State Water Resources Control Board Phase II Comprehensive Review of the Bay-Delta Plan

Workshop 3: Analytical Tools for Evaluating Water Supply, Hydrodynamics & Hydropower Effects

November 13-14, 2012

Submitted by:

State Water Contractors, Inc.
San Luis & Delta-Mendota Water Authority

Public Water Agencies Panel

Presenter	Topic
Mr. Wayne Lifton	Adaptive Management
Dr. Paul Hutton	A Model to Estimate Natural Delta Outflow
Dr. David Sunding	Modeling the Economic Impact of Changes in Delta Water Supplies
Dr. Ray Hilborn	Life cycle models, decision making, and resolving scientific uncertainty

Next up:

Mr. Wayne Lifton, Cardno-Entrix, Inc.

Adaptive Management

Adaptive Management

- **What will be Discussed**
  - Description of adaptive management
  - Considerations of using adaptive management
  - Limitations
  - Core elements

- **What will not be Discussed**
  - Opinions on whether adaptive management should be applied

What Is Adaptive Management

- **Adaptive Management** is a systematic science-based approach for improving resource management by iterative learning from the outcomes of management actions in the presence of uncertainty.

- The use and appropriateness of an adaptive management process is a decision that should be carefully assessed. This needs to include both science and socio-political considerations.

- Adaptive management does not replace the need for decision-making based on sound science.

- It is not a means of putting off a decision.

Decision to Use Adaptive Management

- Adaptive management is a commitment of resources for a long-term period.
- Choosing to adaptively manage is a decision not be taken lightly.
- Some basic conditions for the application of adaptive management include:
  - There are information gaps/uncertainties that limit informed decision making
  - Application of the process will help fill-in information gaps
  - Management actions be represented and evaluated by models
  - Monitoring be designed to evaluate results and inform decision-making
  - Management actions are not irrevocable and can be changed in response to learning
- There are additional considerations that would need to be considered in the decision to apply adaptive management as well

Adaptive Management Considerations

- An adaptive management program should be based on:
  - Clearly annunciated objectives that can be used as the basis for management, testable hypotheses, and success criteria.
  - Best available science including a sound knowledge of baseline conditions that will form the basis for comparison.
  - Individual management actions that do not overlap others, do not confound results, or contribute to increased uncertainty.
  - Well defined models that can be used to assess potential alternative management actions, compare them based on predicted benefits, and provide guidance to monitoring and identifying whether success criteria are met.

Adaptive Management Considerations (continued)

- An adaptive management program should be based on:
  - Monitoring that allows testing of model predictions and whether success criteria are achieved.
  - Decision criteria for making changes to models, actions, and objectives.
  - A formal, structured peer-reviewed plan that includes the input of affected stakeholders.

Roles in Adaptive Management

- There are many agencies with overlapping responsibilities in the management of resources in the Bay, Delta, and tributaries.
- There are many agencies taking actions affecting natural resources in these areas.
- The are many monitoring programs with differing objectives evaluating resources in these areas.
- The role of the agencies with responsibilities in management of resources would affect how an adaptive management program could be structured.
- An integrated structure of programs affecting resources to be managed would be necessary.

Integrating Adaptive Management

- Adaptive management would require coordination and integration among parties managing resources of the Bay, Delta, and tributaries.

- Adaptive management actions would likely affect habitats and biological populations beyond those targeted.

- Adaptive management modeling and monitoring would need to consider all of the affected areas and biota.

Integrating Adaptive Management (continued)

- Adaptive management would likely **<u>not</u>** provide necessary learning, if:
  - There are multiple management actions taken concurrently affecting the same biota and habitats,
  - There is no means of predicting the effects of those multiple manipulations,
  - Monitoring is not sufficiently coordinated to provide feedback on affected biota and habitats, model verification, and management action efficacy.

What is Often Called Adaptive Management Is Not

- Trial and error experiments are not adaptive management.

- The term often is misapplied.

- Frequently in these experiments, monitoring of ecosystem effects is inadequate.

- Many of these programs fail.

Sources of Failure in Adaptive Management Programs

- Walters (2007) reviewed more than 100 programs and concluded most fail due to:
  - Lack of resources for the expanded monitoring needed to carry out large-scale experiments;
  - There needs to be recognition that there is uncertainty in the outcome of decisions, regardless of the quality of the underlying science, which may not be resolved without experimentation; and
  - lack of leadership in implementation of new and complex management programs.

Sources of Failure in Adaptive Management Programs (continued)

- Allen and Gunderson (2011) in their review added:
  - Lack of stakeholder participation,
  - Experiments are difficult,
  - Surprises are suppressed,
  - Delay of action, avoiding action,
  - Learning is not used to modify management or plans, and
  - Avoiding risk.
- Lee (1993) emphasized the need for institutional support over a sufficient time-scale, as a prerequisite for success.

Summary

- Adaptive Management, itself, is not a decision, it is a structured approach.
- An adaptive management plan should be structured, formal, well-designed, and reviewed prior to implementation.
- Adaptive management takes substantial dedicated resources and sufficient time.
- Programs affecting the resources to be managed need to be integrated and not operated piece-meal.
- Learning derived from adaptive management should improve knowledge and facilitate actions more effective at meeting objectives.
- Adaptive management may not be the right answer, if it cannot carried out properly.

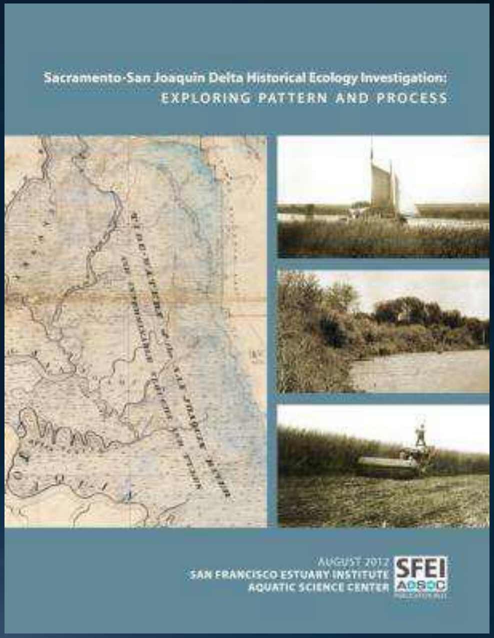
Next up:

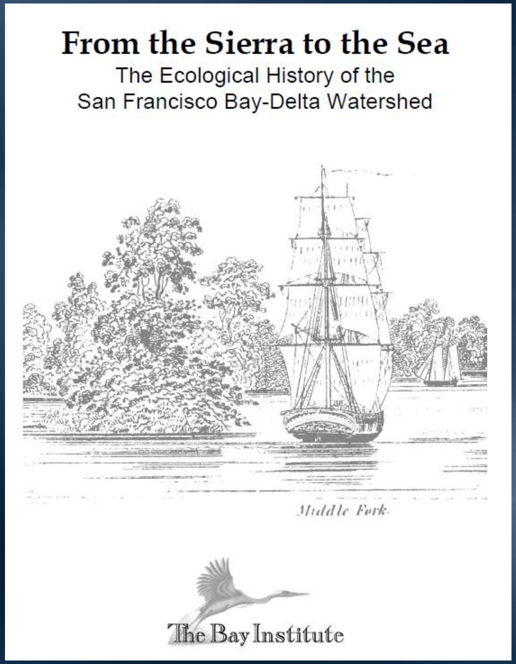
Dr. Paul Hutton, Metropolitan Water District

A Model to Estimate Natural Delta Outflow

Purpose

- Gain Insights into Natural Hydrologic Conditions
  - A return to natural conditions is not a realistic goal.
  - However, understanding the biological functions provided under natural conditions is necessary for effective restoration efforts.
- Demonstrate that Unimpaired Outflow Does Not Provide a Reasonable Approximation of Natural Hydrologic Conditions





Appropriate & Inappropriate Uses of Unimpaired Flow Calculations

- Index of Water Supply Available at Valley Rim
  - Definition of D-1641 Water Year Types
  - Climate-Based Regulatory Trigger (Eight River Index)
  - Other Metrics Representing Climatic Variability

- ~~Proxy for Natural Flow Conditions Downstream of Valley Rim~~

Unimpaired Flow Continues to be Equated with Natural Flow

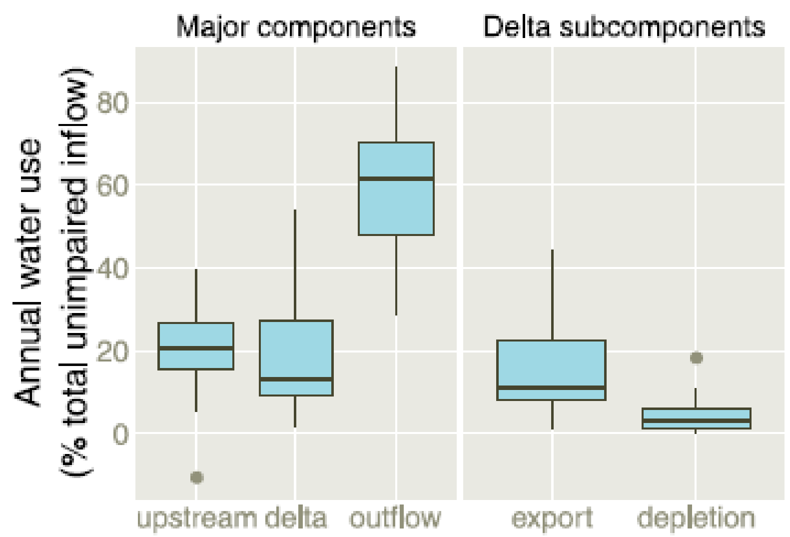


Figure 6. The fate of tributary water to San Francisco Bay as a percentage of total unimpaired inflow to the Delta during 1956–2003, i.e., the inflow to the Delta that would have occurred in the absence of upstream human activities. (left) The major fates include net upstream use (including consumption, reservoir storage or release, and import or diversion), Delta use, and outflow from the Delta to the Bay. (right) Uses in the Delta can be classified as exports to state and federal water projects and depletions within the Delta (the net result of consumption, precipitation, and evapotranspiration).

3.3. Significance of the Changes

[17] Flow management in the San Francisco Bay–Delta watershed is so pronounced that a median 39% of its unimpaired runoff is consumed upstream or diverted from the estuary (Figure 6), and the Sacramento–San Joaquin River system is thus classified as "strongly affected" by fragmentation [*Dynesius and Nilsson*, 1994].

Dynesius & Nilsson (1994) classifies the system based on its "virgin mean annual discharge (the discharge before any significant direct human manipulations)".

Ref: Cloern & Jassby (2012). Drivers of Change in Estuarine-Coastal Ecosystems: Discoveries from Four Decades of Study in San Francisco Bay, pp. 7-8

A Model to Estimate Natural Delta Outflow

Purpose

Annual Model

Monthly Model

Next Steps

Natural Delta Outflow Estimate

Annual Delta Outflow = Water Supply - Water Use

where:

Water Supply = Rim Inflow + Precipitation

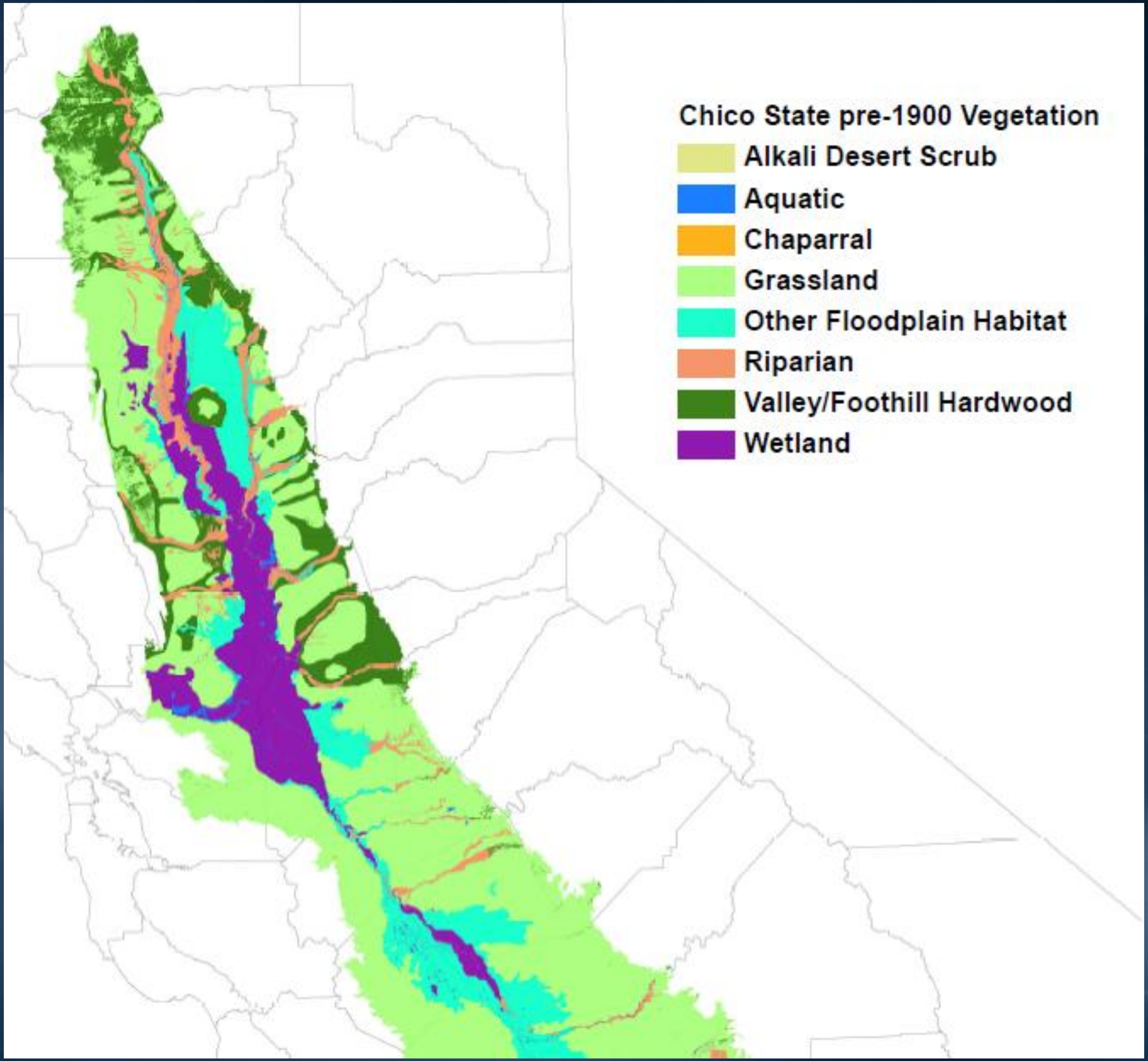
- **Rim Inflow = Long Term (1922-2010) Average Unimpaired Inflow**
- **Precipitation = Long Term (1922-2008) Average**

Water Use = $\sum$ ET * A

- **ET = evapotranspiration for vegetation type**
- **A = area of vegetation type**

Natural Delta Outflow Estimate (cont'd)

- Vegetation
  - CSU Chico Pre-1900 Map (2003)
  - Independent GIS Confirmation
- Evapotranspiration
  - Range of ET Values to Bound Uncertainty
  - Two Estimation Methods
    - Literature Review of Field Experiments
    - Climate-Based Assessment Calculations


Chico State pre-1900 Vegetation
Alkali Desert Scrub
Aquatic
Chaparral
Grassland
Other Floodplain Habitat
Riparian
Valley/Foothill Hardwood
Wetland

Natural Delta Outflow Estimate (cont'd)

- Vegetation
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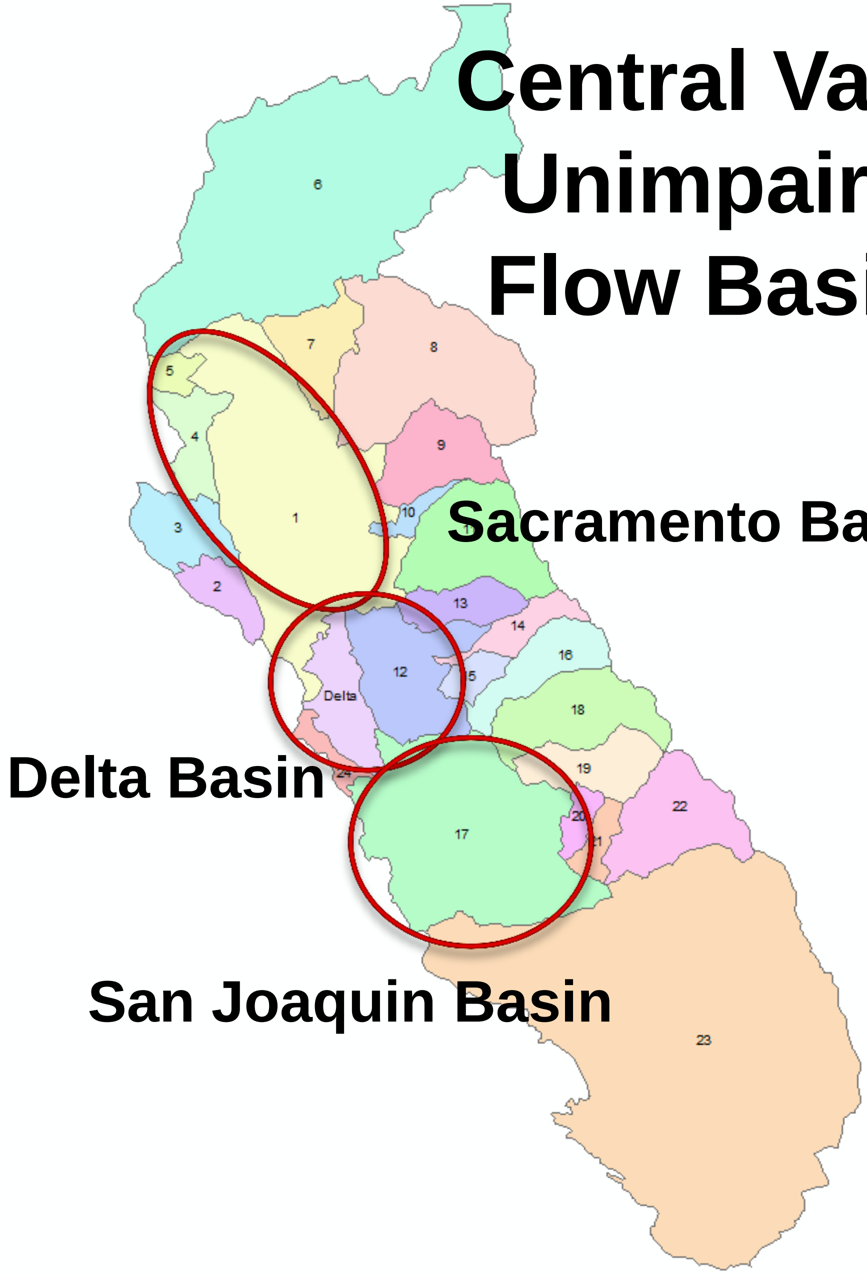
Comparison of ET Estimation Methods

Vegetation	Et_c Range (ft/yr)	
	Field	Climate-Based
Grassland	0.8-2.9	0.8-1.4
Riparian	4.2-9.5	4.2-6.4
Valley / Foothill Hardwood	0.9-4.0	2.0-3.8
Wetland	5.1-13.0	5.1-6.5

Central Valley Unimpaired Flow Basins



Natural Water Use Estimate

Sacramento Basin

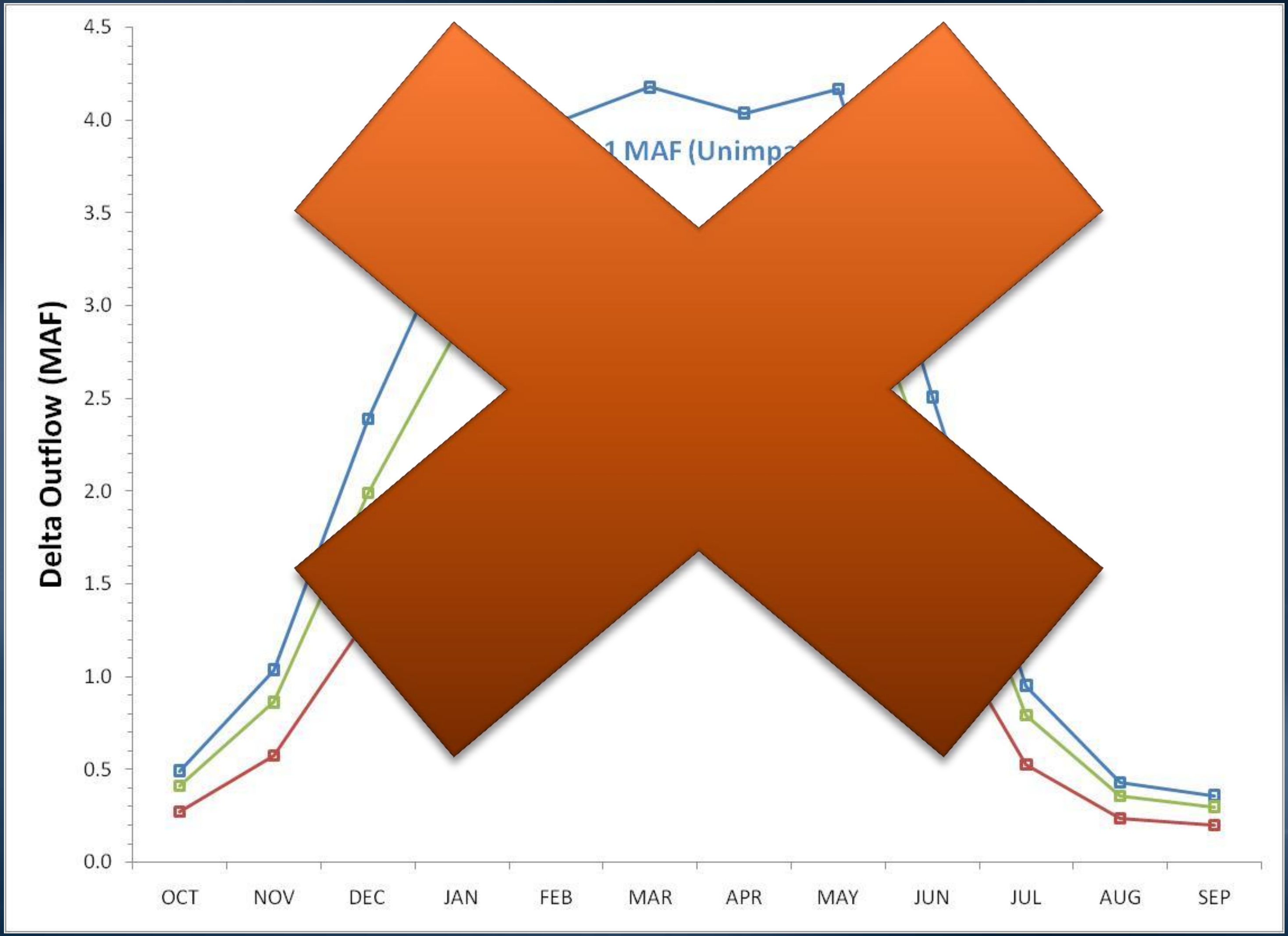
Vegetation	Et_c (ft/yr)	Area (1000 acres)	Et_c (MAF/yr)
Aquatic	4.4-4.8	33	0.15-0.16
Grassland	0.8-1.4	1591	1.27-2.23
Other Flood Plain Habitat	3.5-5.6	475	1.66-2.66
Riparian	4.2-5.8	444	1.86-2.58
Valley/Foothill Hardwood	2.0-3.7	640	1.28-2.37
Wetland	5.1-6.0	530	2.70-3.18
Total	---	3713	8.85-13.18

Natural Delta Outflow Estimate

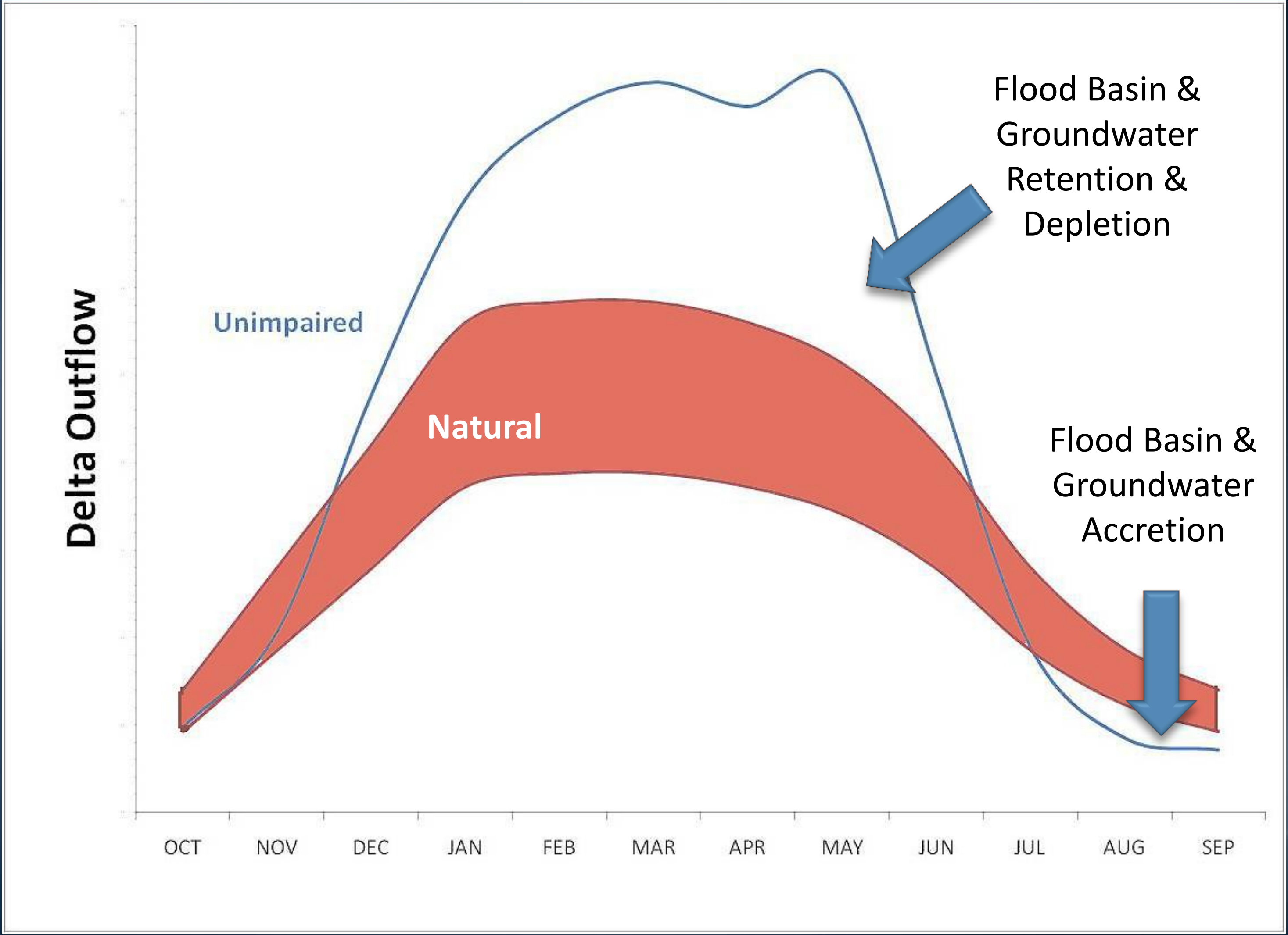
Long-Term Annual Average (MAF/yr)

	Annual Water Volume	
	Low Water Use	High Water Use
WATER SUPPLY		
Unimpaired Rim Inflow	29.2	29.2
Valley Floor Precipitation	11.2	11.2
Total Water Supply	40.4	40.4
WATER USE		
Sacramento Basin	8.9	13.2
Delta Basin	3.6	5.2
San Joaquin Basin	4.6	6.5
Total Water Use	17.1	24.9
DELTA OUTFLOW	**23.3**	**15.5**

Natural Flow Pattern Not Represented by Unimpaired Flow Pattern

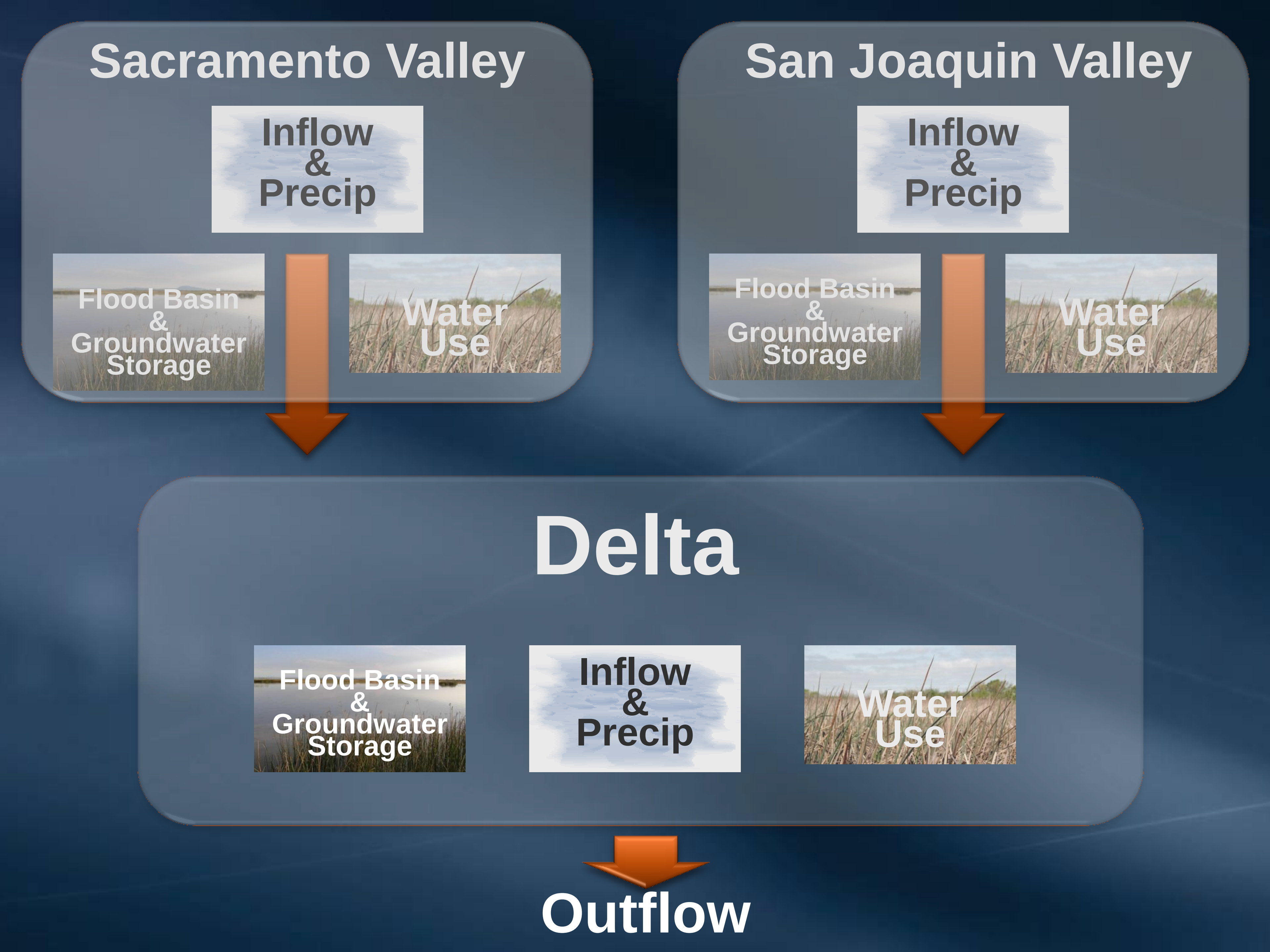


Natural Flow Pattern Differs From Unimpaired Flow Pattern

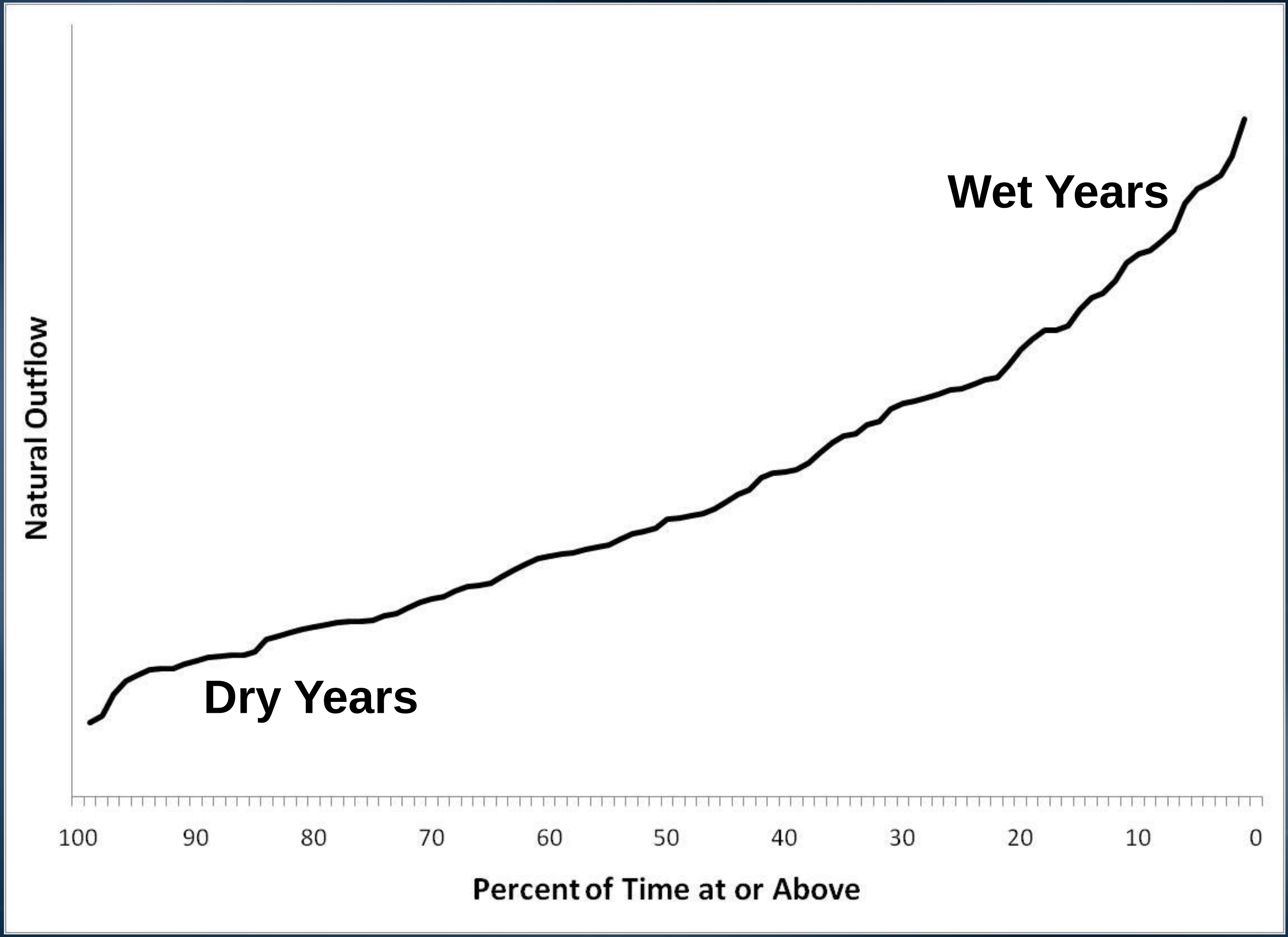


A Model to Estimate Natural Delta Outflow

- Purpose
- Annual Model
- **Monthly Model**
- Next Steps


Sacramento Valley
Inflow & Precip
Flood Basin & Groundwater Storage
Water Use
San Joaquin Valley
Inflow & Precip
Flood Basin & Groundwater Storage
Water Use
Delta
Flood Basin & Groundwater Storage
Inflow & Precip
Water Use
Outflow

Monthly Model Will Estimate Natural Outflow Inter- and Intra-Annual Variability



A Model to Estimate Natural Delta Outflow

Purpose

Annual Model

Monthly Model

Next Steps

Next Steps

- Complete Monthly Modeling Effort
- Refine Natural Hydrology
  - Natural Vegetation ET Estimates
  - Groundwater-Surface Water Interactions
- Simulate Delta Hydrodynamics and Salinity Transport Under Natural Conditions
  - Landscape
  - Channel Configuration

Next up:

Dr. David Sunding, U.C. Berkeley

Modeling the Economic Impact of Changes in Delta Water Supplies

The Brattle Group

Modeling the Economic Impact of Changes in Delta Water Supplies

Presented by:
David Sunding

November 7, 2012

Economic Impacts

Changes in Delta water supplies can have significant economic consequences

Types of impacts:

- Commercial & industrial water shortages can lead to lost profits and jobs
- Agricultural water shortages affect land use, farm profits, employment, and can have regional economic consequences
- Increased groundwater extraction
- Increased expenditures on urban water supply alternatives
- Mandatory conservation in the residential sector leads to quality of life impacts

Least - Cost Planning Simulation Model (LCPSIM)

LCPSIM is developed by DWR and CH2MHill to measure the economic impacts of urban water supply losses

Optimization model based on historic hydrology

- Determines optimal investment portfolio by balancing costs and benefits
  1. Cost of reliability-enhancing investments
  2. Benefit from reduced shortages

Analysis

- Regional analysis: South Coast and South SF Bay Area
- One year of forecasted demand (year 2020)
- One hydrologic run (1922 – 2003)

Supply - Demand Balance Simulation Model

SDBSIM is jointly developed by State Water Contractors and MWD with assistance from The Brattle Group

- Currently being used to assess benefits of BDCP

Probabilistic water portfolio simulation model

- Apportions and values shortages based on a given water supply portfolio and variable Delta supplies

Analysis Parameters

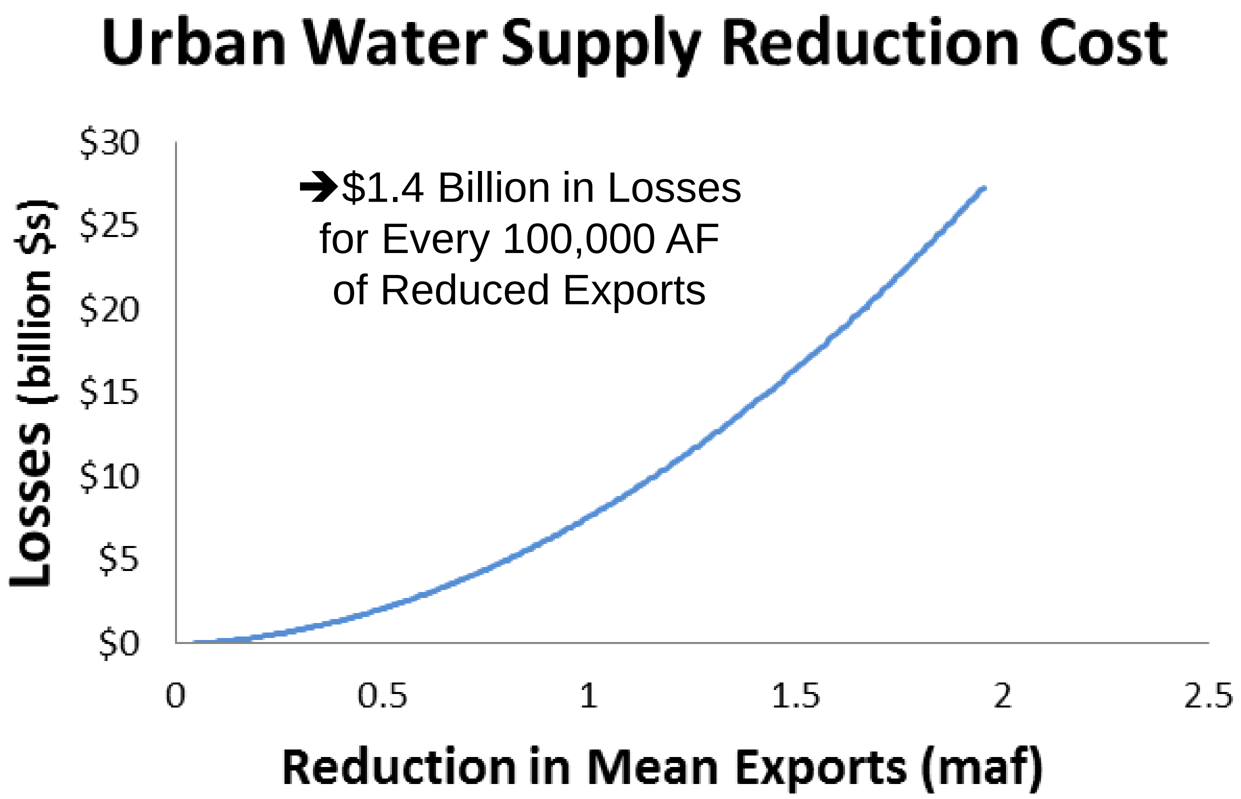
- Agency-level analysis: 36 distinct water agencies
- Trajectory of forecasted demand (2012 – 2050)
- Monte Carlo simulation of 83 hydrologic runs (1922 – 2004)
- Evaluates losses by sector within each agency

Comparison of SDBSIM to LCPSIM

SDBSIM has numerous advantages compared to LCPSIM

- Pairs trajectory of demand forecasts w/ hydrologic sequence
  - Captures storage supply evolution
- Based on econometrically estimated demand forecasts and demand elasticities
  - Consistent with historical experience
  - Allows for construction of standard errors around impact estimates and formal hypothesis testing
- Rotates through 83 trials
  - Probabilistic simulation of impacts
- Agency-level vs. regional-level analysis
  - Demand elasticities and rates vary widely across agencies
- Includes commercial & industrial and MFR sectors

Costs to Urban Sector vs. Reduction in Delta Exports



Statewide Agricultural Production (SWAP)

Developed and maintained by researchers at UC Davis

Positive mathematical programming model

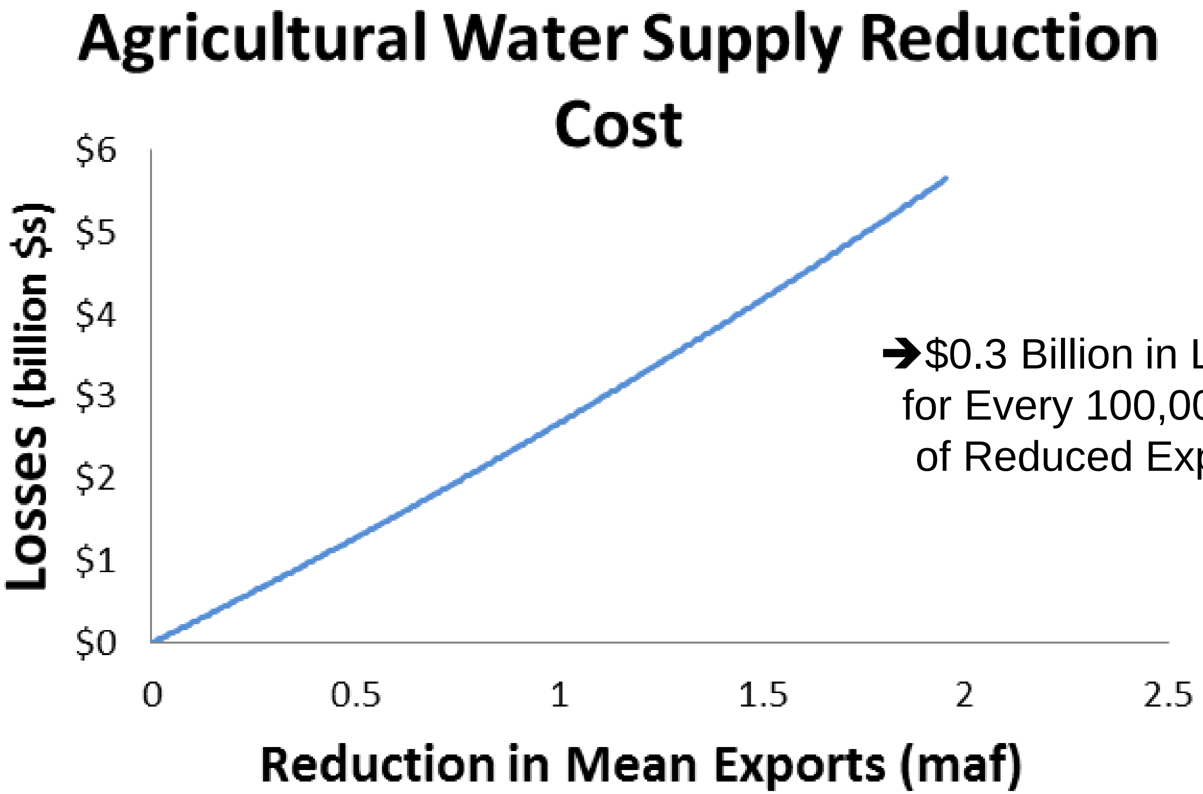
- Large-scale analysis of agricultural water supply and cost changes

Simulates the profit-maximizing decisions of agricultural producers given inputs:

  - Availability and cost of water
  - Land
  - Labor
  - Other

Accounts for SWP & CVP water, other local supplies, and groundwater

Costs to Ag Sector vs. Reduction in Delta Exports



➔$0.3 Billion in Losses for Every 100,000 AF of Reduced Exports

Concerns About SWAP

Built on many relatively untested assumptions

Validity of the underlying data

Calibration procedures used to fit the model to the data

Unrealistic assumptions about groundwater

SWAP may significantly underestimate the impacts of changing surface water supplies to agriculture

Recommendations for SWAP

Conduct a systematic peer review focusing on underlying assumptions and calibration procedures

Develop an econometric model of the agricultural sector in the San Joaquin Valley using remote sensing data and other sources

Test predictions of SWAP against actual changes in land allocation and employment

Incorporate a more realistic treatment of groundwater

Reconfigure the SWAP regions to better reflect variations in water rights, project service areas, and groundwater conditions