Using Field, Flume, and Modeling Studies to Inform Texas's First Freshwater Mussel Reintroduction

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USACE EcoMod Seminar Series

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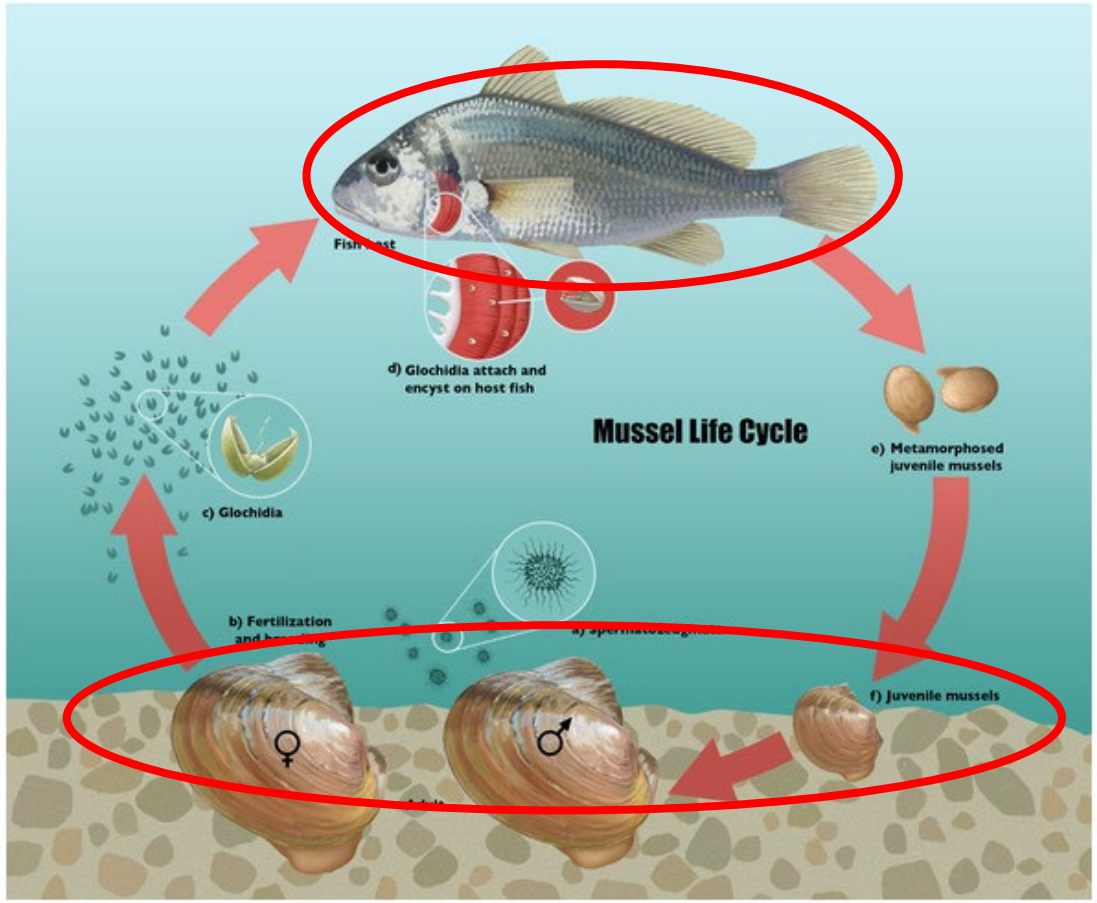
Freshwater Mussels

- Benthic fauna
  - Minimal movement
- Widely distributed in North America
  - Over 300 species
  - Reduced populations due to habitat fragmentation and degradation
- Ecological Functions
  - Create habitat, stabilize sediment
  - Filter feeder
  - Food source
  - Indicator for river health

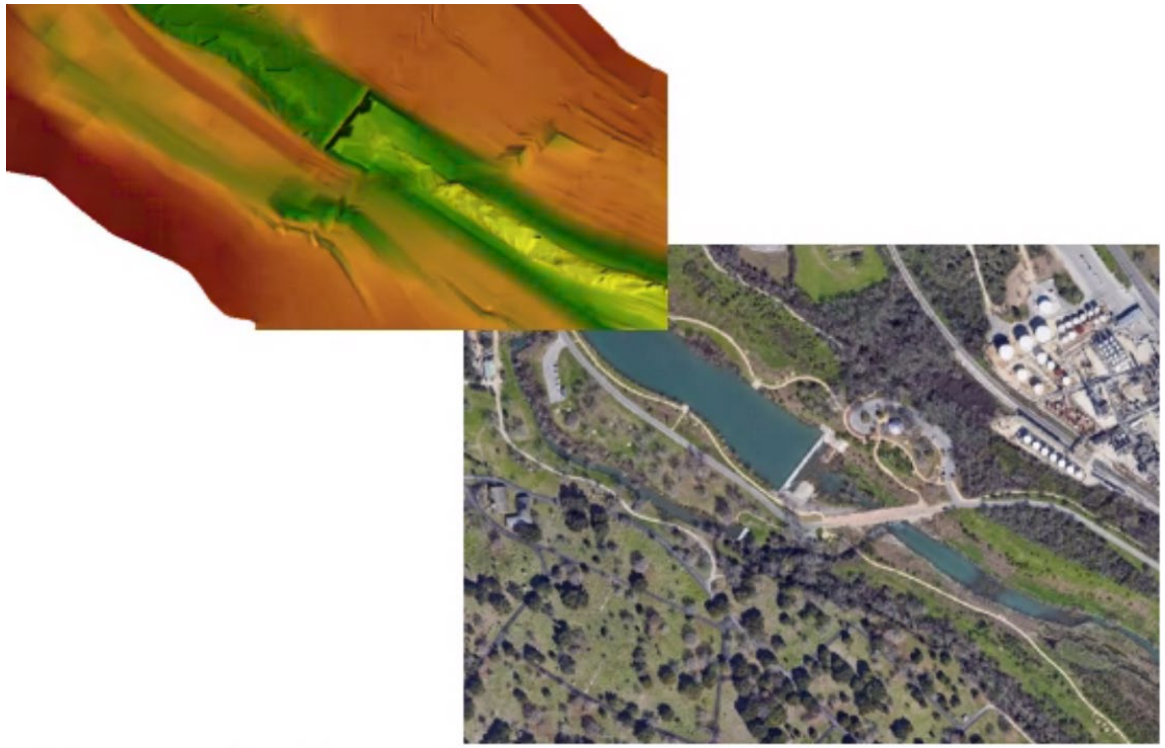
Freshwater Mussels & Reintroduction

- Reintroductions and restoration projects underway
- Probability of successful reproduction depends largely on: bed stability and host fish movement
- Limited understanding of subadult phase: burrowing into bed until reproducing adult (3-5 yrs)



Haag 2012

Informing freshwater mussel reintroduction in restored urban streams



Knowledge Gaps

Predicting shear stress movement thresholds for juvenile mussels and estimating mussels transfer rates along the stream length.

US Army Corps of Engineers

ERDC

SAN ANTONIO RIVER AUTHORITY

Value Statement

Improve understanding of how urban streams with increasingly flashy hydrology can recover ecosystem services while maintaining flood control and recreation

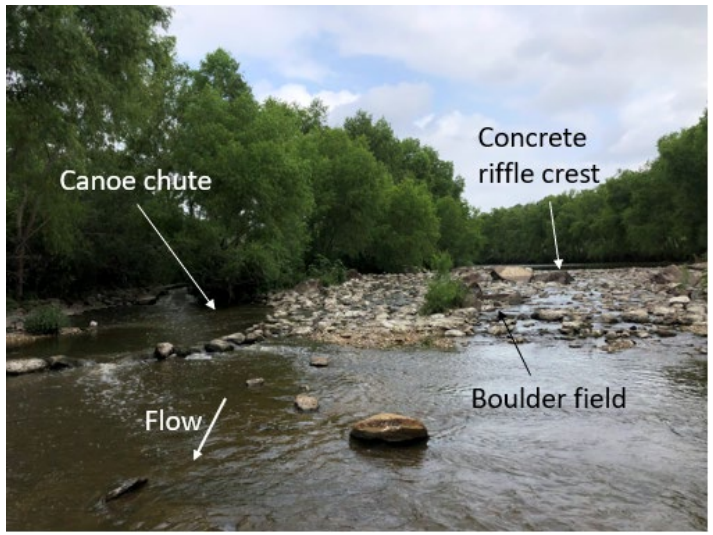
Project design guidelines for habitat and passage

Generalized risk-based ecohydraulic modeling framework

- Quantify hydraulic and geomorphic thresholds
- Account for complex species life history
- Assess likelihood of threshold exceedance along a river network over a target life history period

The San Antonio River Mission Reach

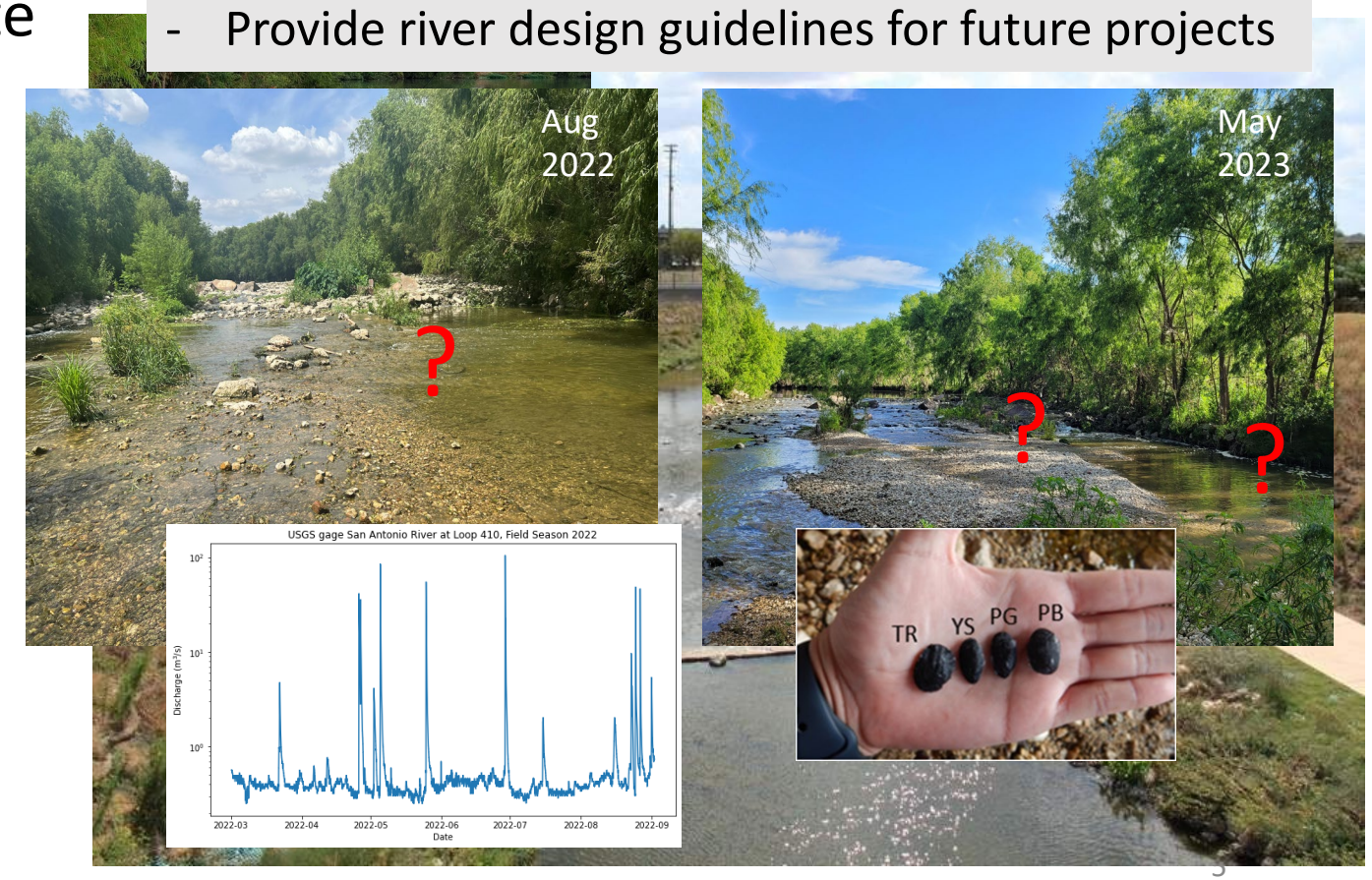
- $400M flood control, recreation, aquatic habitat restoration project
- Engineered channel with concrete sill structures throughout



- Current mussel populations restricted to relic side arms

Aims:

- Assess subadult mussel hydraulic thresholds and identify suitable locations for reintroduction
- Provide river design guidelines for future projects

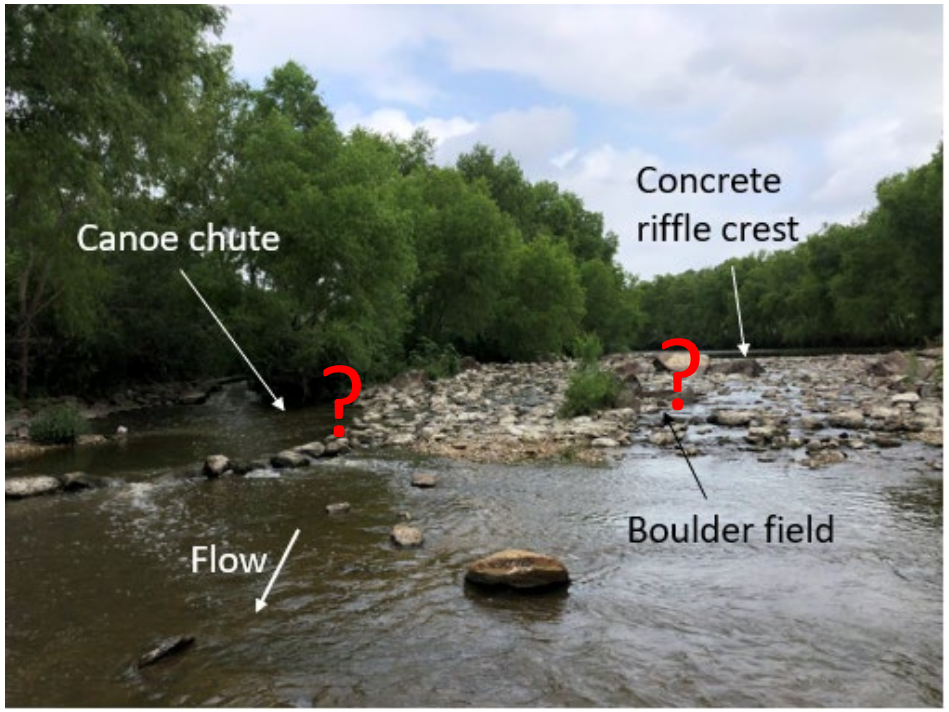


The San Antonio River Mission Reach

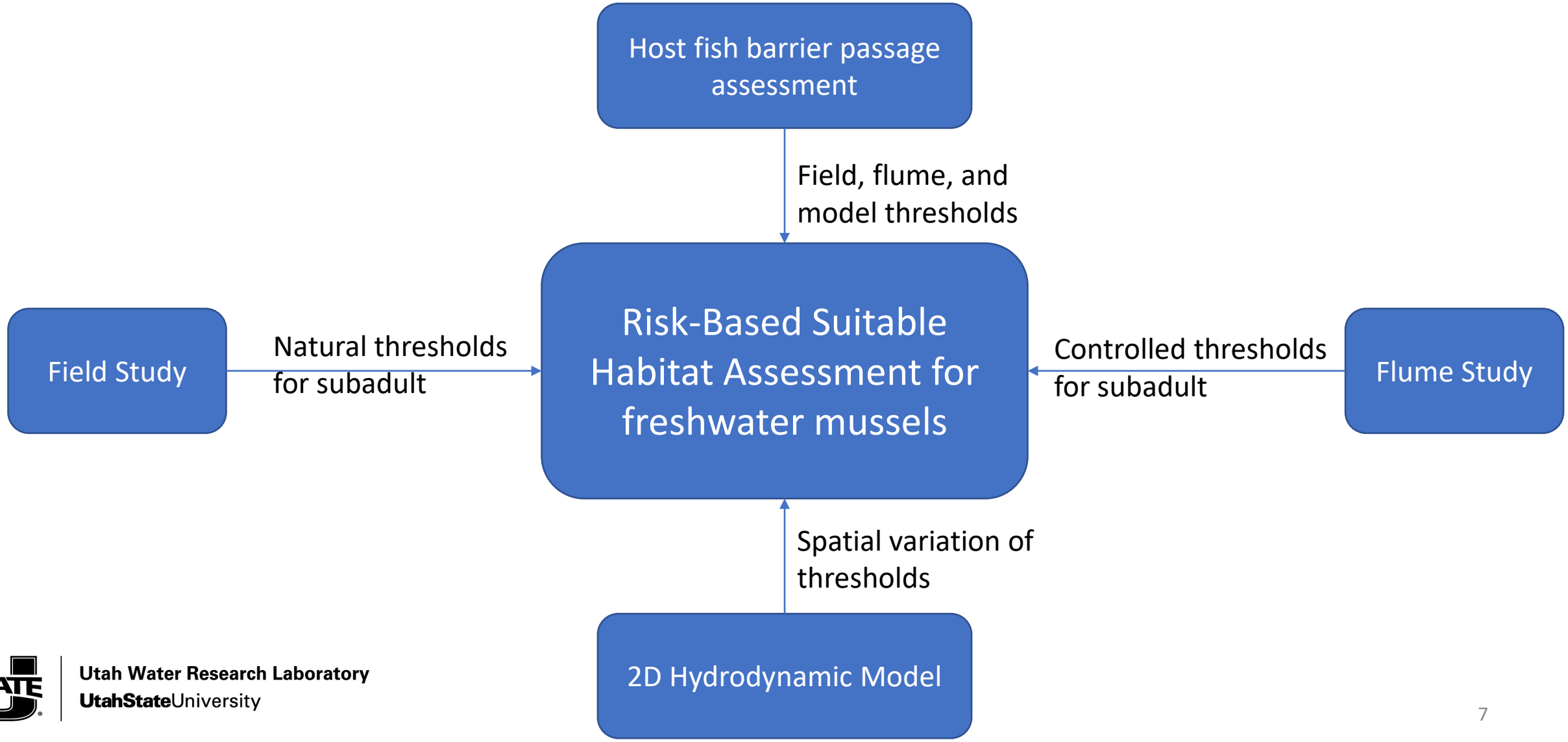
- Small barriers greatly outnumber large dams, but far fewer passage studies
- Poor-swimming fish have distinct passage needs

Aims:

- Identify barrier design traits (e.g., chute slope, width) that best facilitate upstream passage
- Estimate probability of passage across flows based on fish and barrier characteristics



Generalized Ecohydraulics Modeling Framework



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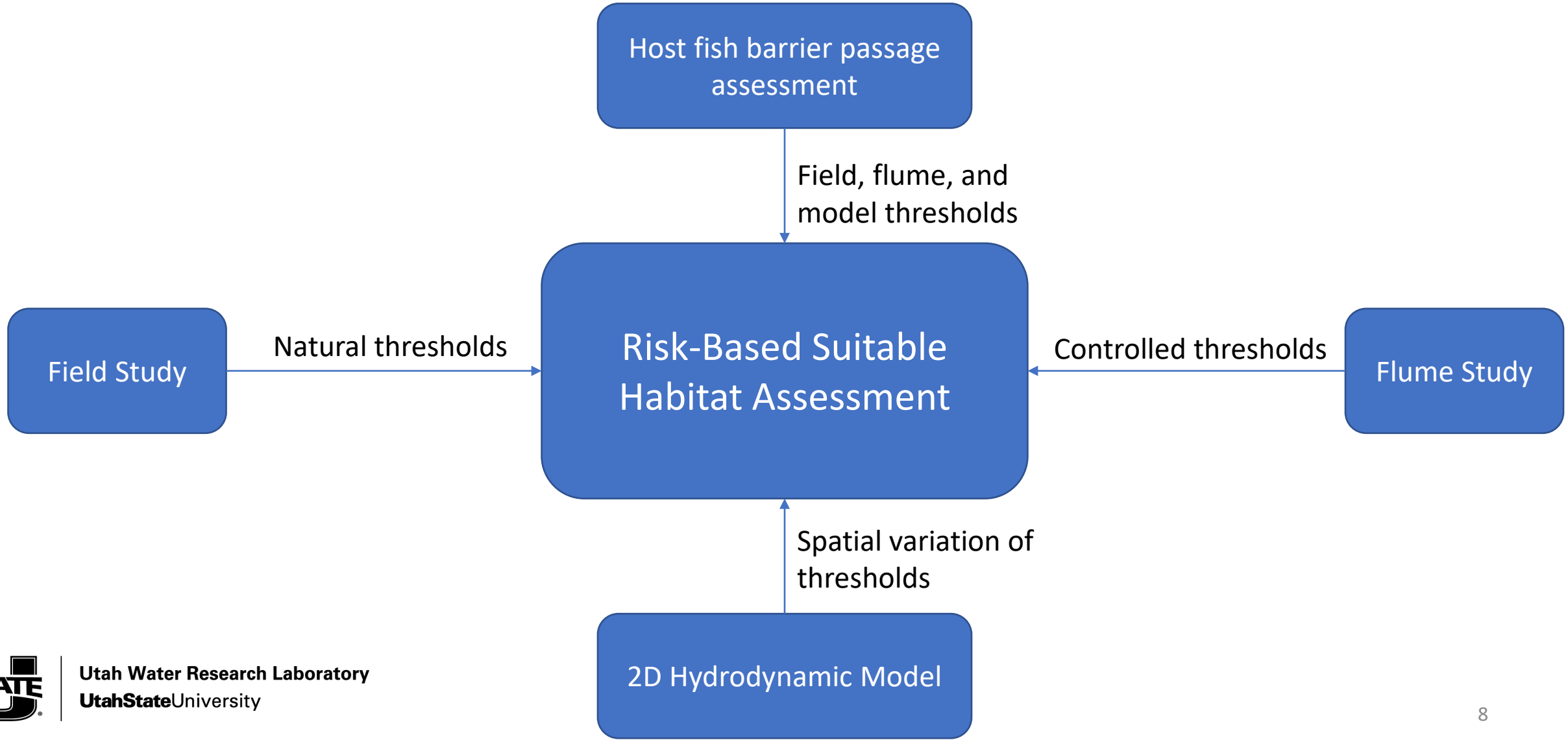

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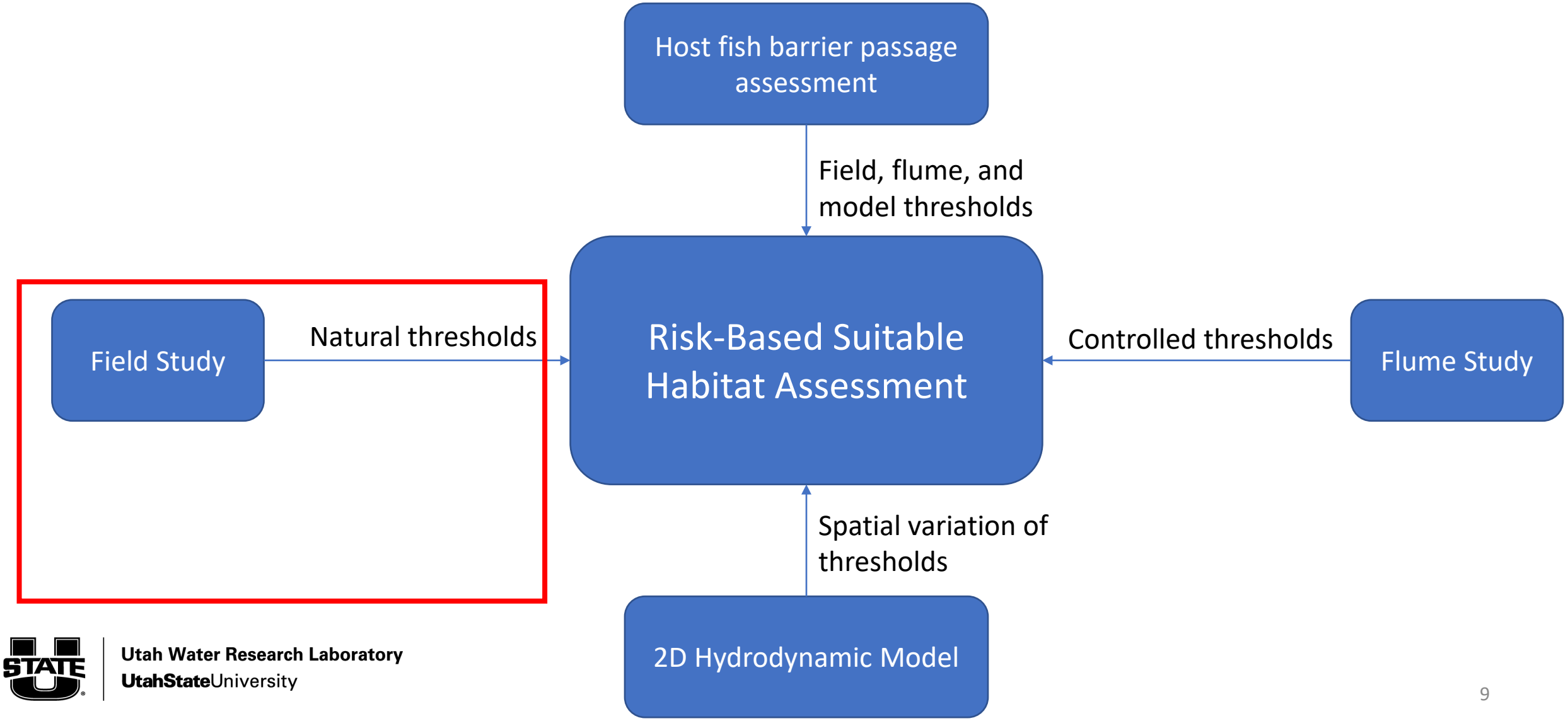

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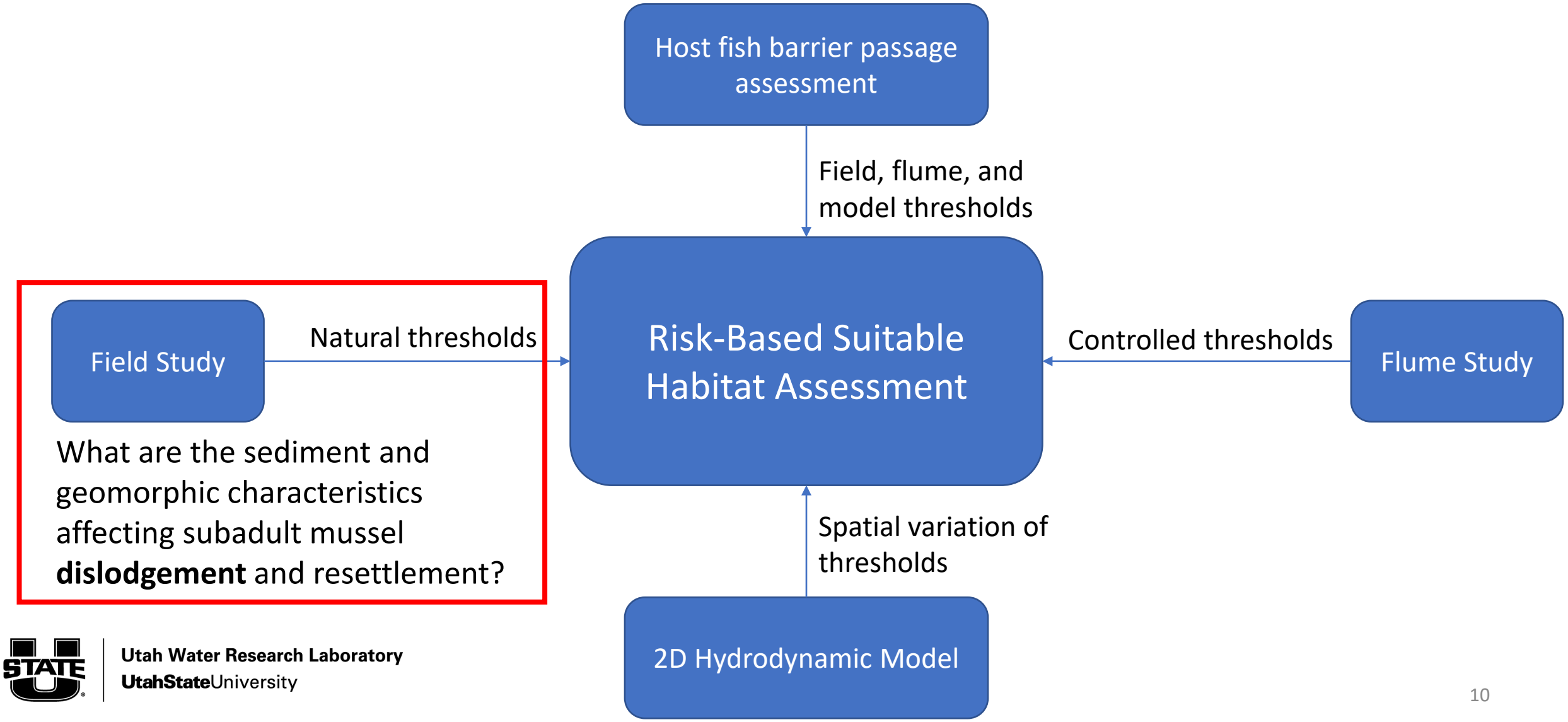
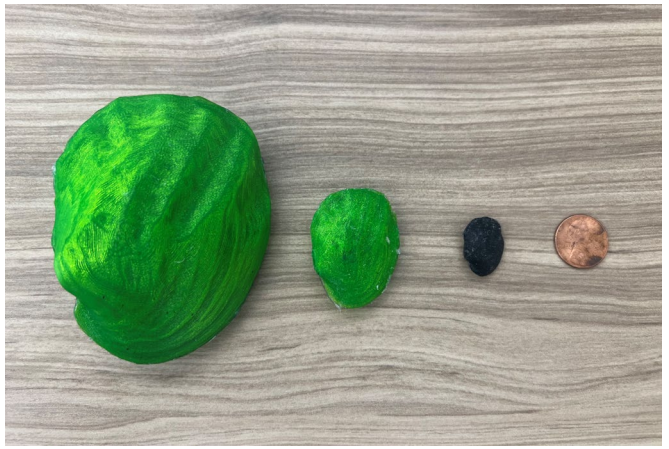


3D Printed Freshwater Mussels

- Sediment tracking principles applied to various sized printed mussels

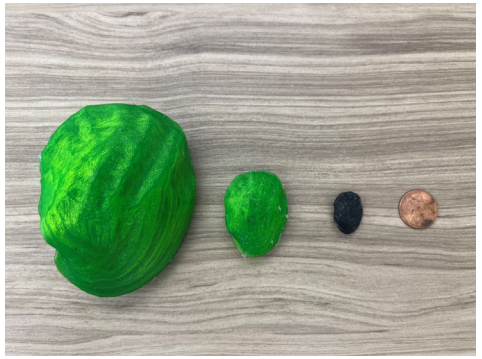


Field Study Methods

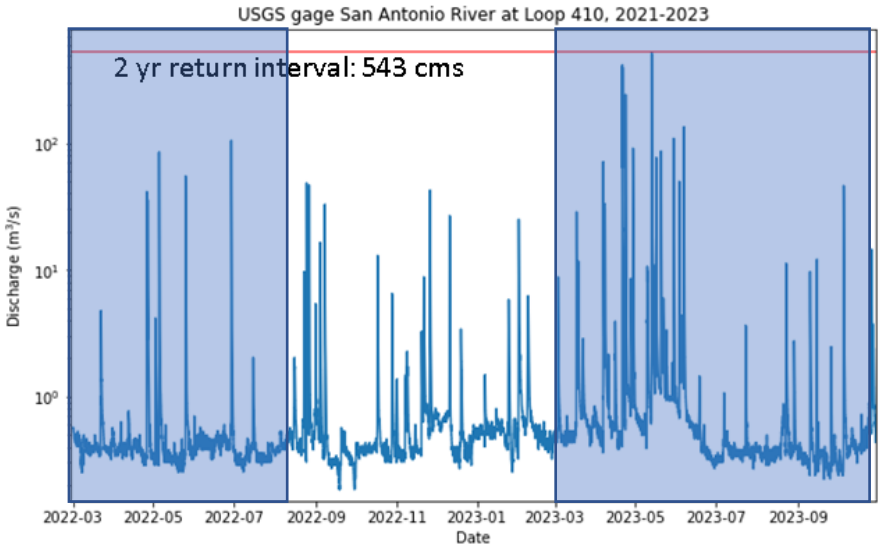
- Embedded and monitored 3D printed mussels over wet season
  - 2022: 20mm mussels at 3 sites
  -
- Rescanned after high flow events to track dislodgement

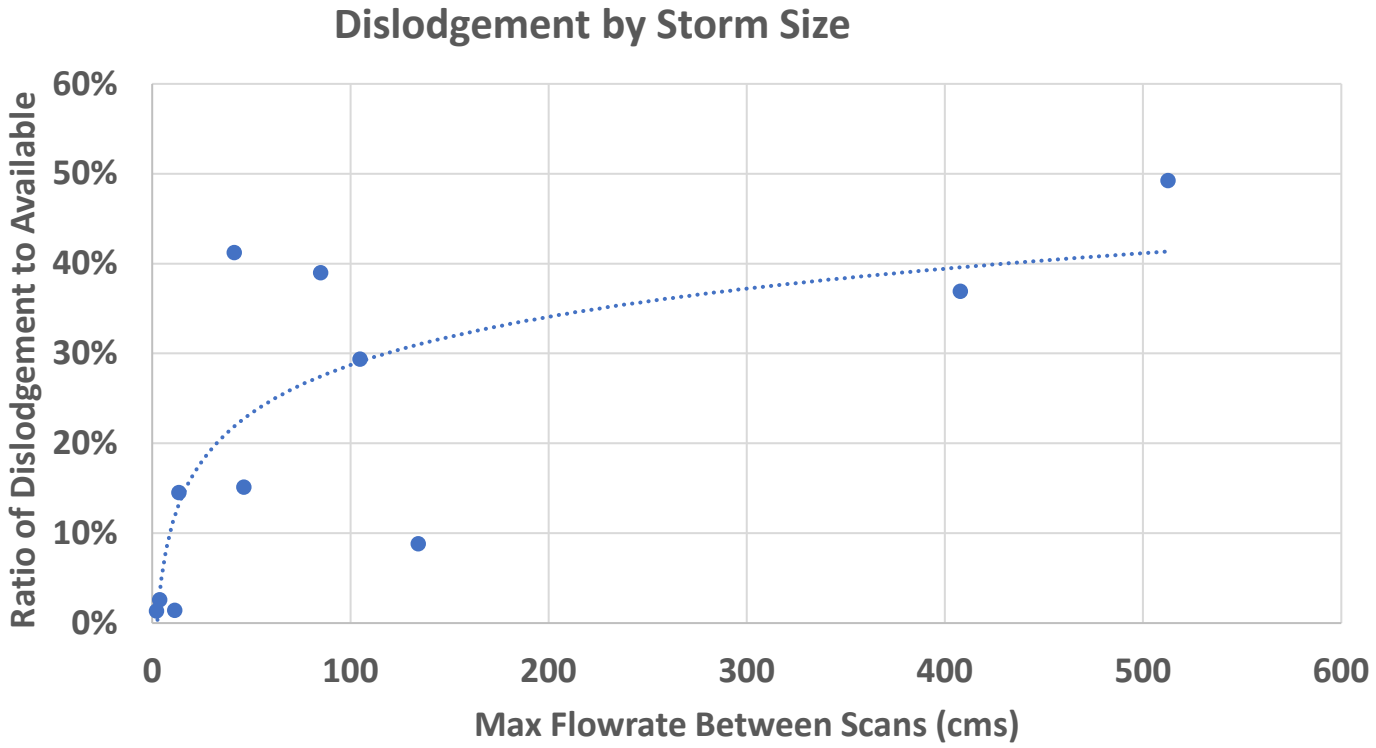
Field Study Methods

- Embedded and monitored 3D printed mussels over wet season
  - 2022: 20mm mussels at 3 sites
  - 2023: 20mm, 40mm and adult mussels at 5 sites
- Rescanned after high flow events to track dislodgement



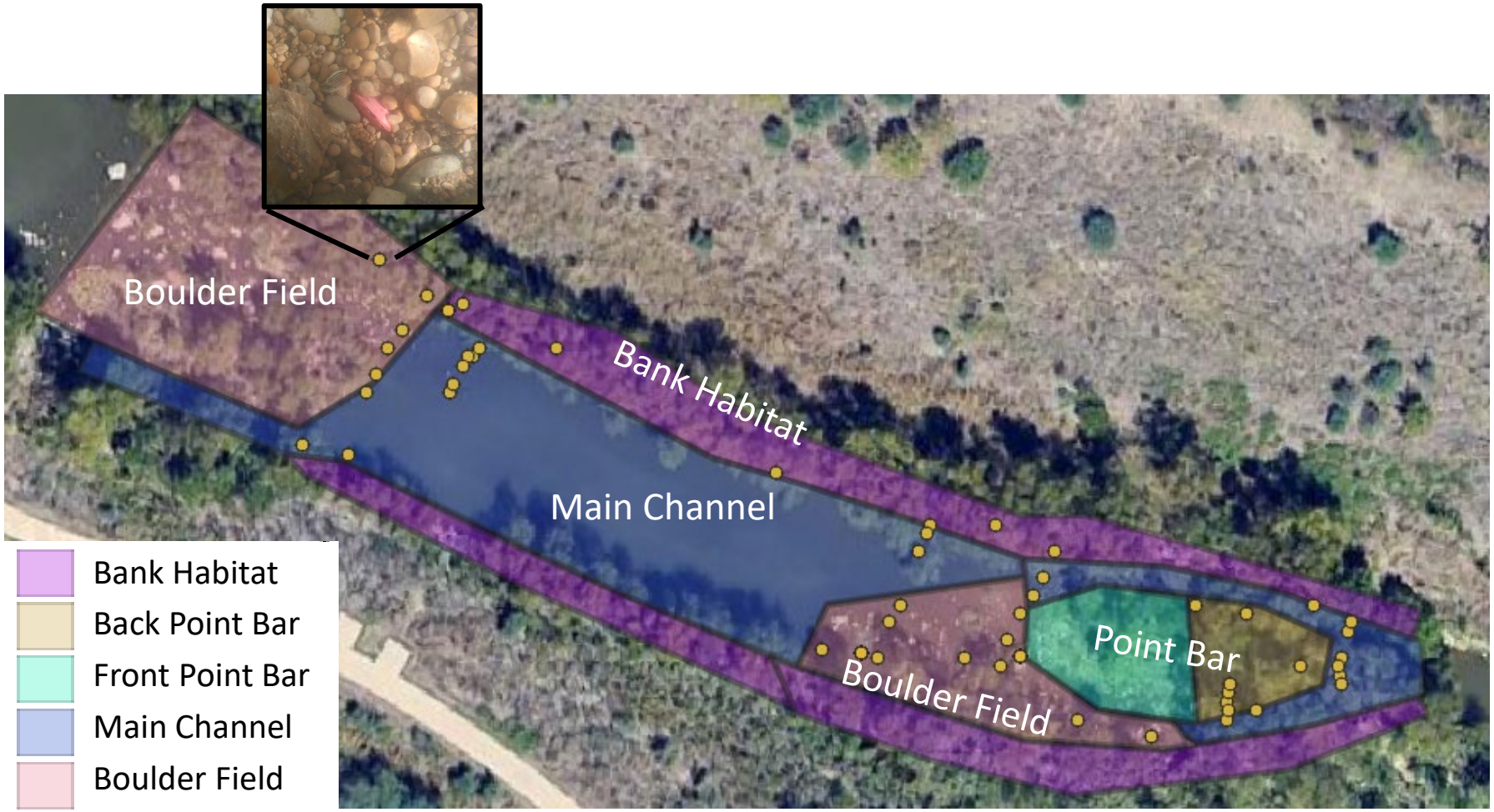
Field Study Initial Results - Flow

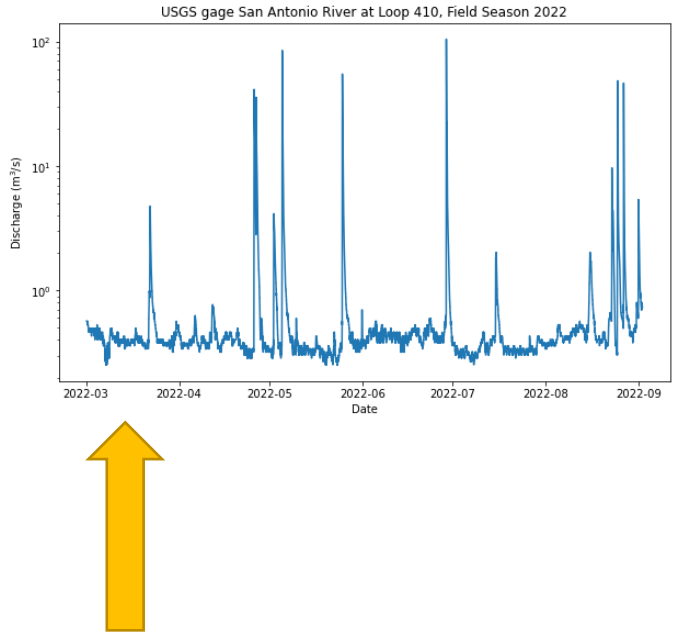




- Dislodgement rate increases with increasing storm size

Field Study – Habitat and Sediment





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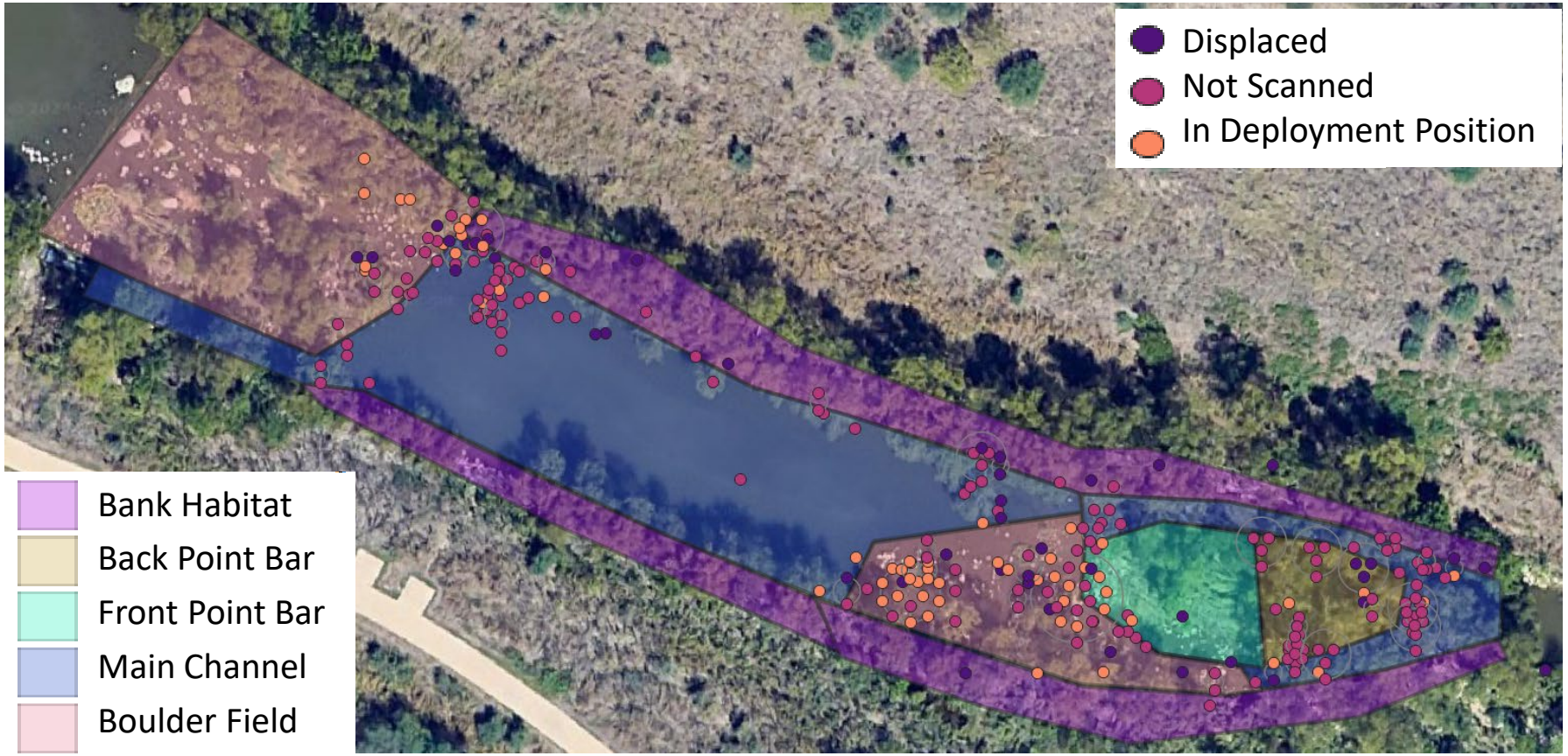

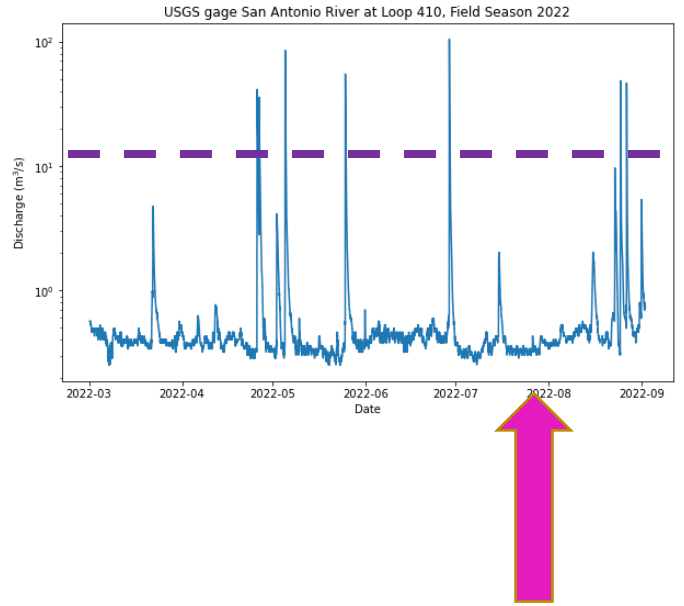

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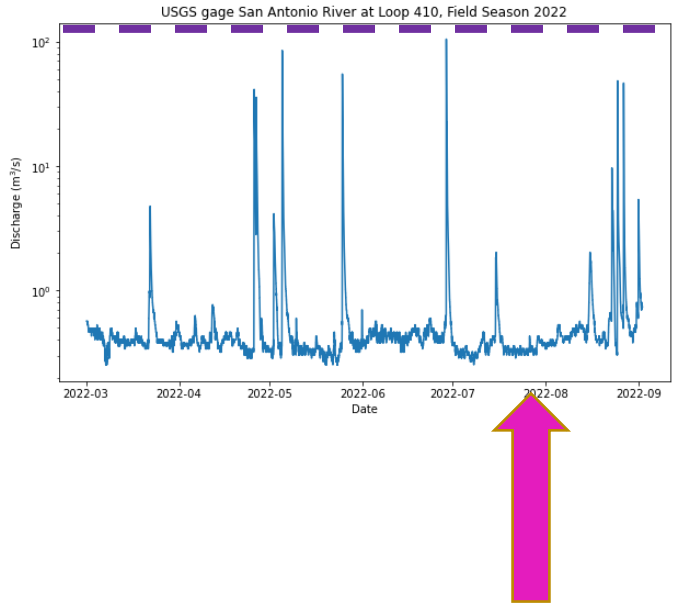
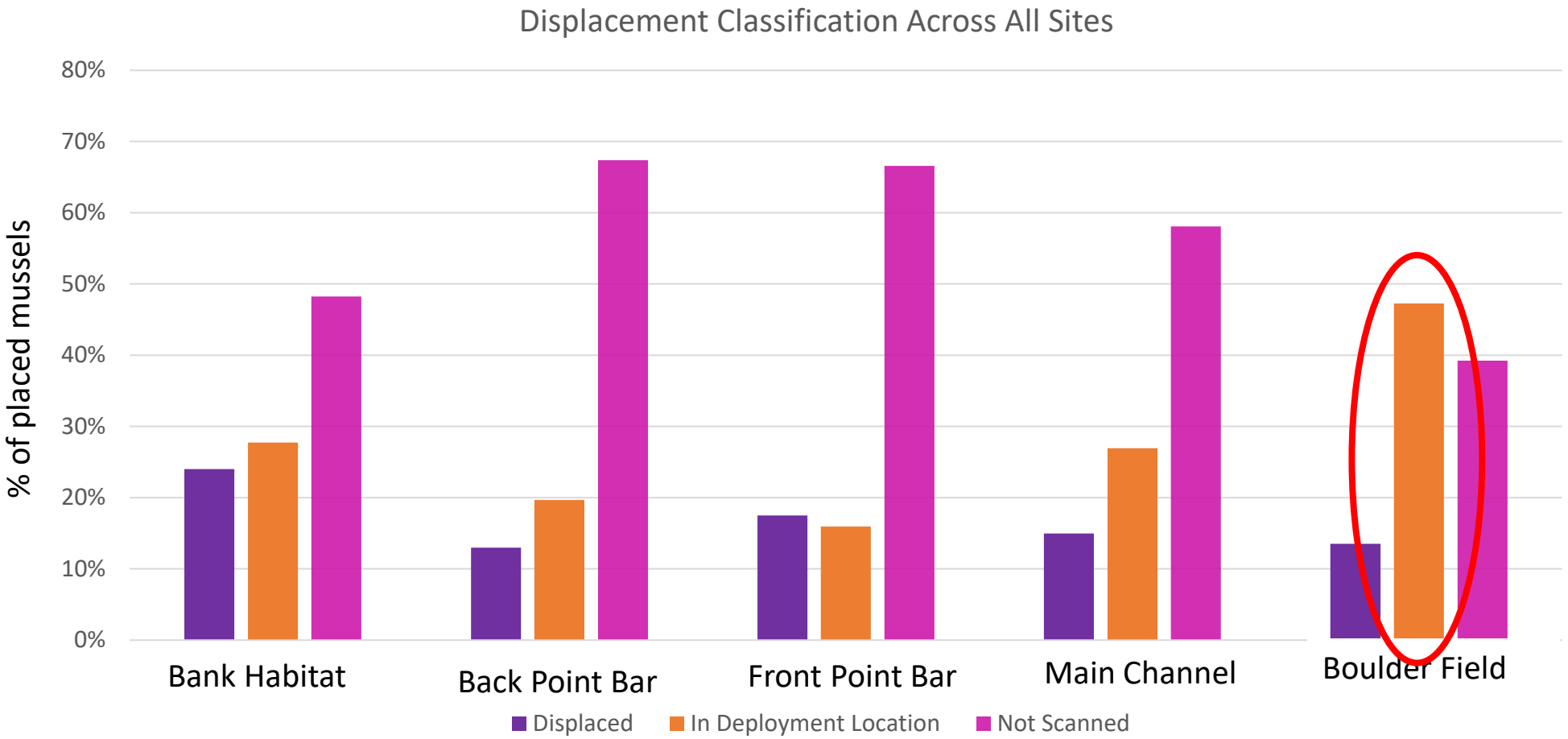
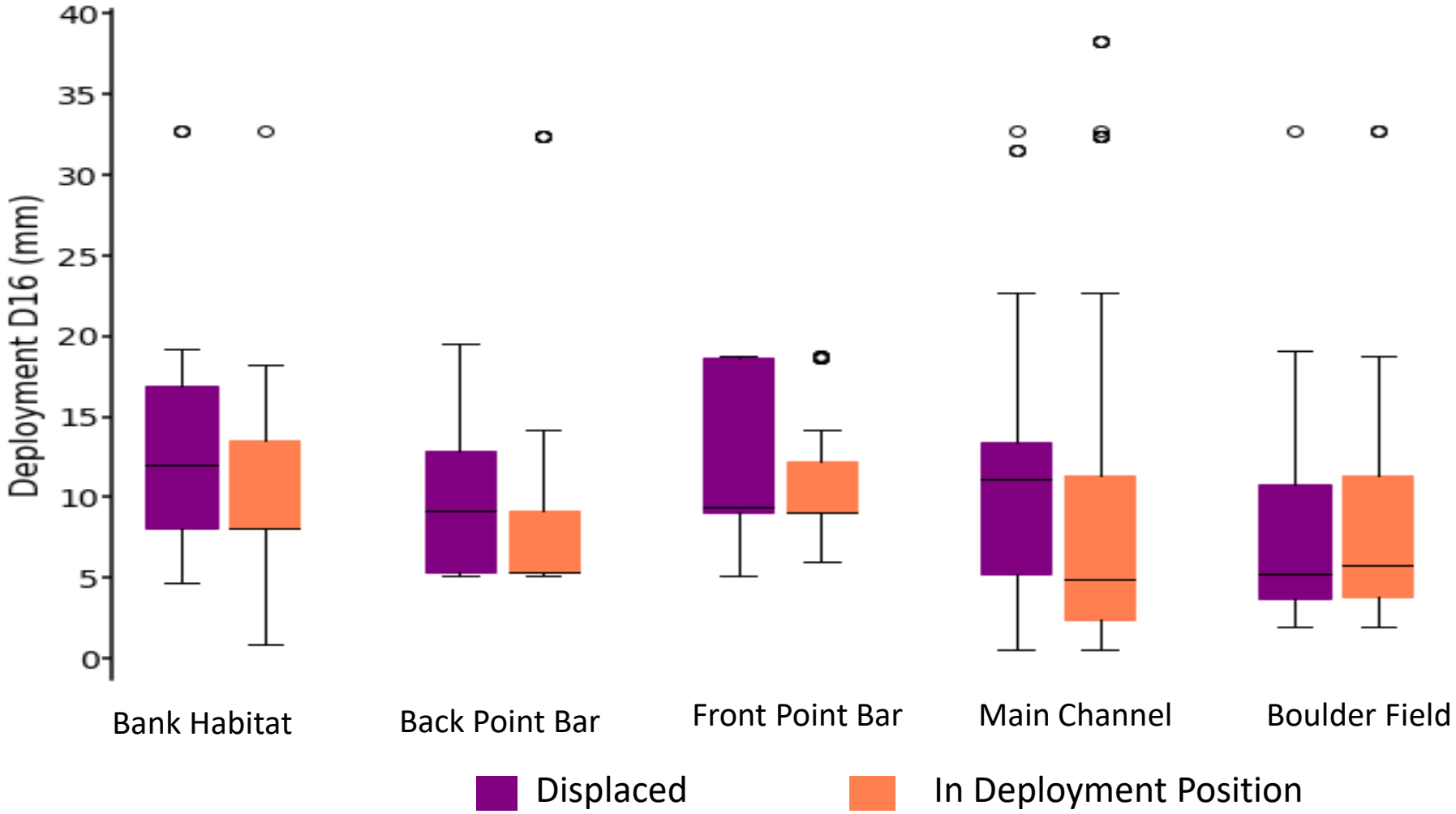


Field Study Initial Results - Habitat



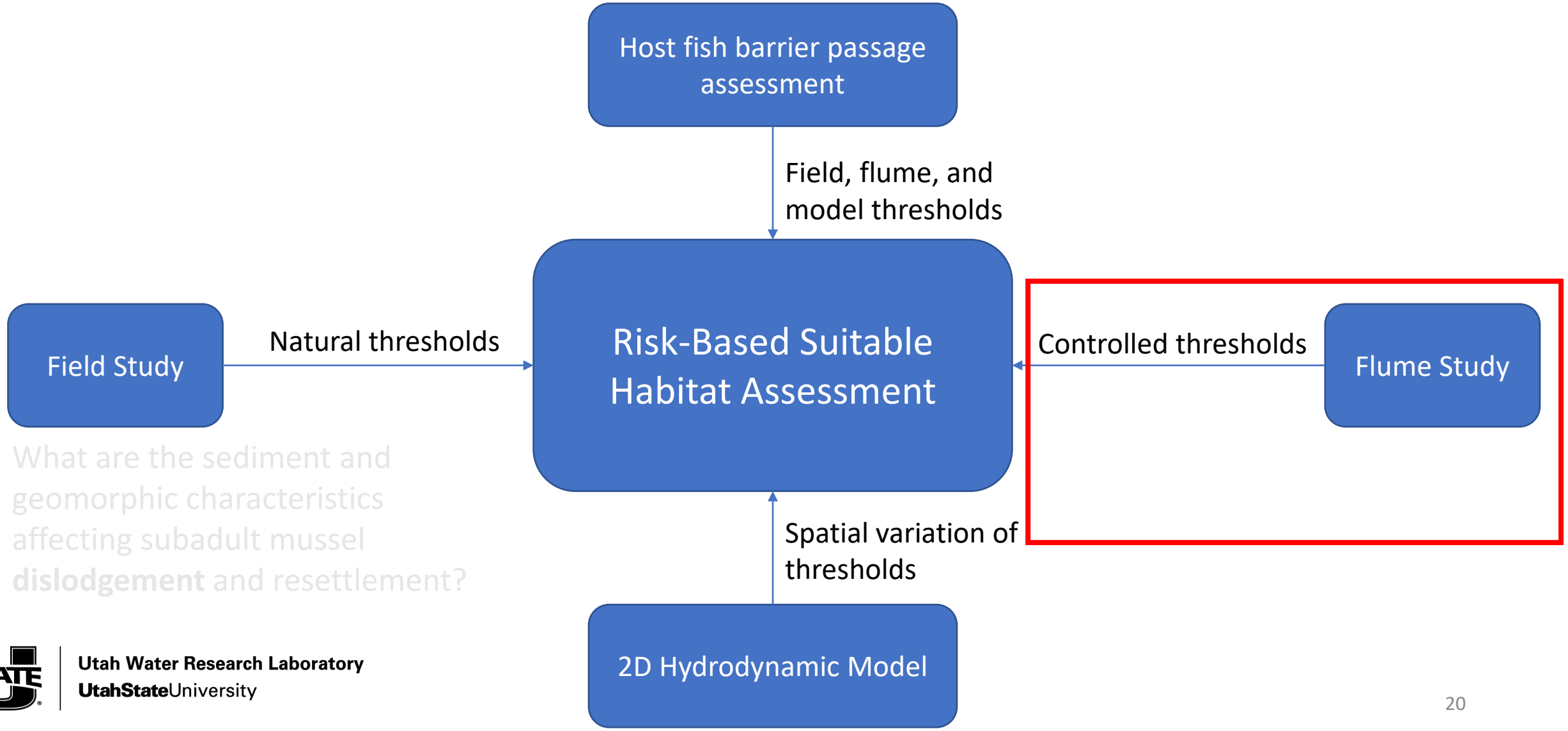
- Boulder Fields provided most stable habitat conditions

Field Study Initial Results - Sediment



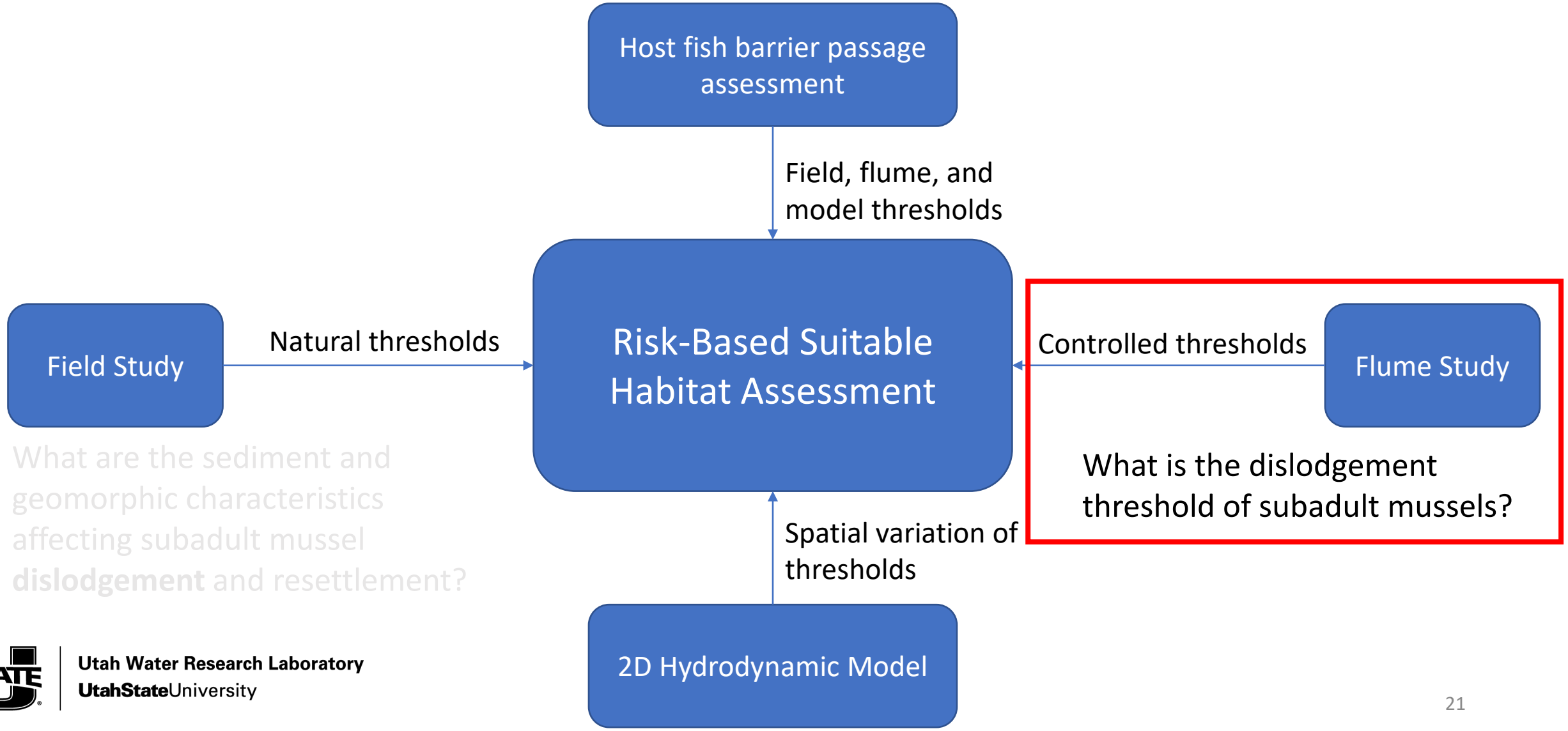
- Finer sediments provide the most stable habitat conditions

Generalized Modeling Framework



What are the sediment and geomorphic characteristics affecting subadult mussel **dislodgement** and resettlement?

Generalized Modeling Framework



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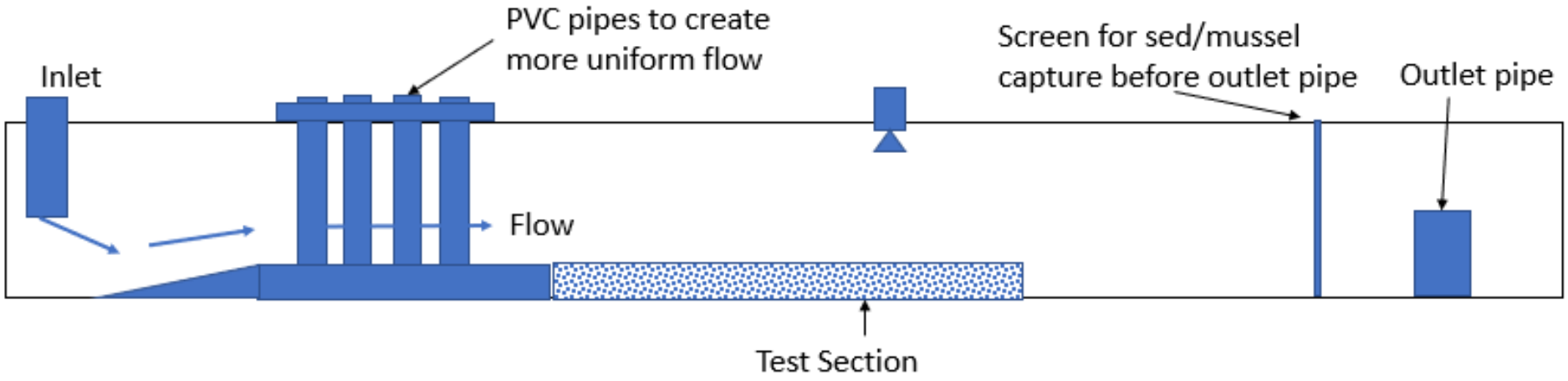
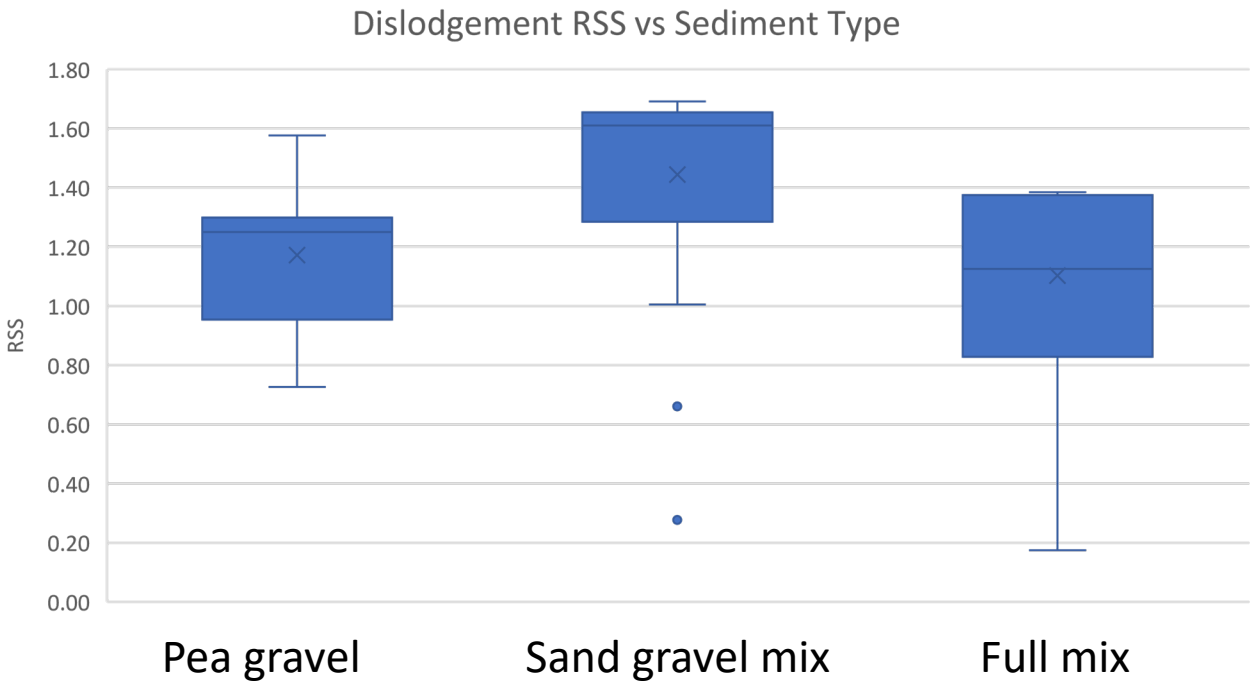
Flume Set Up

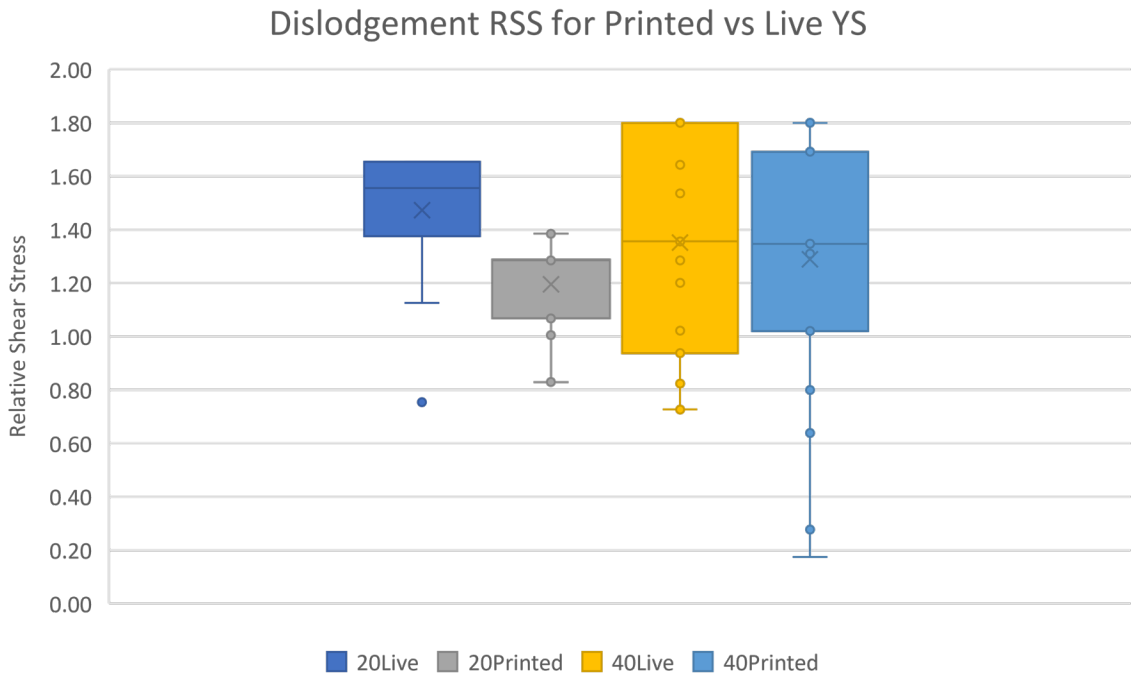

PVC pipes to create more uniform flow
Inlet
Screen for sed/mussel capture before outlet pipe
Outlet pipe
Flow
Test Section

Trial Details

- 18 trials
  - 6 mussel sizes (2 printed, 4 live)
  - 3 sediment types
- Live mussels were given 1 hour to acclimate to flume sediments and embed themselves in the sediment
- Pump level increased every 5 minutes until all mussels were dislodged or the pump was maxed out
- Pump level noted when a mussel was dislodged
  - later converted into shear stress

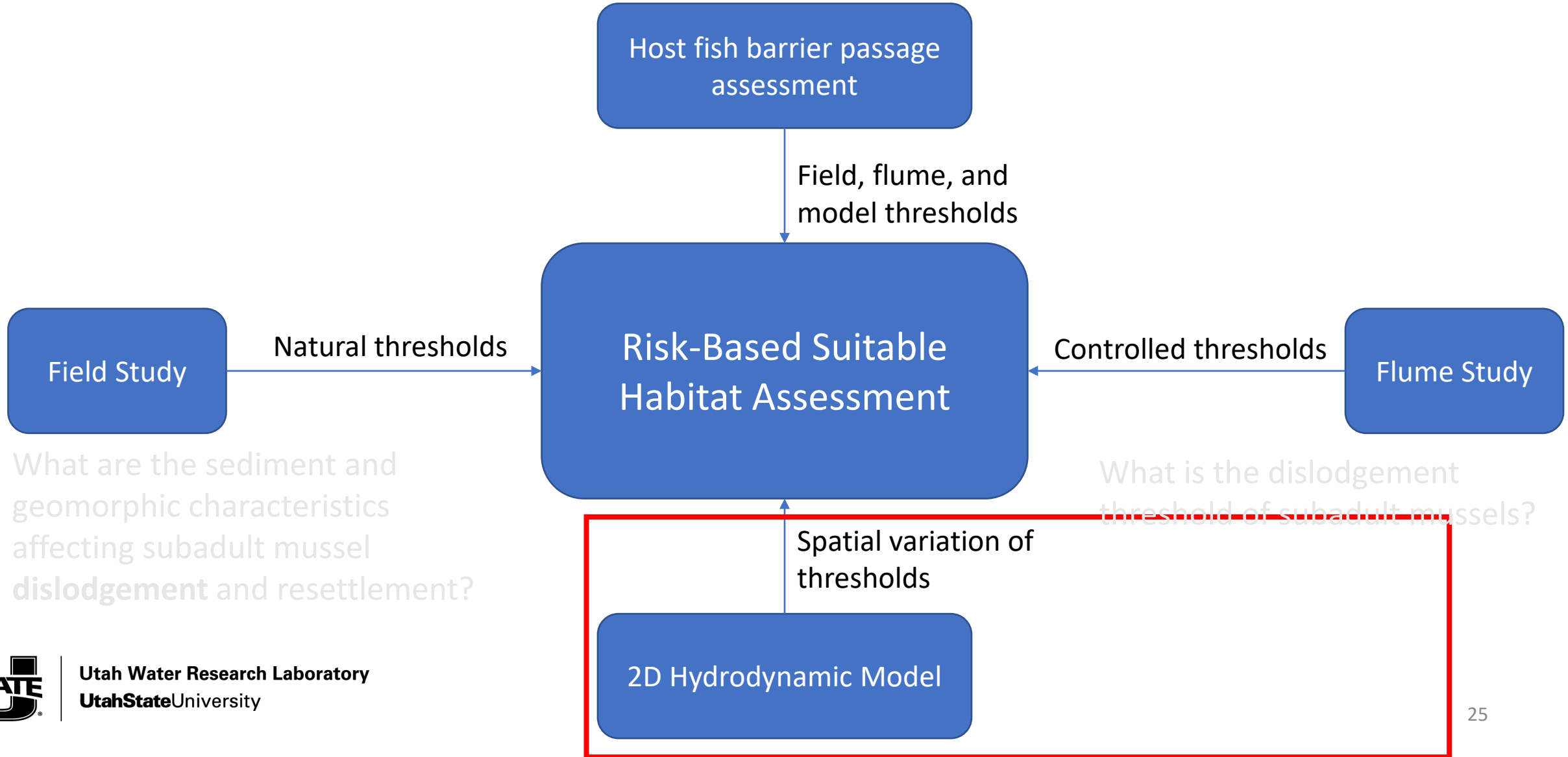
Initial Flume Results





- Finest sediment mix created most stable habitat
- Printed mussels had a lower entrainment level than live mussels

Generalized Modeling Framework



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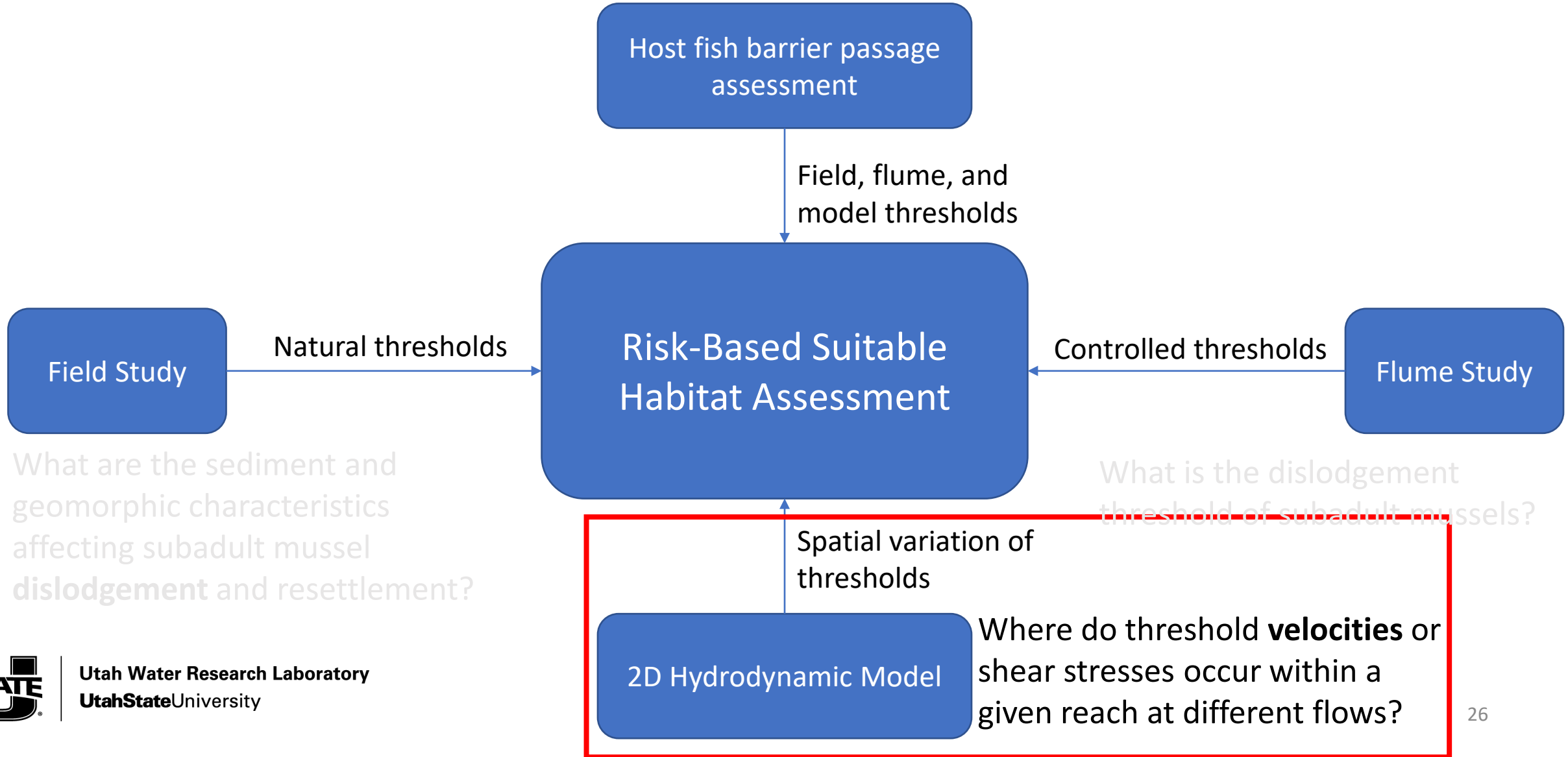
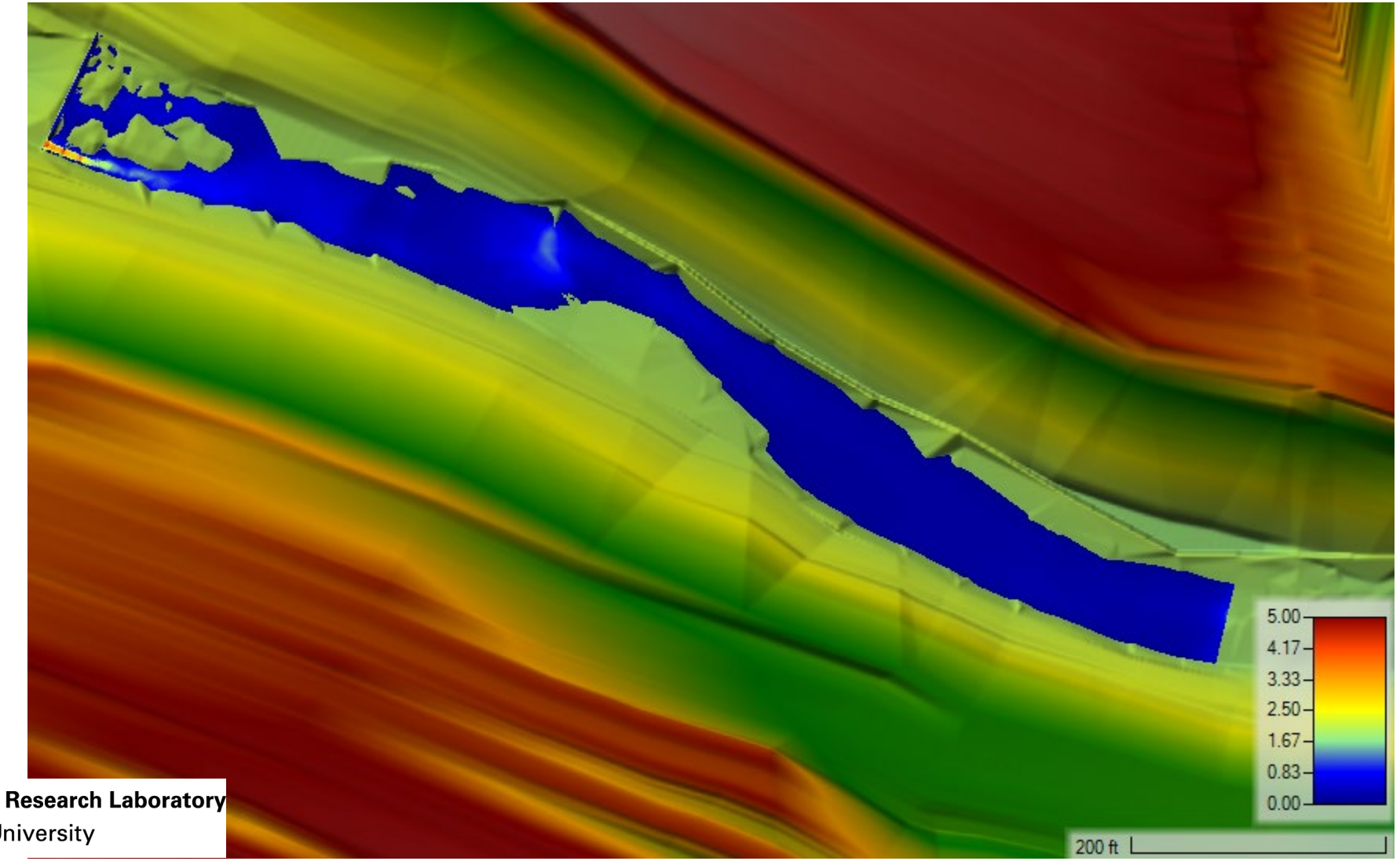


Modeling Initial Results



Modeling Initial Results

15 cfs

Highest velocity in chute

4740 cfs

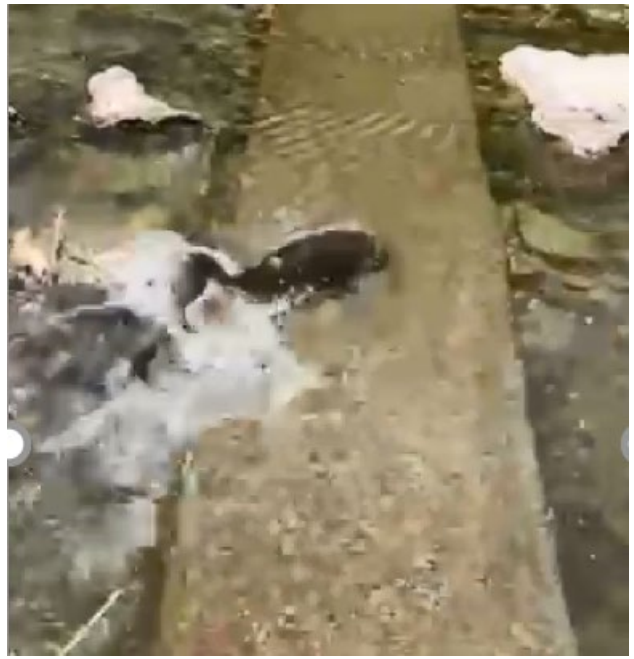
Bar creating lower velocity on river right

18100 cfs

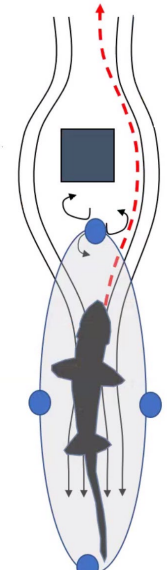
Host fish barrier passage assessment

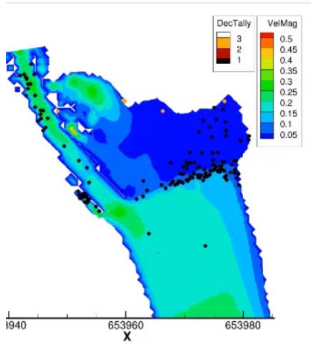
Field-based fish tagging and tracking

- >1000 fish tagged across 19 species
- Biweekly sampling at indiv. barriers
- Monthly longitudinal floats

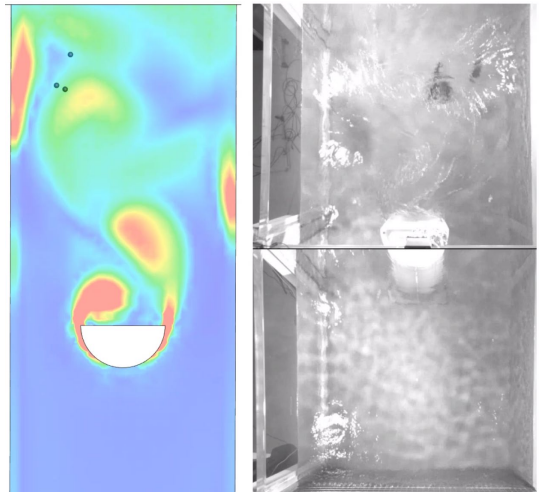


Particle-based fish movement modeling





Flume studies with live fish

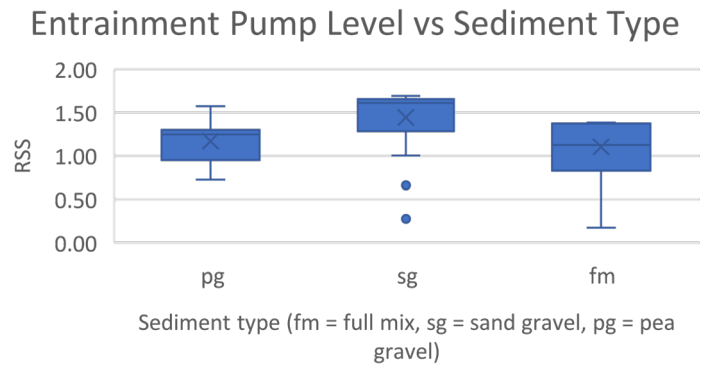


Probability of passage across flows based on fish and barrier characteristics

Combining the Parts

Host fish barrier passage assessment

Field, flume, and model thresholds



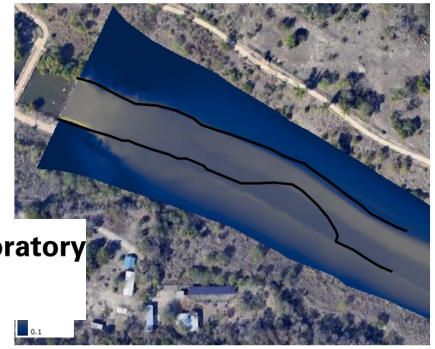
Field Study

Natural thresholds

Risk-Based Suitable Habitat Assessment

Controlled thresholds

Flume Study

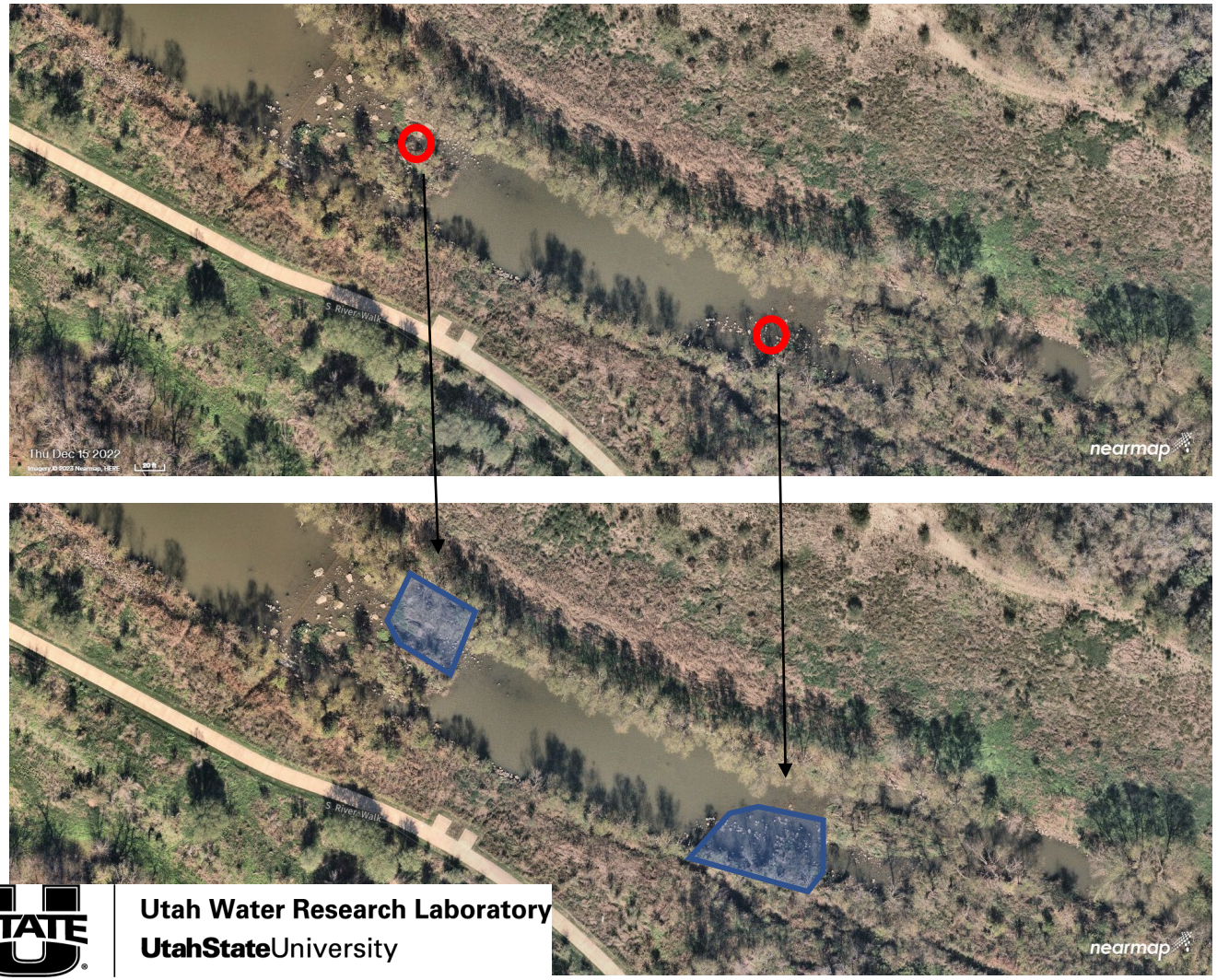


Spatial variation of thresholds

2D Hydrodynamic Model

Utah Water Research Laboratory
UtahStateUniversity

Reintroduction to the Mission Reach



- Recommending highest performing deployment areas
  - SARA expanding these sites to zones large enough to support mussel reintroduction
- Using dislodgement thresholds to build monitoring plan

Reintroduction to the Mission Reach

- Subadult Yellow Sandshell ready to be released
- Reintroduction in two waves, the first planned for August 2024
- ~10% of mussels will be tagged with PIT tags for tracking
- Additional species to be reintroduced over next year and beyond

Future Work

- Additional Flume Trials
  - Using other printed species used in field work
- Additional Hydrodynamic Model Development
  - Other individual sites and entire Mission Reach
- Fish Movement Study with Texas A&M
  - Aims to understand mussels dispersal potential and provide insight on longitudinal frequency of reintroduction in an urban watershed to create a self-sustaining mussel population

Questions