Oak Ridge National Laboratory

# Improving Hydropower Benefits by Linking Environmental and Power System Tradeoffs Through Flow Release Decisions

Brenda Pracheil

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U.S. DEPARTMENT OF ENERGY

HydroWIRES
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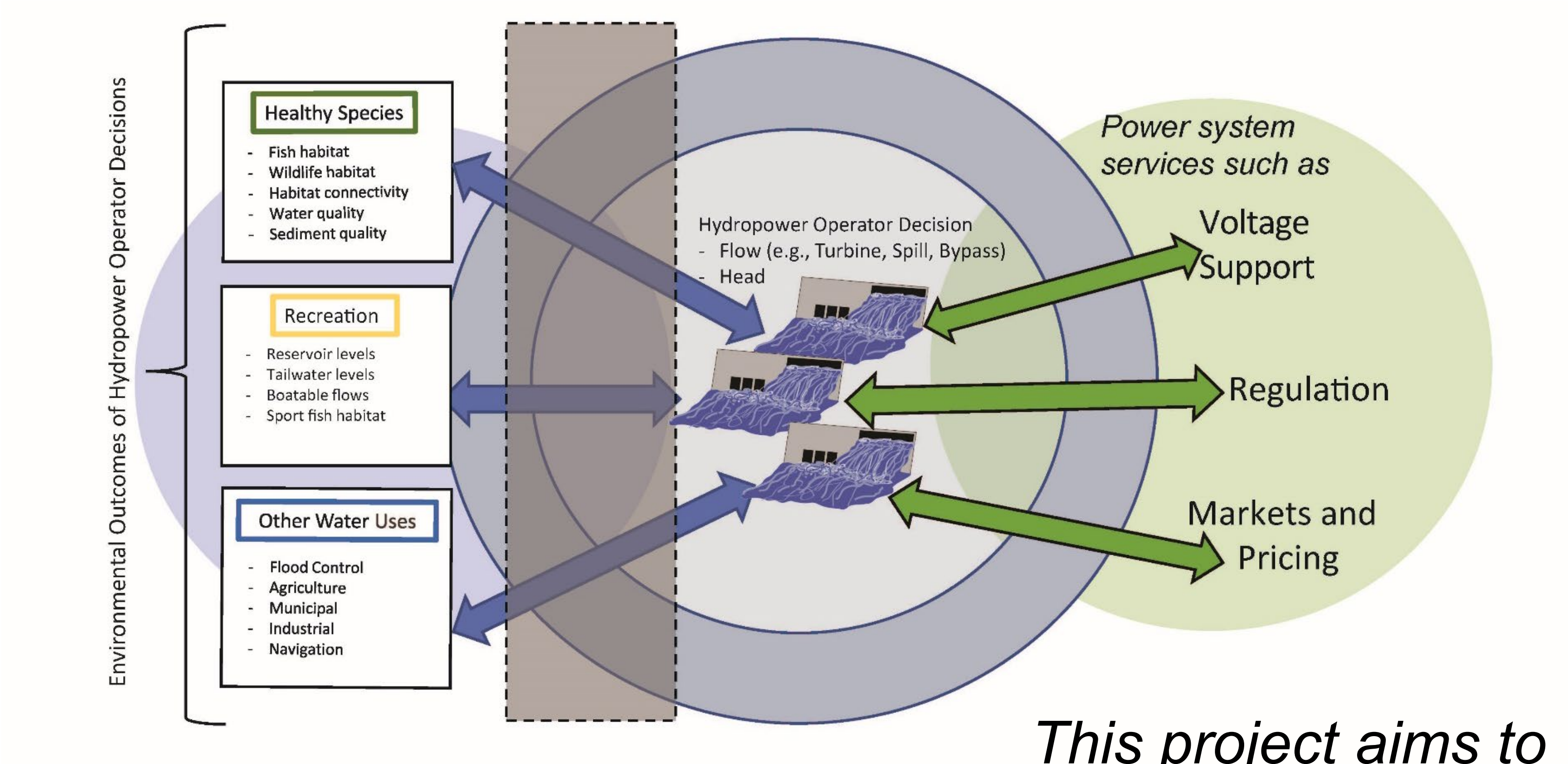
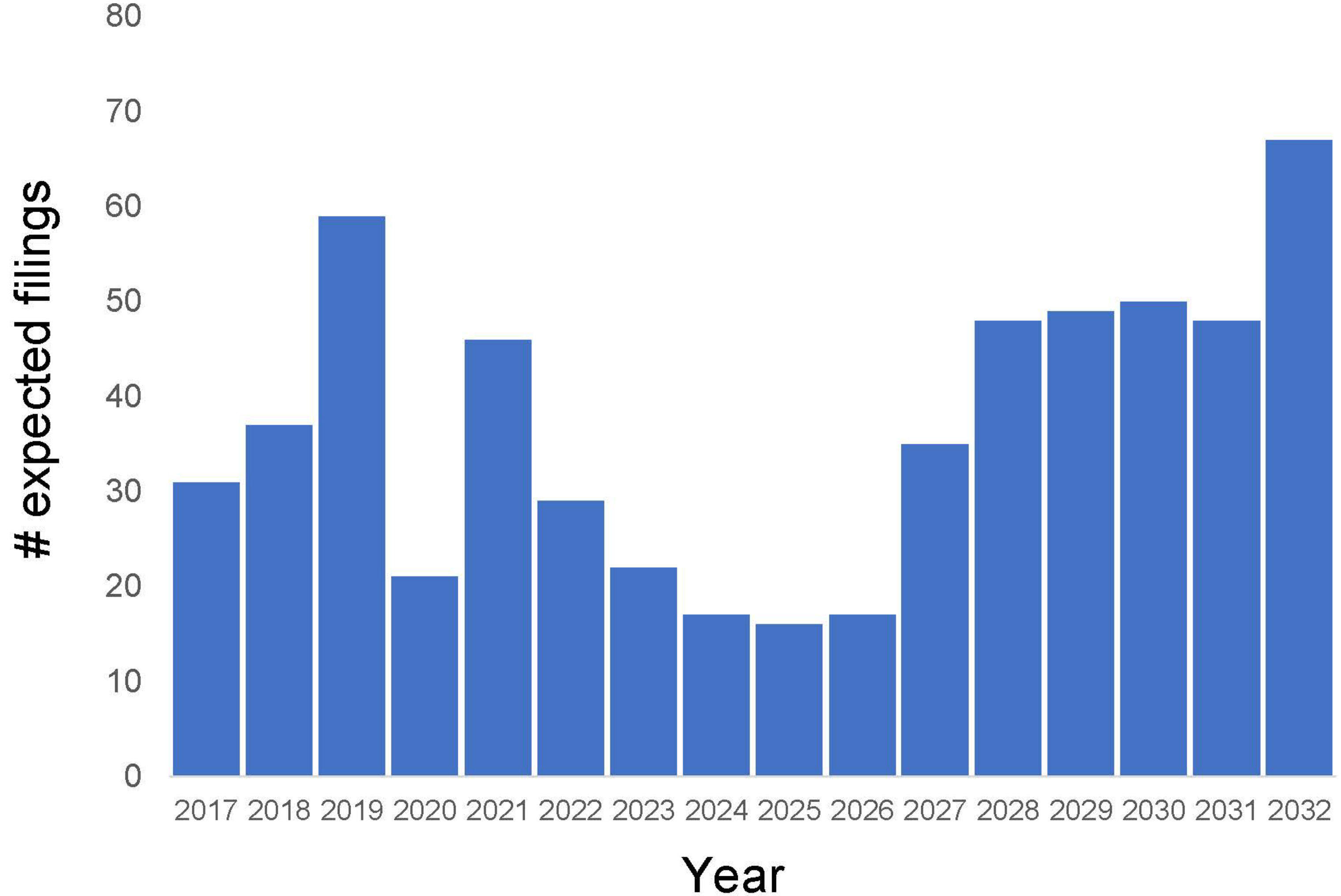


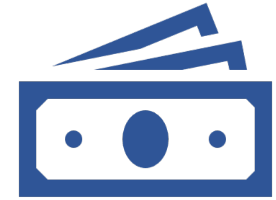

*This project aims to **quantify hydropower operational flexibility given non- flow requirements***

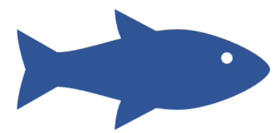
# Large numbers of hydropower projects are expected to be relicensed in the coming years



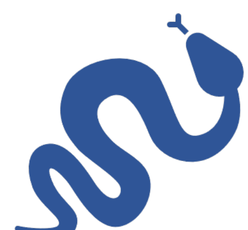
# U.S. Hydropower Regulatory Process

- Regulatory process stakeholder-driven
  - Environmental
  - Recreational
  - Developers
  - Investors
  - Tribal
  - State
  - Federal
- Stakeholders help determine Protection, Mitigation, and Enhancement measures like environmental flow requirements







# Non-power constraints on flexibility

*What does flexibility look like in light of flow constraints?*

**Protection, Mitigation, Enhancement**

- Negotiated among stakeholders as part of regulatory process
- Fish/ Wildlife
- Recreation
- Cultural sites
- Water quality

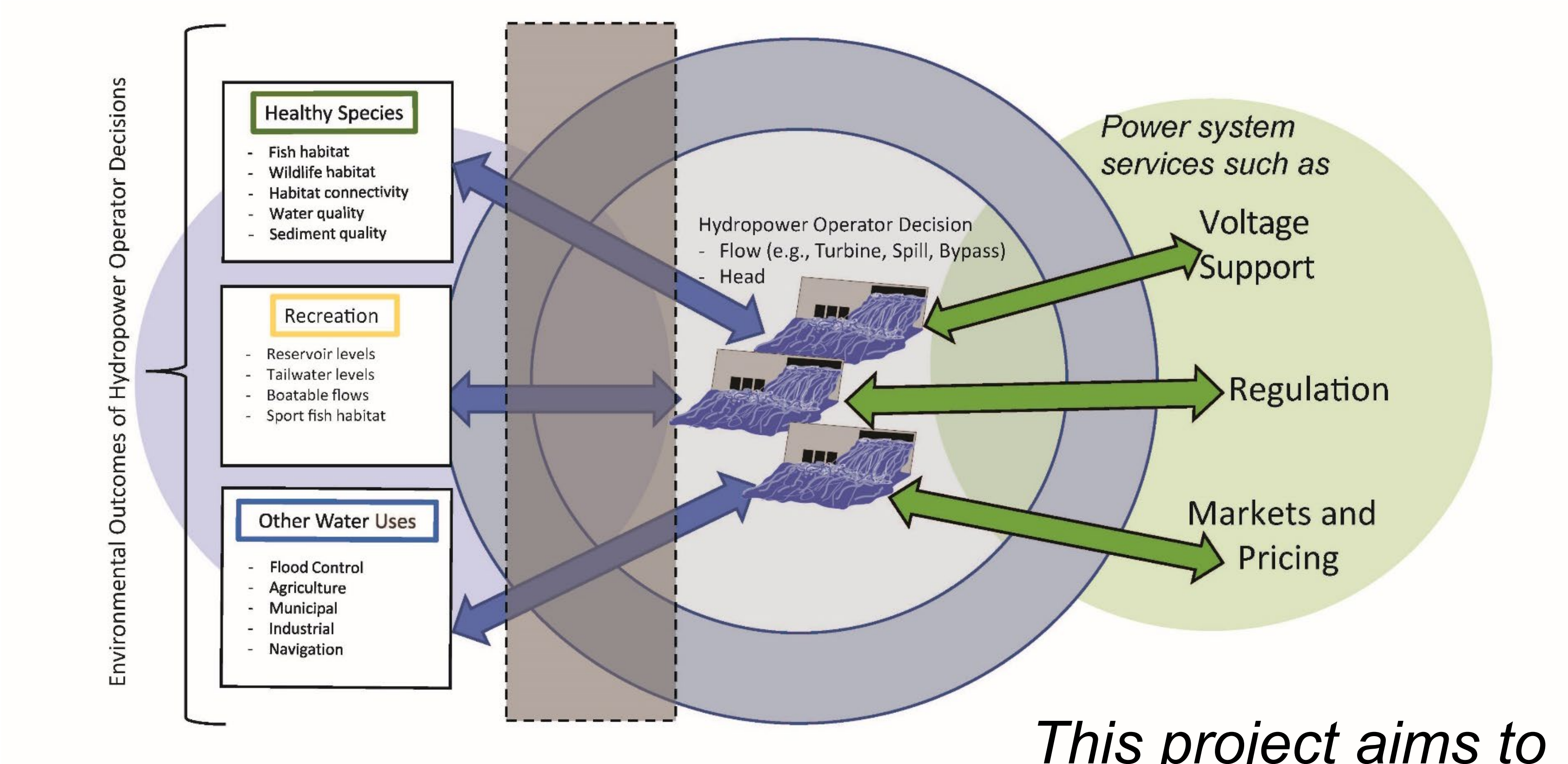
**Water rights**

- Municipal
- Irrigation
- Industrial

**Other mandates**

- Navigation
- Flood control
- Irrigation
- Drought management
- Water quality

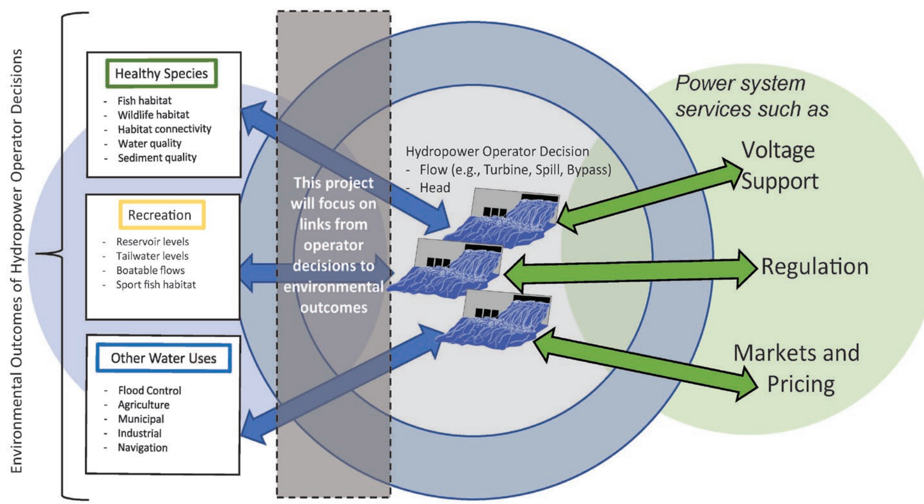
**Flow decision/ Power generation**




*This project aims to* ***quantify hydropower operational flexibility given non- flow requirements***

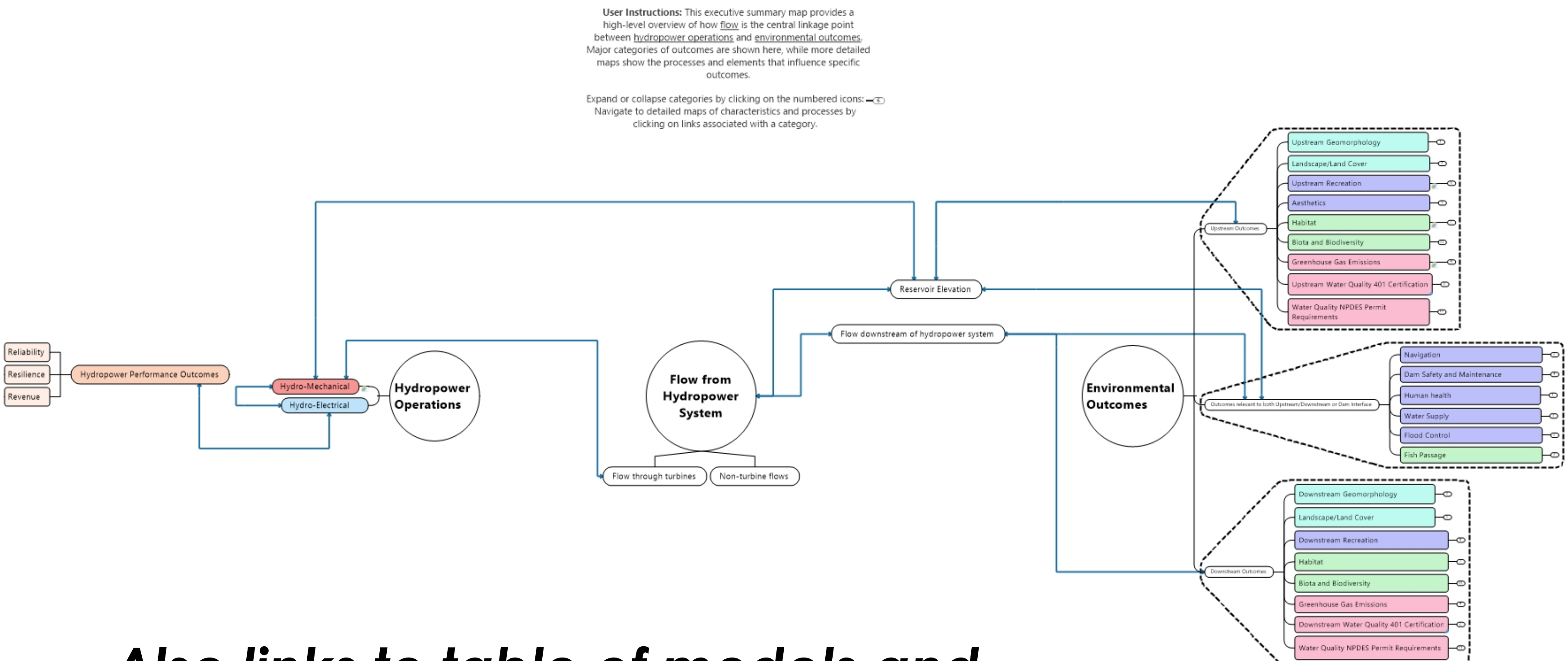
# Project approach

- Quantify hydropower operational flexibility given non-power flow requirements by linking power system and environmental outcomes through the common hub of flow decisions
  - **Task 1: Linking flow decisions to environmental outcomes**
  - **Task 2: Linking power system needs to flow decisions**
  - **Task 3: Case studies demonstrating co-optimization of power system and environmental outcomes**



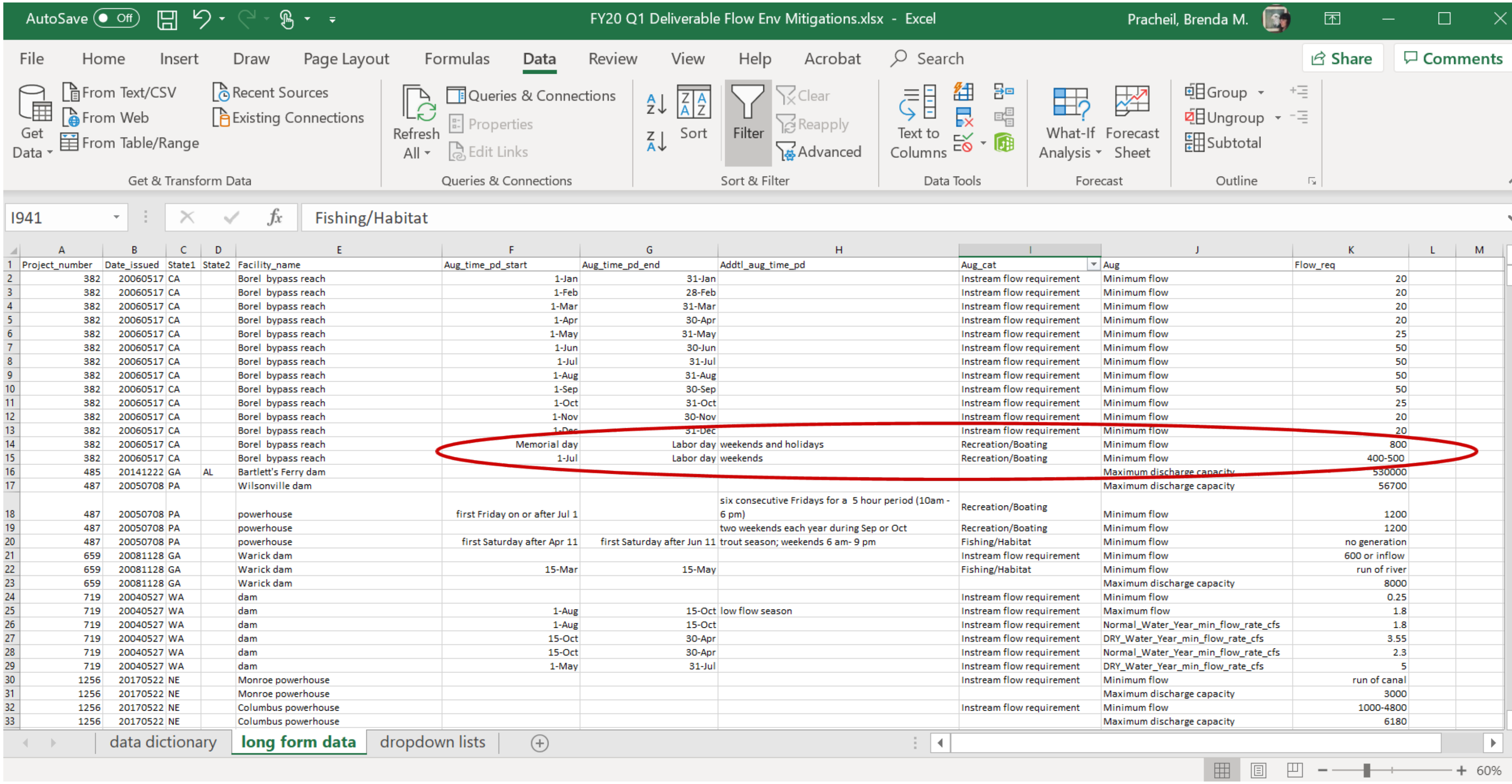
# Power system to environment linkage map

- file://ornldata.ornl.gov/Home/HydroWIRES/Case%20studies/ExecutiveSummaryMap%20(2).html




***Also links to table of models and tools needed to create linkages***

# Dataset of environmental flow requirements




| 1 | Project_number | Date_issued | State1 | State2 | Facility_name | Aug_time_pd_start | Aug_time_pd_end | Addtl_aug_time_pd | Aug_cat | Aug | Flow_req |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 382 | 20060517 | CA | | Borel bypass reach | 1-Jan | 31-Jan | | Instream flow requirement | Minimum flow | 20 |
| 3 | 382 | 20060517 | CA | | Borel bypass reach | 1-Feb | 28-Feb | | Instream flow requirement | Minimum flow | 20 |
| 4 | 382 | 20060517 | CA | | Borel bypass reach | 1-Mar | 31-Mar | | Instream flow requirement | Minimum flow | 20 |
| 5 | 382 | 20060517 | CA | | Borel bypass reach | 1-Apr | 30-Apr | | Instream flow requirement | Minimum flow | 20 |
| 6 | 382 | 20060517 | CA | | Borel bypass reach | 1-May | 31-May | | Instream flow requirement | Minimum flow | 25 |
| 7 | 382 | 20060517 | CA | | Borel bypass reach | 1-Jun | 30-Jun | | Instream flow requirement | Minimum flow | 50 |
| 8 | 382 | 20060517 | CA | | Borel bypass reach | 1-Jul | 31-Jul | | Instream flow requirement | Minimum flow | 50 |
| 9 | 382 | 20060517 | CA | | Borel bypass reach | 1-Aug | 31-Aug | | Instream flow requirement | Minimum flow | 50 |
| 10 | 382 | 20060517 | CA | | Borel bypass reach | 1-Sep | 30-Sep | | Instream flow requirement | Minimum flow | 50 |
| 11 | 382 | 20060517 | CA | | Borel bypass reach | 1-Oct | 31-Oct | | Instream flow requirement | Minimum flow | 25 |
| 12 | 382 | 20060517 | CA | | Borel bypass reach | 1-Nov | 30-Nov | | Instream flow requirement | Minimum flow | 20 |
| 13 | 382 | 20060517 | CA | | Borel bypass reach | 1-Dec | 31-Dec | | Instream flow requirement | Minimum flow | 20 |
| 14 | 382 | 20060517 | CA | | Borel bypass reach | Memorial day | Labor day | weekends and holidays | Recreation/Boating | Minimum flow | 800 |
| 15 | 382 | 20060517 | CA | | Borel bypass reach | 1-Jul | Labor day | weekends | Recreation/Boating | Minimum flow | 400-500 |
| 16 | 485 | 20141222 | GA | AL | Bartlett's Ferry dam | | | | | Maximum discharge capacity | 530000 |
| 17 | 487 | 20050708 | PA | | Wilsonville dam | | | | | Maximum discharge capacity | 56700 |
| 18 | 487 | 20050708 | PA | | powerhouse | first Friday on or after Jul 1 | | six consecutive Fridays for a 5 hour period (10am - 6 pm) | Recreation/Boating | Minimum flow | 1200 |
| 19 | 487 | 20050708 | PA | | powerhouse | | | two weekends each year during Sep or Oct | Recreation/Boating | Minimum flow | 1200 |
| 20 | 487 | 20050708 | PA | | powerhouse | first Saturday after Apr 11 | first Saturday after Jun 11 | trout season; weekends 6 am- 9 pm | Fishing/Habitat | Minimum flow | no generation |
| 21 | 659 | 20081128 | GA | | Warick dam | | | | Instream flow requirement | Minimum flow | 600 or inflow |
| 22 | 659 | 20081128 | GA | | Warick dam | 15-Mar | 15-May | | Fishing/Habitat | Minimum flow | run of river |
| 23 | 659 | 20081128 | GA | | Warick dam | | | | | Maximum discharge capacity | 8000 |
| 24 | 719 | 20040527 | WA | | dam | | | | Instream flow requirement | Minimum flow | 0.25 |
| 25 | 719 | 20040527 | WA | | dam | 1-Aug | 15-Oct | low flow season | Instream flow requirement | Maximum flow | 1.8 |
| 26 | 719 | 20040527 | WA | | dam | 1-Aug | 15-Oct | | Instream flow requirement | Normal_Water_Year_min_flow_rate_cfs | 1.8 |
| 27 | 719 | 20040527 | WA | | dam | 15-Oct | 30-Apr | | Instream flow requirement | DRY_Water_Year_min_flow_rate_cfs | 3.55 |
| 28 | 719 | 20040527 | WA | | dam | 15-Oct | 30-Apr | | Instream flow requirement | Normal_Water_Year_min_flow_rate_cfs | 2.3 |
| 29 | 719 | 20040527 | WA | | dam | 1-May | 31-Jul | | Instream flow requirement | DRY_Water_Year_min_flow_rate_cfs | 5 |
| 30 | 1256 | 20170522 | NE | | Monroe powerhouse | | | | Instream flow requirement | Minimum flow | run of canal |
| 31 | 1256 | 20170522 | NE | | Monroe powerhouse | | | | | Maximum discharge capacity | 3000 |
| 32 | 1256 | 20170522 | NE | | Columbus powerhouse | | | | Instream flow requirement | Minimum flow | 1000-4800 |
| 33 | 1256 | 20170522 | NE | | Columbus powerhouse | | | | | Maximum discharge capacity | 6180 |

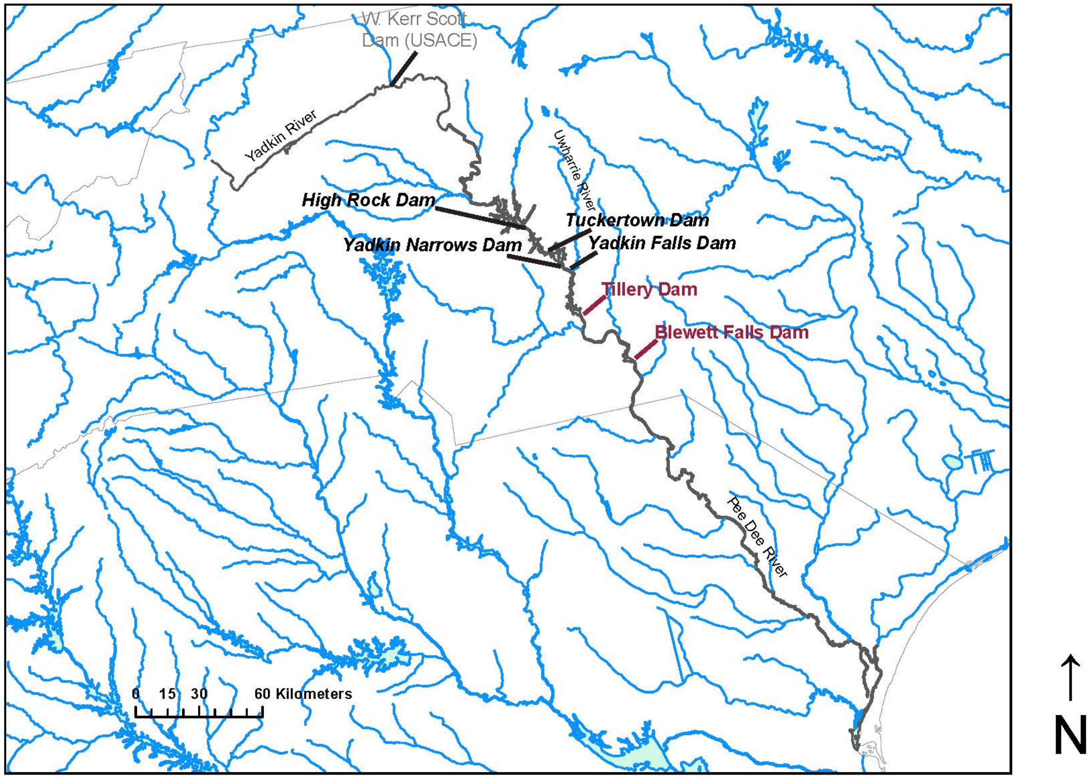
# Examples of environmental flow requirements

- Walleye spawning flows*
  - **800 cfs minimum flow beginning when water temp is $\geq$ 4$^{o}$C for 4 consecutive days after Mar 15 to 30 days after water temp is $\geq$ 10$^{o}$C for 4 consecutive days**
- Whitewater flows*
  - **Up to 70 hr of 525 cfs releases/ year to support whitewater races**
- Maximum flows*
  - **When inflow is 200-399 cfs, releases $\leq$ 1.5 times inflow from July 1-15**

***Above requirements all from FERC hydropower licenses***

# Case studies

*Yadkin-Pee Dee River Basin*
- *Energy- environment trade-offs*
- *Two producers*





*Also focused case studies on:*
1. *economic valuation of hydro flexibility (Poe Project, California)*
2. *new modeling techniques to assess environment tradeoffs with hydro flexibility (Glen Canyon Dam, Arizona)*