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Pacific Northwest
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Energy Flexibility-Environment Tradeoff Toolset

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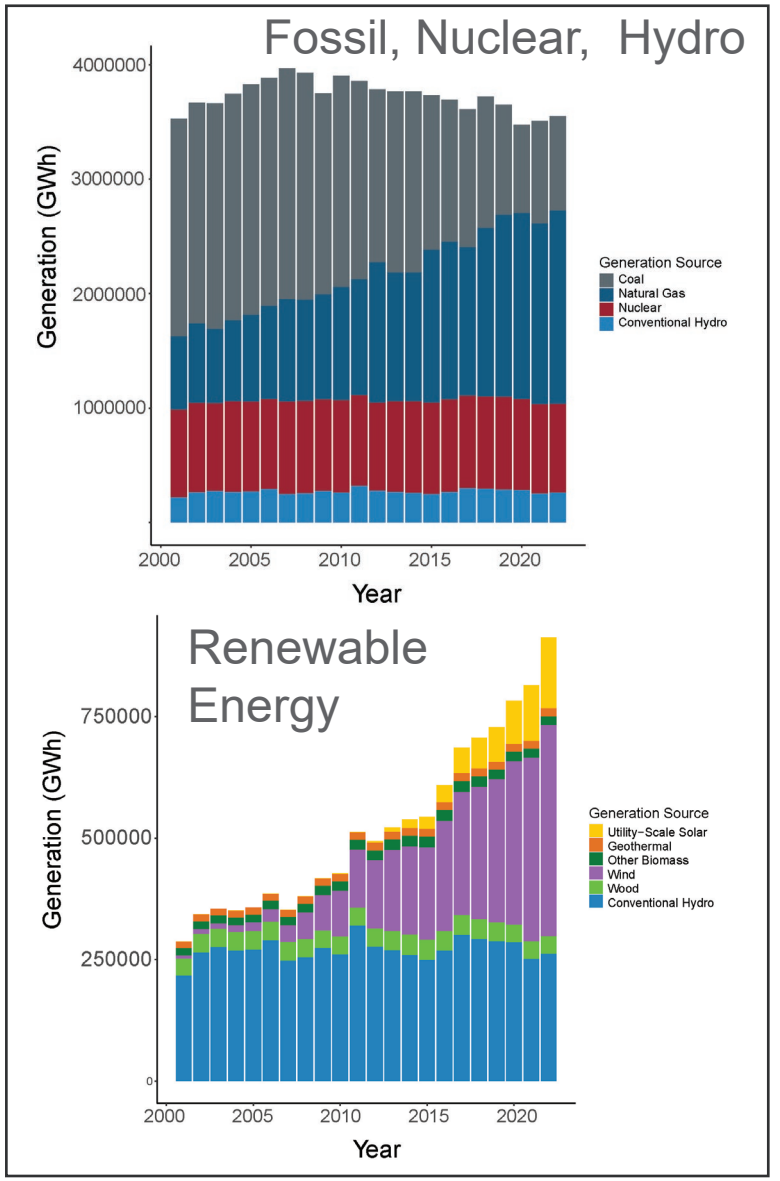
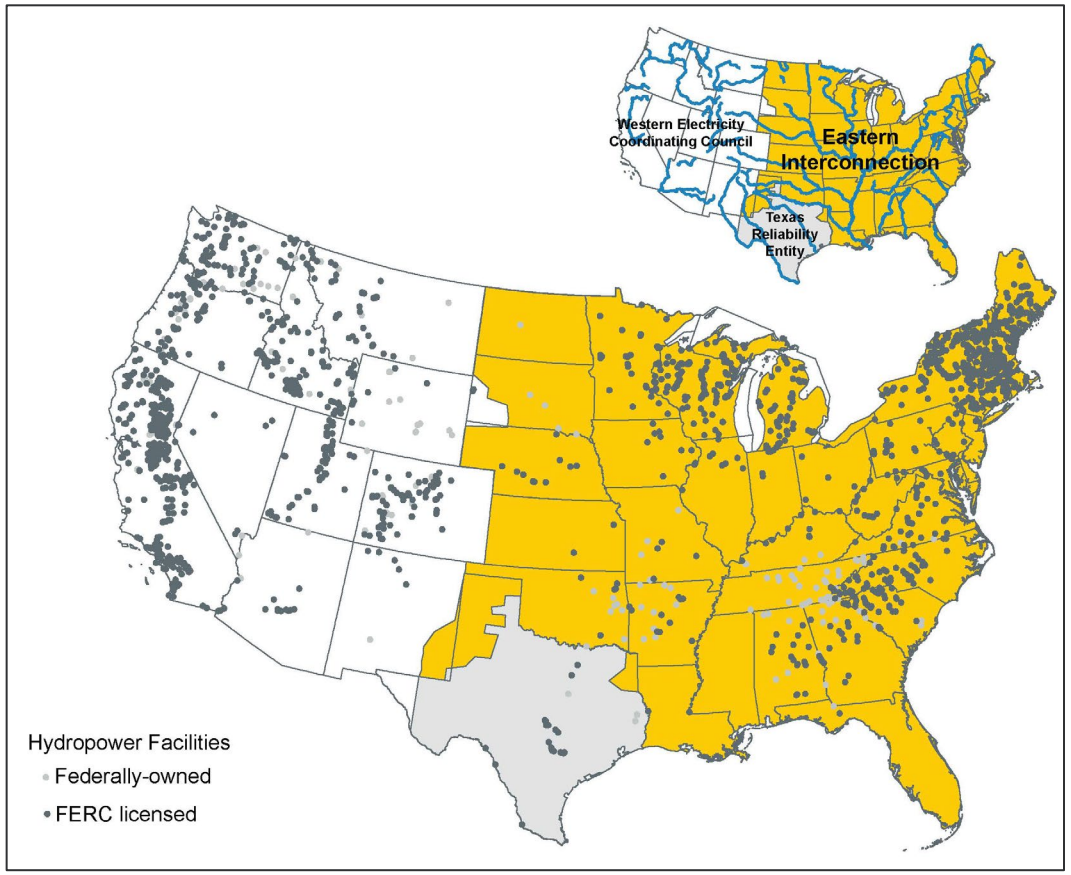
Hydropower impacts and mitigations

- Minimizing and mitigating environmental impacts of hydropower key challenge
  - Impacts and mitigations highly influenced by operational mode (e.g., load-following vs. peaking vs. run-of-river)
- Mitigations can come in different forms
  - Built structures such as fish passage, fish safer turbines, boat ramps, trails
  - Flow mitigations such as minimum flows, ramp rate restrictions
  - Operational flows can be designed to minimize impacts



Designing environmental flows to enable solar and wind integration



- Solar and wind generation require quick generation ramp up/down
- Environmental flows restricting hydropower response speed are common
- Environmental flows most common during times with most grid stress
  - No requirement to consider grid reliability
  - Potential pinch points for grid reliability and biota as more wind and solar integrated
- Different tools may be needed to understanding sub-hourly impacts

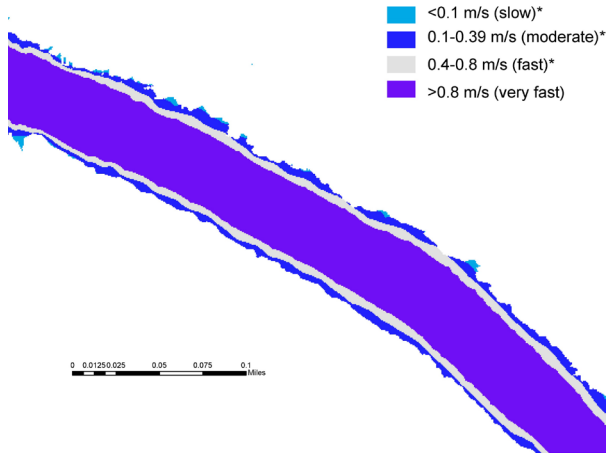
What are we trading off?

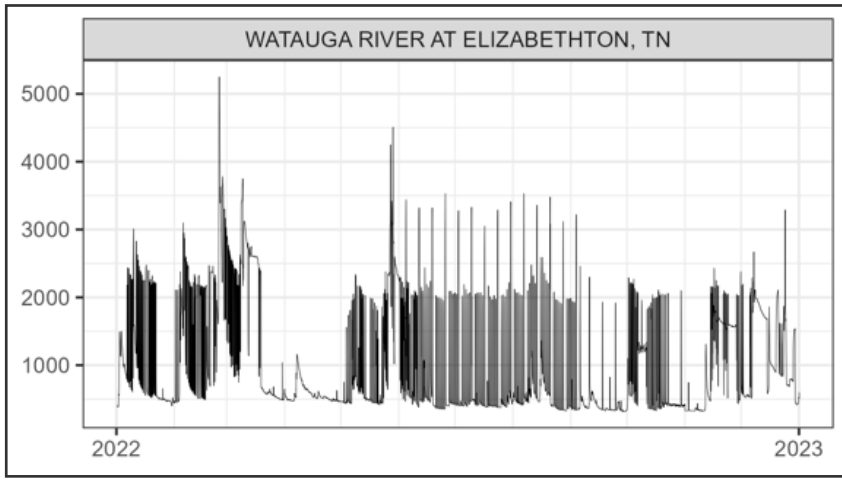
Grid Services	Grid Service Temporal Scale	Minimum Flow	Prescribed Flow	Ramp Rate Restriction
Load-following	Hourly plan, 5-10 minutes			
Volt/Var support	Continuous, <1 minute			
Frequency regulation	Seconds to minutes			
Spinning reserve	<10 minutes			
Non-spinning reserve	<10 minutes			
Replacement reserves	60 minutes to 2 hours			
System black start	As required			
Firm capacity	As required			

Prescribed flow is a set amount of flow for a set time period (e.g., 800 cfs from 8:00-15:00)

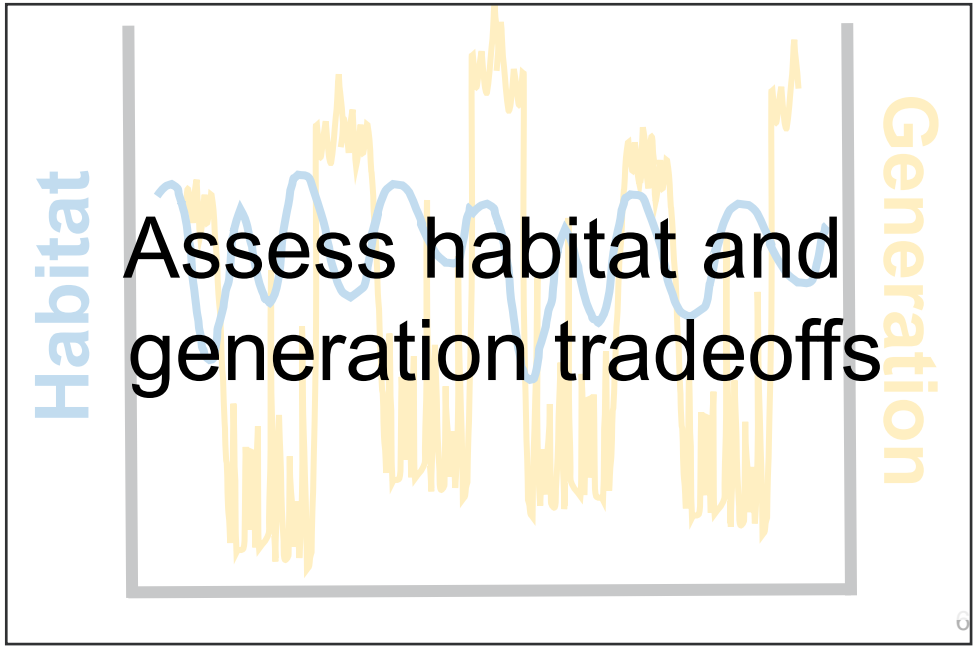
Optimize and evaluate energy and environment outcomes

Quantify fish habitat and connectivity metrics



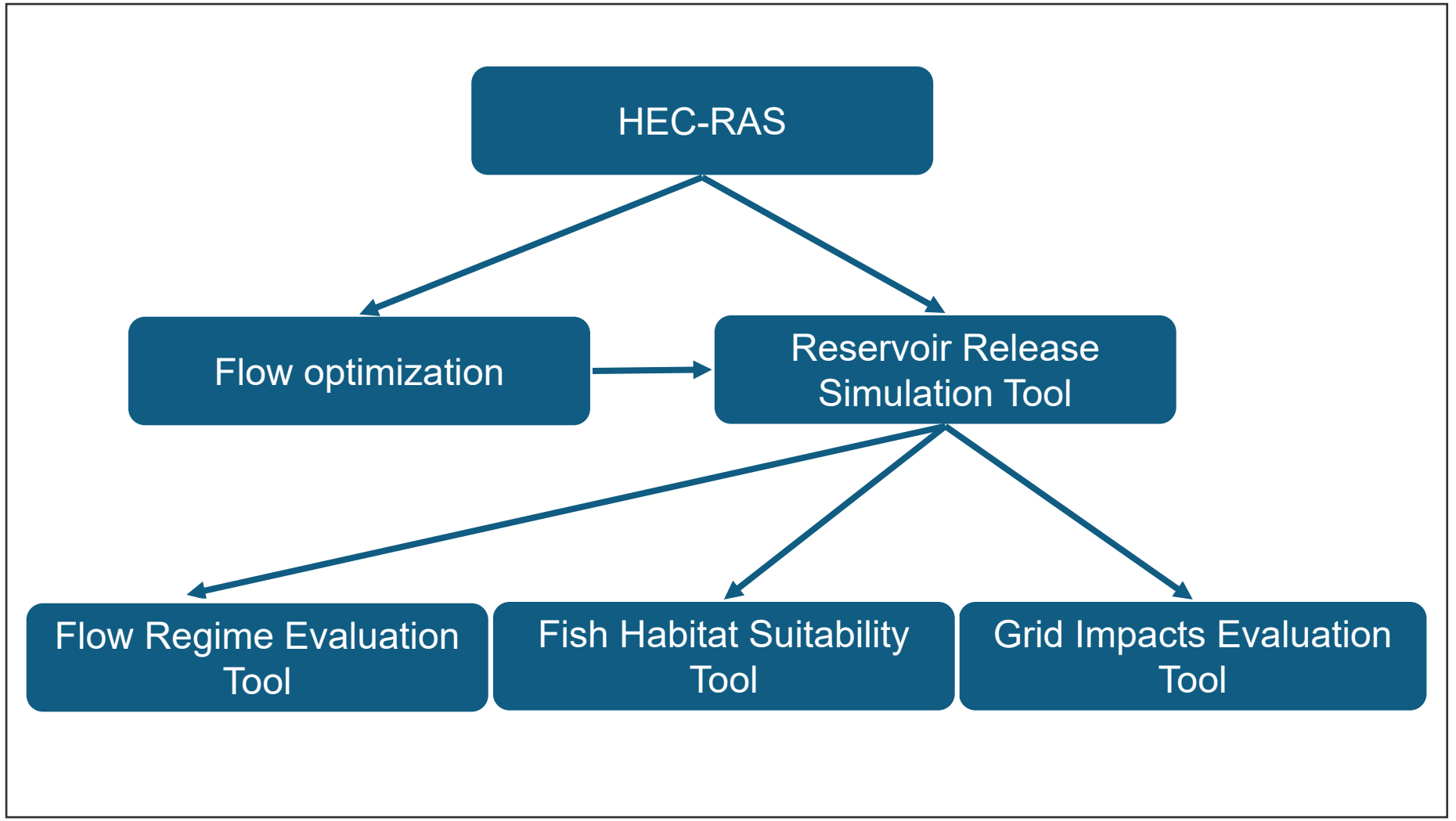


Input proposed flows or use tool-optimized flows



Assess habitat and generation tradeoffs

Optimize and evaluate energy and environment outcomes



1. Input HEC-RAS model

2. Simulate the Reservoir Releases

3. Evaluate Proposed Flow

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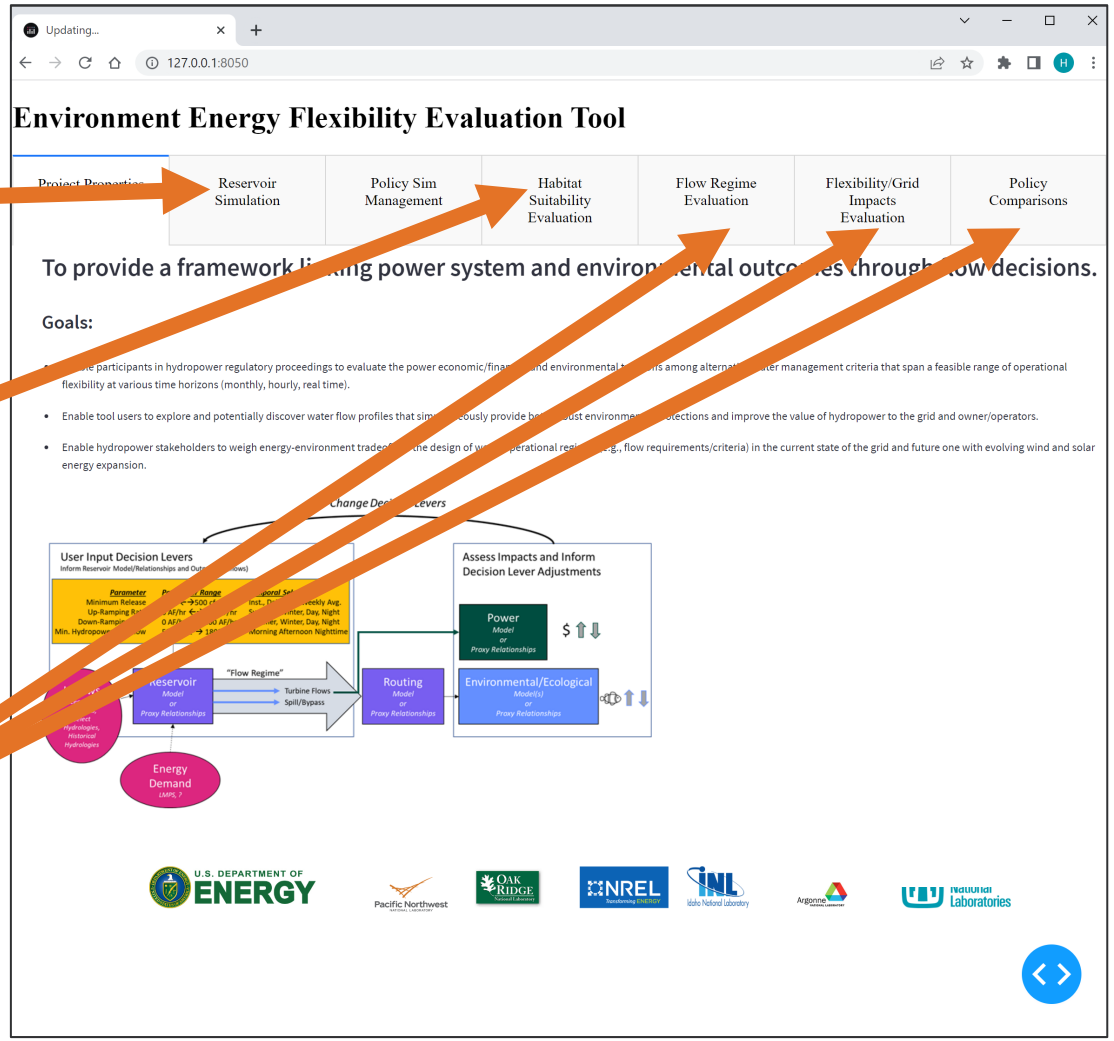
Web-based tool will allow users to evaluate and compare flows based on environmental characteristics

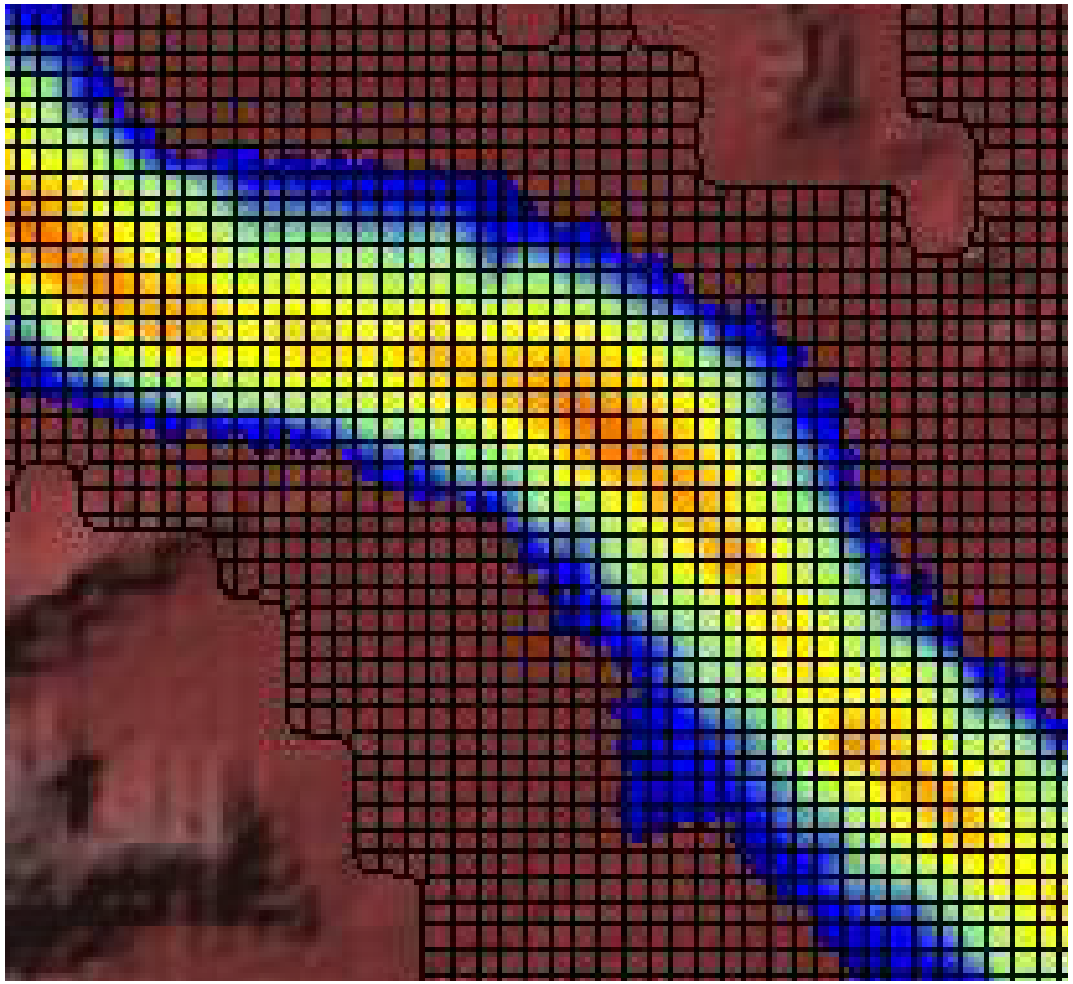
Tabs allow users to input characteristics of their system of interest **AND**

quantify environmental outcomes of flows **AND**

quantitatively and qualitatively compare evaluated flows from environment and energy perspectives



Input 1-D unsteady flow model of river

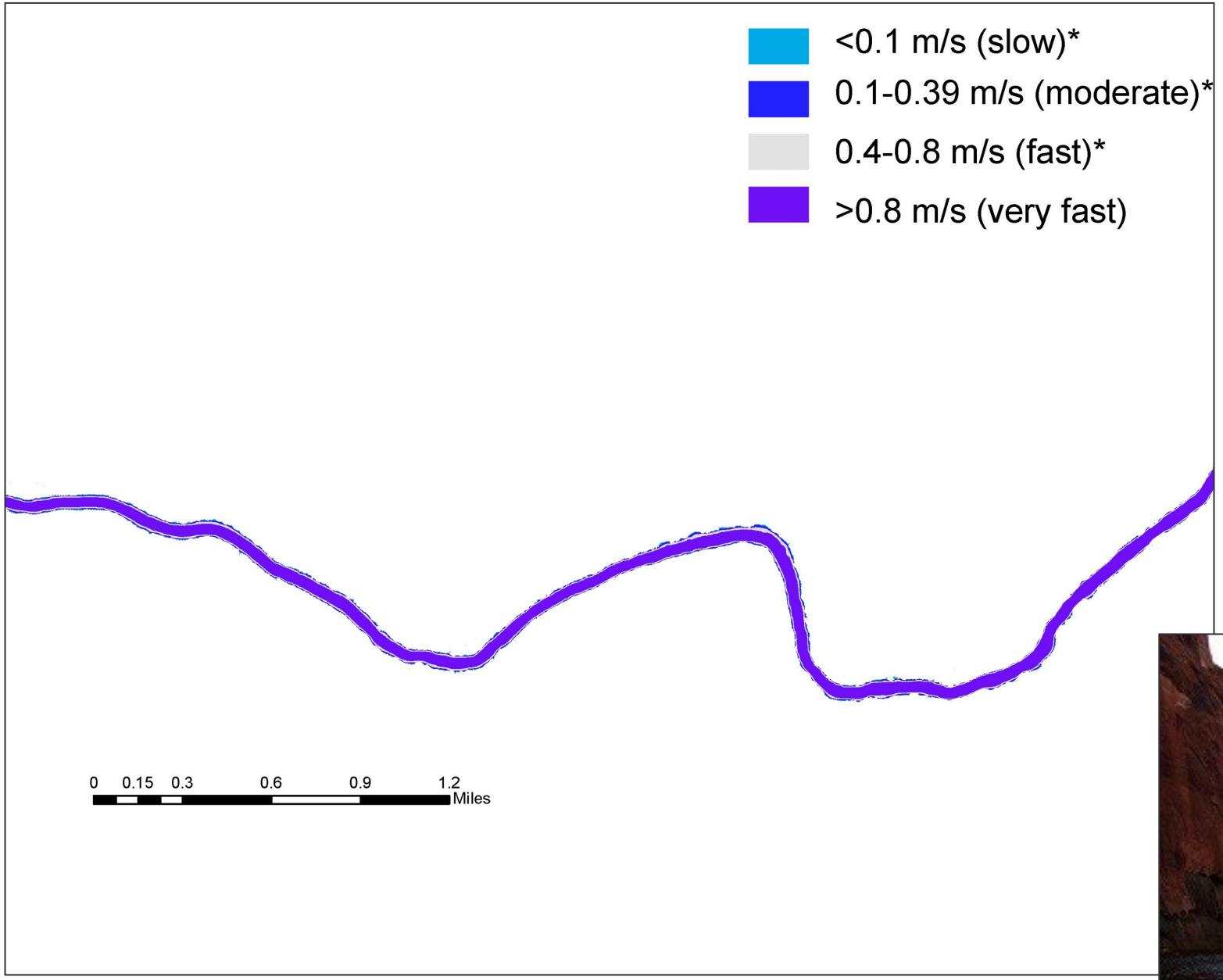


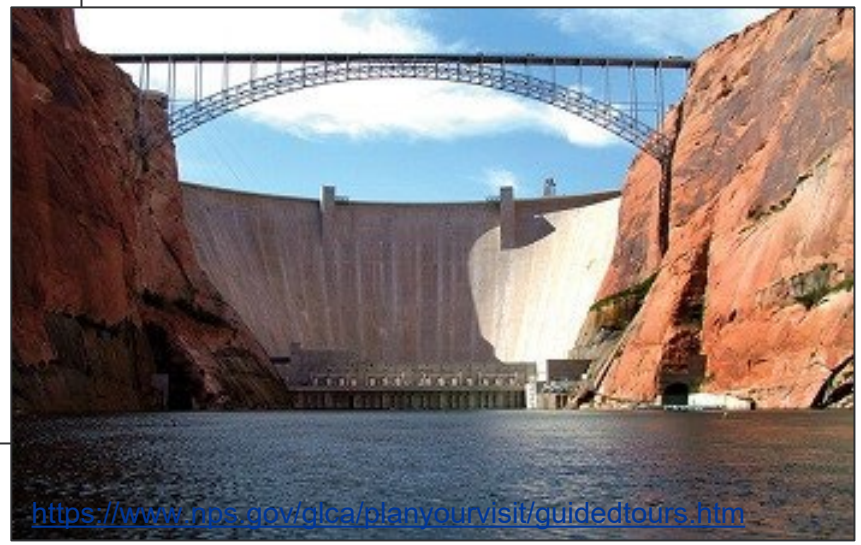
- HEC-RAS is a free tool developed by USACE that can model flow velocities, depth, and some other environmental variables given bathymetric measurements

- Simulates short time-scale flow fluctuations that can simulate load-following from hydropower plant (15-min resolution)

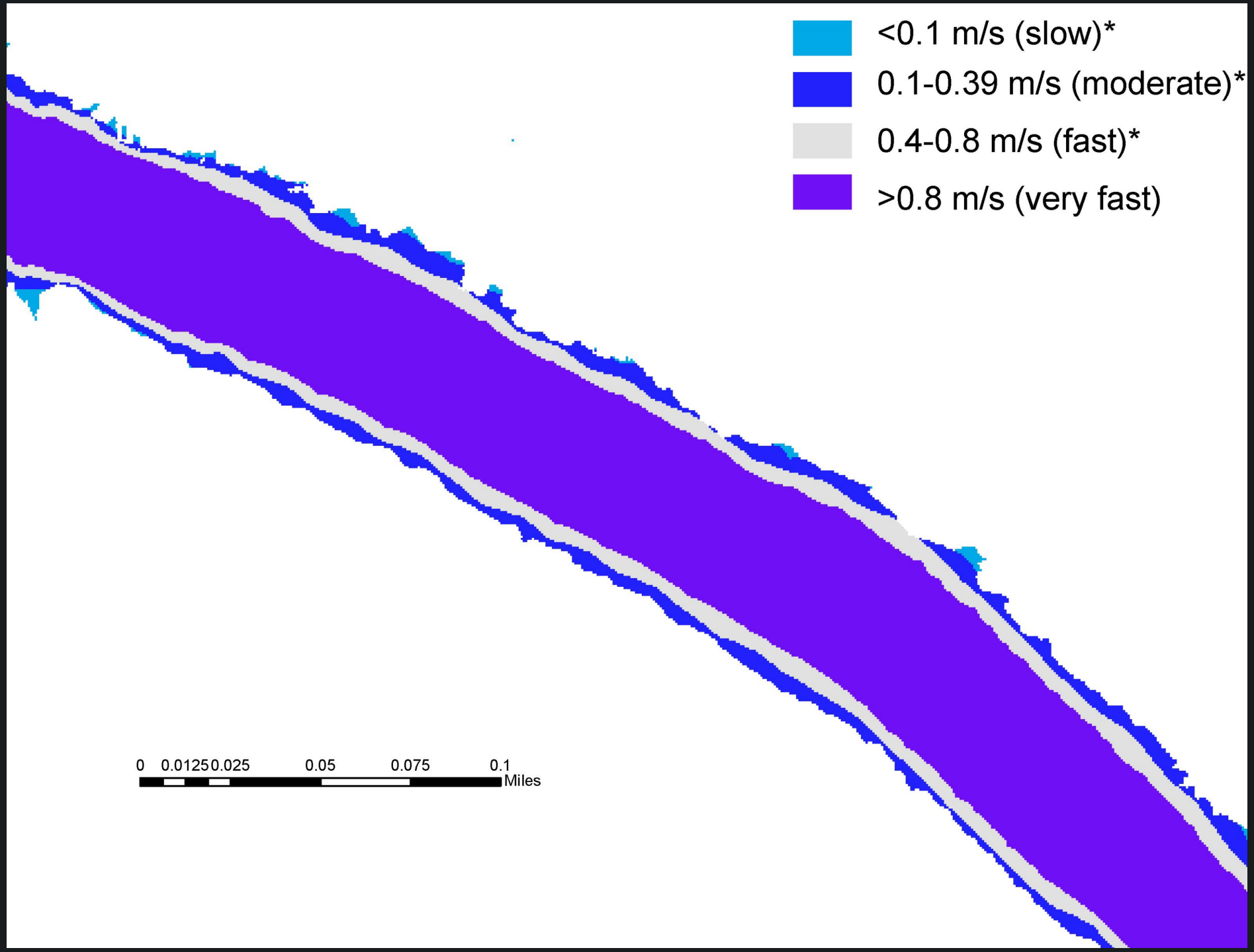
Flow depth and velocities filtered and area quantified

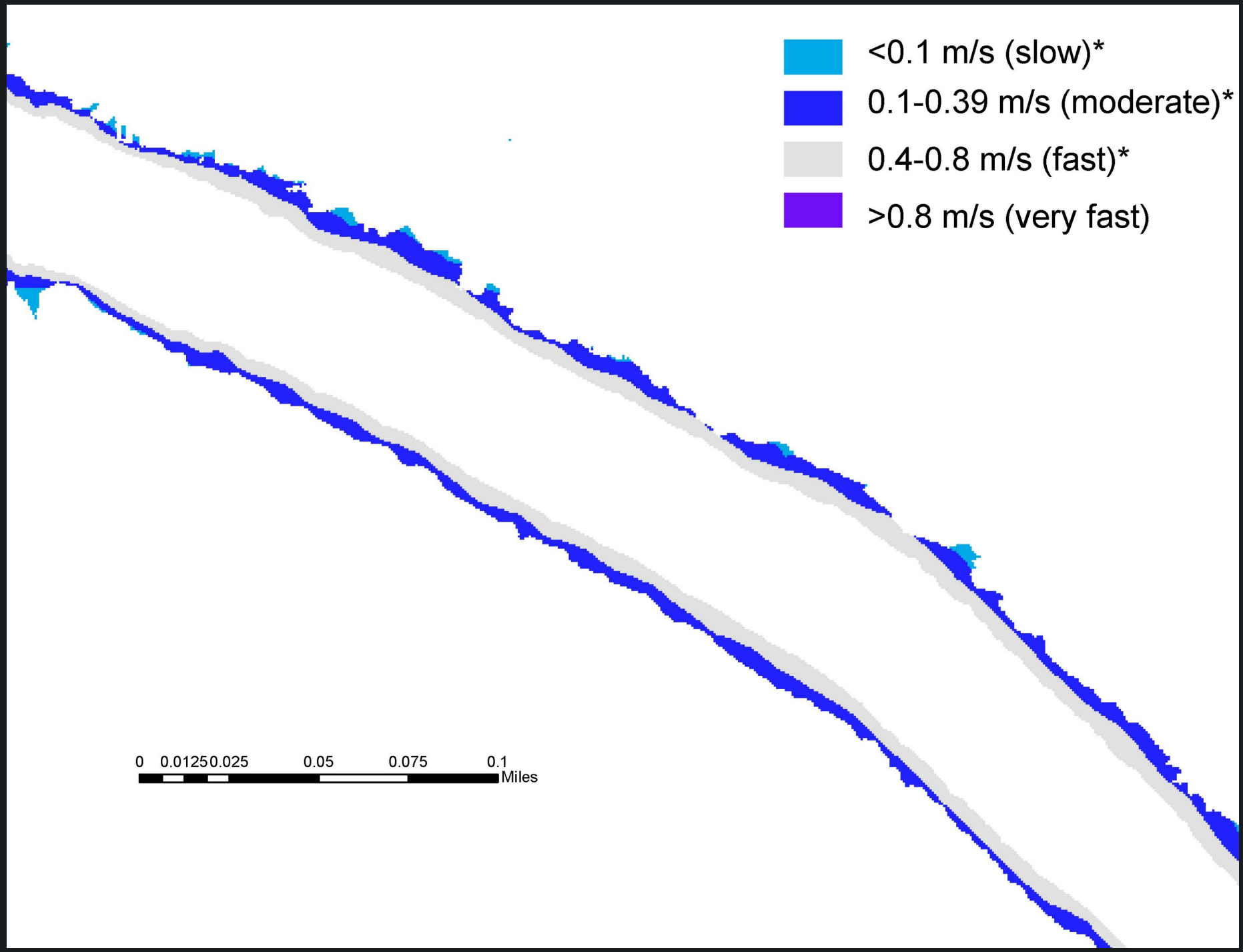
- Tool interfaces with QGIS to filter and quantify connectivity (spatial and temporal) of habitat types
- Use Fish Traits Database (Frimpong and Angermeier 2007) to define flow preferences for fish species
  - Fast, moderate, and slow velocities





Colorado River below Glen Canyon Dam


<0.1 m/s (slow)*
0.1-0.39 m/s (moderate)*
0.4-0.8 m/s (fast)*
>0.8 m/s (very fast)
0 0.0125 0.025 0.05 0.075 0.1
Miles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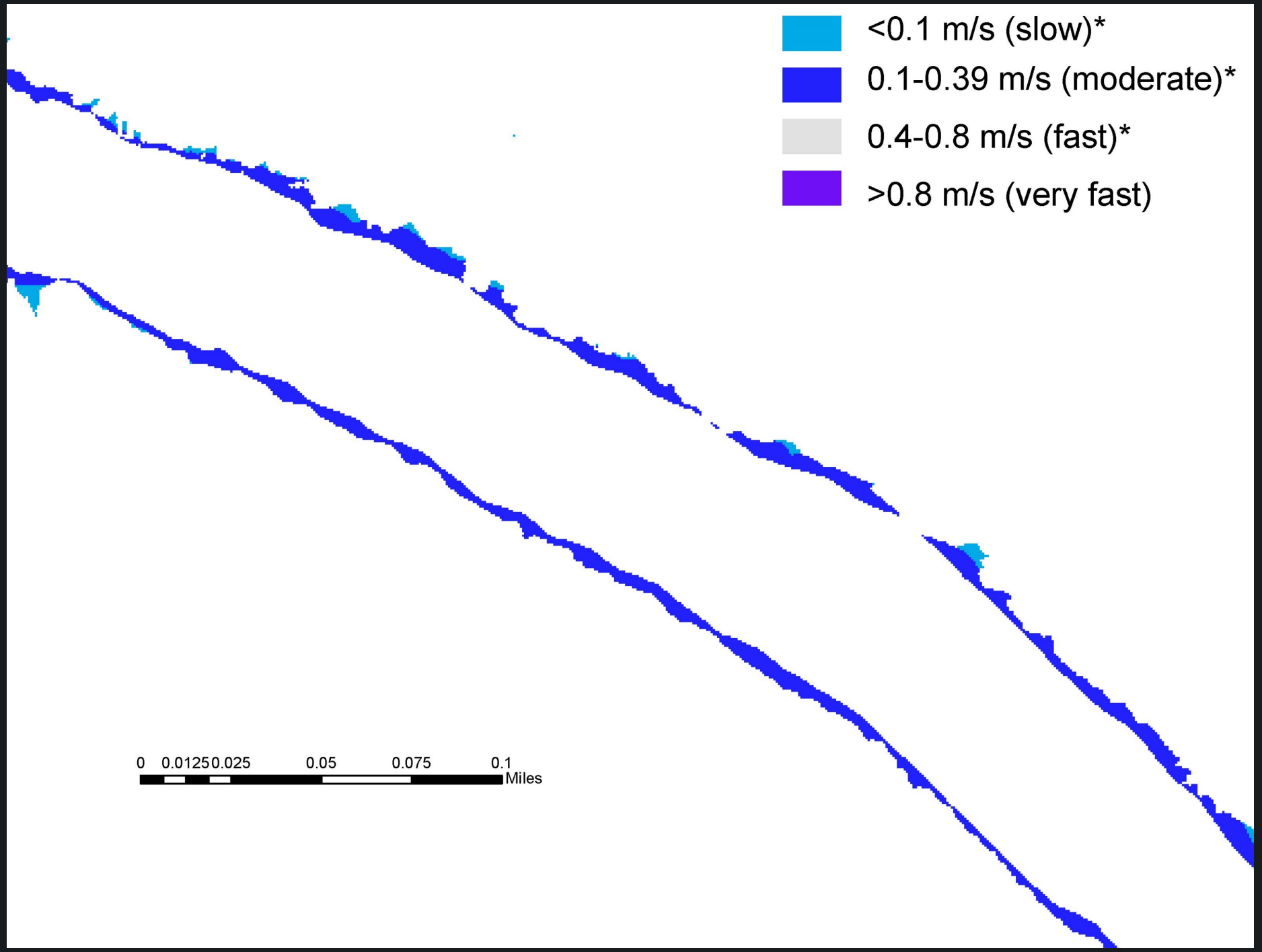
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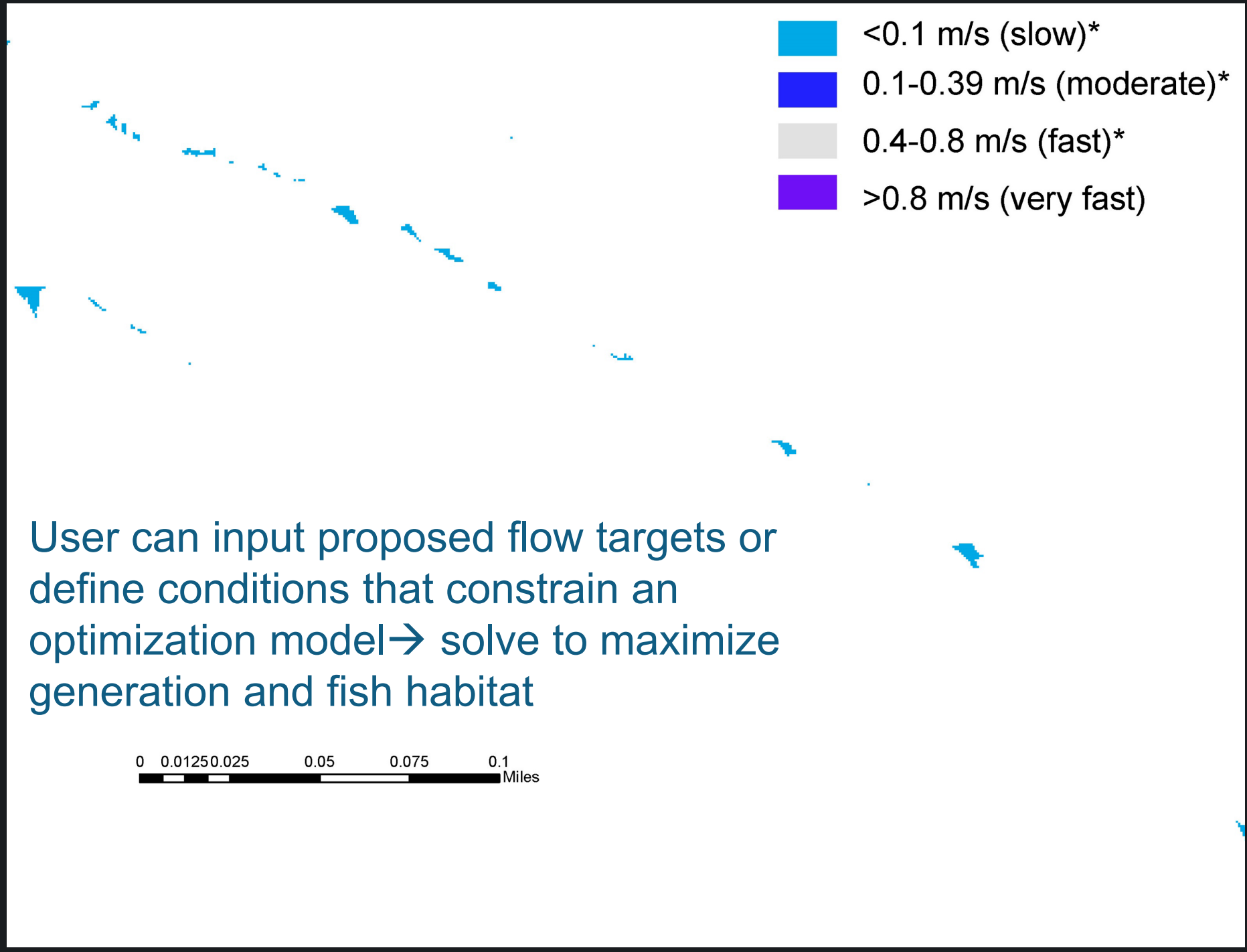
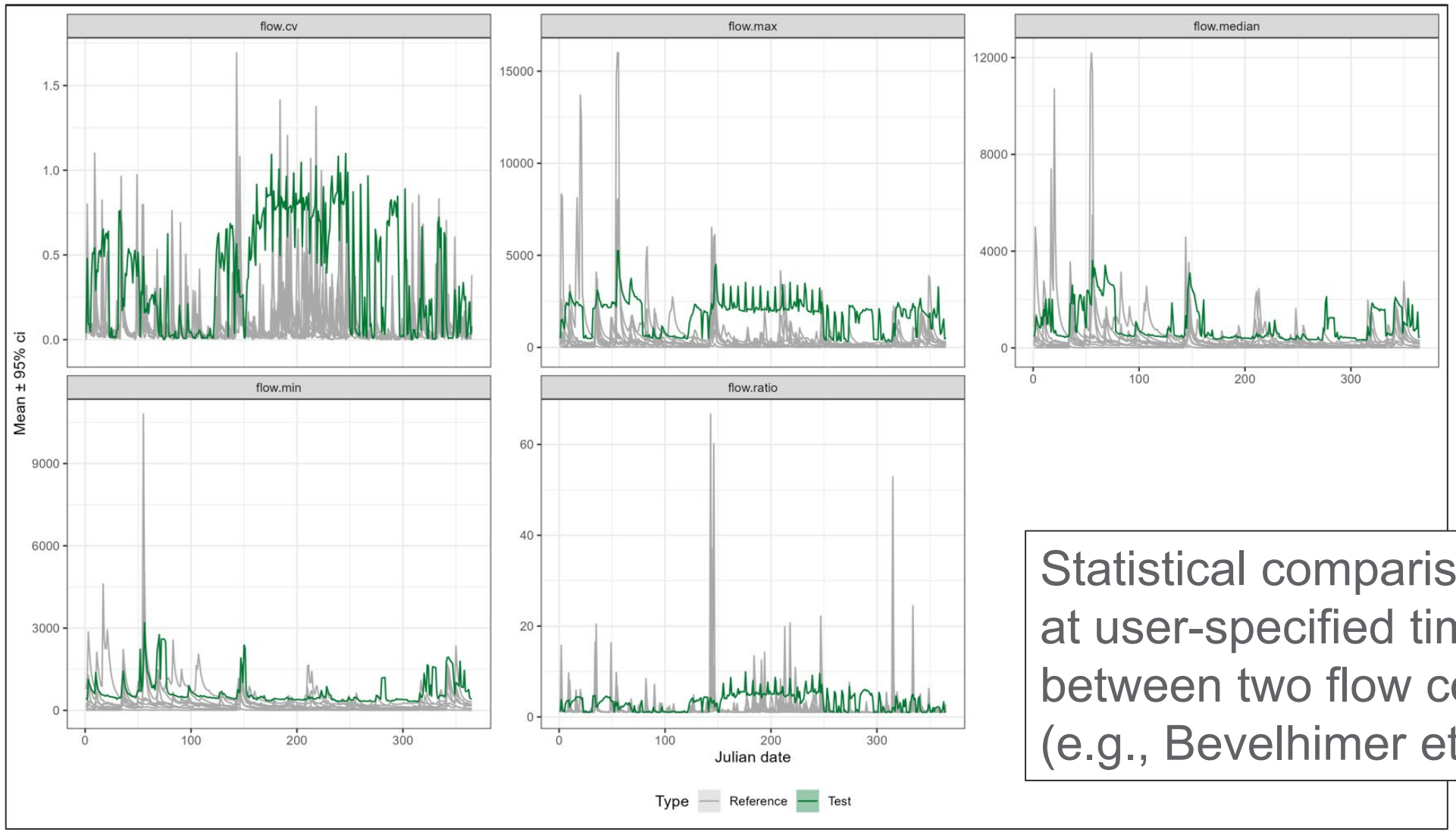


User can input proposed flow targets or define conditions that constrain an optimization model→ solve to maximize generation and fish habitat

Flow regime evaluation tool

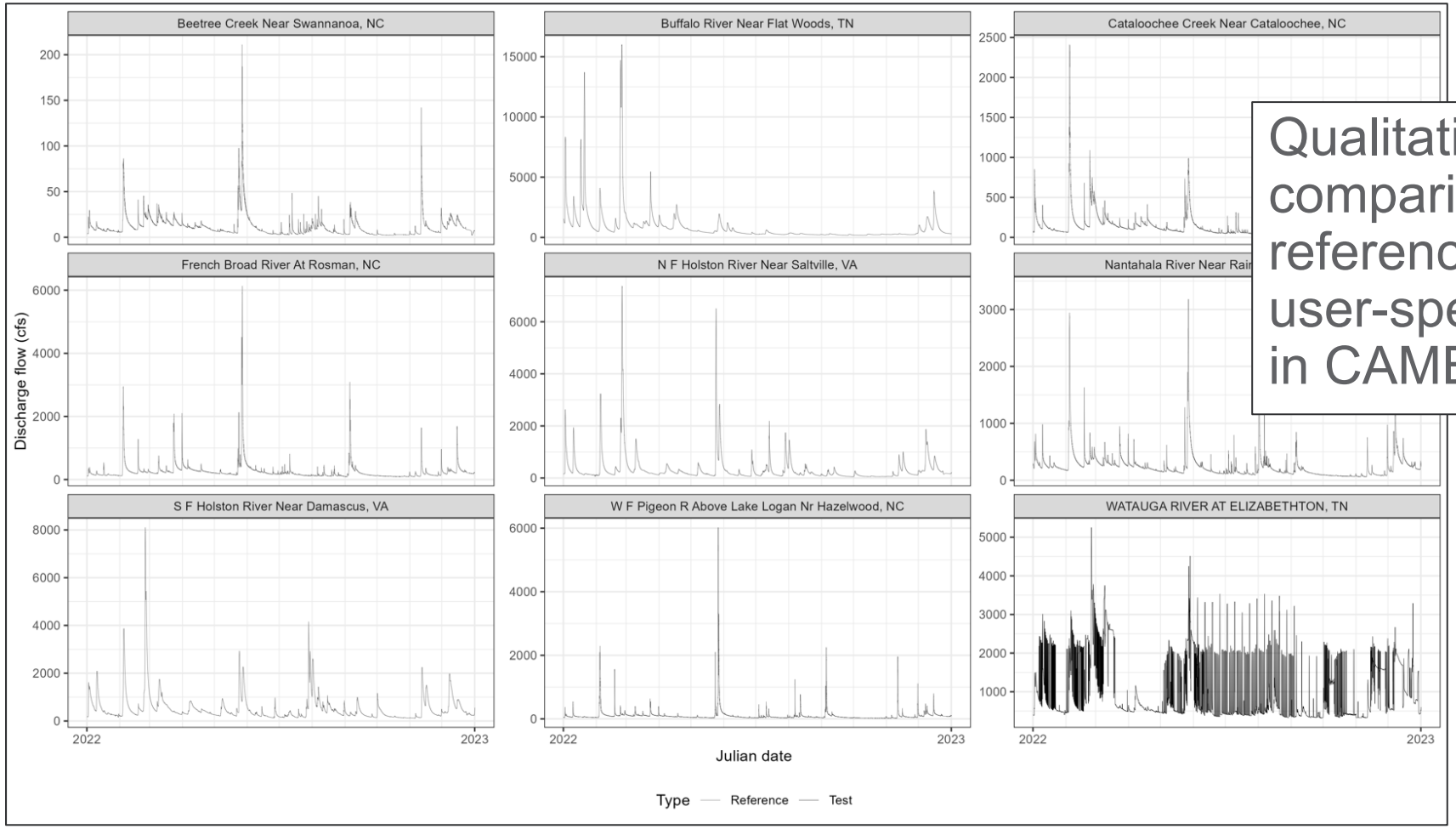
- How do flows compare to historic or other reference flows?
  - Quantitative measures of sub-daily flow variability between
    - ✓ Different flow patterns
    - ✓ Test and reference gages
  - Connects to USGS CAMELS dataset (Newman et al. 2014)

Flow regime evaluation tool



Statistical comparison of flows at user-specified time-scale between two flow conditions (e.g., Bevelhimer et al. 2015)

Flow regime evaluation tool



Qualitative comparison of reference flows from user-specified gages in CAMELS dataset

Energy-Environment Tradeoffs

- This tool is designed with FERC hydropower licensing in mind although other applications are possible
- Initial software testing in FY24
- We are looking for feedback!
  - Does this seem useful?
  - Are endpoints appropriate?
  - Are you interested in helping us test and demo this product?

Contact

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