



Eastern Snake Plain Aquifer Model

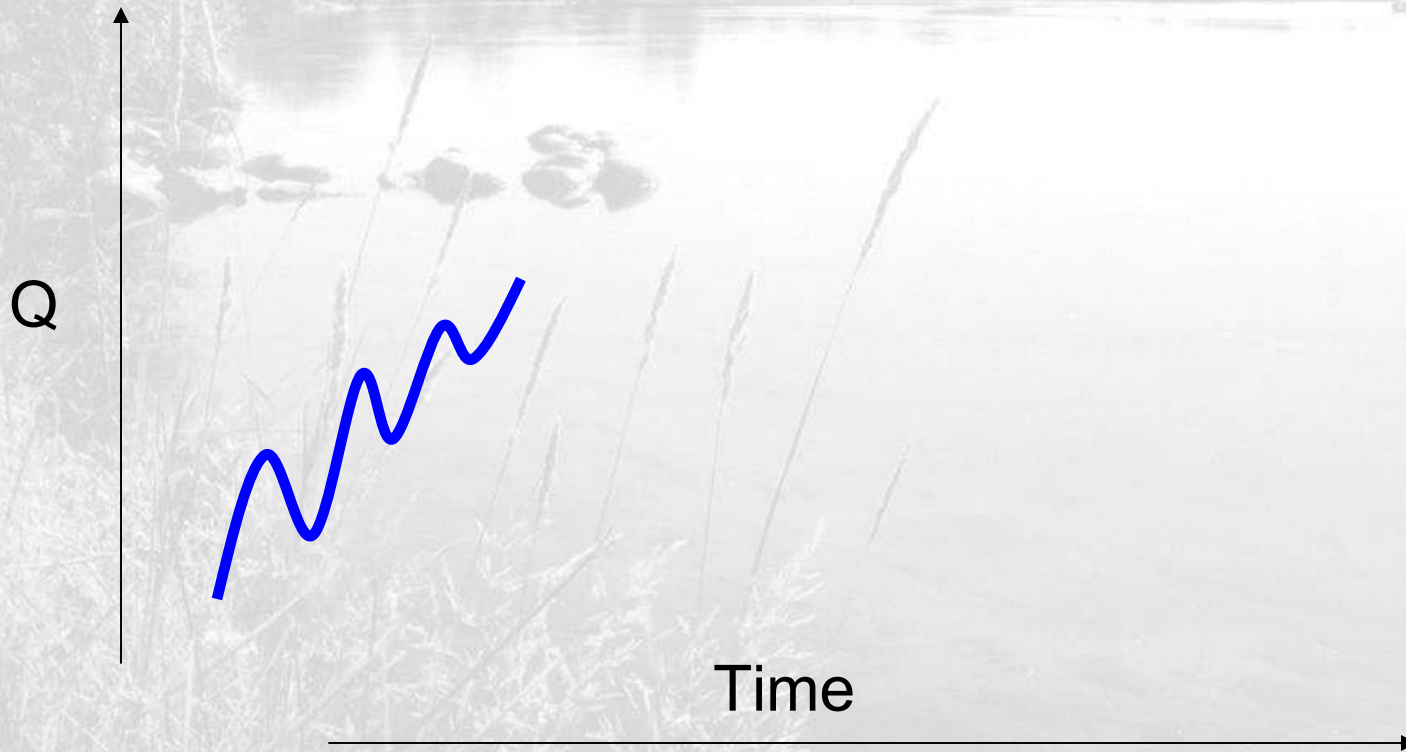
Presentation to IWRB Advisory Group
23 August 2007

B. Contor
Idaho Water Resources Research
Institute

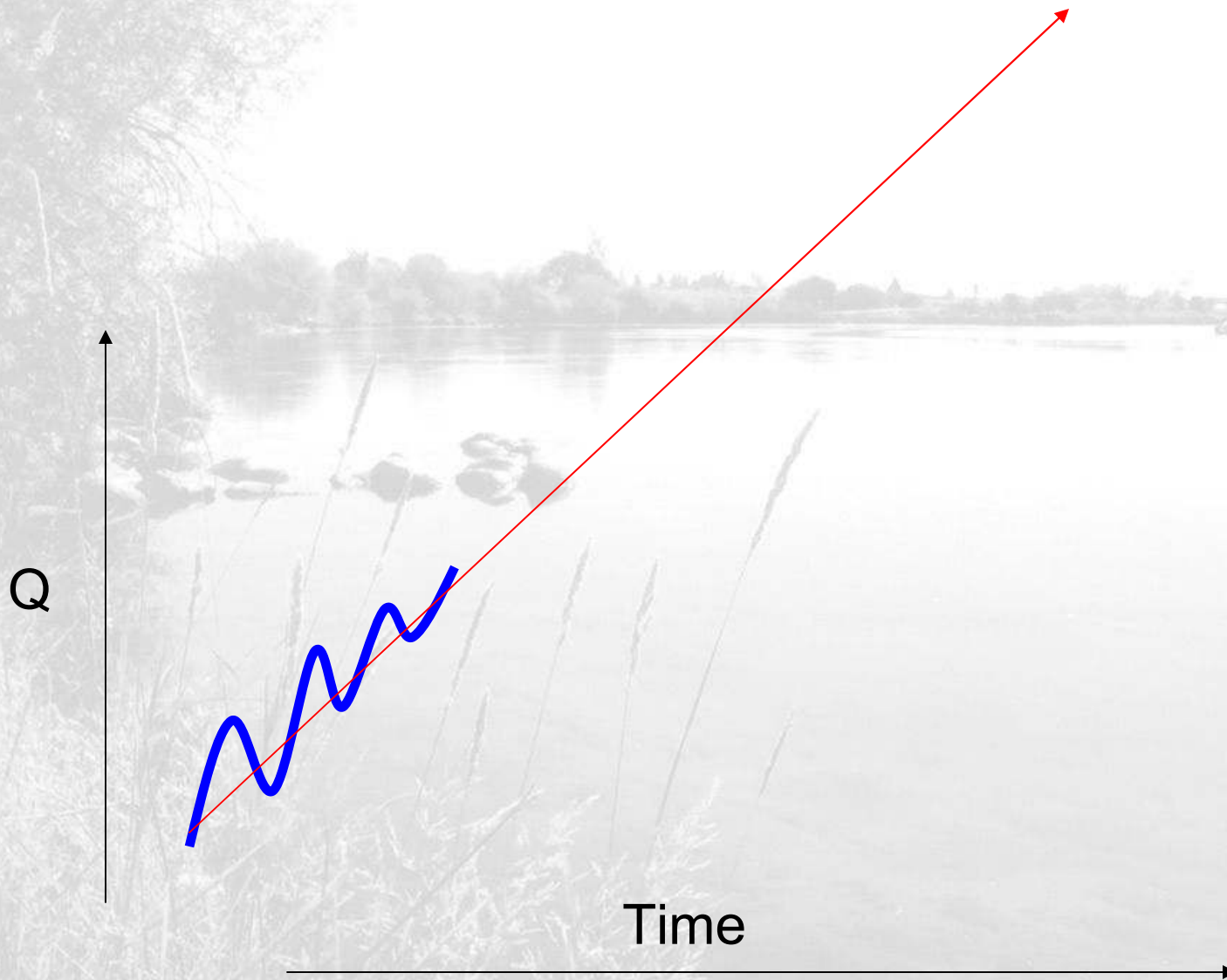
Outline

- What is “equilibrium?”
- What is a model?
- What is calibration?
- What is the Eastern Snake Plain Aquifer Model (ESPAM 1.1) good for?
- What are its limitations?
- What are specific issues with the model?
- What is planned for the model?
- How can I find out more information?

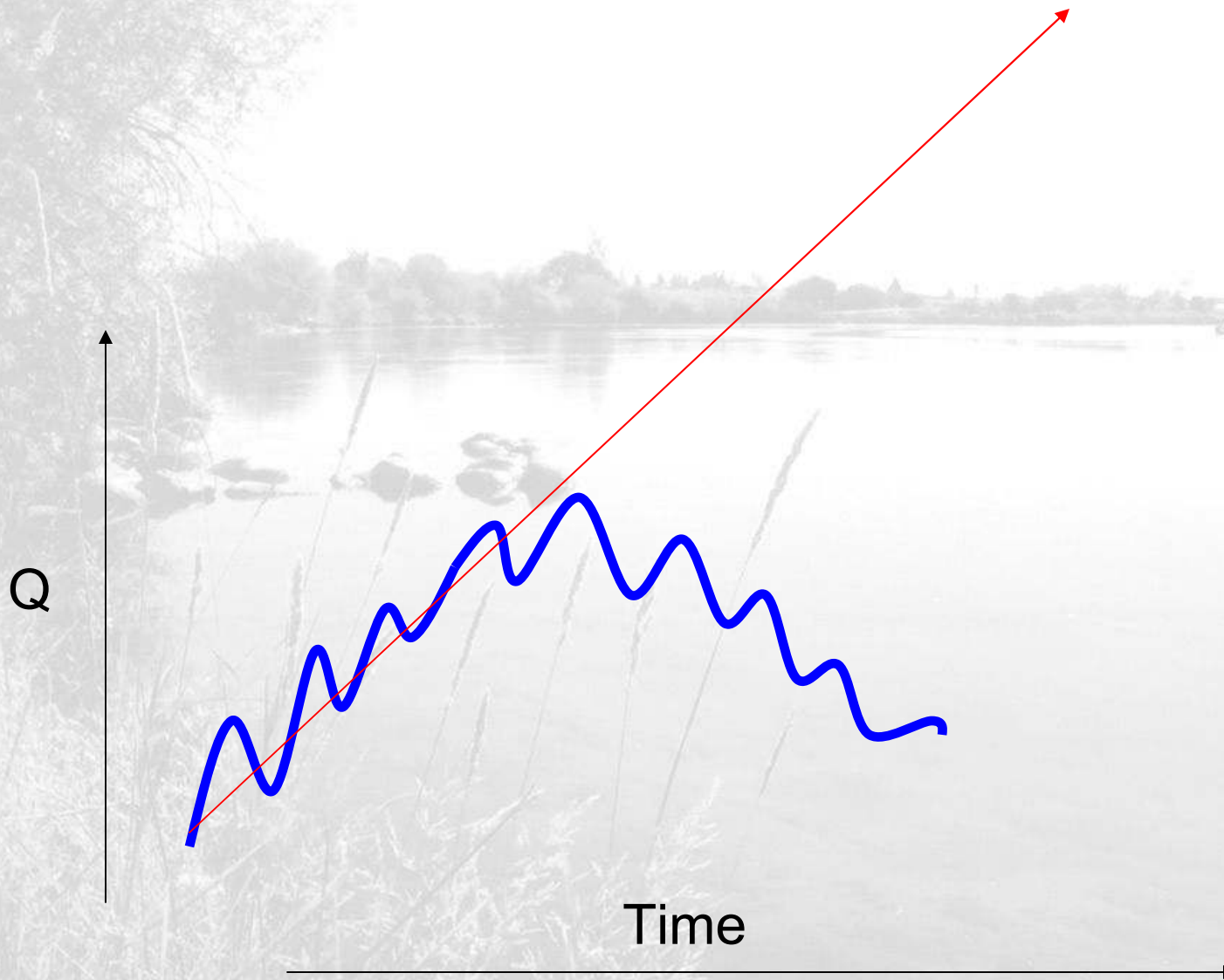
What is Equilibrium?



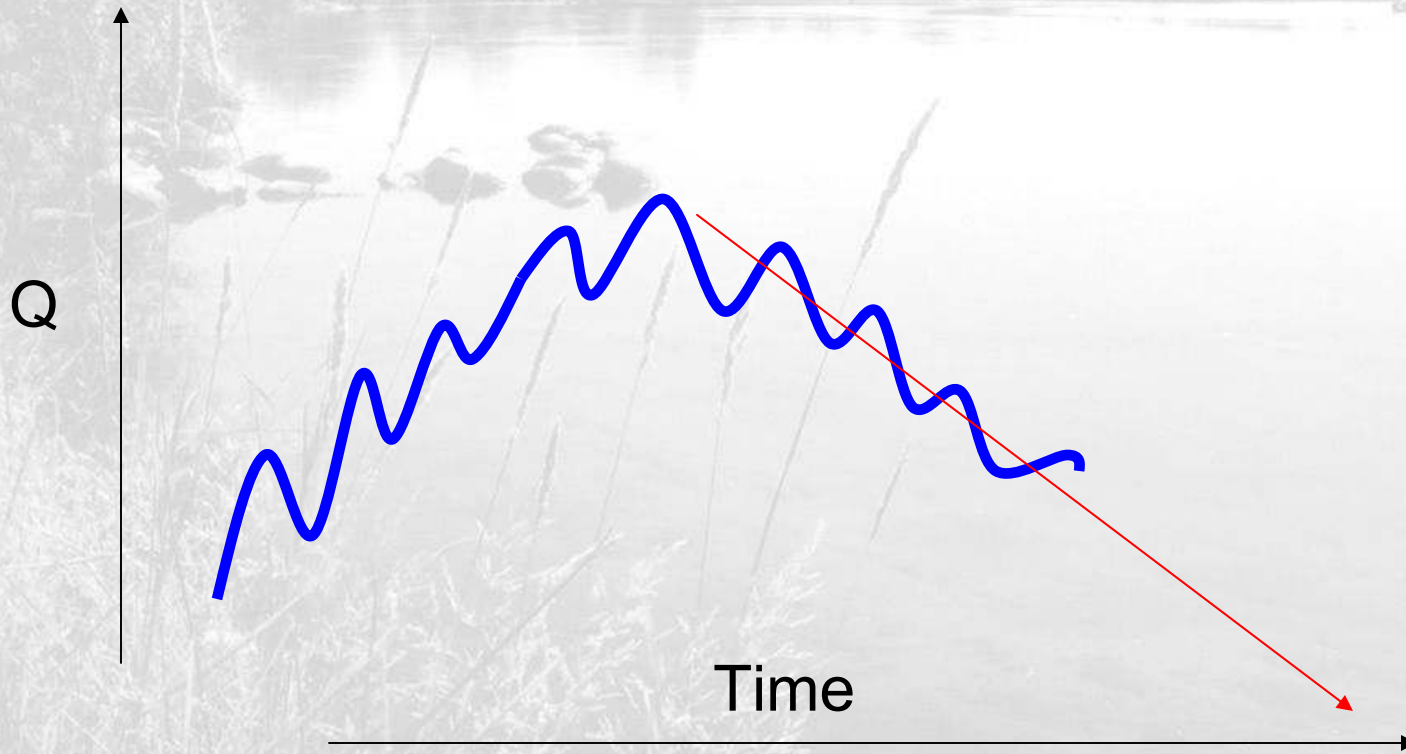
What is Equilibrium?



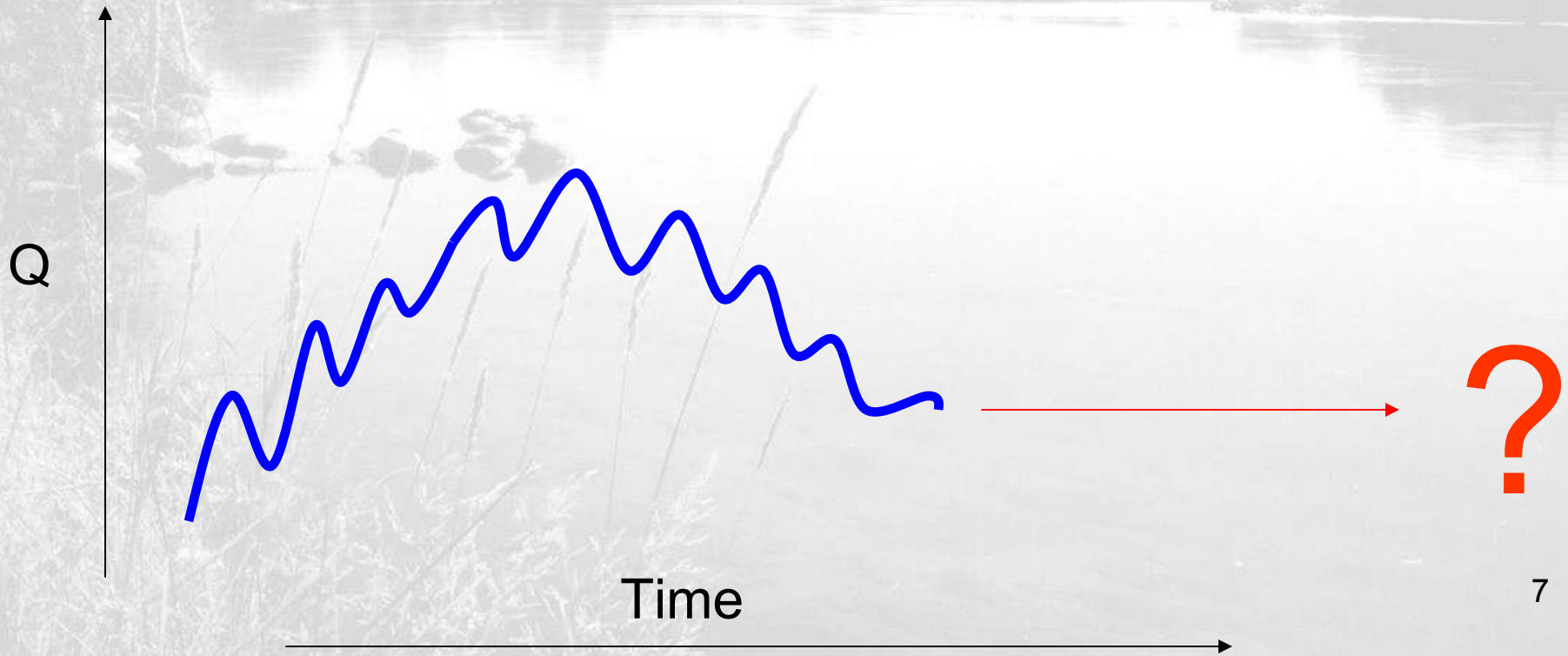
What is Equilibrium?



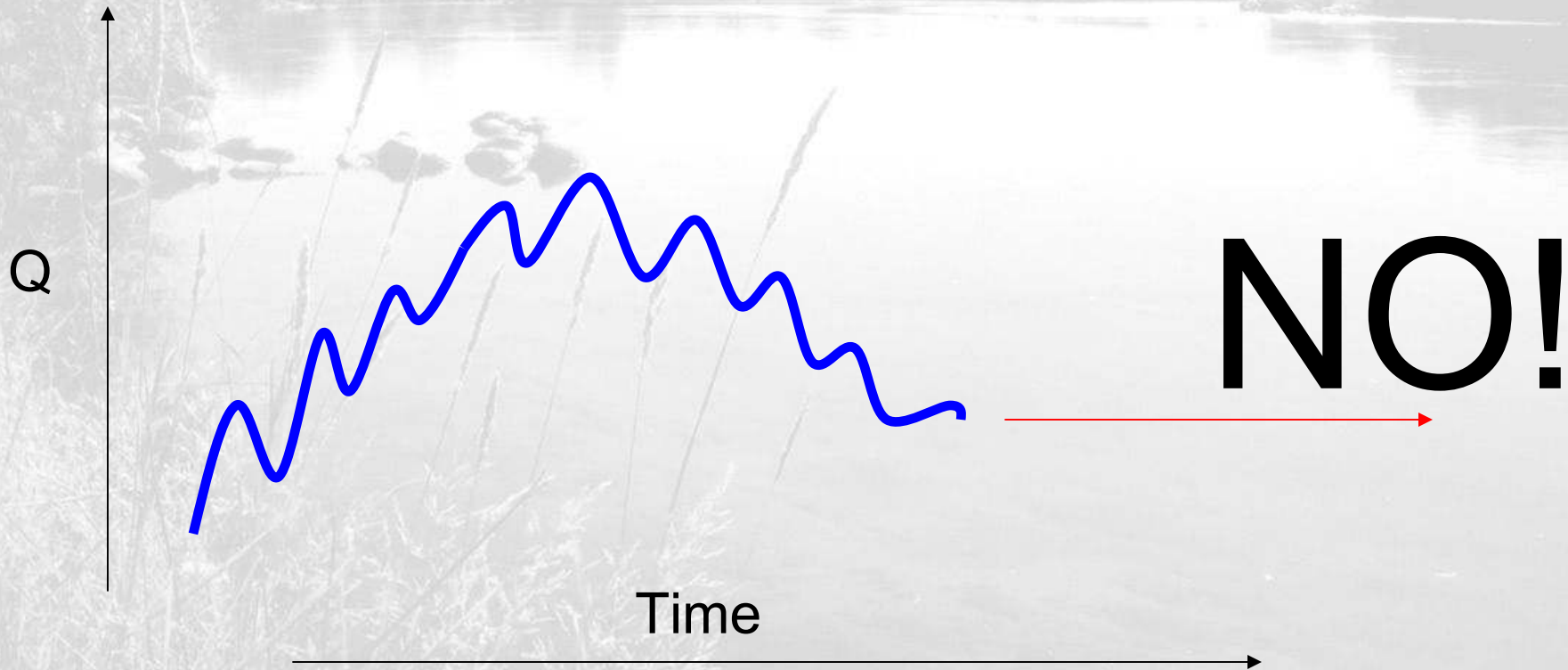
What is Equilibrium?



What is Equilibrium?

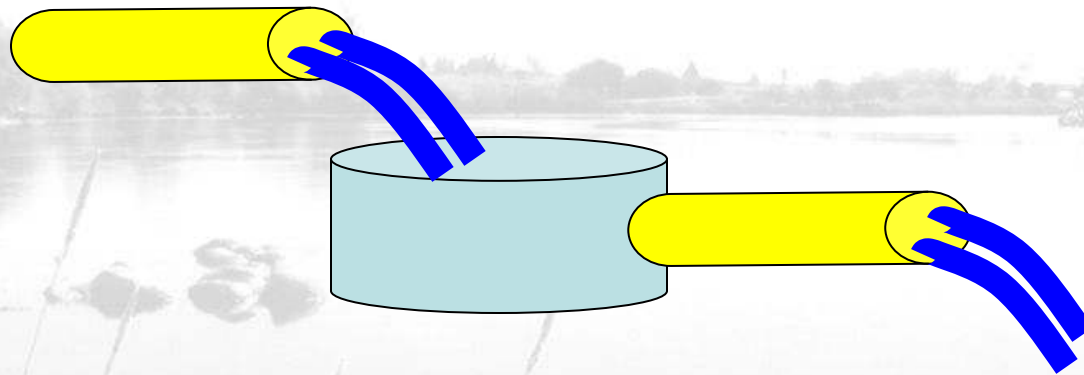


What is Equilibrium?



What is Equilibrium?

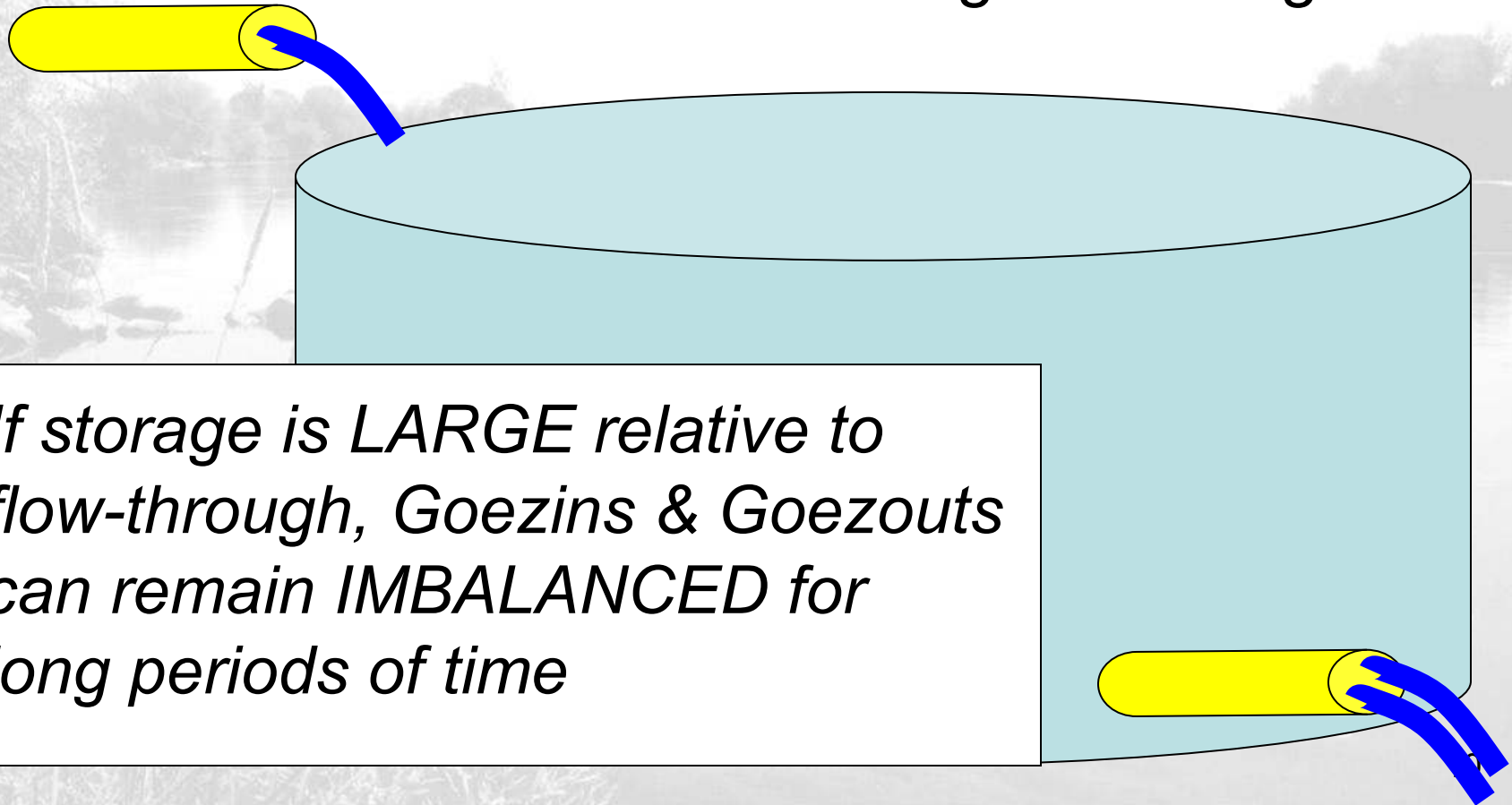
Goezins + Goezouts = Change in Storage



If storage is SMALL relative to flow-through, Goezins & Goezouts generally BALANCE within a short period of time.

What is Equilibrium?

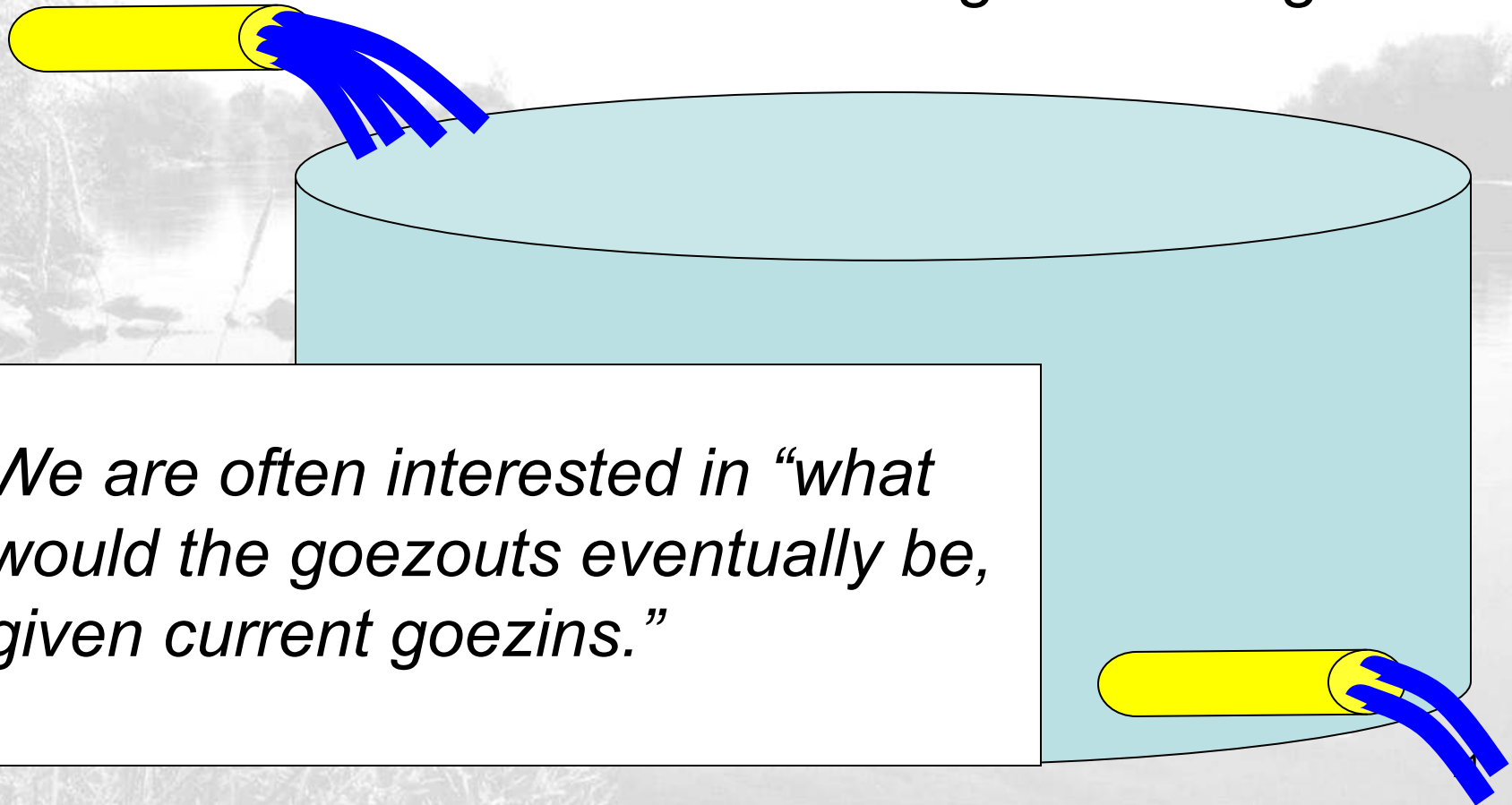
Goezins + Goezouts = Change in Storage



If storage is LARGE relative to flow-through, Goezins & Goezouts can remain IMBALANCED for long periods of time

What is Equilibrium?

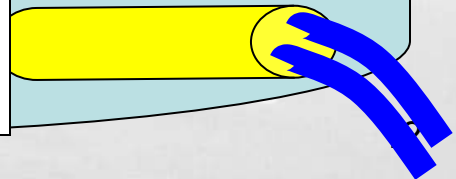
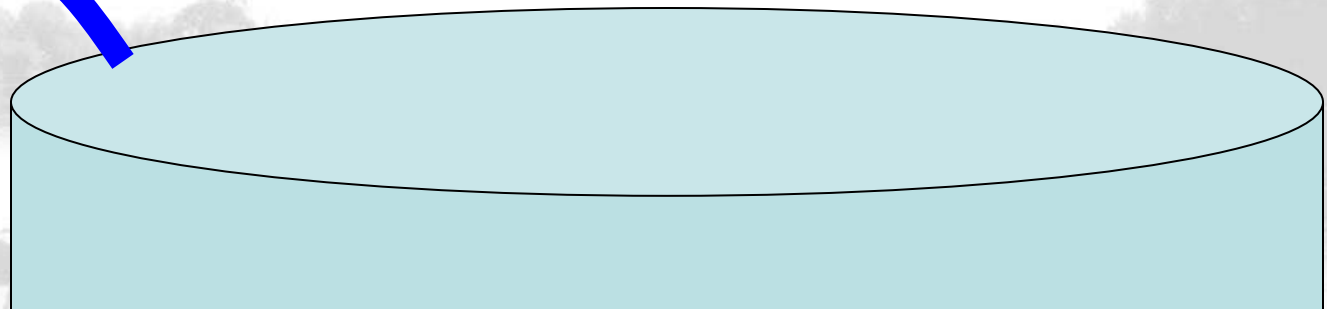
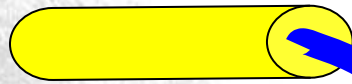
Goezins + Goezouts = Change in Storage



We are often interested in “what would the goezouts eventually be, given current goezins.”

What is Equilibrium?

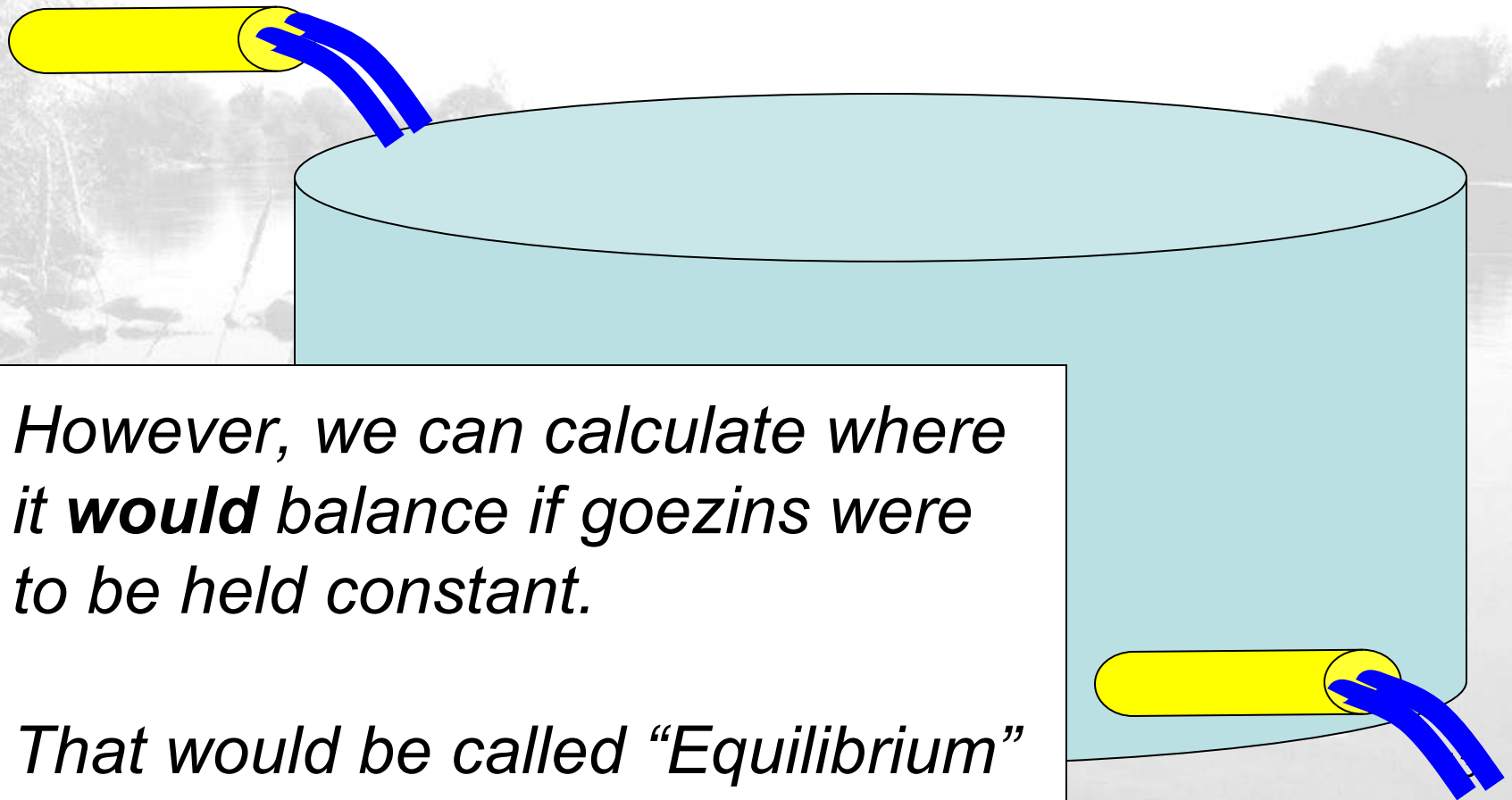
Goezins + Goezouts = Change in Storage



*Because of STORAGE BUFFERING,
we can't just look at current goezouts.*

What is Equilibrium?

$$\text{Goezins} + \text{Goezouts} = \text{Change in Storage}$$

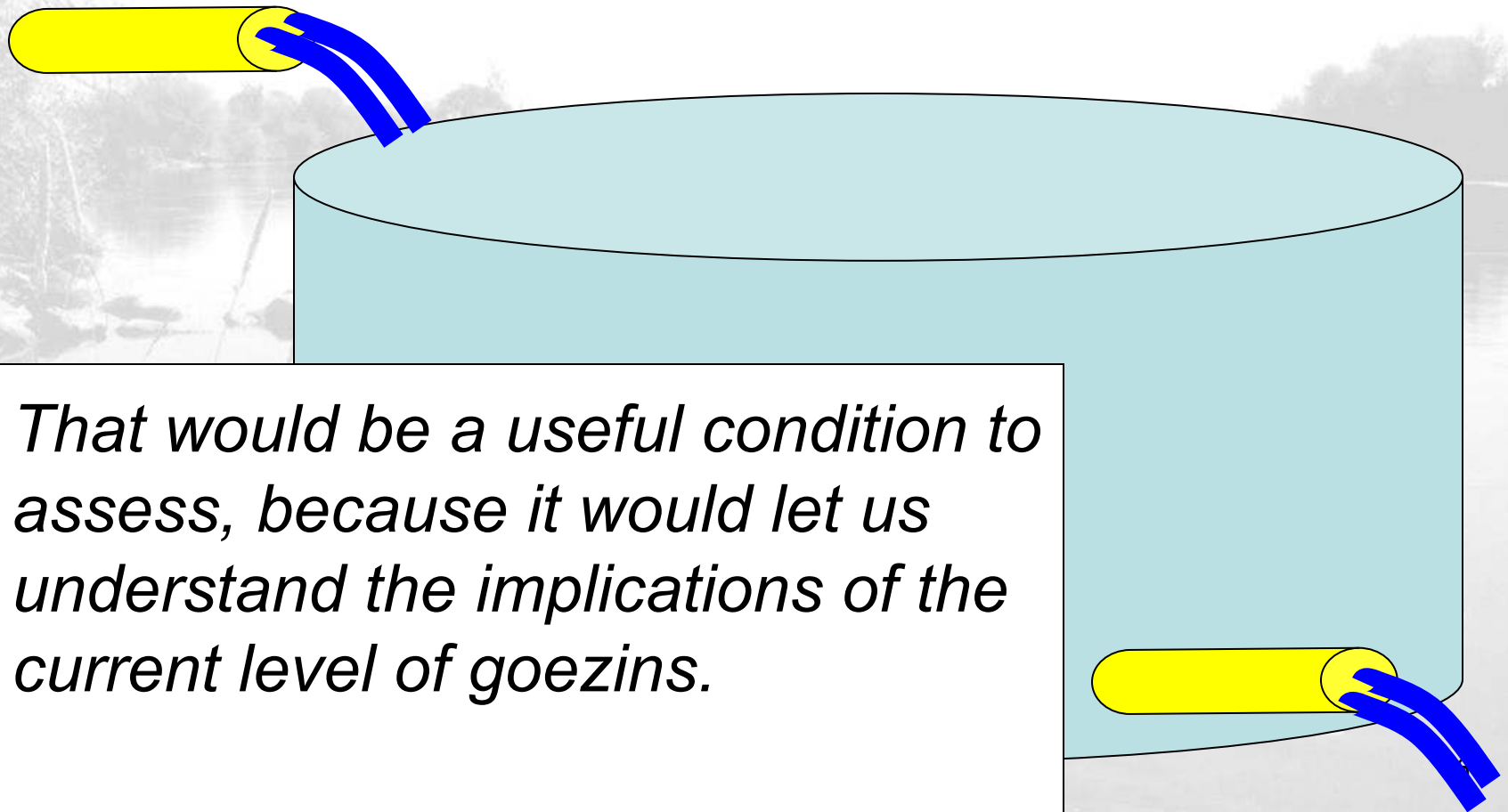


*However, we can calculate where it **would** balance if goezins were to be held constant.*

That would be called "Equilibrium"

What is Equilibrium?

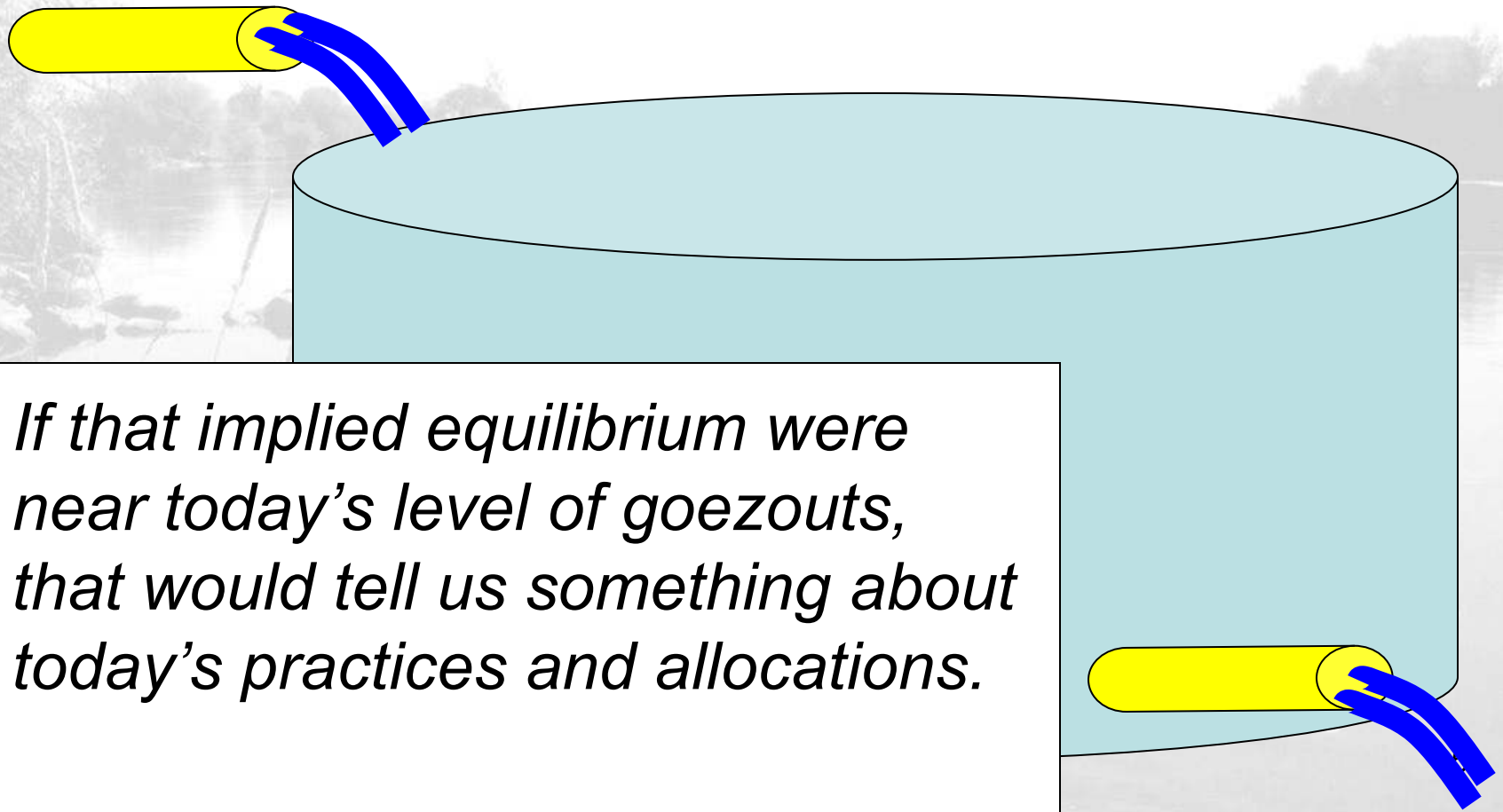
$$\text{Goezins} + \text{Goezouts} = \text{Change in Storage}$$



That would be a useful condition to assess, because it would let us understand the implications of the current level of goezins.

What is Equilibrium?

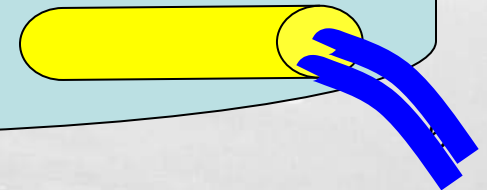
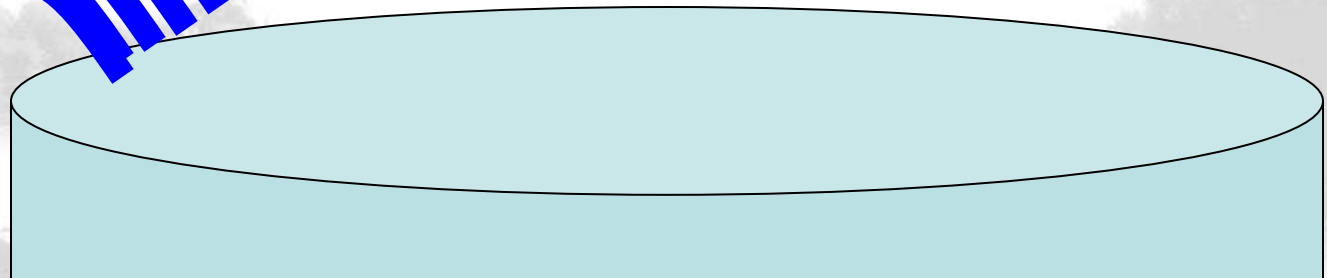
$$\text{Goezins} + \text{Goezouts} = \text{Change in Storage}$$



If that implied equilibrium were near today's level of goezouts, that would tell us something about today's practices and allocations.

What is Equilibrium?

Goezins + Goezouts = Change in Storage



*That DOESN'T MEAN that things
couldn't or wouldn't change.*

What is Equilibrium?

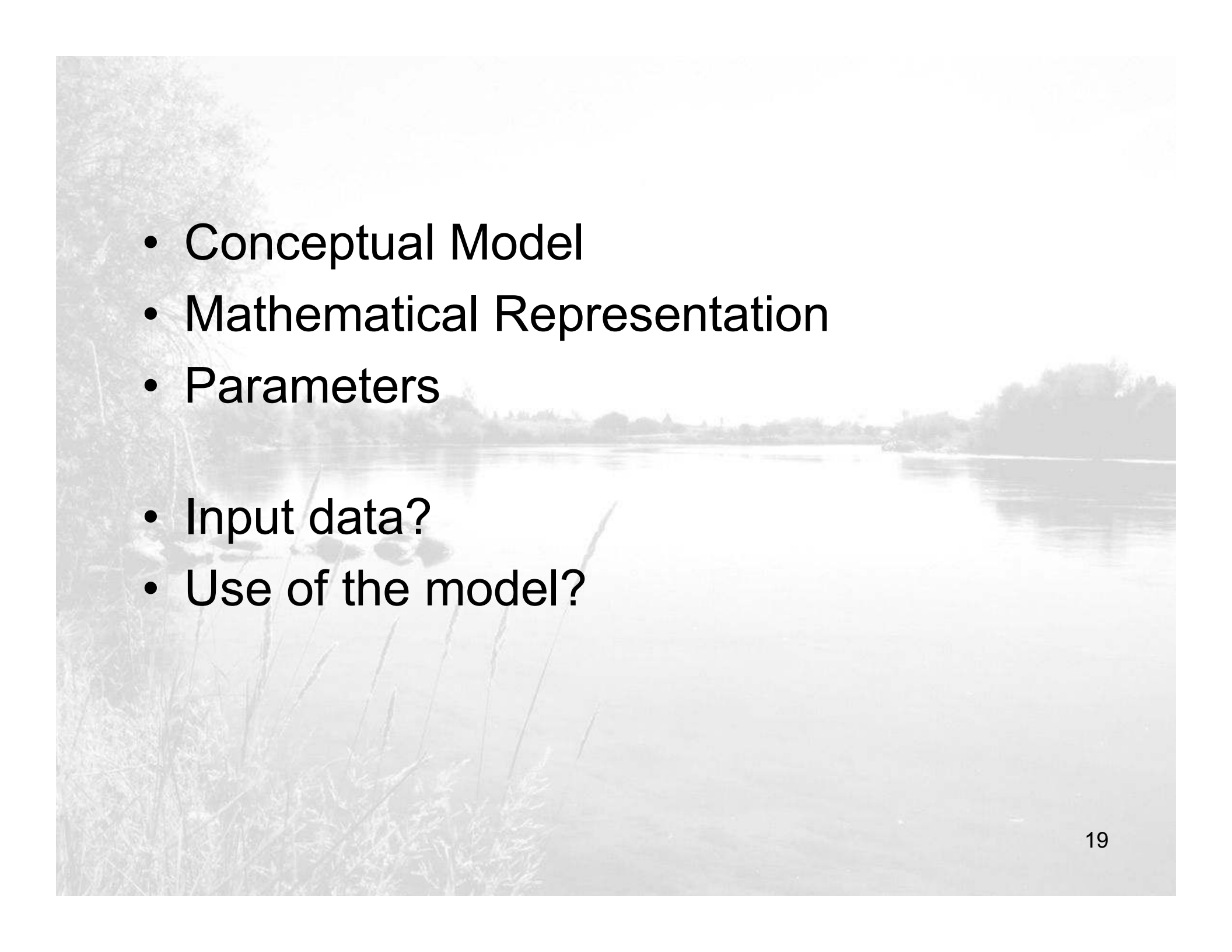
Here's another way to think about it:

Tomorrow's flows depend on what happened yesterday, what happens today, and what will happen tomorrow.

*If the system is currently "near equilibrium" it means there are no surprises coming **because of what happened yesterday and today.** But tomorrow could still bring something new!*



What is a Model?

- 
- Conceptual Model
 - Mathematical Representation
 - Parameters

 - Input data?
 - Use of the model?

Conceptual Model

- Gas consumption
 - Fuel used depends on a whole bunch of things; time of year, brand of fuel, road conditions, tire inflation, gender of driver....
- Eastern Snake Plain Aquifer
 - Flow at springs depends on the hydraulic properties of every cubic inch of the aquifer and upon all hydrologic impacts from time immemorial through the present. Flow is governed by many physical processes (laminar flow, turbulent flow, unsaturated flow, tidal effects, barometric effects, temperature and viscosity...) which vary over space and time

Conceptual Model includes “simplifying assumptions”

- Gas consumption
 - Fuel used depends on gas mileage & distance traveled
- Eastern Snake Plain Aquifer
 - Single-layer porous medium with recharge and discharge along the boundaries and from land surface, with hydraulic connection to springs and to the Snake River defined by laminar flow

*“The best maps are at a scale of one-to-one
but they are hard to fold”*

- Mark Twain ?

Mathematical Representation

- Gas consumption: one equation
 - Gallons = miles / MPG
- Eastern Snake Plain Aquifer: two equations
 - Darcys Law
 - Continuity Equation

Parameters

- Gas consumption
 - Miles per gallon
- Eastern Snake Plain Aquifer
 - Table of hydraulic properties
 - transmissivity
 - storage coefficient
 - spring/riverbed conductance
 - spring/riverbed elevation
 - Table of aquifer, river and spring geometry

Input Data

- Gas consumption
 - Miles driven
- Eastern Snake Plain Aquifer
 - starting heads*
 - recharge & discharge across land surface & along borders
 - locations of all inputs

*sometimes

Example use of model

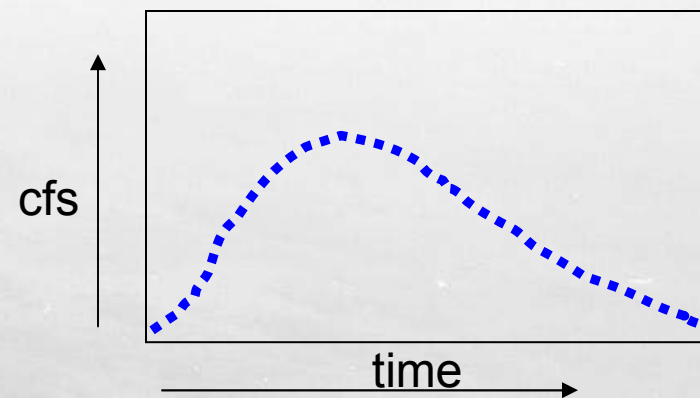
- Gas consumption

- I drove 341.5 miles:

$$341.5 \text{ miles} / 30 \text{ mpg} = 11.4 \text{ gallons}$$

- Eastern Snake Plain Aquifer

- Recharge of 10,000 acre feet at site X in 2007 produces the following time series of benefits to My Favorite Reach:



Models **DO NOT** give “PREDICTIONS”

(as the term is commonly used)

- “Prediction:”
 - “You will burn 543.21 gallons of gas next year”
 - “Spring discharge in My Favorite Reach will be 1234.567 cfs next year”
- **Conditional estimate:**
 - “**If** you drive 15,000 miles next year, you will burn about 500 gallons of gas”
 - “**If** you recharge X acre feet/year at Wendell, spring discharge in My Favorite Reach will increase by about 12 cfs

A grayscale photograph of a calm river or lake. In the foreground, there are tall reeds or grasses on the left side. The water is still, reflecting the sky and the surrounding trees. The background shows a line of trees on the far bank. The overall scene is peaceful and natural.

What is Calibration?

Using *Input Data* and
Known Targets,
we adjust *Parameters* to try to
match the targets

Input Data

Trip 1 300 miles
Trip 2 400 miles
Trip 3 270 miles

Target

11 gallons
12 gallons
9 gallons

Iteration 1: Parameter “20 miles per gallon”

	Input Data	Model Result	Target
Trip 1	300 miles	15 gallons	11 gallons
Trip 2	400 miles	20 gallons	12 gallons
Trip 3	270 miles	13.5 gallons	9 gallons

Iteration 2: Parameter “40 miles per gallon”

	Input Data	Model Result	Target
Trip 1	300 miles	7.5 gallons	11 gallons
Trip 2	400 miles	10 gallons	12 gallons
Trip 3	270 miles	6.8 gallons	9 gallons

Iteration 3: Parameter “30 miles per gallon”

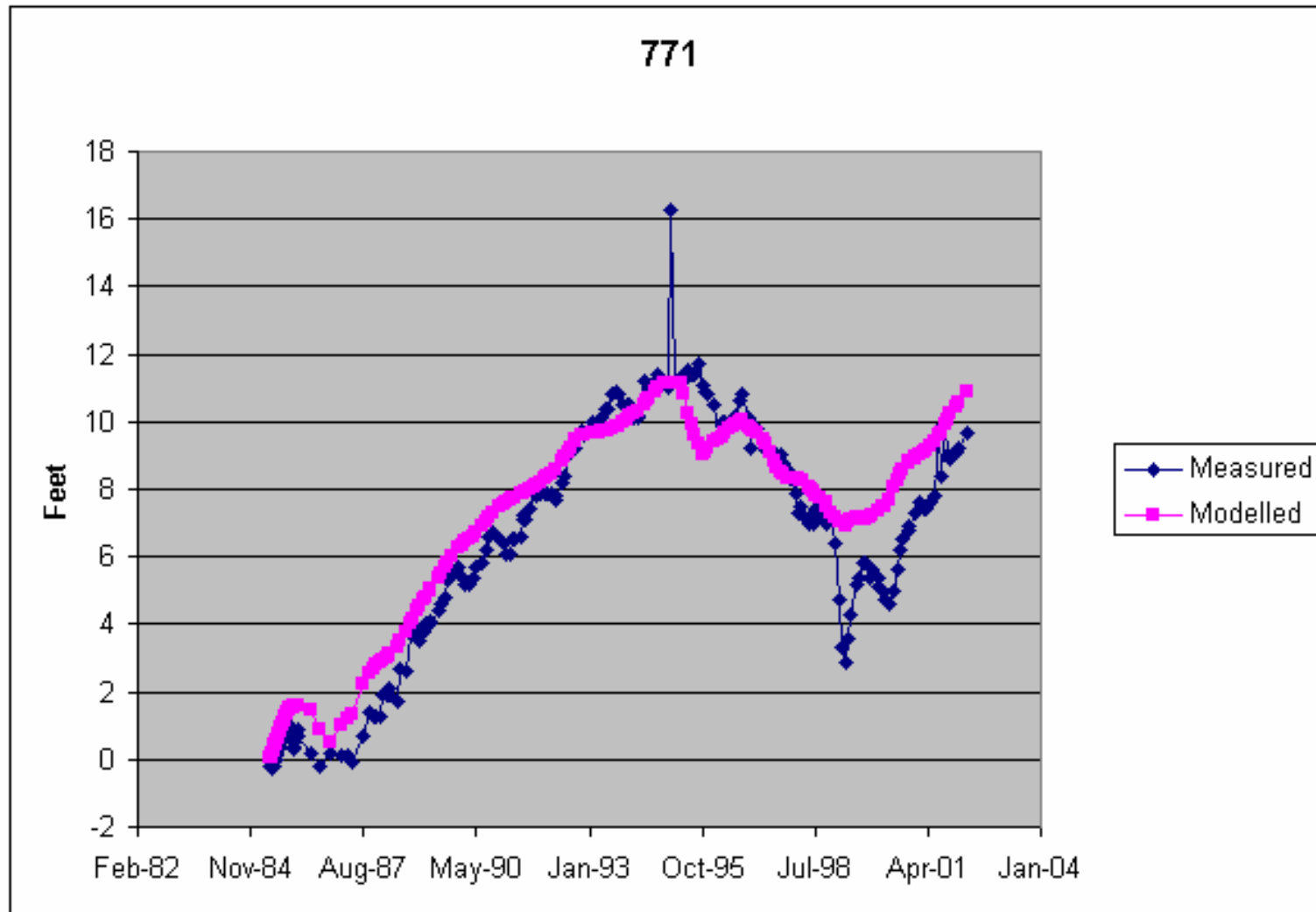
	Input Data	Model Result	Target
Trip 1	300 miles	10 gallons	11 gallons
Trip 2	400 miles	13 gallons	12 gallons
Trip 3	270 miles	9 gallons	9 gallons

ESPAM 1.1 calibration:

Match to ~ 15,000 data points

- Inputs varied every six months; output calculated every 18 days
- Head values interpolated to exact date of target
- Gains & discharges compared to filtered (smoothed) data
- A few hundred parameters were adjusted
- Sophisticated software was used to make the adjustments, over tens of thousands of model runs

Sample comparison



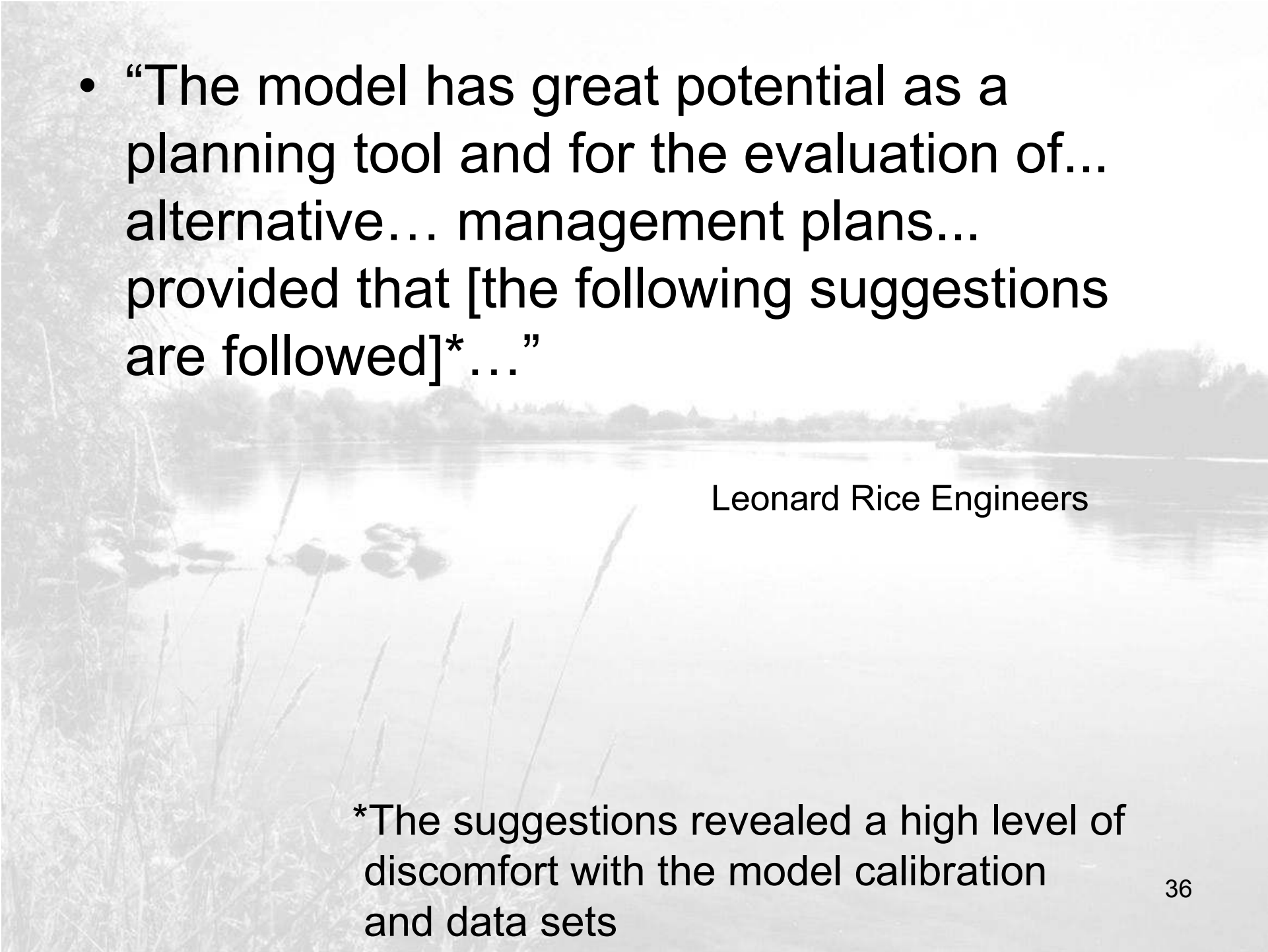


What is ESPAM 1.1 Good For?

(These are opinions from the “White Paper” presented without comment or evaluation. They represent individual views and not consensus.)

- “The model can be used to [help determine] how [aquifer] water use... will impact gains or losses to the river in specified reaches.... The ESPAM was designed to make broad-scale predictions.”

IDWR

- 
- “The model has great potential as a planning tool and for the evaluation of... alternative... management plans... provided that [the following suggestions are followed]* ...”

Leonard Rice Engineers

*The suggestions revealed a high level of discomfort with the model calibration and data sets

- “The model ... can be used for...
 - [evaluation of] the aquifer response and effect on aggregated river reaches from changes in net aquifer recharge across wide areas...
 - [evaluation of] specific ground-water levels and aggregated river reach gains...
 - [development of] an aquifer management plan...
 - support[ing] administrative actions”

HDR Engineering
Brockway Engineering
Idaho Power
Principia Mathematica

- “[The model] presents a coherent and reasonably accurate picture of the aquifer-river interactions that occur in the ESP.”

Bureau of Reclamation

- “The ESPAM is suitable for use in performing regional-scale analyses of the effects of [aquifer] water management and administration... and is an appropriate tool for the IWRB to use in its effort to develop an ESPA management plan.”

Hydrosphere

- “The model is most useful and suited for predicting regional water level [and] reach gains [changes] over relatively long periods.”

Spronk Water Engineers

IWRRI statement, Appropriate Uses of ESPAM 1.1

- The ESPAM is a regional model
 - Estimate effects on aggregated river reaches or groups of springs.
 - Estimate regional water-level impacts.
- Suited for 6-month or longer evaluations.
- The best use of the model is to evaluate *changes* expected from a particular practice or event.



What are ESPAM's limitations?

(These are opinions from the “White Paper” presented without comment or evaluation. They represent individual views and not consensus.)

- “[ESPAM] was not designed to assess localized phenomena such as the impact from pumping a specific well on a specific spring.”

IDWR

- “The current model has no technical credibility as a tool for water rights administration.”

Leonard Rice Engineers

- “The model needs to include a high[er] degree of spatial and temporal accuracy [than it currently exhibits].”

HDR Engineering
Brockway Engineering
Idaho Power
Principia Mathematica

- “To the extent that [pre-1980] legacy effects are unaccounted for in the model, they can influence model calibration and... (thereby) model predictions of river response.”

Bureau of Reclamation

- “[ESPAM] cannot be used reliably to determine the absolute effects of localized water management activities on specific springs.”

“Model scenarios constructed to simulate more extreme stresses [than included in calibration data] should be viewed with great circumspection.”

Hydrosphere

- “The model should not be used to evaluate changes in water levels, reach gains, spring flows, etc. over periods of shorter duration [than six months to one year].”

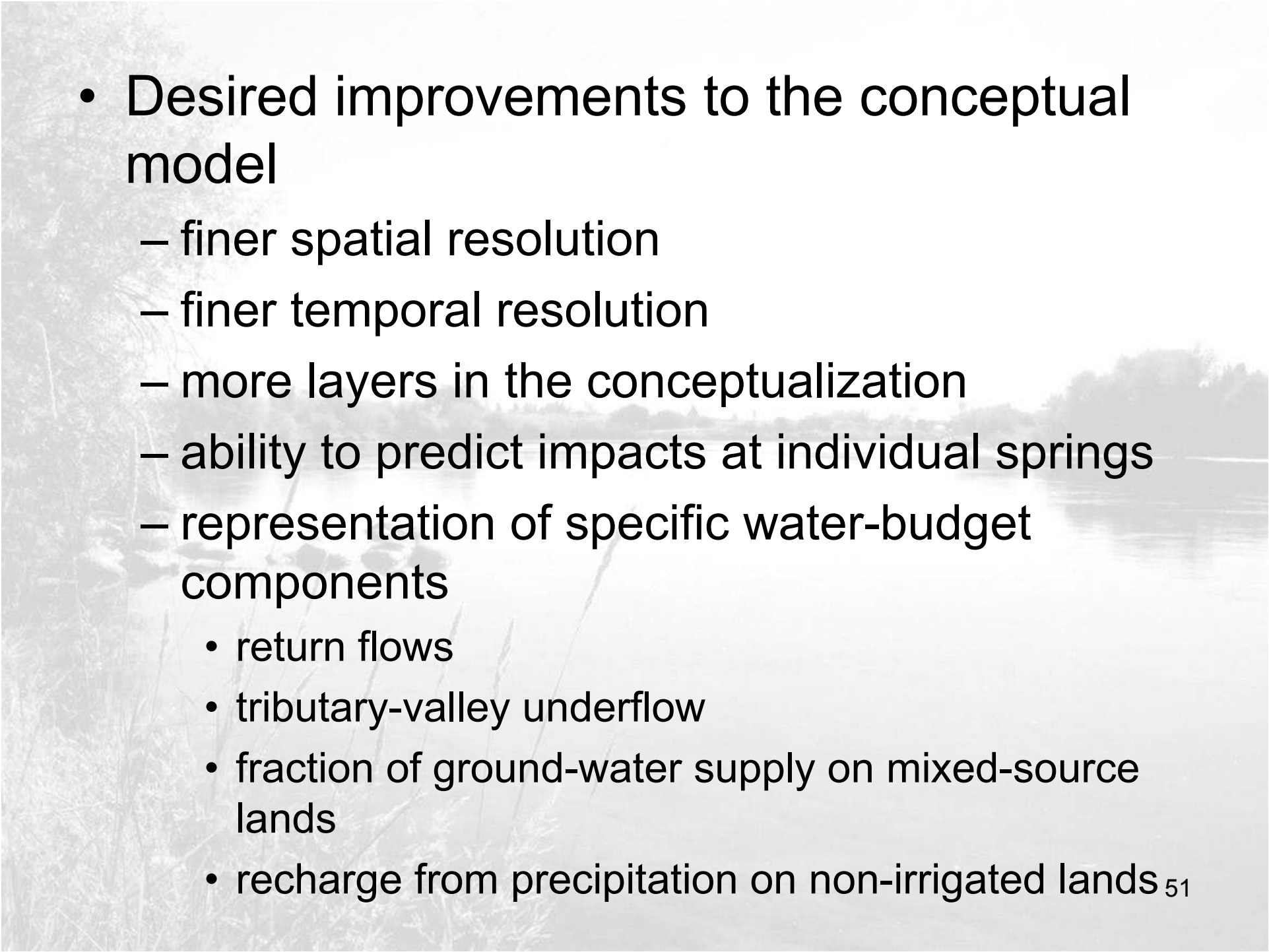
Spronk Water Engineers

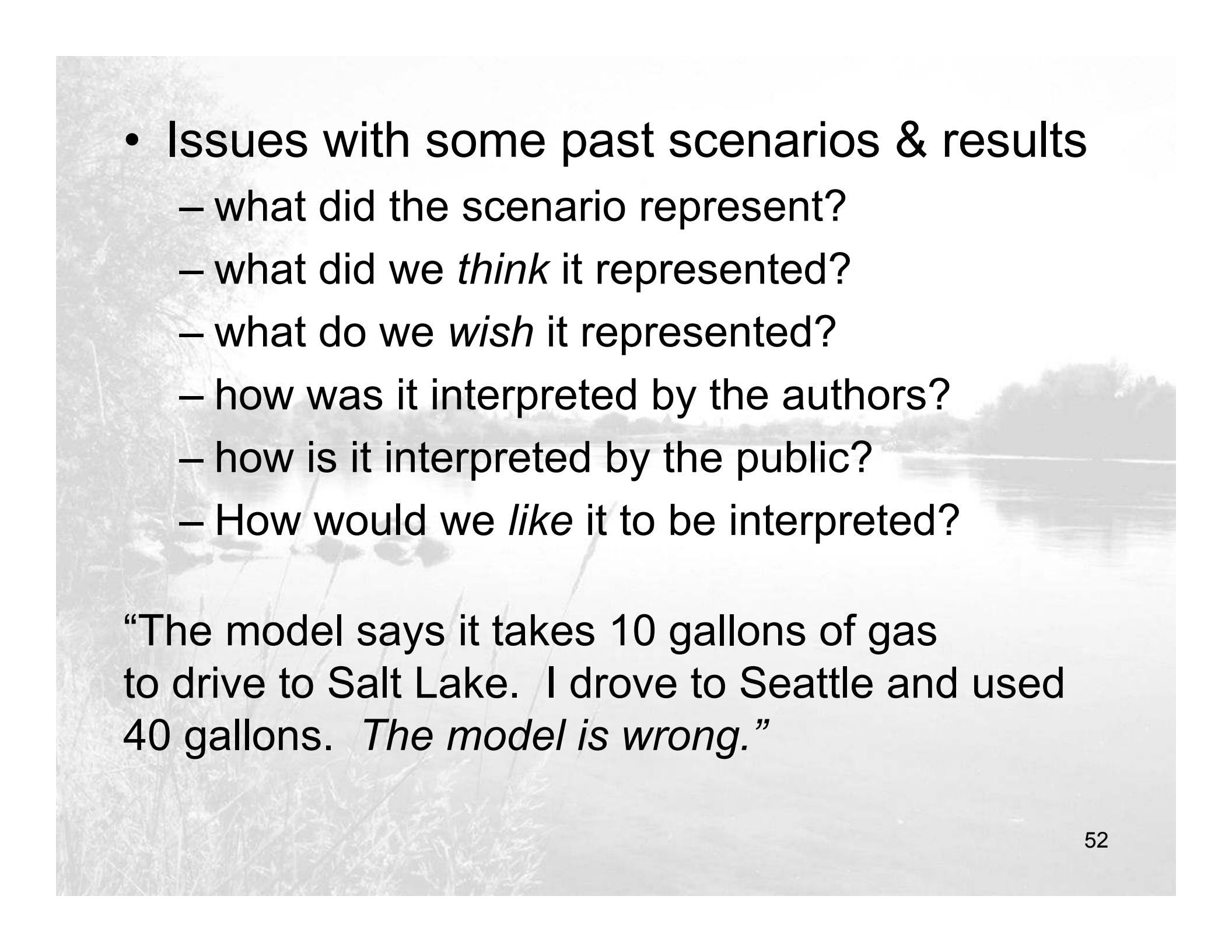
IWRRI Statement, Limitations of ESPAM 1.1

- Less reliable for analysis of impacts close to springs (~ 10 miles) and river (~ 5 miles).
- Less reliable for analysis of short-term effects.
- Not intended to evaluate impacts of an individual well upon an individual spring.
- Estimates of *absolute* values are not as reliable as estimates of *expected changes*.

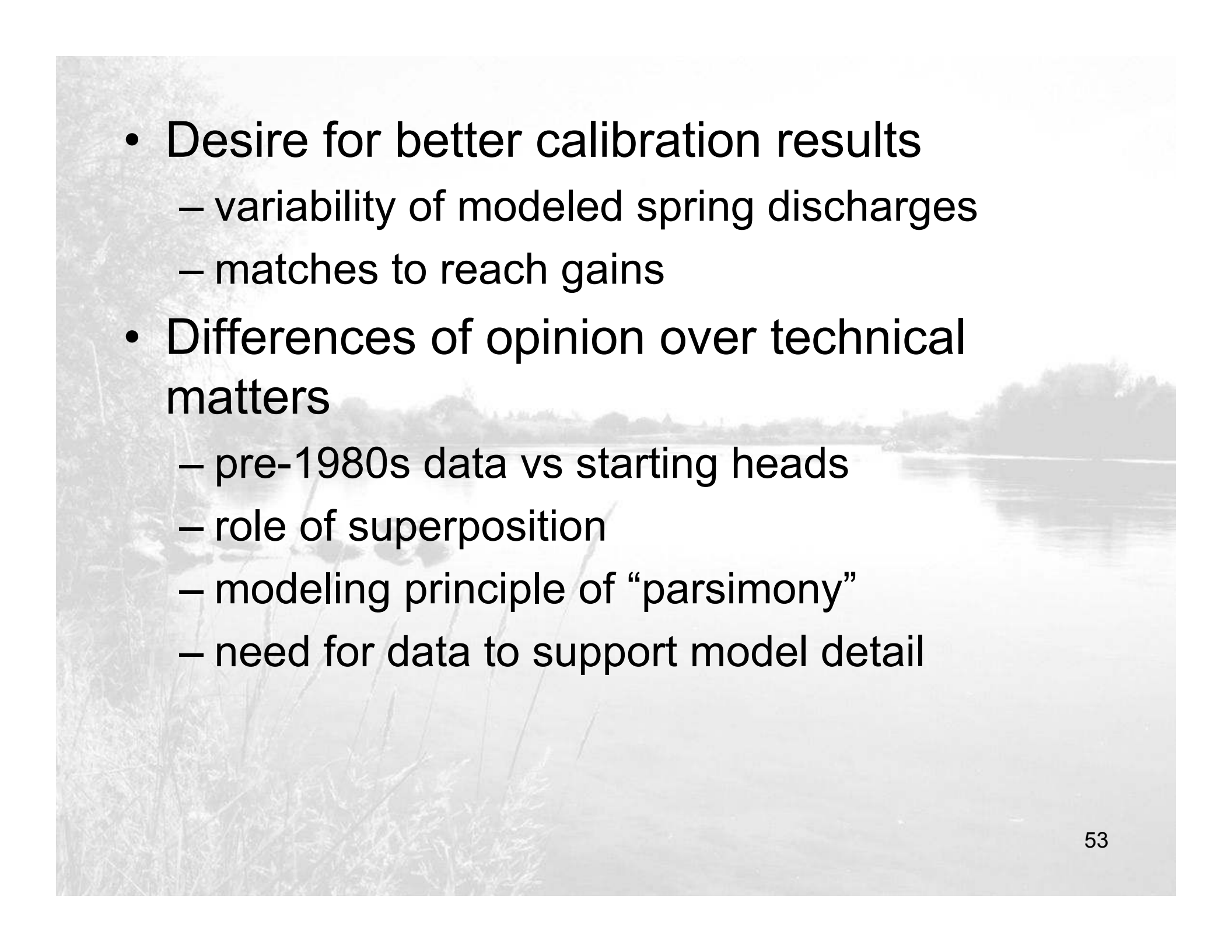
A grayscale photograph of a river or lake. In the foreground, there are tall reeds or grasses on the left side. The water is calm, reflecting the sky and the surrounding trees. The background shows a line of trees and a bright sky. The overall scene is peaceful and natural.

**What are specific issues with
the model?**

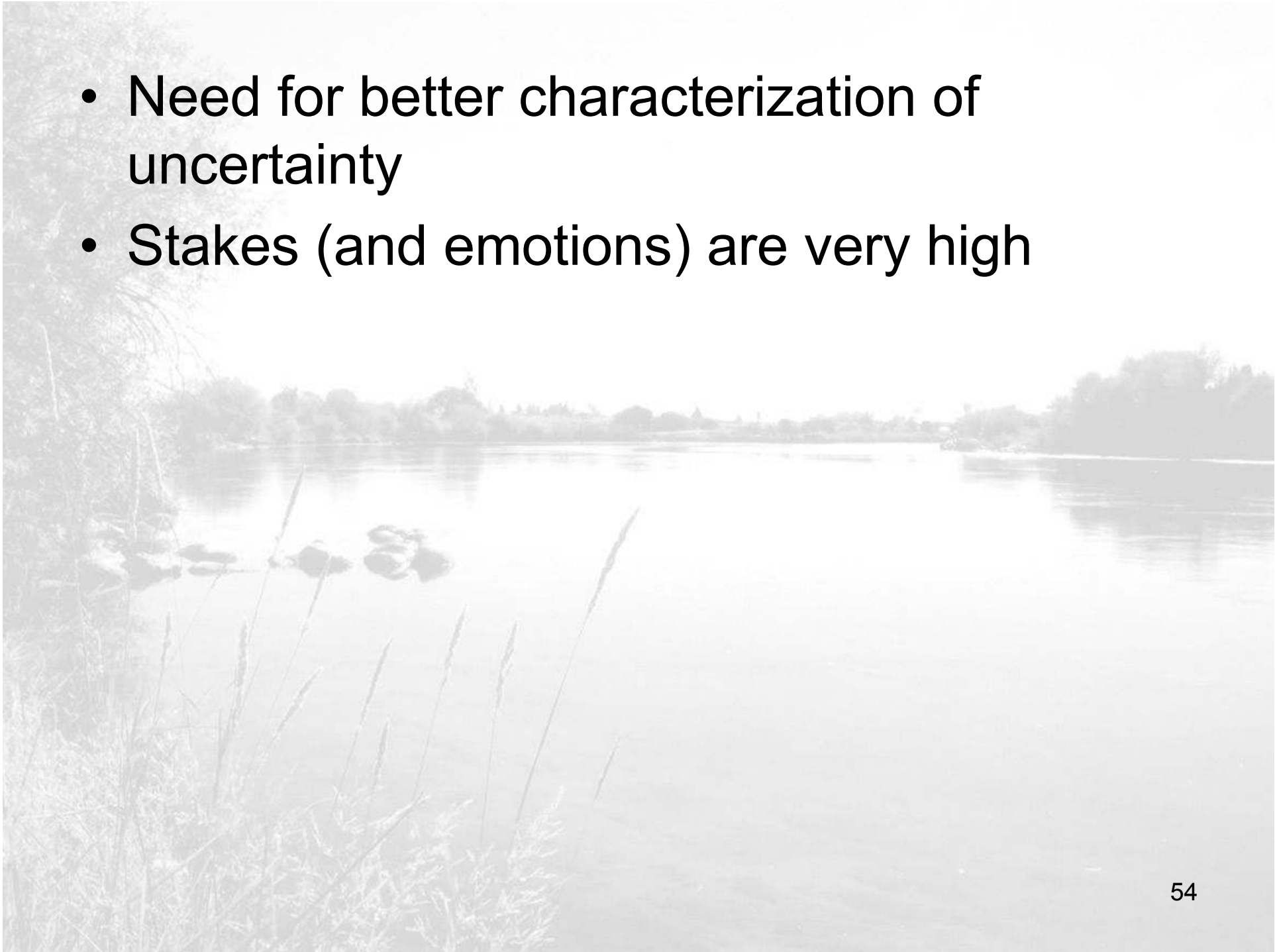
- 
- Desired improvements to the conceptual model
 - finer spatial resolution
 - finer temporal resolution
 - more layers in the conceptualization
 - ability to predict impacts at individual springs
 - representation of specific water-budget components
 - return flows
 - tributary-valley underflow
 - fraction of ground-water supply on mixed-source lands
 - recharge from precipitation on non-irrigated lands ⁵¹

- 
- Issues with some past scenarios & results
 - what did the scenario represent?
 - what did we *think* it represented?
 - what do we *wish* it represented?
 - how was it interpreted by the authors?
 - how is it interpreted by the public?
 - How would we *like* it to be interpreted?

“The model says it takes 10 gallons of gas to drive to Salt Lake. I drove to Seattle and used 40 gallons. *The model is wrong.*”

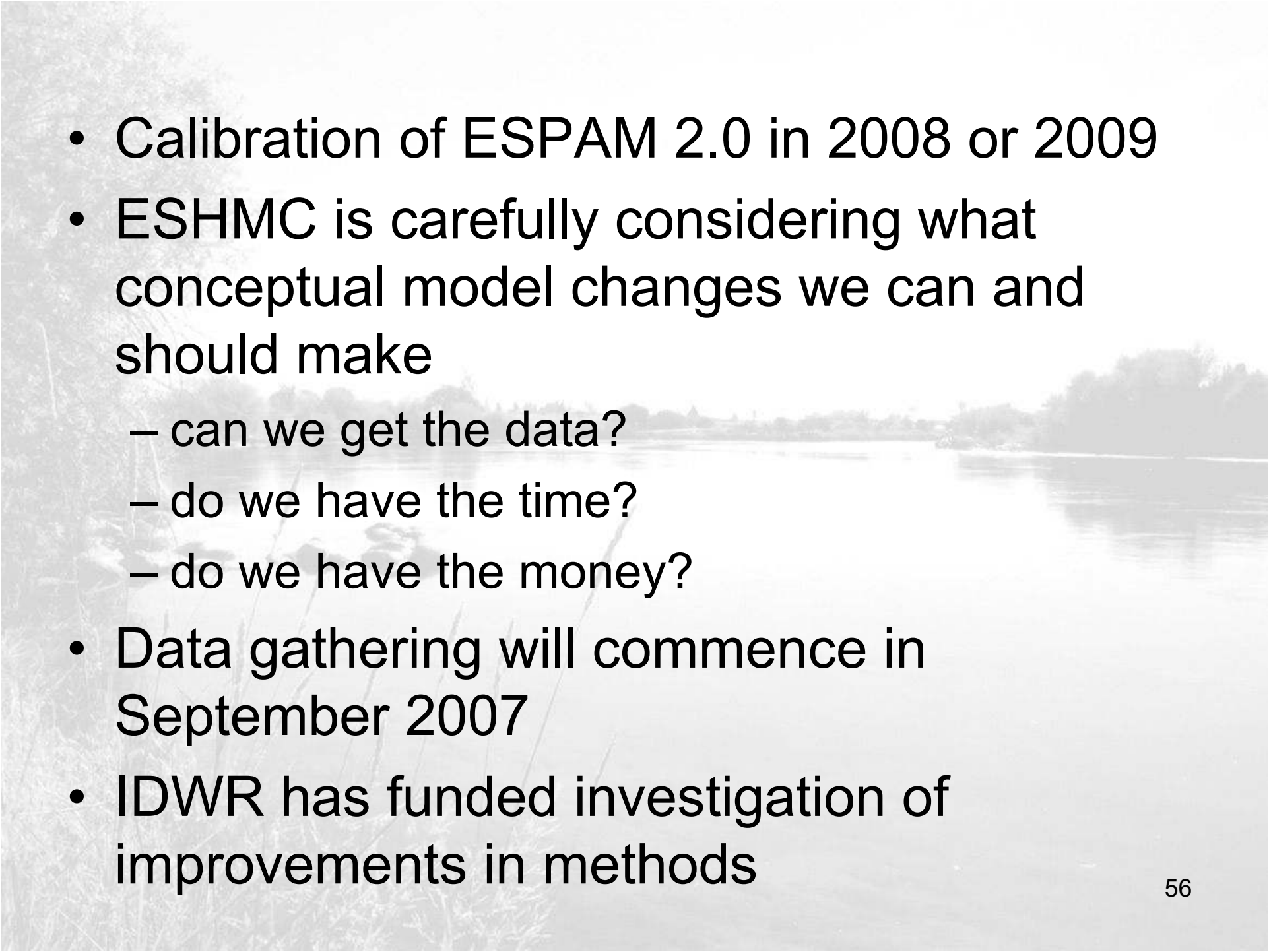
- 
- Desire for better calibration results
 - variability of modeled spring discharges
 - matches to reach gains
 - Differences of opinion over technical matters
 - pre-1980s data vs starting heads
 - role of superposition
 - modeling principle of “parsimony”
 - need for data to support model detail

- Need for better characterization of uncertainty
- Stakes (and emotions) are very high



A grayscale photograph of a river or lake. In the foreground, there are tall reeds or grasses on the left side. The water is calm, reflecting the sky and the trees in the distance. The background shows a line of trees along the far bank. The overall scene is peaceful and natural.

What is planned for the model?

- 
- Calibration of ESPAM 2.0 in 2008 or 2009
 - ESHMC is carefully considering what conceptual model changes we can and should make
 - can we get the data?
 - do we have the time?
 - do we have the money?
 - Data gathering will commence in September 2007
 - IDWR has funded investigation of improvements in methods

Take-Home Message

- The model is a tool. Not a perfect tool, but a useful tool.
- Some things don't need a model.
- Some things are not uncertain.

“If I take a bucket of water from the aquifer, it WILL come from the river or springs eventually.”



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- Welcome to Casita...
- Welders - Welding ...
- gcdbqq
- Persian Online Dicti...
- PersianRadio.com
- Stock Music - Cutti...
- Teardrop Parts
- MSN.com
- Radio Station Guide

(Note: these slides were provided during the training session held May 11 -14, 2004)

ESPAM Model Software

- [ESPAM Transient Fully Populated Files](#)
- [ESPAM Steady State Superposition Files](#)

ESPAM Project Reports

Final Report

- [Main Body of Report \(pdf\)](#)
- [Final Report Figures \(pdf\)](#)
- [Main Body Tables \(pdf\)](#)
- [Appendix Tables \(pdf\)](#)

Model Scenarios

- Base Case Scenario (ESPAM v1.1)**
- [Final Report \(v1.1\)](#)
- [Addendum \(not yet updated to v1.1\)](#)
- [Steady State v1.1 Data Files](#)
- [Transient Data Files v1.1 \(full recharge\)](#)

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Oct 13 2004 Curtailment Scenario - Donna Cosgrove

Snake River Plain Aquifer Enhancement Reports - Final and As Built

Field Work Reports

- [DDF-001 - ADCP - Spring/Fall 2001](#)
- [DDF-005 - ADCP - Final Report](#)
- [DDF-006 - Return Flow Measurements Plan](#)
- [DDF-007 - Return Flow Monitoring Report 2002](#)

Model Design Reports

- [DDM-001 - Design Objectives](#)
- [DDM-002 - Model Boundary](#)
- [DDM-003 - Model Layers](#)
- [DDM-008 - Calibration Report](#)
- [DDM-011 - Estimating Elevation, Well Heads, River Surf](#)
- [DDM-012 - Delineating the Bottom of the Aquifer](#)
- [DDM-015 - Model Grid and Grid Orientation](#)
- [DDM-016 - Confined vs Unconfined Aquifer](#)

Water Budget Reports

- [DDW-001 - Determination of Crop Mix Revision 1](#)
- [DDW-002 - Percolation, Runoff and Deficit Irrigation](#)
- [DDW-003 - Recharge-Precip.-Non Irrigated Lands](#)
- [DDW-008 - Aggregating SW Canal Co](#)
- [DDW-009 - GW Irrigation Entities for Recharge](#)
- [DDW-010 - Calculation of Traditional Evapotranspiration](#)
- [DDW-011 - Estimation of Precipitation using PRISM](#)
- [DDW-012 - Estimating Snake River Diversions](#)
- [DDW-013 - Historical Gaging Station Locations](#)
- [DDW-014 - Historical Water Level Measurements](#)
- [DDW-015 - Land Use](#)

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- PersianRadio.com
- Stock Music - Cutti...
- Teardrop Parts
- MSN.com
- Radio Station Guide

DDW-022 - Method of Irrigation Water Application
DDW-024 - Non-Snake River Perched Seepage
Non-Irrigated Land Recharge Rates Memorandum

Snake River Plain Aquifer Enhancement Reports - In Final Review

Model Design Reports

- [DDM-010 - Model River Representation](#)
- [DDW-017 - River Reach Gain/Loss Estimates](#)
- [DDW-021 - ET Adjustment Factors](#)

Water Budget Reports

- [DDW-005 - Calculating Return Flow Lag Factors](#)
- [DDW-026 - Representation of Fixed Point Pumping](#)

IWRRI Technical Reports

Cosgrove, D.M., G.S. Johnson, C.E. Brockway, C.W. Robison, 1997, [Geohydrology and Development of a Steady State Ground-Water Model for the Twin Falls, Idaho Area](#): Idaho Water Resources Research Institute, University of Idaho, Moscow, ID, 99p

Cosgrove, D.M., G.S. Johnson, C.E. Brockway, C.W. Robison, 1998, [Development of a Transient Ground-Water Model for the Twin Falls Area, Idaho](#): Idaho Water Resources Research Institute, University of Idaho, Moscow, ID, 66p

Cosgrove, D.M., G.S. Johnson, S. Laney and J. Lindgren, 1999, [Description of the Snake River Plain Aquifer Model \(SRPAM\)](#): Idaho Water Resources Research Institute, University of Idaho, Moscow, ID, 101 p.

Johnson, G.S., D.M. Cosgrove, S. Laney, and J. Lindgren, 1999, [Conversion of the IDWR/UI Ground Water Flow Model to ModFlow: The Snake River Plain Aquifer Model \(SRPAM\)](#): Idaho Water Resources Research Institute, University of Idaho, Moscow, ID, 50 p.

Johnson, G.S. and D.M. Cosgrove., 1999, [Application of Steady State Response Ratios to the Snake River Plain Aquifer](#): Idaho Water Resources Research Institute, University of Idaho, Moscow, ID, 31 p

Lovell, Mark D. and Johnson, Gary S., 1999, [Assessment of Needs and Approaches for Evaluating Ground Water and Surface Water Interactions for Hydrologic Units in the Snake River Basin](#):

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