Improving Ecological Flow Science in the Mainstem Delaware River:
Overview of a Decision Support System

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Improving Ecological Flow Science in the Mainstem Delaware River:

Overview of a Decision Support System

- What is Ecological Flow Science
- What is the Decision Support System
    - What did it start out as?
    - What are we working on?
    - What are we aiming toward?

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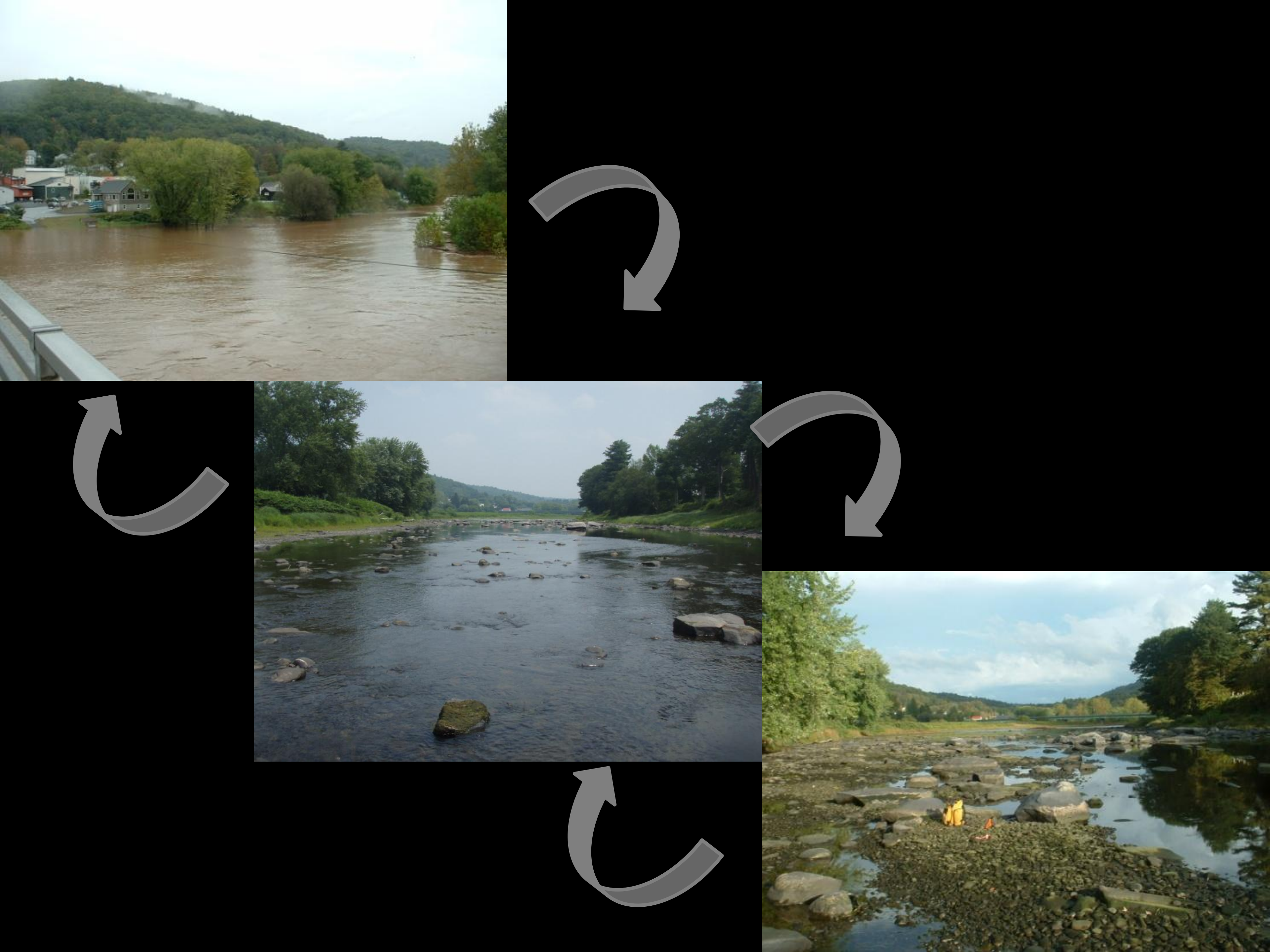
Ecological Flow Science:

Studying the relationship between flow alterations and the ecological responses to those changes (Poff et. al. 2009)

- Flow alterations result in many complex changes
  - Velocity
  - Depth
  - Substrate
  - Nutrients
  - Dissolved Gases
  - etc…
- Biota of interest determines
  - Scale
  - River Position
  - Area of interest
  - etc…

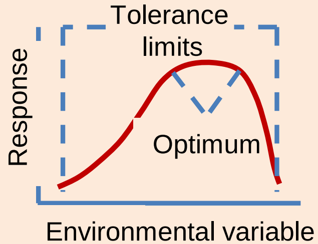


Decision Support System (DSS):

Tool for management that integrates different aspects of flow science into something meaningful.

Flow Release Model (OASIS)

Habitat Suitability Criteria (HSCs)

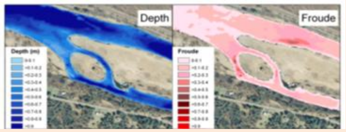


Synthesis Tool (DSS)

Temperature & Other Parameters

$$T_w = k + a_1T_a + a_2T_a^2 + a_3H + a_4W + a_5S + a_6Q_1 + a_7(Q_2 - Q_1) + a_9YT_w$$

Flow-Specific Estimates of Habitat



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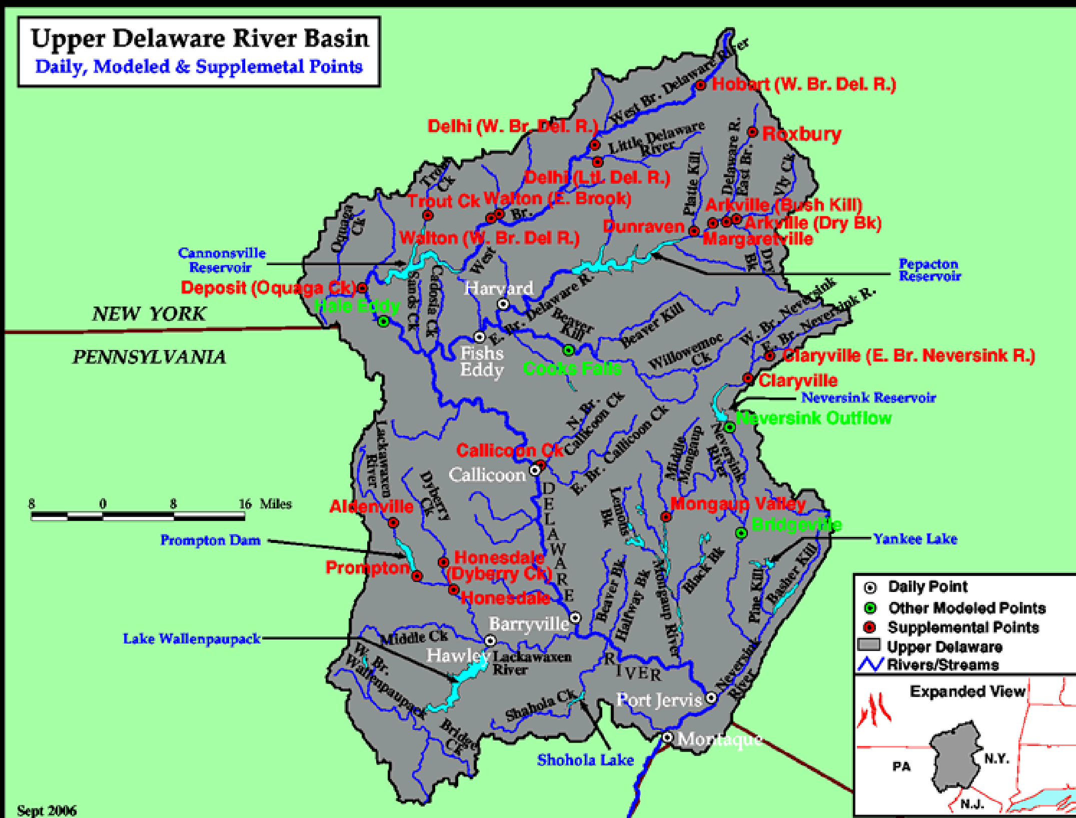
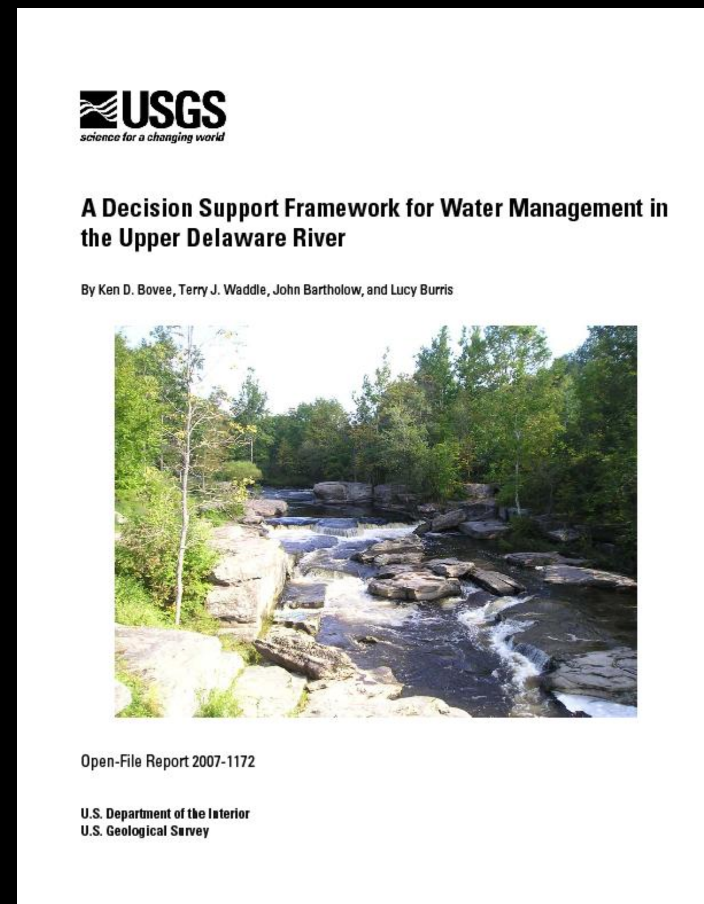
Ecological Flow Science in the Mainstem

Current DSS

Upper Delaware Decision Support System





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A Decision Support Framework for Water Management in the Upper Delaware River

By Ken D. Bovee, Terry J. Waddle, John Bartholow, and Lucy Burris

Open-File Report 2007-1172

U.S. Department of the Interior
U.S. Geological Survey

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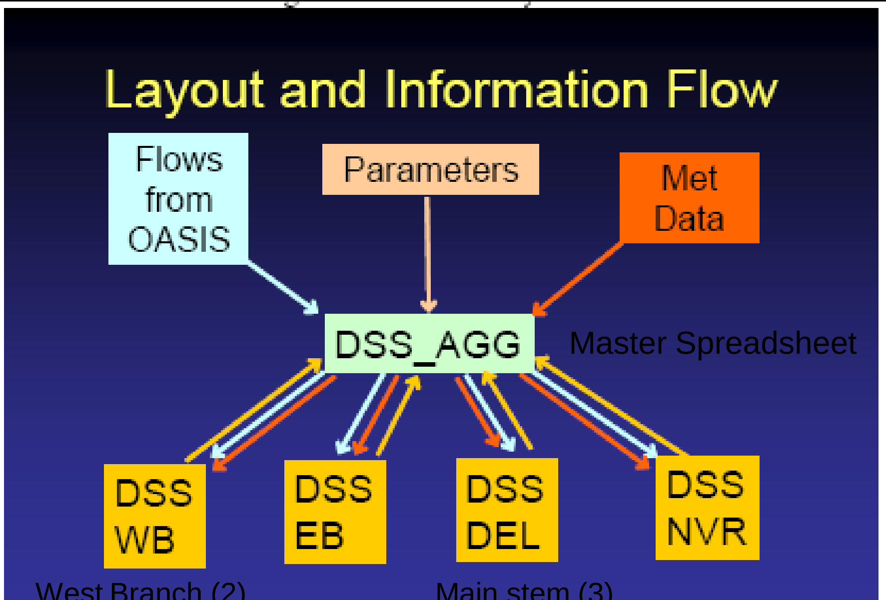
Ecological Flow Science in the Mainstem

Current DSS

- 11 Reaches
- Integrates:
  - OASIS flow estimates
  - Temperature
  - User defined parameters
  - Habitat curves



October - April 15

Resource	West Branch Pct Chg	West Branch Δ Hab	West Branch Pct Chg	West Branch ΔTCondHab	East Branch Pct Chg	East Branch Δ Hab	East Branch Pct Chg	East Branch ΔTCondHab
Trout Adult, ha	21%	13.50			8%	12.31		
Trout Spawning/incu, ha	91%	2.39			3%	0.10		
SSCV, ha	8%	1.11			-9%	-2.64		
SFCV, ha	52%	2.44			41%	1.04		
Shad Juvenile, ha								
Shad Spawning, ha								
Dwarf Wedge Mussel, ha								
Spills, minor, count	-6%	-1.00			14%	1.00		
Spills, moderate, count	13%	2.00			15%	2.00		
Spills, major, count	-13%	-2.00			-14%	-4.00		

April 16 - June

Resource	West Branch Pct Chg	West Branch Δ Hab	West Branch Pct Chg	West Branch ΔTCondHab	East Branch Pct Chg	East Branch Δ Hab	East Branch Pct Chg	East Branch ΔTCondHab
Trout Adult, ha	16%	11.47	16%	11.41	4%	6.77	4%	6.84
Trout Spawning/incu, ha								
SSCV, ha	2%	0.24	2%	0.24	-4%	-0.84	-3%	-0.77
SFCV, ha	11%	0.40	11%	0.40	8%	0.24	8%	0.24
Shad Juvenile, ha								
Shad Spawning, ha					16%	5.50	16%	5.50
Dwarf Wedge Mussel, ha								
Spills, minor, count	0%	0.00			14%	1.00		
Spills, moderate, count	0%	0.00			-21%	-8.00		
Spills, major, count	0%	0.00			-5%	-2.00		

Figure 11. Expanded view of the scoring summary page, showing details of the scores and metrics for biological resources and spills in the DRDSS.

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Ecological Flow Science in the Mainstem

Needs:

- Test the temperature model
- Extend the meteorological data
- Include other species
- Update habitat suitability criteria for fish & other T&E Species
- Improve DSS

water SMART

Preliminary Draft Framework for
WaterSMART (Sustain and Manage America's Resources for Tomorrow) Program
Delaware River Basin Focus Area

Hutson, S.S., Stuckey, M.H., Fischer, J.M., and Coon, W.F.
August 22, 2011

Ecological Flow Science in the Mainstem

Specific objectives :

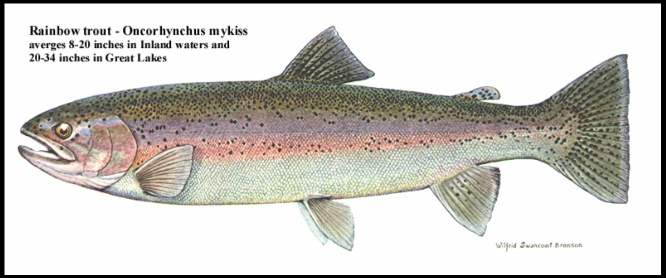
1. Update habitat suitability criteria (HSC) models and include additional species of interest

Target Organism	Depth Range (m)	Velocity Range (m/s)
Brown trout adult	0.3–100[1]	0.0–1.0
Brown trout juvenile	0.2–0.8	0.0–0.7
Brown trout spawning	0.2–0.6	0.3–0.81
Brown trout incubation	0.2–1.0	0.15–1.2
Rainbow trout adult	0.3–100[1]	0.0–1.2
Rainbow trout juvenile	0.2–1.0	0.0–0.8
American shad spawning	0.3–3.0	0.2–0.7
American shad juvenile	0.25–1.6	0.0–0.6
Shallow-fast guild	0.05–0.3	0.3–1.2
Shallow-slow guild[2]	0.05–0.3	0.0–0.3

Bovee et al. 2007

Methods

1. Evaluate known HSC (Bovee et al. 2007)



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Ecological Flow Science in the Mainstem

Specific objectives :

1. Update habitat suitability criteria (HSC) models and include additional species of interest

Methods

1. Evaluate known HSC (Bovee et al. 2007)
2. Incorporate **persistent** HSC for freshwater mussels and other sedentary taxa

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Ecological Flow Science in the Mainstem

Specific objectives :

1. Update habitat suitability models and include additional species of interest

Methods

1. Evaluate known HSC (Bovee et al. 2007)
2. Incorporate persistent HSC for DWM and other sedentary taxa
3. Identify additional species (American eel, bridle shiner, sea lamprey, river herring, SAV, Didymo) , conduct literature review and experiments to develop HSC

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Ecological Flow Science in the Mainstem

Specific objectives :

2. Extend the aerial coverage of the DSS

Methods

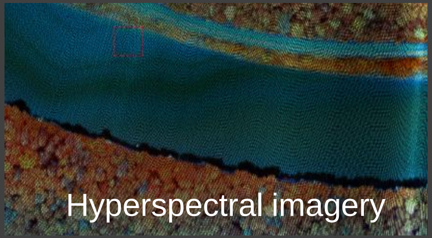
1. RTK GPS & Side-Scan Sonar

2. Hyperspectral Imagery

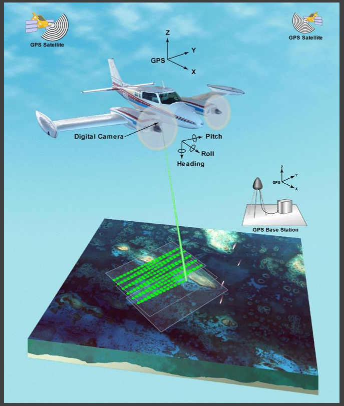
3. Experimental Advanced Airborne Research LiDAR (EAARL)

Bathymetry

RTK GPS &side-scan sonar



Hyperspectral imagery



Experimental LiDAR

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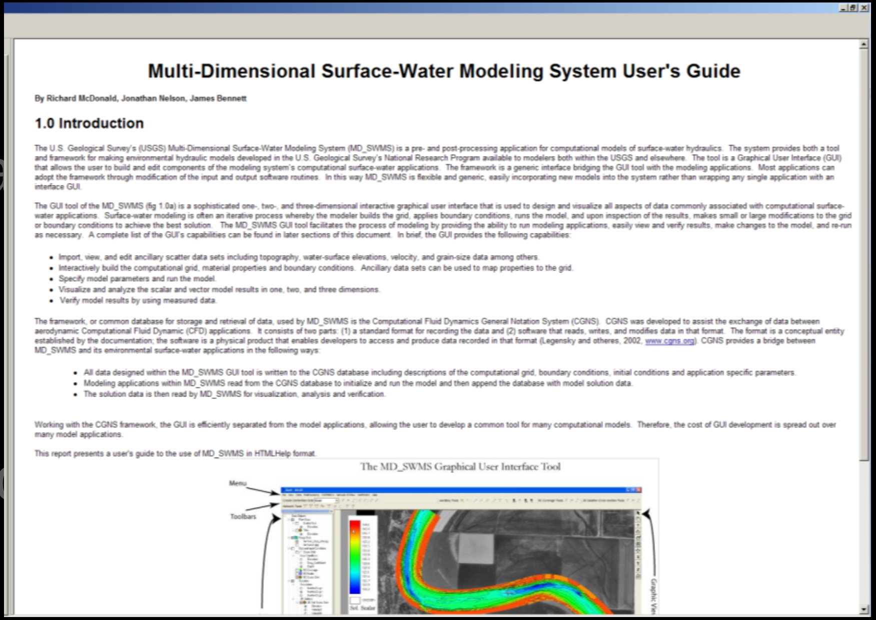
Ecological Flow Science in the Mainstem

Specific objectives :

2. Extend the aerial coverage of the DSS

Methods

1. RTK GPS & Side-Scan Sona
2. Hyperspectral Imagery
3. Experimental Advanced Airb (EAARL)



Multi-Dimensional Surface-Water Modeling System User's Guide

By Richard McDonald, Jonathan Nelson, James Bennett

1.0 Introduction

The U.S. Geological Survey's (USGS) Multi-Dimensional Surface-Water Modeling System (MD_SWMS) is a pre- and post-processing application for computational models of surface-water hydraulics. The system provides both a tool and framework for making environmental hydraulic models developed in the U.S. Geological Survey's National Research Program available to modelers both within the USGS and elsewhere. The tool is a Graphical User Interface (GUI) that allows the user to build and edit components of the modeling system's computational surface-water applications. The framework is a generic interface bridging the GUI tool with the modeling applications. Most applications can adopt the framework through modification of the input and output software routines. In this way MD_SWMS is flexible and generic, easily incorporating new models into the system rather than wrapping any single application with an interface GUI.

The GUI tool of the MD_SWMS (fig 1.0a) is a sophisticated one-, two-, and three-dimensional interactive graphical user interface that is used to design and visualize all aspects of data commonly associated with computational surface-water applications. Surface-water modeling is often an iterative process whereby the modeler builds the grid, applies boundary conditions, runs the model, and upon inspection of the results, makes small or large modifications to the grid or boundary conditions to achieve the best solution. The MD_SWMS GUI tool facilitates the process of modeling by providing the ability to run modeling applications, easily view and verify results, make changes to the model, and re-run as necessary. A complete list of the GUI's capabilities can be found in later sections of this document. In brief, the GUI provides the following capabilities:

- Import, view, and edit ancillary scatter data sets including topography, water-surface elevations, velocity, and grain-size data among others.
- Interactively build the computational grid, material properties and boundary conditions. Ancillary data sets can be used to map properties to the grid.
- Specify model parameters and run the model.
- Visualize and analyze the scalar and vector model results in one, two, and three dimensions.
- Verify model results by using measured data.

The framework, or common database for storage and retrieval of data, used by MD_SWMS is the Computational Fluid Dynamics General Notation System (CGNS). CGNS was developed to assist the exchange of data between aerodynamic Computational Fluid Dynamic (CFD) applications. It consists of two parts: (1) a standard format for recording the data and (2) software that reads, writes, and modifies data in that format. The format is a conceptual entity established by the documentation; the software is a physical product that enables developers to access and produce data recorded in that format (Legensky and otheres, 2002, www.cgns.org). CGNS provides a bridge between MD_SWMS and its environmental surface-water applications in the following ways:

- All data designed within the MD_SWMS GUI tool is written to the CGNS database including descriptions of the computational grid, boundary conditions, initial conditions and application specific parameters.
- Modeling applications within MD_SWMS read from the CGNS database to initialize and run the model and then append the database with model solution data.
- The solution data is then read by MD_SWMS for visualization, analysis and verification.

Working with the CGNS framework, the GUI is efficiently separated from the model applications, allowing the user to develop a common tool for many computational models. Therefore, the cost of GUI development is spread out over many model applications.

This report presents a user's guide to the use of MD_SWMS in HTMLHelp format.

4. USGS International River Interface Cooperative (iRIC) hydrodynamic model (MD-SWMS) – Flow specific, pixel resolution model estimates of hydraulic parameters

Ecological Flow Science in the Mainstem

Specific objectives :

3. Develop an improved DSS

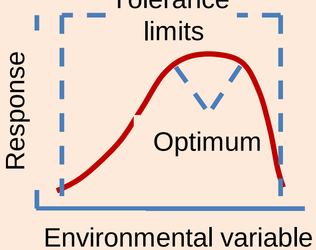
Suggested Improvements

1. Test predictive accuracy of existing temperature models.
2. Extend meteorological database to match OASIS.
3. Automate data import from OASIS to the DSS.
4. Convert the DSS to web-based platform such as Visual Basic to increase usability.

What is the Decision Support System (DSS)?

Flow Release Model (OASIS)

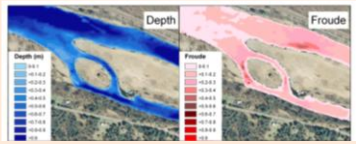
Habitat Suitability Criteria (HSCs)



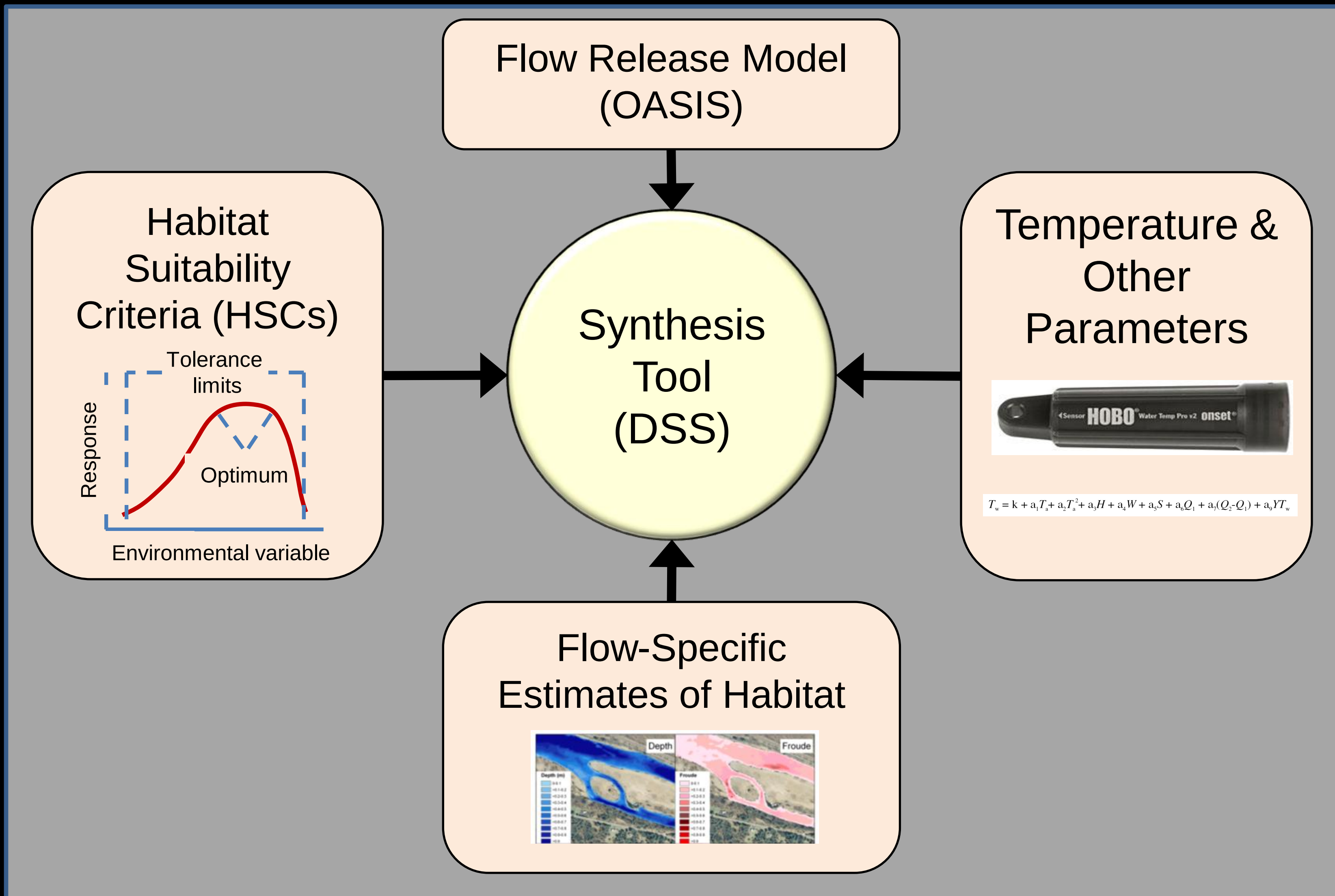
Temperature & Other Parameters

$$T_w = k + a_1 T_a + a_2 T_a^2 + a_3 H + a_4 W + a_5 S + a_6 Q_1 + a_7 (Q_2 - Q_1) + a_9 Y T_w$$

Flow-Specific Estimates of Habitat



Decision Support System



Ecological Flow Science in the Mainstem

Suggested Improvements

1. Test predictive accuracy of existing temperature models.

Temperature

1. SNTEMP model
2. Multivariate Model

A) Construct models with data from 2000-01; test with recent data
B) Deploy temp loggers to gather more data
C) Gather data for entire Delaware

U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

The Stream Segment and Stream Network Temperature Models:

A Self-Study Course

Version 2.0
March, 2000

by

John M. Bartholow[1]

Open-File Report 99-112

$$T_w = k + a_1 T_a + a_2 T_a^2 + a_3 H + a_4 W + a_5 S + a_6 Q_1 + a_7 (Q_2 - Q_1) + a_9 Y T_w$$

Ecological Flow Science in the Mainstem

Suggested Improvements

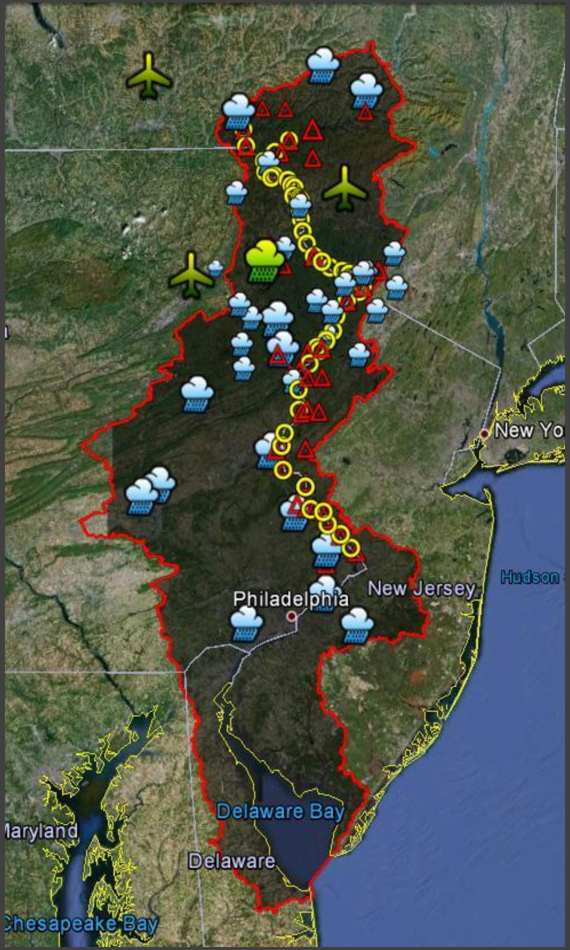
2. Extend meteorological database to

Meteorological

A) Current station limited to 1994.
B) Use other stations to extend by proxy
C) Gather data for entire Delaware

Temperature

- 13 stations
- 37 stream gages
- Deployed 60 HOBO loggers



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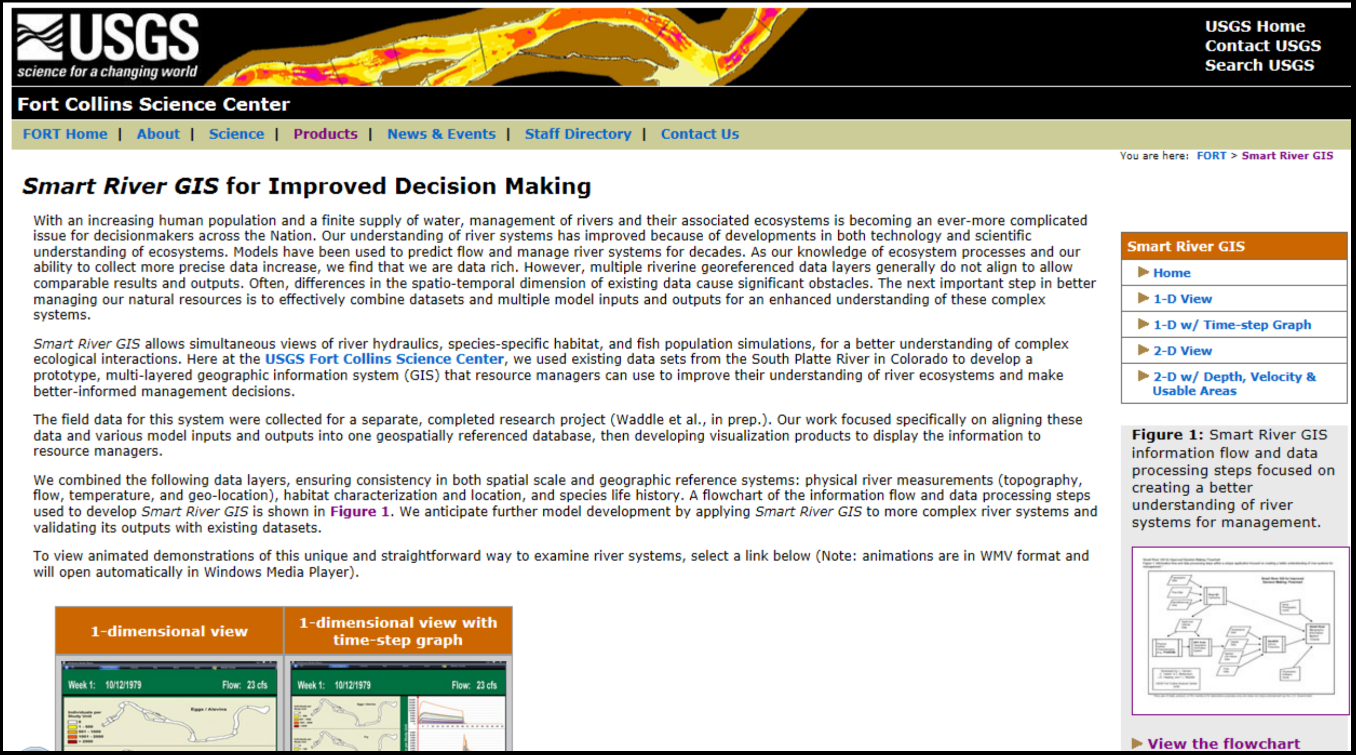
Ecological Flow Science in the Mainstem

Suggested Improvements

3. Automate data import from OASIS to the DSS.
4. Convert the DSS to web-based platform such as Visual Basic to increase usability

Methods

USGS FORT – SmartRiver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You are here: FORT > Smart River GIS

Smart River GIS for Improved Decision Making

With an increasing human population and a finite supply of water, management of rivers and their associated ecosystems is becoming an ever-more complicated issue for decisionmakers across the Nation. Our understanding of river systems has improved because of developments in both technology and scientific understanding of ecosystems. Models have been used to predict flow and manage river systems for decades. As our knowledge of ecosystem processes and our ability to collect more precise data increase, we find that we are data rich. However, multiple riverine georeferenced data layers generally do not align to allow comparable results and outputs. Often, differences in the spatio-temporal dimension of existing data cause significant obstacles. The next important step in better managing our natural resources is to effectively combine datasets and multiple model inputs and outputs for an enhanced understanding of these complex systems.

Smart River GIS allows simultaneous views of river hydraulics, species-specific habitat, and fish population simulations, for a better understanding of complex ecological interactions. Here at the USGS Fort Collins Science Center, we used existing data sets from the South Platte River in Colorado to develop a prototype, multi-layered geographic information system (GIS) that resource managers can use to improve their understanding of river ecosystems and make better-informed management decisions.

The field data for this system were collected for a separate, completed research project (Waddle et al., in prep.). Our work focused specifically on aligning these data and various model inputs and outputs into one geospatially referenced database, then developing visualization products to display the information to resource managers.

We combined the following data layers, ensuring consistency in both spatial scale and geographic reference systems: physical river measurements (topography, flow, temperature, and geo-location), habitat characterization and location, and species life history. A flowchart of the information flow and data processing steps used to develop *Smart River GIS* is shown in Figure 1. We anticipate further model development by applying *Smart River GIS* to more complex river systems and validating its outputs with existing datasets.

To view animated demonstrations of this unique and straightforward way to examine river systems, select a link below (Note: animations are in WMV format and will open automatically in Windows Media Player).

1-dimensional view	1-dimensional view with time-step graph

Smart River GIS
- Home
- 1-D View
- 1-D w/ Time-step Graph
- 2-D View
- 2-D w/ Depth, Velocity & Usable Areas

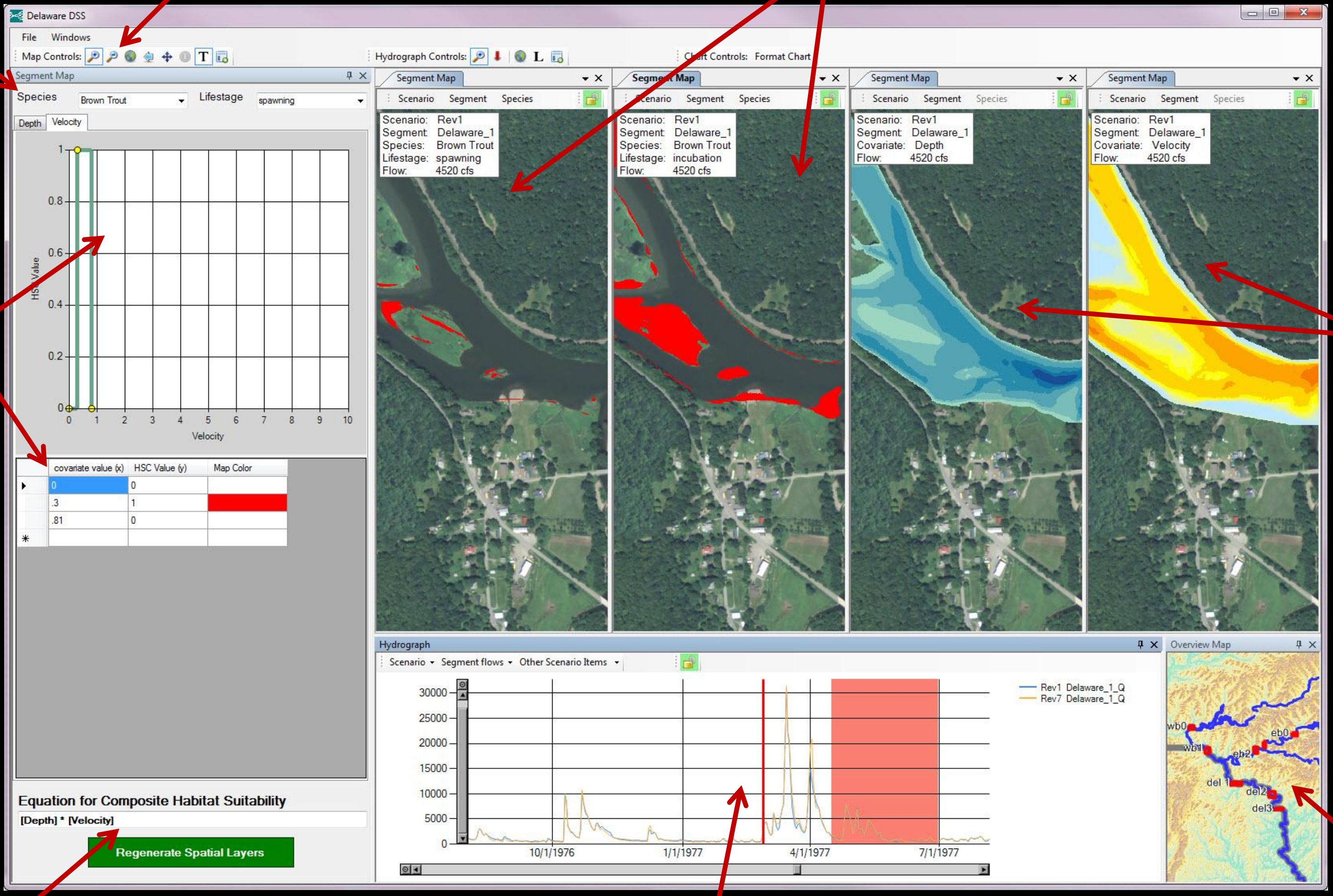
Figure 1: Smart River GIS information flow and data processing steps focused on creating a better understanding of river systems for management.

View the flowchart

Selection of key species

Geographic Information System (GIS) functionality

Color coded habitat suitability maps



Habitat suitability criteria can be modified

Color coded habitat maps

Equation for displayed habitat suitability maps

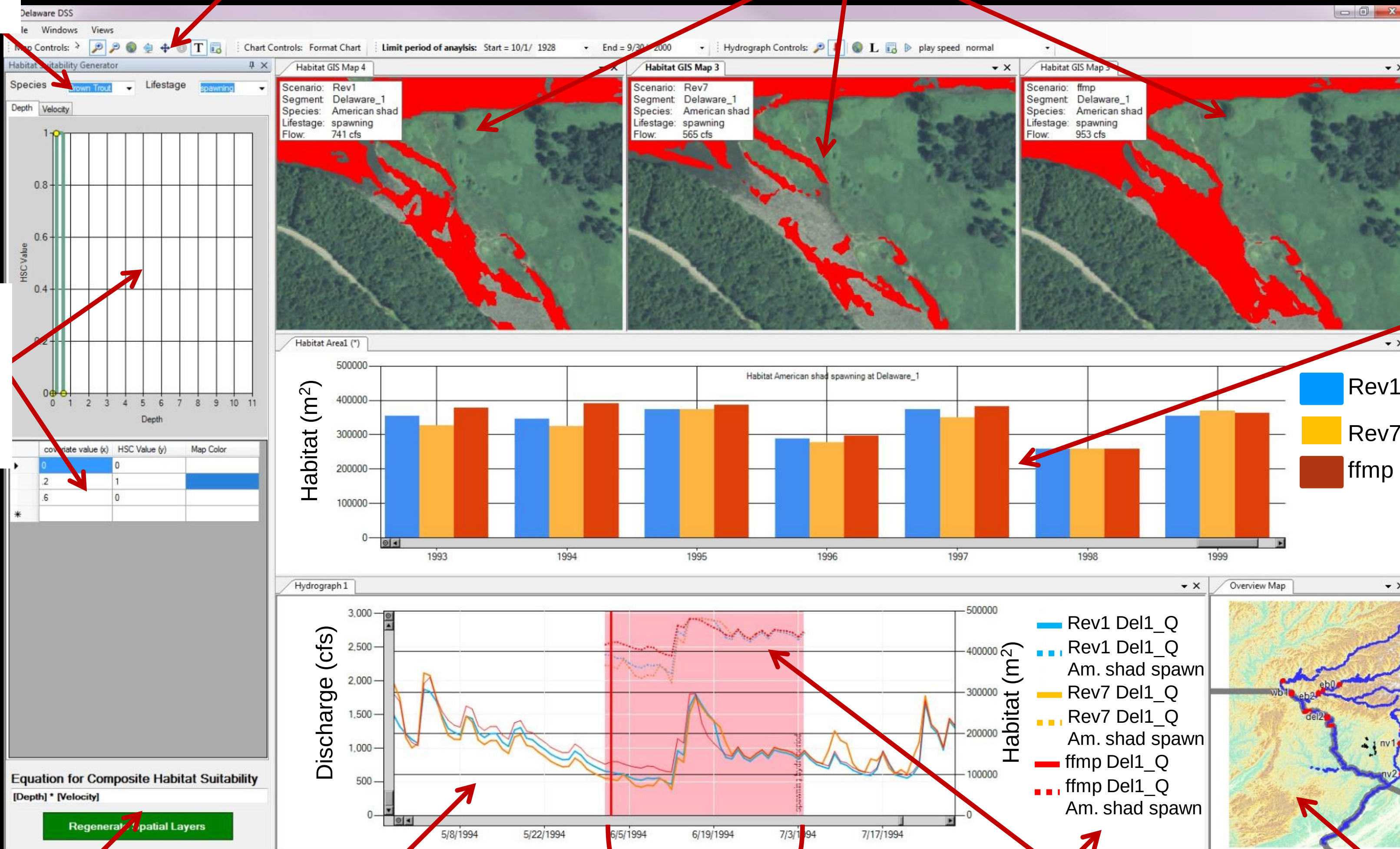
Display of current hydrograph

Map of site location

Selection of key species

Geographic Information System (GIS) functionality

Color coded habitat maps for each scenario



Habitat suitability criteria can be modified

Daily average amount of available habitat over period of interest

Equation for displayed habitat suitability maps

Display of hydrograph for all scenarios

Hydroperiod of interest

Amount of available habitat by scenario by date

Map of site location

Where are we going?

- Nail down what “persistent habitat” means
- Ultimate goal is to extend to Trenton
- Linked 2D flow models to cover entire stretch
- Look at applying DSS approach in other systems
- Evaluate the application of hyperspectral data for bathymetry
- Include some type of ecosystem services into models

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Questions?
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