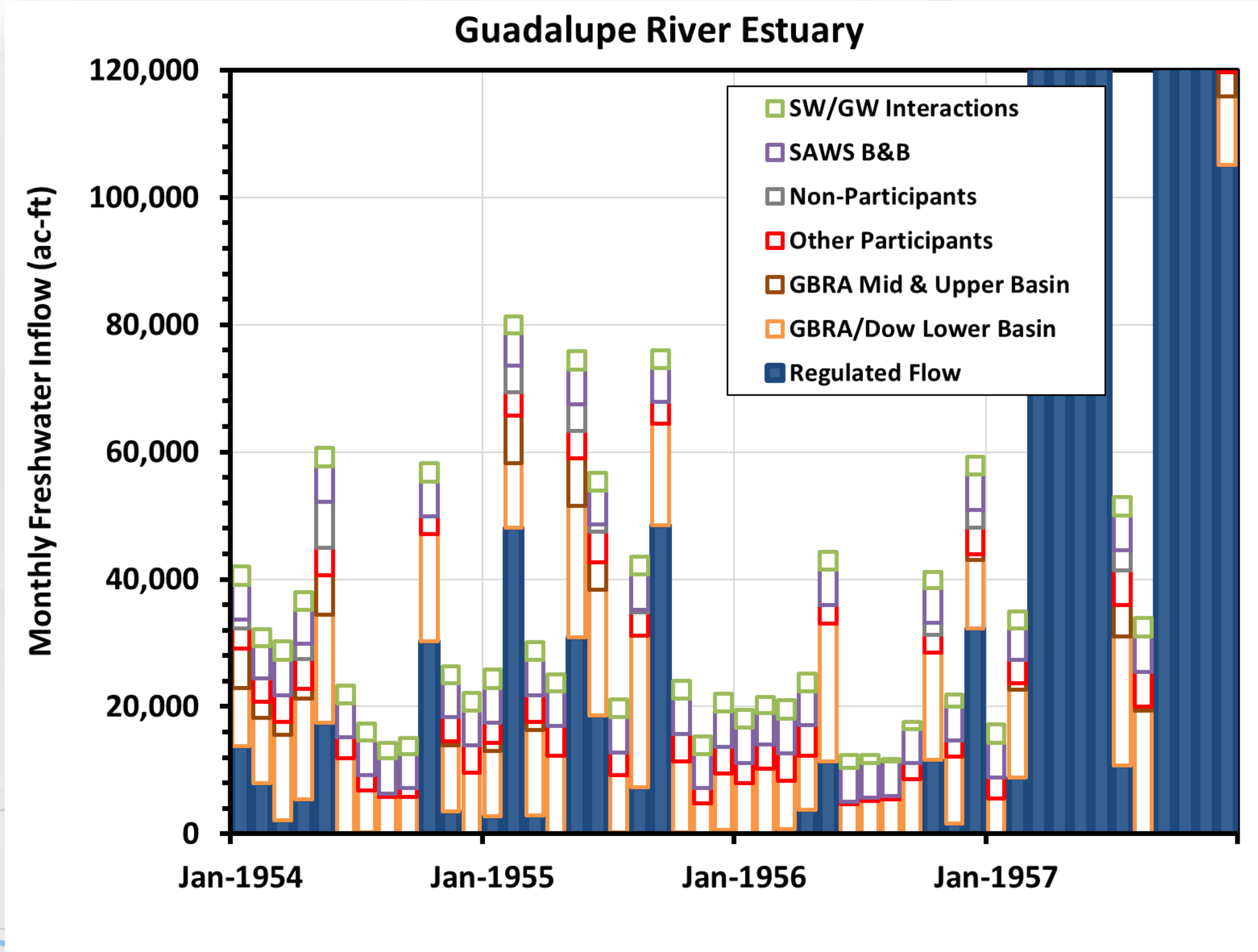
Changes to Inundated Habitat

Natural Flow Scenario with inundated habitat



Covered Activities Scenario reducing inundated suitable habitat

Apportionment of Inundation Impacts



Q&A

Photo Credit: Christy Hand,
South Carolina Department of Natural Resources

Next Steps in GRHCP Planning

- **2022** – Determine plan area, permit term, permit structure
- Develop list of covered species and covered activities
- **2023** – Develop modeling parameters
- **2024** – Run models and interpret results
- **2025** – Finalize conservation strategy and complete draft HCP
- **2026** – Submit Admin and public HCP Draft to USFWS
- Apply for Incidental Take Permit
- **2027** – Receive Incidental Take Permit

- **Spring 2026:** Public Stakeholder Meeting - *GRHCP Conservation Strategy*
- **Summer 2026:** Public Stakeholder Meeting - *Complete Administrative Draft GRHCP*

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THANK YOU!

Submit additional comments and questions here:
grhcp@gbra.org

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