

# Managing Groundwater Withdrawals to Sustain Aquatic Ecosystems

Kristen Blann, Eloise Kendy, and Phil Gerla  
The Nature Conservancy

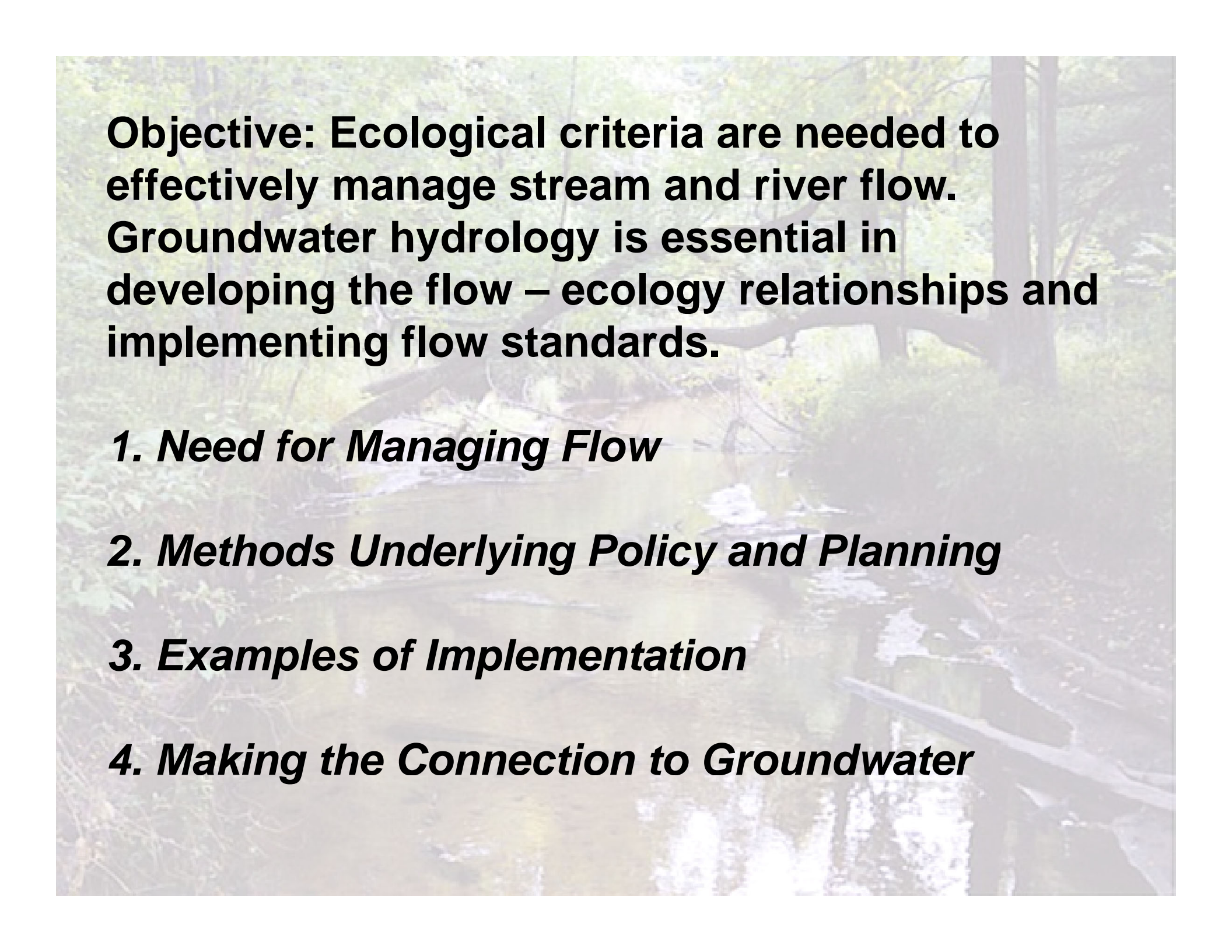
*Crystal  
Light.*

GREAT LAKES BASIN PROJECT  
Collaboration for U.S. Freshwater Sustainability

The Nature  
Conservancy   
Protecting nature. Preserving life.







**Objective: Ecological criteria are needed to effectively manage stream and river flow. Groundwater hydrology is essential in developing the flow – ecology relationships and implementing flow standards.**

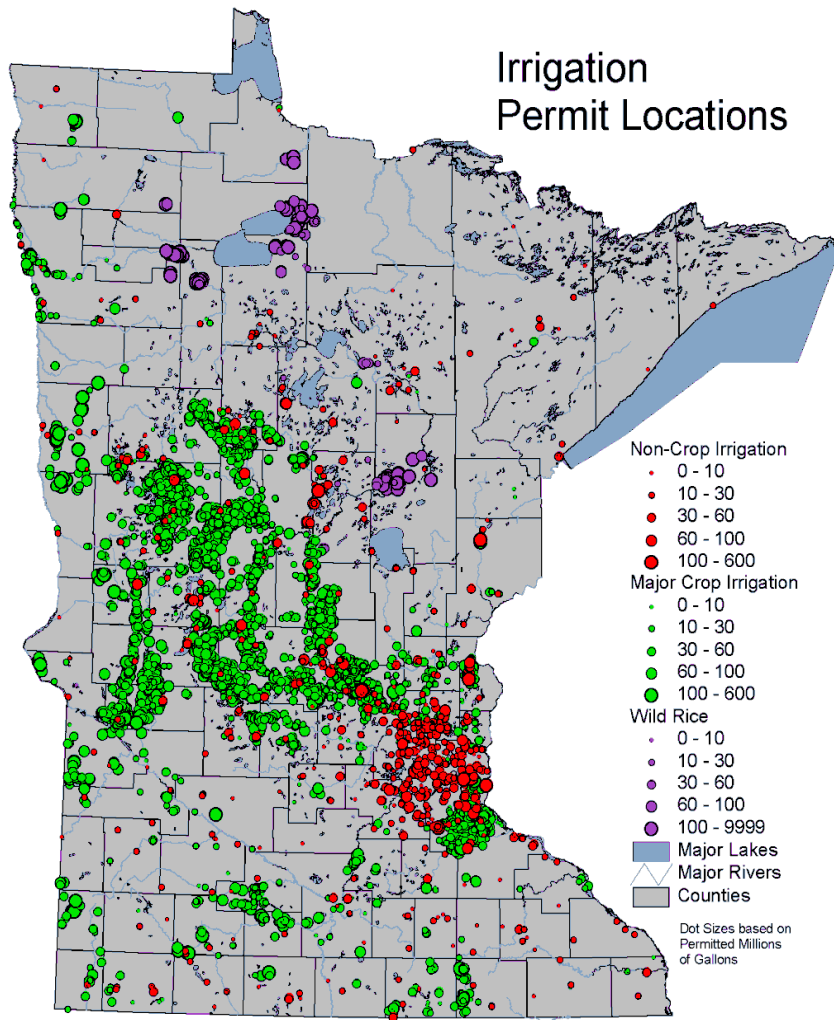
***1. Need for Managing Flow***

***2. Methods Underlying Policy and Planning***

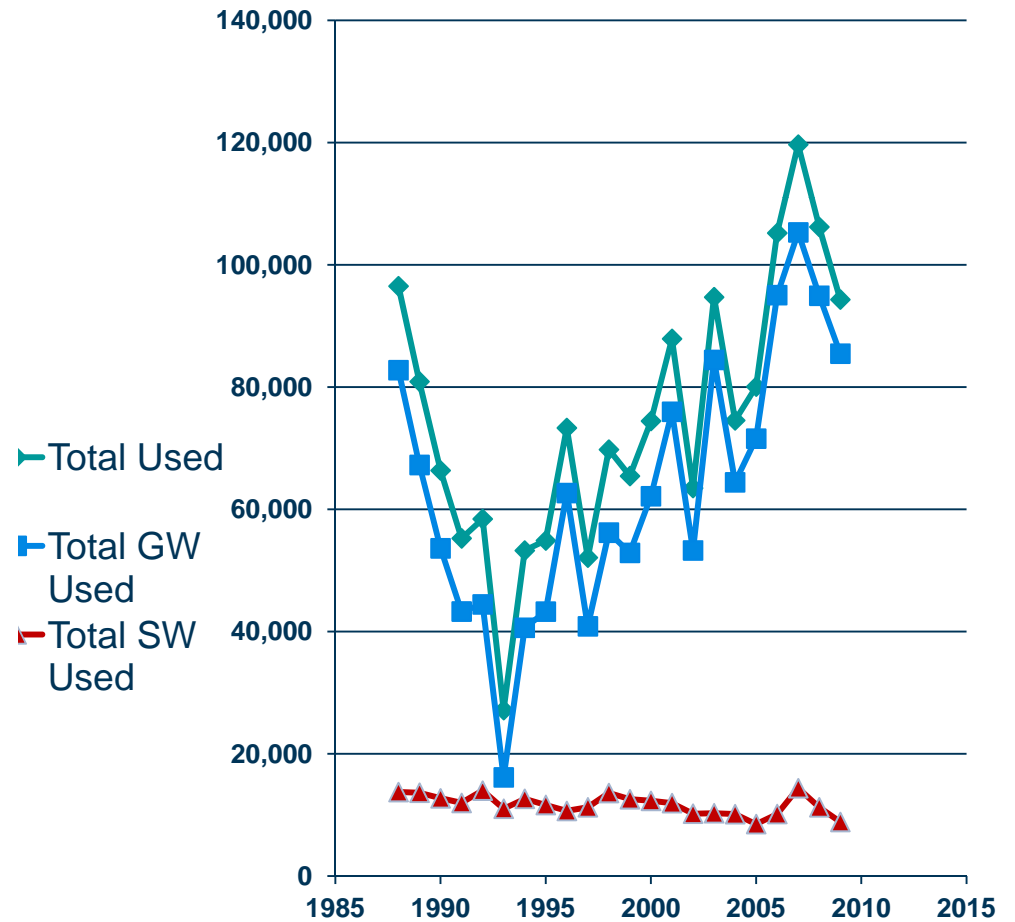
***3. Examples of Implementation***

***4. Making the Connection to Groundwater***

# Water Use Increases in Minnesota



## Major Crop Irrigation (10<sup>6</sup> gallons)



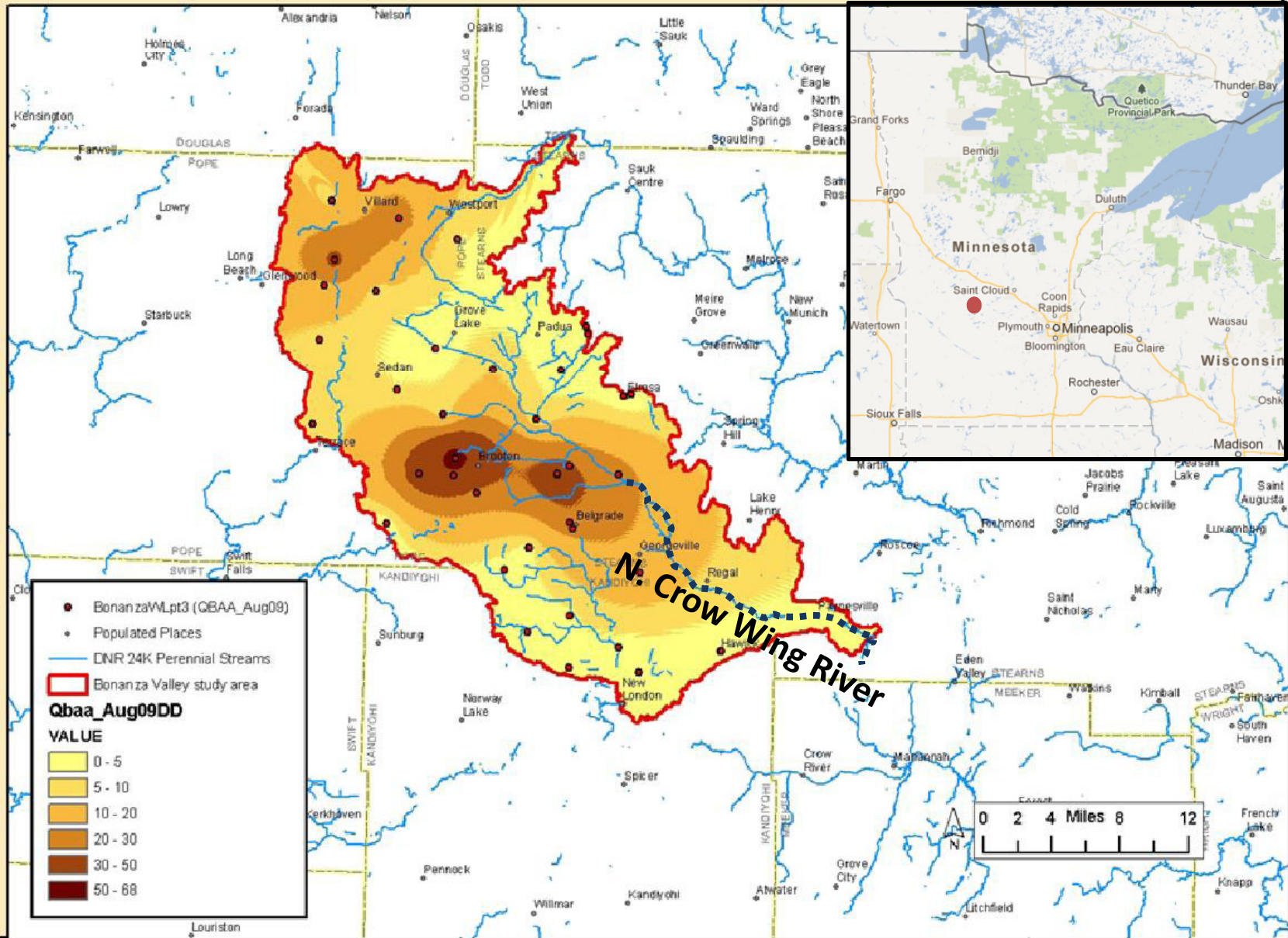
50 0 50 100 Miles

Minnesota DNR Waters  
Water Appropriation Permit Program

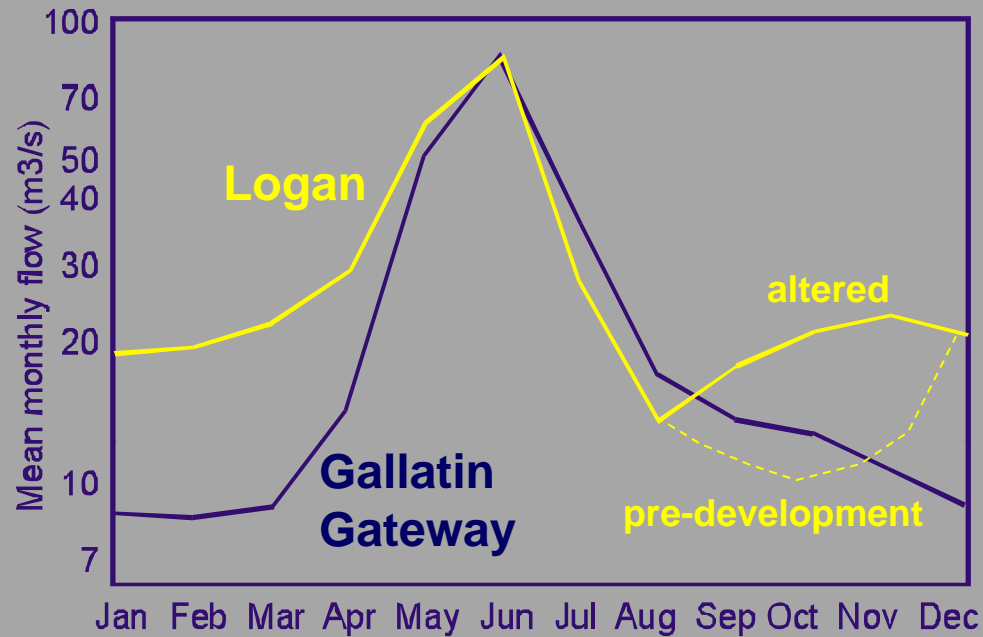




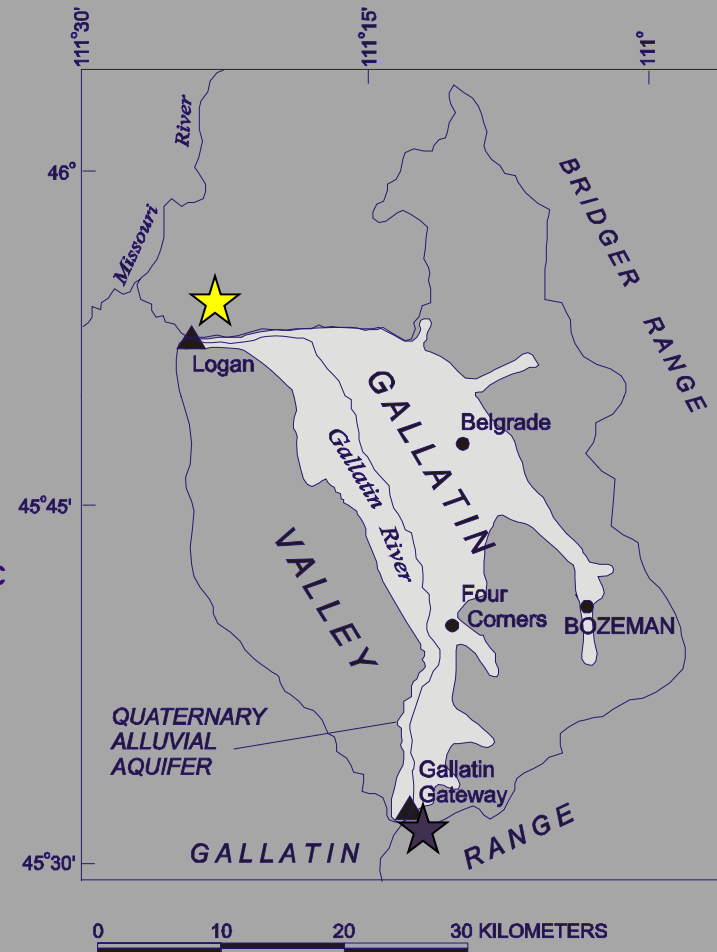
# Bonanza Valley Study Area (Summer Drawdown in the Buried Aquifer, 2009)



From E. Drivas and J. Leete, Minnesota DNR



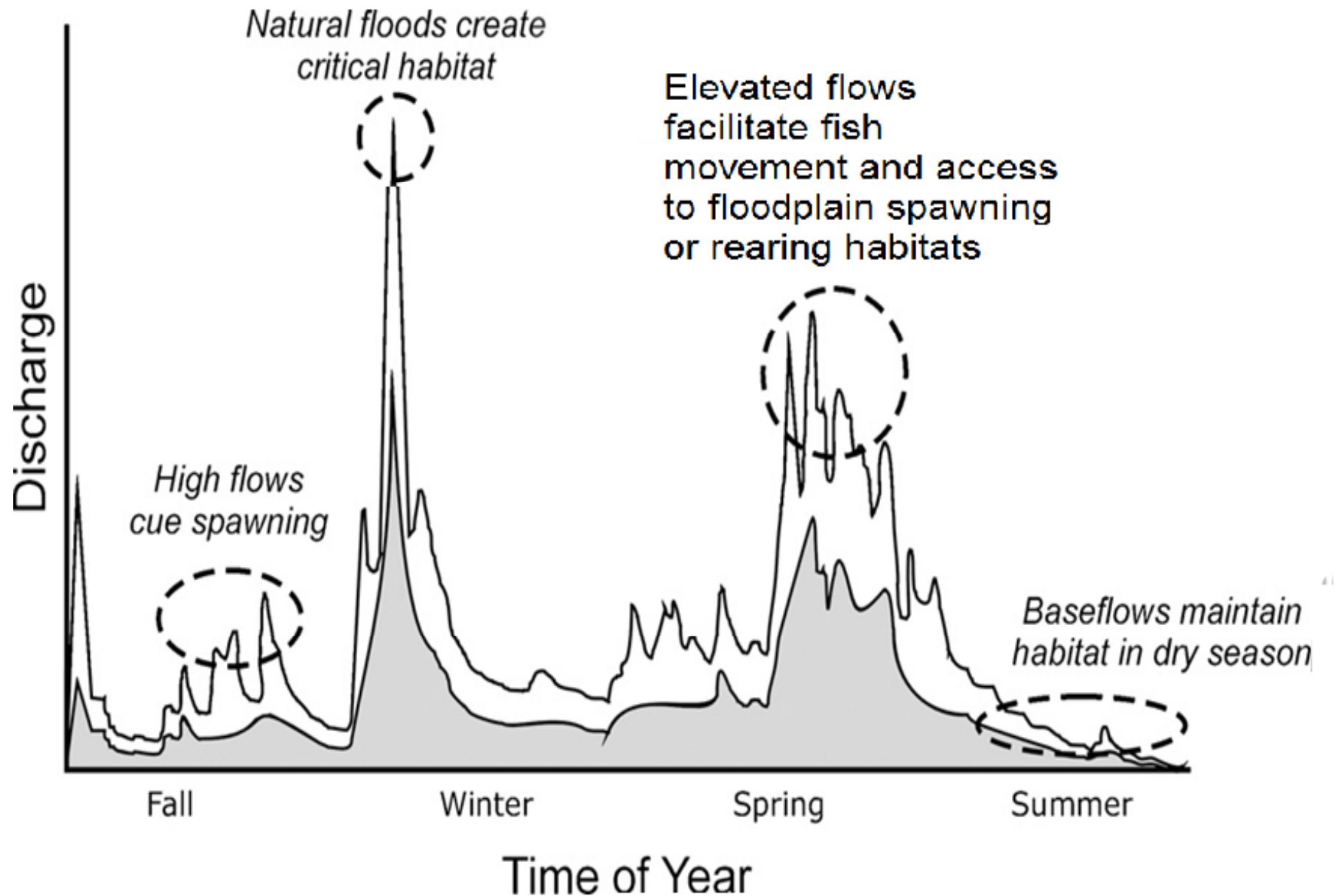
## Average monthly flow of the Gallatin River, Montana



Kendy and Bredehoeft 2006

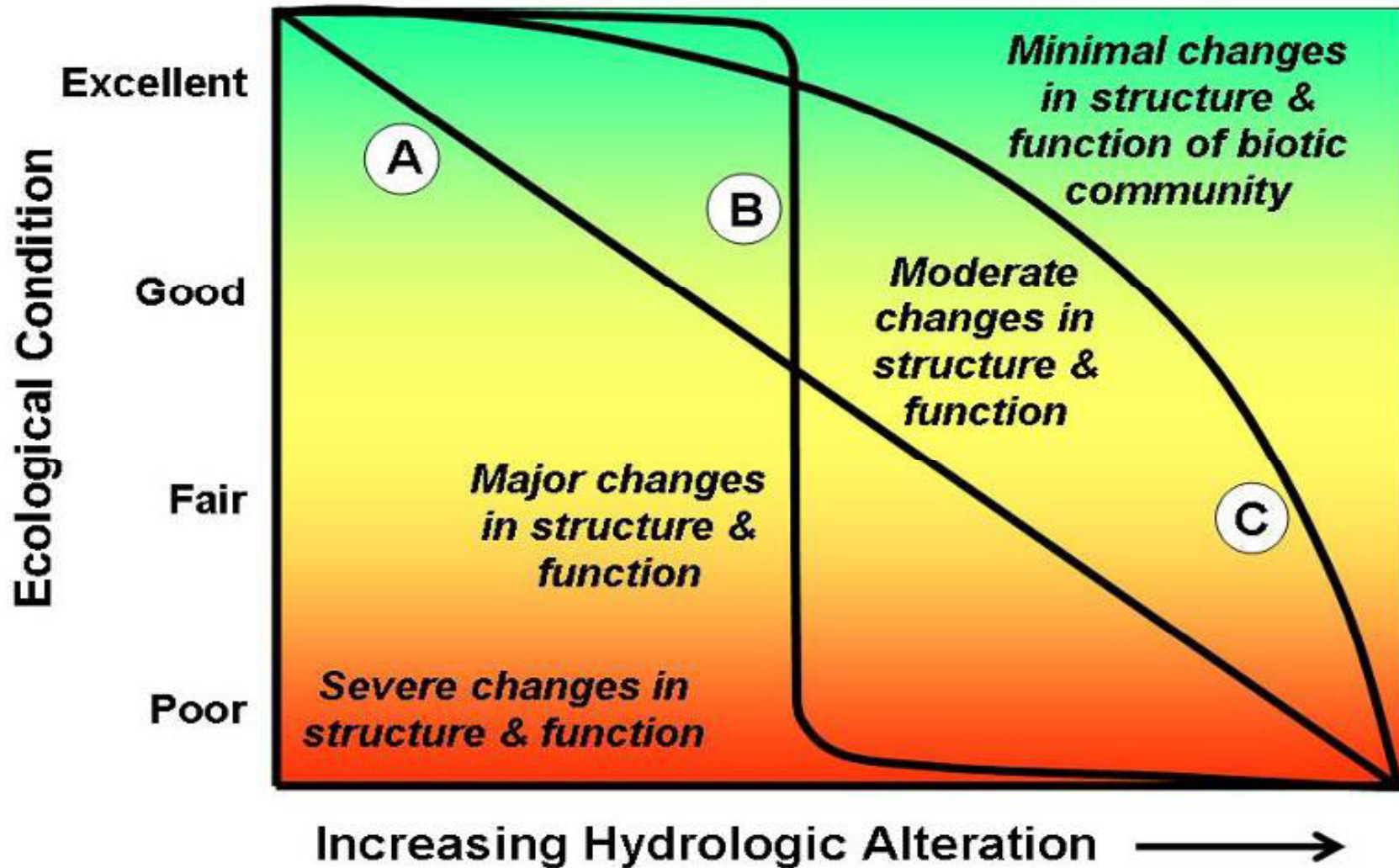
*altered flow affects ecology*

# Ecological Consequences of Altered Flow



# Flow-Ecology Relationship - Concept

*A unique curve for classes of streams and river reaches ... essential for optimal permitting*



from Kendy et al. 2012. A Practical Guide to Environmental Flows for Policy and Planning



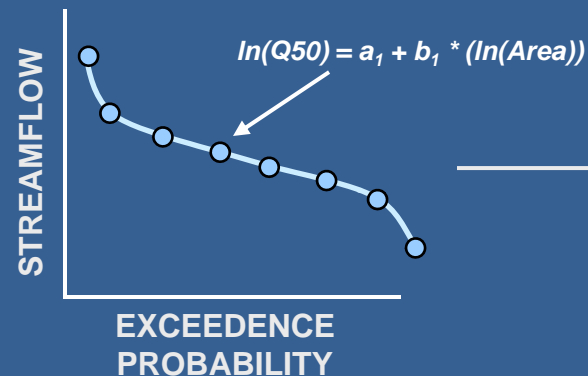
# Sustainable Yield Estimate Approach

Estimate basin characteristics

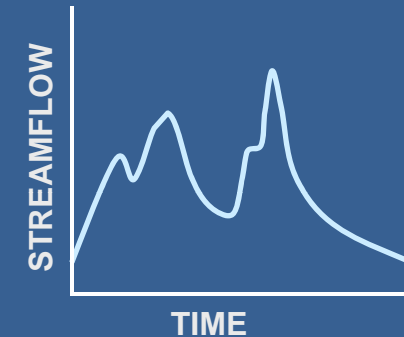


Area = XX.X mi<sup>2</sup>

Develop a flow-duration curve by solving the regression equations



Generate hydrograph using index gages



*Groundwater is implicit in the regression equations*

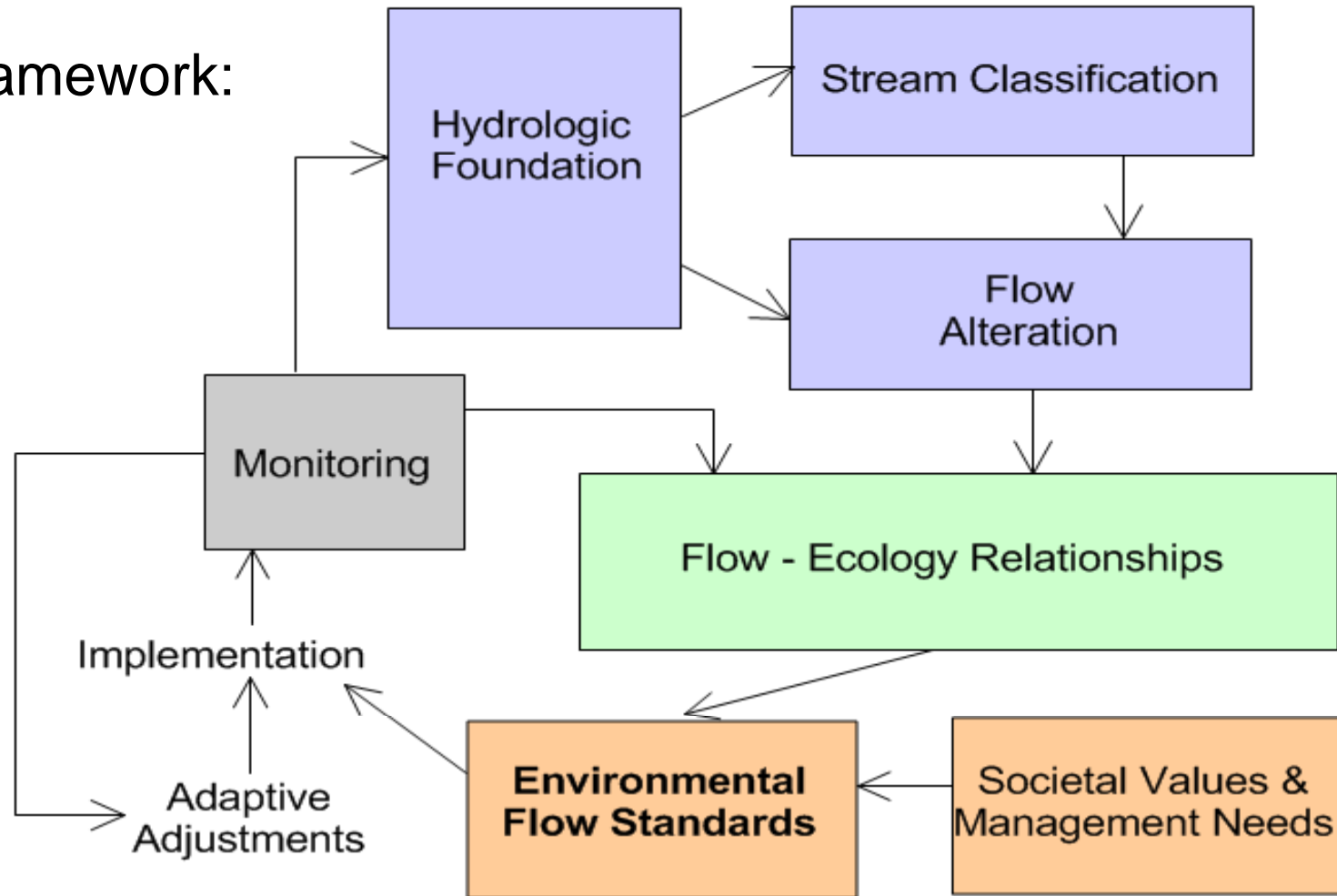
*Generated hydrographs are applied to biological data*

Sources: U.S. Geological Survey --- Archfield and others, 2010.; Ries and Friesz (1999); Fennessey (1994)



# ELOHA – Ecological Limits of Hydrological Alteration

Framework:



adapted after Poff et al. 2010

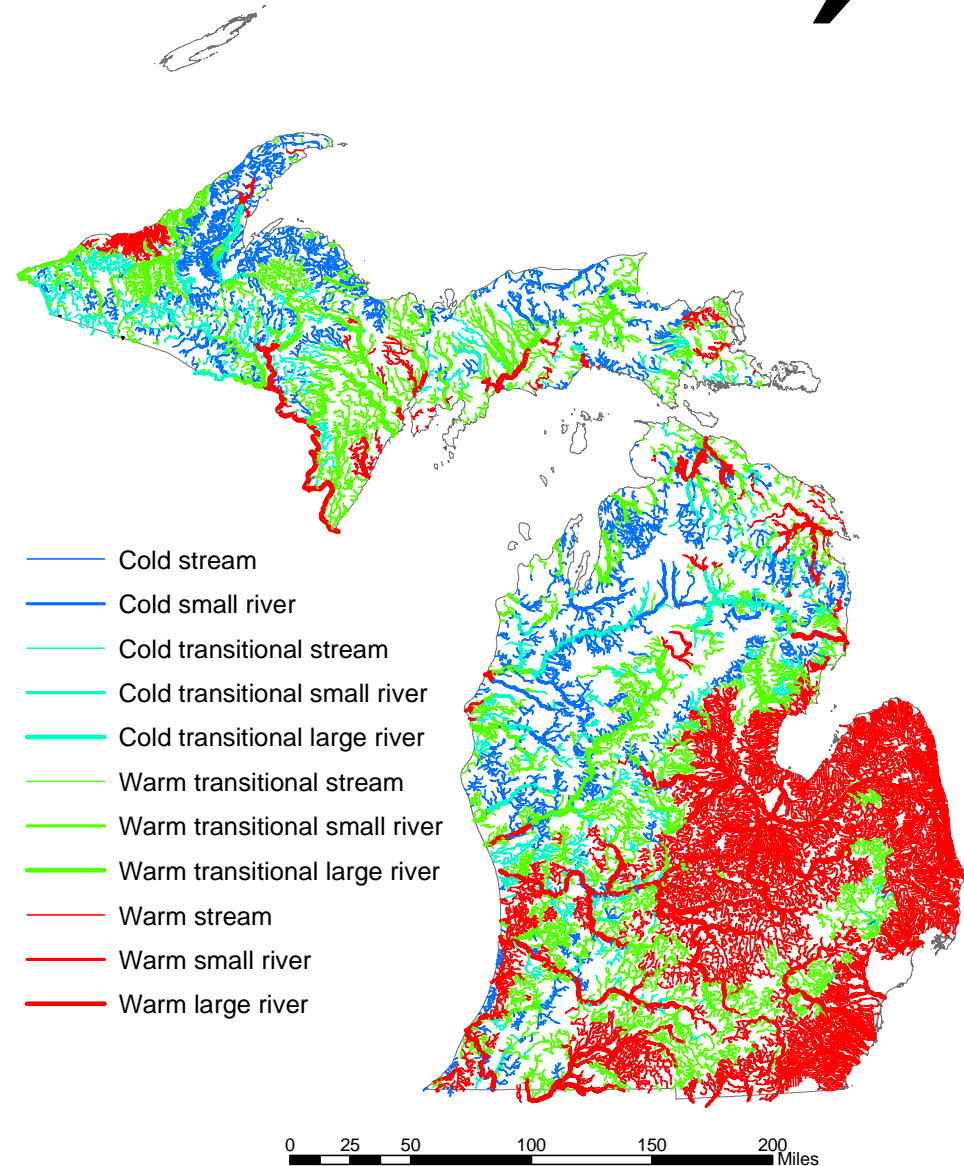
# Michigan --- components

1. **HYDROLOGIC FOUNDATION:** August median flow; streamflow depletion model - GW pumping with delay (STRMDEPL).
2. **CLASSIFICATION:** Size and thermal class.
3. **GOAL CONDITION:** “Avoid Adverse Resource Impact” defined by broad stakeholder group.
4. **FLOW ECOLOGY** Fish community-flow models based on occurrence and abundance database (Zorn et al. 2008).
5. **APPLICATION:** On-line water withdrawal screening tool that checks for an adverse impact standard (fishes).

# Michigan --- stream classification

- hydrology
- geomorphology
- water temperature
- ecoregion / habitat

Seelbach et al. 2006





# Michigan: Flow-Ecology Response Curves

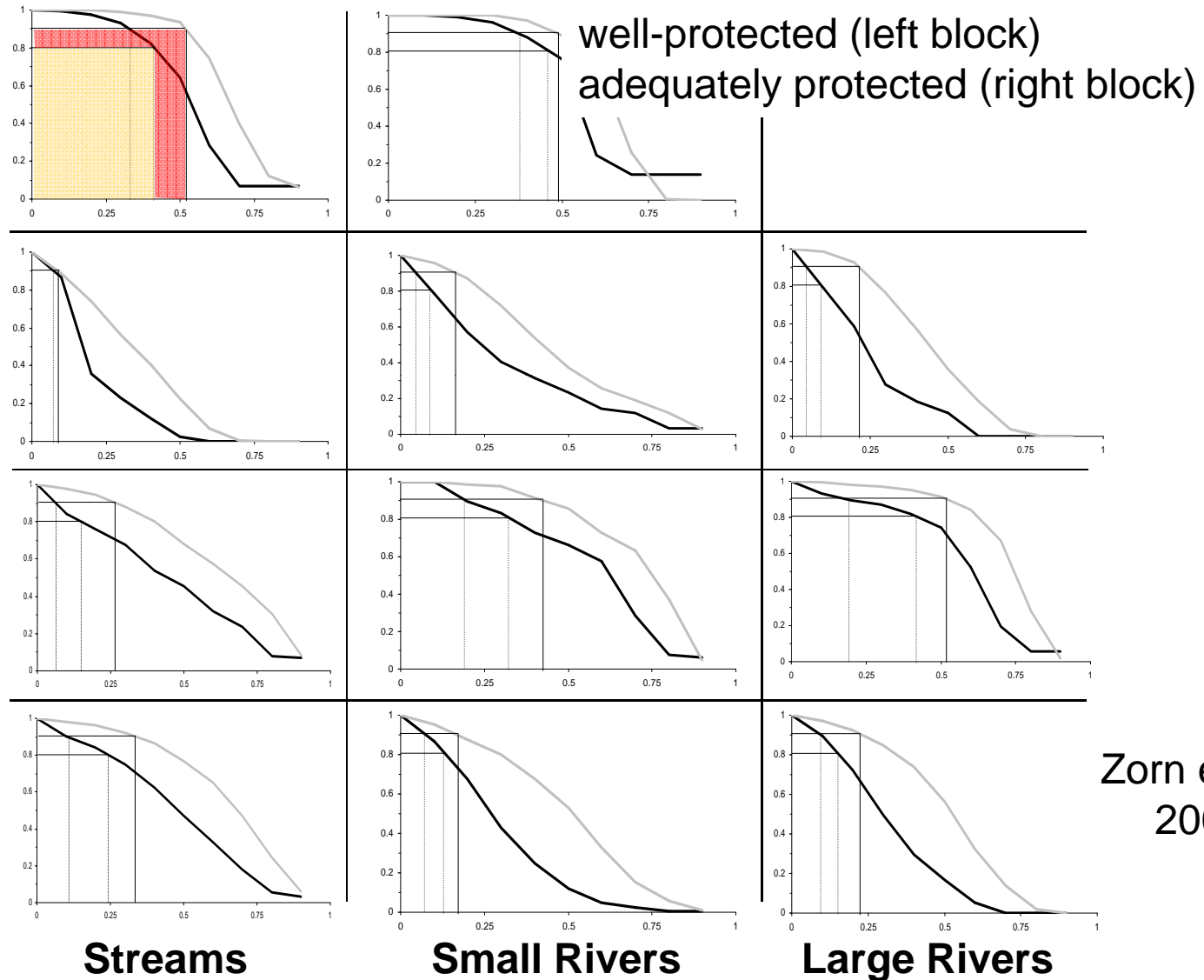
Y – axes: better ecological condition

Cold

Trans

Cool

Warm

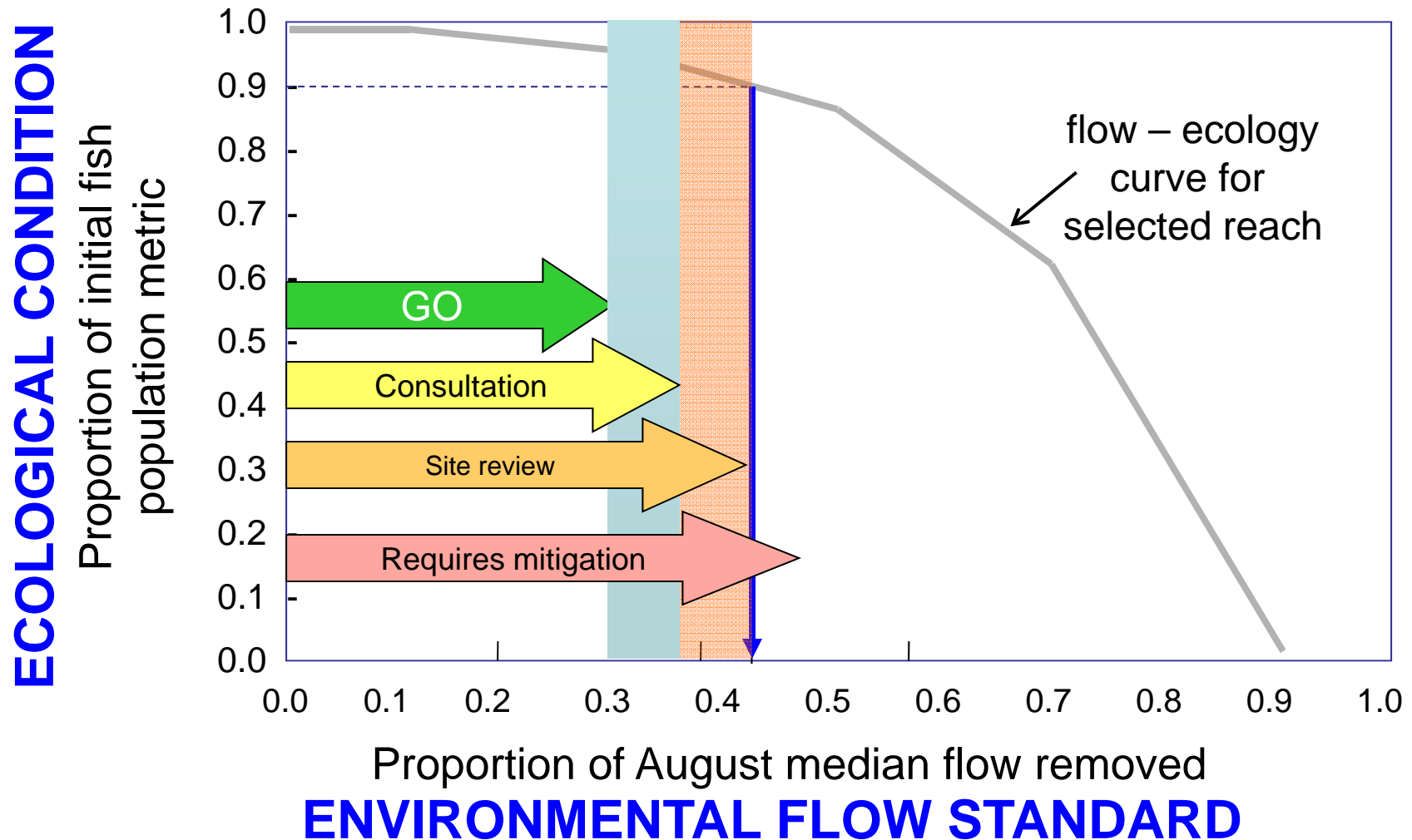


X – axes: increasing hydrological alteration

Zorn et al.,  
2008

# Michigan: Example Flow-Ecology Relationship

Limits: 10% change in the fish metric and 44% flow depletion



# ...water withdrawal management

The Water Withdrawal Assessment Tool (WWAT) is designed to estimate the likely impact of a water withdrawal on nearby streams and rivers. Use of the WWAT is required of anyone proposing to make a new or increased large quantity withdrawal (over 70 gallons per minute) from the waters of the state, including all groundwater and surface water sources, prior to beginning the withdrawal.

You must use the WWAT to determine if a proposed withdrawal is likely to cause an Adverse Resource Impact, and to register the withdrawal. The results page provides a quick link to submitting a registration. A registration is valid for 18 months; the withdrawal capacity must be installed within that 18 months or the registration becomes void.

## Michigan's Water Withdrawal Assessment Tool Version 1.0

A small map of the state of Michigan is positioned to the right of the title text, showing the outline of the state in a light blue color.

### Information Window

- [Educational Material](#)
- [Provide Feedback](#)
- [Help Center](#)
- [Requesting Notification](#)
- [Run the Tool](#)
- [Download Data](#)



# WATER WITHDRAWAL ASSESSMENT TOOL

## GIS Tools

Zoom In	Zoom Out
Address	Move Map
Back	Erase
Identify	Toggle Legend
Measure	Set Scale
Overview Map	Print
Query Builder	Help

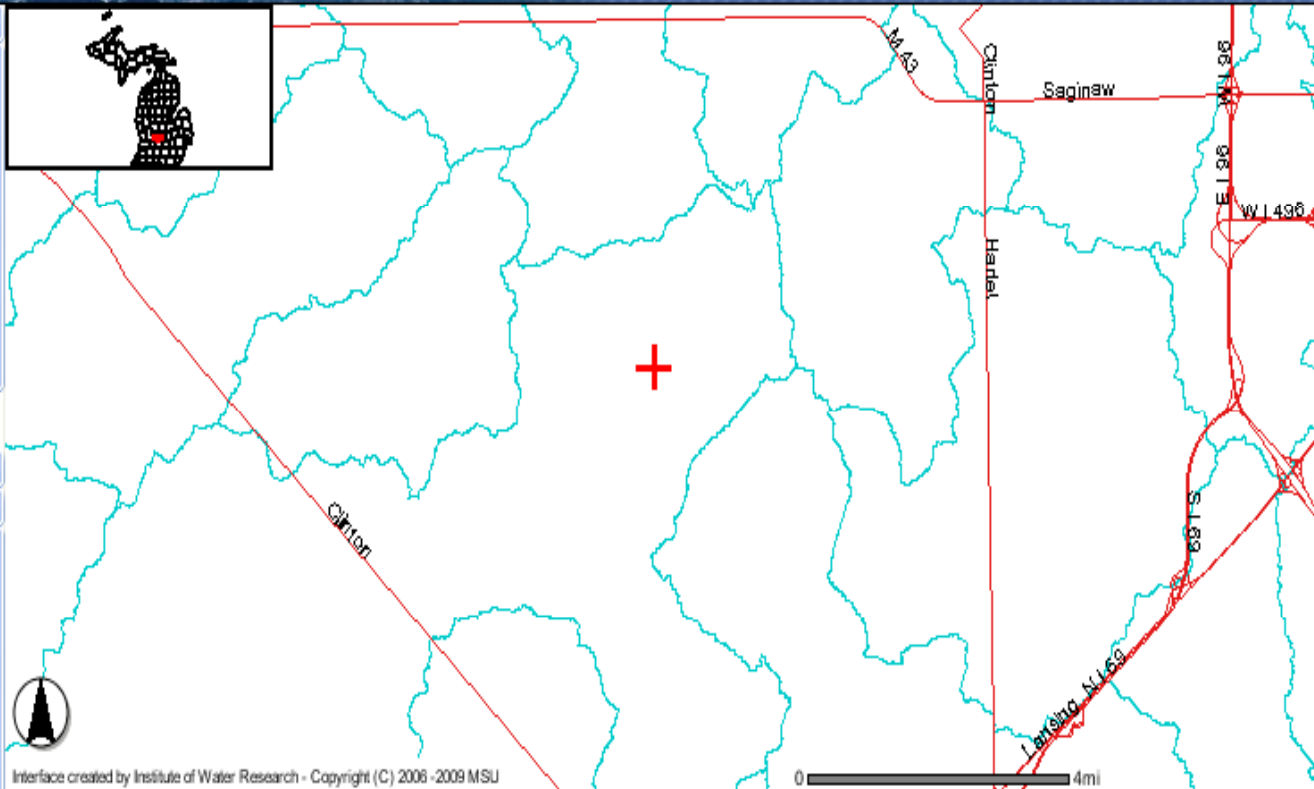
New Withdrawal

## Data Layers

- All Layers
- Roads
- State Roads
- Existing Wells
- Streams
- Lakes
- Watersheds
- Sections
- County
- Aerial Photo (NAIP - 2005)

Refresh Map

Auto Refresh



Interface created by Institute of Water Research - Copyright (C) 2006 -2009 MSU

## Watersheds

Hyperlink to [http://www.miwwat.org/getflow.asp?trans=2478&shore=0&bdrkf=1&bdrkt=99999&aline=1558.671&bline=1971.783&dline=2594.451&dphzoned=83&estdphbdrk=130&pctdrift=25&pctrock=64&kwsmall\\_river&wsid=20741&x=-84.838044&y=42.897185&mapx=595215.1455901071&mapy=239171.20798020425](http://www.miwwat.org/getflow.asp?trans=2478&shore=0&bdrkf=1&bdrkt=99999&aline=1558.671&bline=1971.783&dline=2594.451&dphzoned=83&estdphbdrk=130&pctdrift=25&pctrock=64&kwsmall_river&wsid=20741&x=-84.838044&y=42.897185&mapx=595215.1455901071&mapy=239171.20798020425)

trans=2478&shore=0&bdrkf=1&bdrkt=99999&aline=1558.671&bline=1971.783&dline=2594.451&dphzoned=83&estdphbdrk=130&pctdrift=25&pctrock=64&kwsmall\_river&wsid=20741&x=-84.838044&y=42.897185&mapx=595215.1455901071&mapy=239171.20798020425

## ENTER WITHDRAWAL INFORMATION

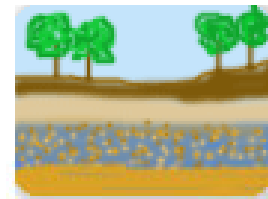
### Pumping Source and Frequency



Withdrawal Source:



Surface Water  
(from stream)



Ground Water



Shallow Pond

Pumping Frequency:



Continuous



Intermittent

### Pumping Parameters

Pumping Capacity (GPM):

Coordinates (X,Y):

Well Depth (FT):

Aquifer Type:



Bedrock



Glacial

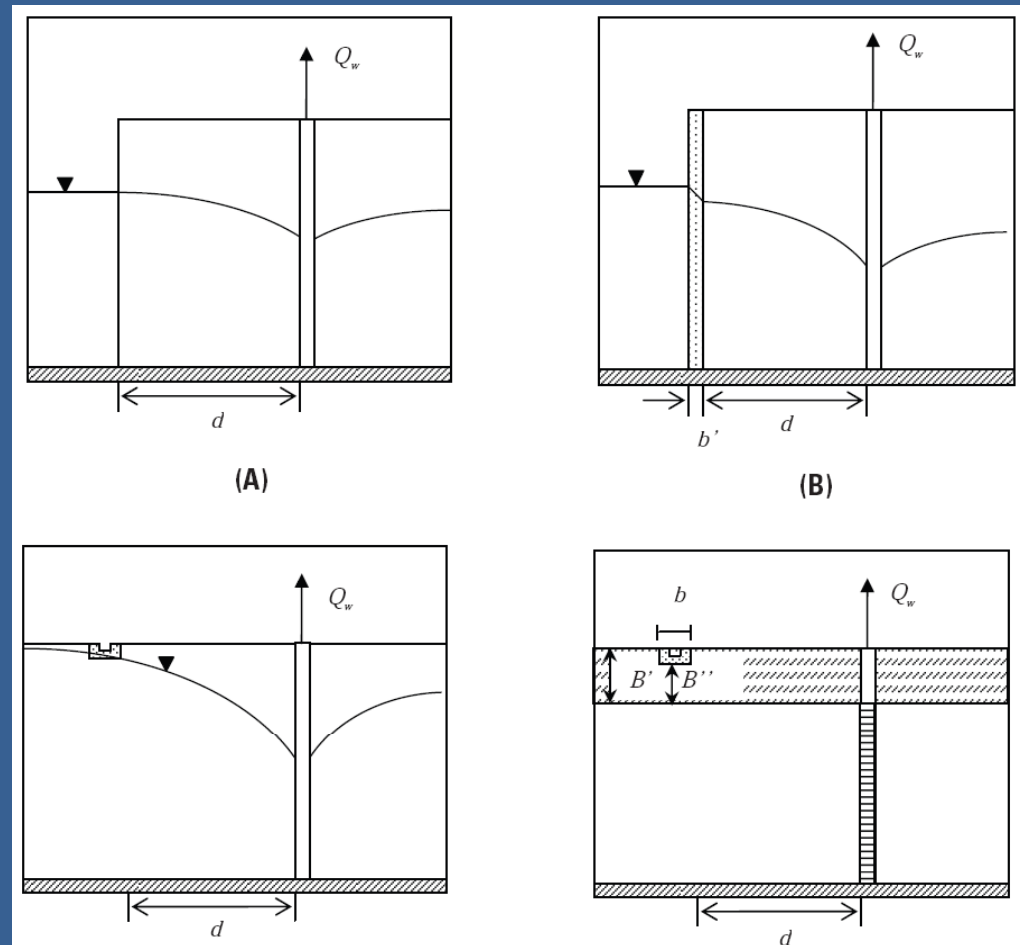
#### Current Stats at Location

- Depth to Bedrock (FT): 130
- Average Well Depth (FT): 83
- Percent Wells in Glacial: 25
- Percent Wells in Bedrock: 64

**Send to Model**

# Michigan: Application of STRMDEPL

- \* Analytical
- \* Accounts for Pumping Delay
- \* Streambed Resistance
- \* Partial Penetration
- \* Leaky Confining Unit



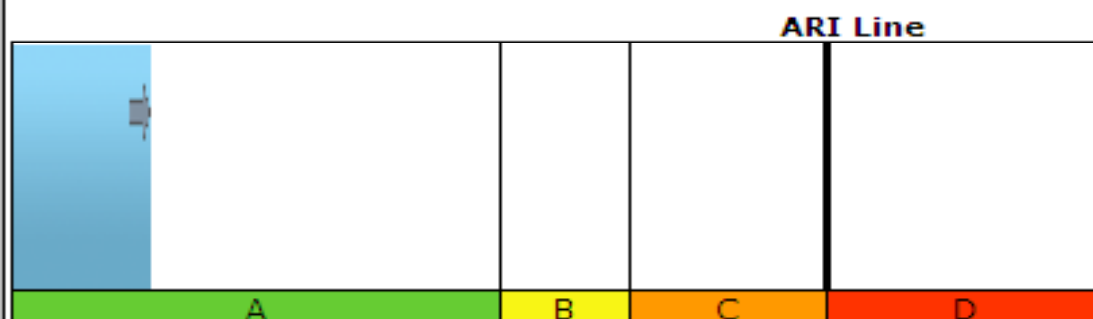
(Hunt, 1999 and 2003; Barlow, 2000; Reeves, 2008)



# Water Withdrawal Screening Results

**WARNING:** For evaluation purpose only.

## Adverse Resource Impact (ARI) Graph



The ARI graph above illustrates the estimated removal of water from a nearby stream and its potential for causing an adverse resource impact (ARI).

The proposed withdrawal has passed in Zone A.

## Screening Results - PASSED

**STREAM CLASSIFICATION:** Cool small river

**TEST VERSION RESULTS:**

The proposed withdrawal would pass the screening process. The projected impact of the withdrawal lies within 'Zone A' and is not likely to cause an adverse resource impact.

**REGISTRATION:**

A Large quantity withdrawal (LQW) with a capacity of 70 gpm or greater must be registered with the Michigan Department of Environmental Quality or with the Michigan Department of Agriculture if the LQW is for

**Actions:**

Help

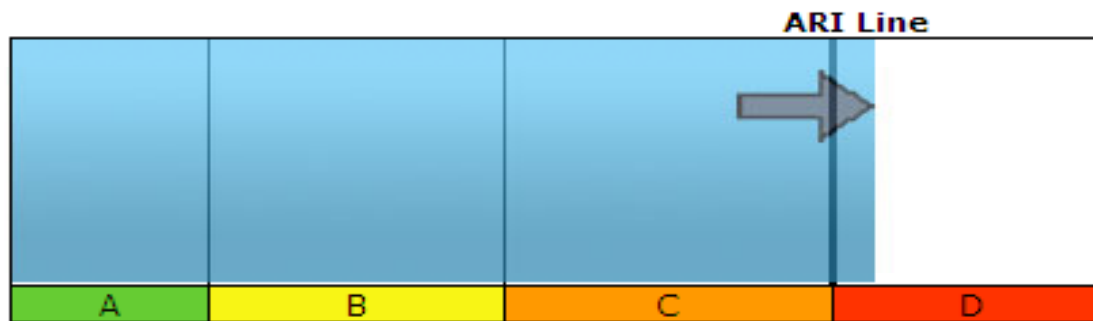
Rerun

Register Now

Feedback

Print Report

## Adverse Resource Impact (ARI) Graph



The ARI graph above illustrates the estimated removal of water from a nearby stream and its potential for causing an adverse resource impact (ARI).

The proposed withdrawal is in Zone D, and is likely to have an adverse resource impact.

## Screening Results - SITE SPECIFIC REVIEW IS REQUIRED.

**STREAM CLASSIFICATION:** Cool stream

**TEST VERSION RESULTS:** The projected impact of the withdrawal lies within 'Zone D' and would likely cause an adverse resource impact. The withdrawal cannot be initiated without a site-specific review conducted by the Michigan Department of Environmental Quality. To pursue approval for the withdrawal as proposed, submit a request for a site-specific review through the button at the right.

### MODIFYING A PROPOSED WITHDRAWAL:

Changing certain characteristics of the proposed withdrawal may decrease the flow taken from nearby river systems, thereby lessening the likelihood of an adverse resource impact. The following withdrawal characteristics may be altered in the screening process to reduce the potential impact to nearby river systems:

- Reduce the pumping frequency
- Reduce the pumping capacity
- Increase the well depth
- Relocate the withdrawal farther from nearby river systems

### Actions:

Help

Rerun

Site Specific Review

Feedback

Print Report

Exit

# Summary

1. States and river authorities can optimize groundwater withdrawal permitting
2. ELOHA provides a framework for assessing and implementing environmental flows
3. Groundwater comes into the framework through:
  - a. Estimating stream flows at ungauged sites
  - b. Predicting stream flow depletion
4. Large-scale, regional watershed-based models and integrated water budgets can help address these needs



Ashcroft view of the Redwing Pool-river in the western slope area of Colorado. © Bill Granda/NSC

## A PRACTICAL GUIDE TO ENVIRONMENTAL FLOWS FOR POLICY AND PLANNING

WITH NINE CASE STUDIES IN THE UNITED STATES

Eloise Kendy, Colin Apse, and Kristen Blann  
with selected case studies by Mark P. Smith and Alisa Richardson

MAY 2012



### ELOHA Toolbox

ELOHA Toolbox Home	Partners	Contact Us	Case Studies	Bibliography
Hydrologic Foundation	River Types	Flow Alteration	Flow-Ecology Relationships	Policy Implementation



Welcome to the **ELOHA Toolbox**, an information resource to foster learning and communication about environmental flow determination and management over large regions.

Ecological Limits of Hydrologic Alteration (ELOHA) is a

#### ELOHA Framework

Building a Hydrologic Foundation

<http://conserveonline.org/workspaces/eloha>





# Hydrological Basis

***Biological data often do not have corresponding flow data***

*Generally, only certain classes of surface-water data will be available -*

***Records limited to altered conditions – restoration targets?***

***Monthly (not daily) flow series – short duration events?***

***Flow statistics based on regression – careful calibration***

***Longer-period daily data – limited spatial distribution***

***Accurate, spatially defined water-use data are essential***