Incorporating Climate Change into the California Water Plan Scenario Analysis

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California Water Plan Update 2009 CTAG Meeting

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Outline

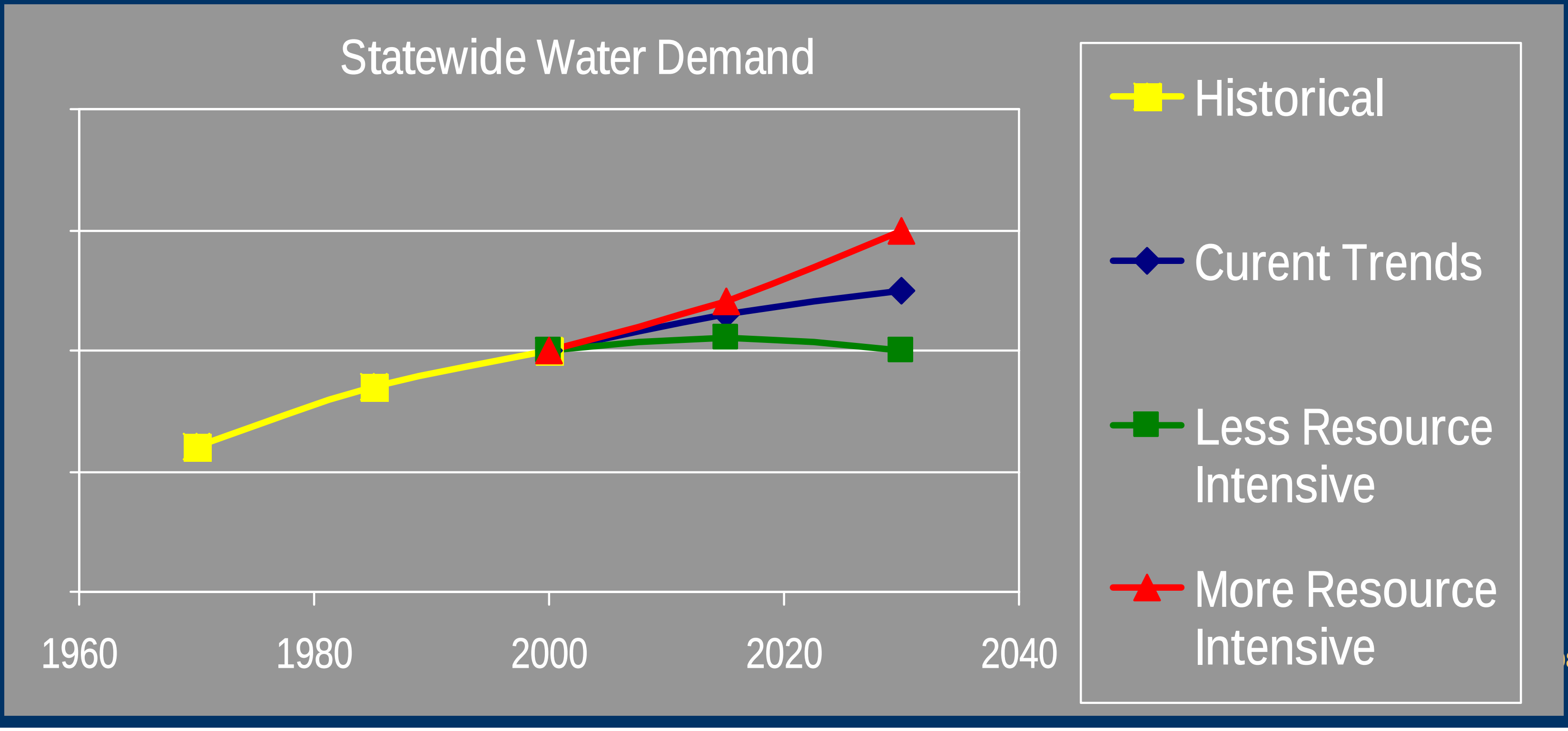
- **Scenario framework for Water Plan Update 2009**
- **Overview of the Water Evaluation And Planning (WEAP) modeling framework**
- **Implementing climate change into the WEAP analysis**

CWP Update 2005
Developed Hand-Crafted Scenarios

- **Identified key drivers**
  - **"Table 1"**
- **Focused on key parameters**
  - **Water demand only**
- **Defined three storylines based on alternative assumptions for key drivers**
  - **"Current trends"**
  - **"Less resource intensive"**
  - **"More resource intensive"**

…and Then Quantified Them

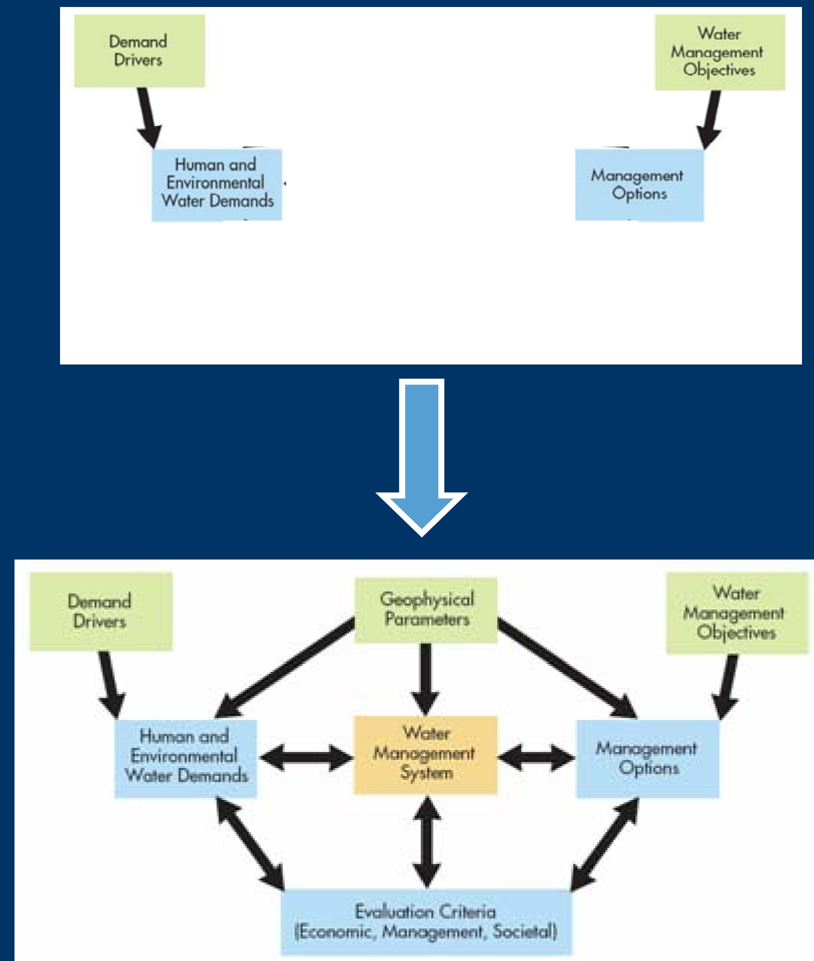
- Used a simple model of water demand by Hydrologic Region
- Defined parameter values consistent with narratives
- Evaluated model for each scenario



CWP Update 2009 Will Build On This Analysis

- Expand scenarios to consider
  - water supply
  - climate change
  - water quality
  - flood issues

- Evaluate response packages against scenarios
  - Increased efficiency
  - Wastewater reuse
  - Additional surface storage
  - Desalination
  - Others



CWP 2009 Update Scenario Analysis Will Have Four Key Components

Key Uncertainties (X)	
Uncertain factors outside of the control of water managers — Basis for “Scenarios”	

Scenario Framework based on RAND Corporation analysis

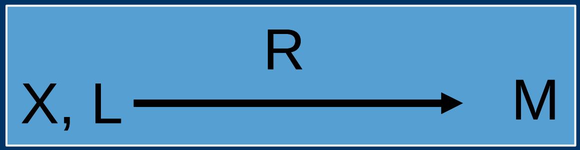
CWP 2009 Update Scenario Analysis Will Have Four Key Components

Key Uncertainties (X)	Management Levers (L)
Uncertain factors outside of the control of water managers — Basis for "Scenarios"	Water management options — "Response Packages"

CWP 2009 Update Scenario Analysis Will Have Four Key Components

Key Uncertainties (X)	Management Levers (L)
Uncertain factors outside of the control of water managers — Basis for “Scenarios”	Water management options — “Response Packages”
	Performance Measures (M)
	Water-related outcomes of interest — “Evaluation Criterion”

CWP 2009 Update Scenario Analysis Will Have Four Key Components

Key Uncertainties (X)	Management Levers (L)
Uncertain factors outside of the control of water managers — Basis for “Scenarios”	Water management options — “Response Packages”
Relationships (R)	**Performance Measures (M)**
Model(s) that estimate outcomes (M) for response packages (L) and specific scenarios (X) 	Water-related outcomes of interest — “Evaluation Criterion”

Summary of CWP 2009 Update Scenario Framework

Scenario Factors (X)	Responses (L)
Economic and Financial Institutional and Political Natural System (climate factors) Technological Cultural Practices	Reduce Water Demand Improve Operational Efficiency & Transfers Increase Water Supply Improve Water Quality Practice Resource Stewardship
Models (L)	**Evaluation Criteria (M)**
Water Evaluation And Planning (WEAP) modeling platform	Performance during average conditions and extreme events – Demand – Reliability – Quality – Flood performance

CWP 2009 Update Scenario Analysis

- **Develop two WEAP models**
  - **Sacramento River Hydrologic Region**
  - **San Joaquin Hydrologic Region**
- **Construct large ensemble of quantitative water management scenarios consistent with:**
  - **New 2009 Water Plan narrative scenarios**
  - **CEC climate change scenarios**
- **Evaluate response packages against scenarios at regional level**

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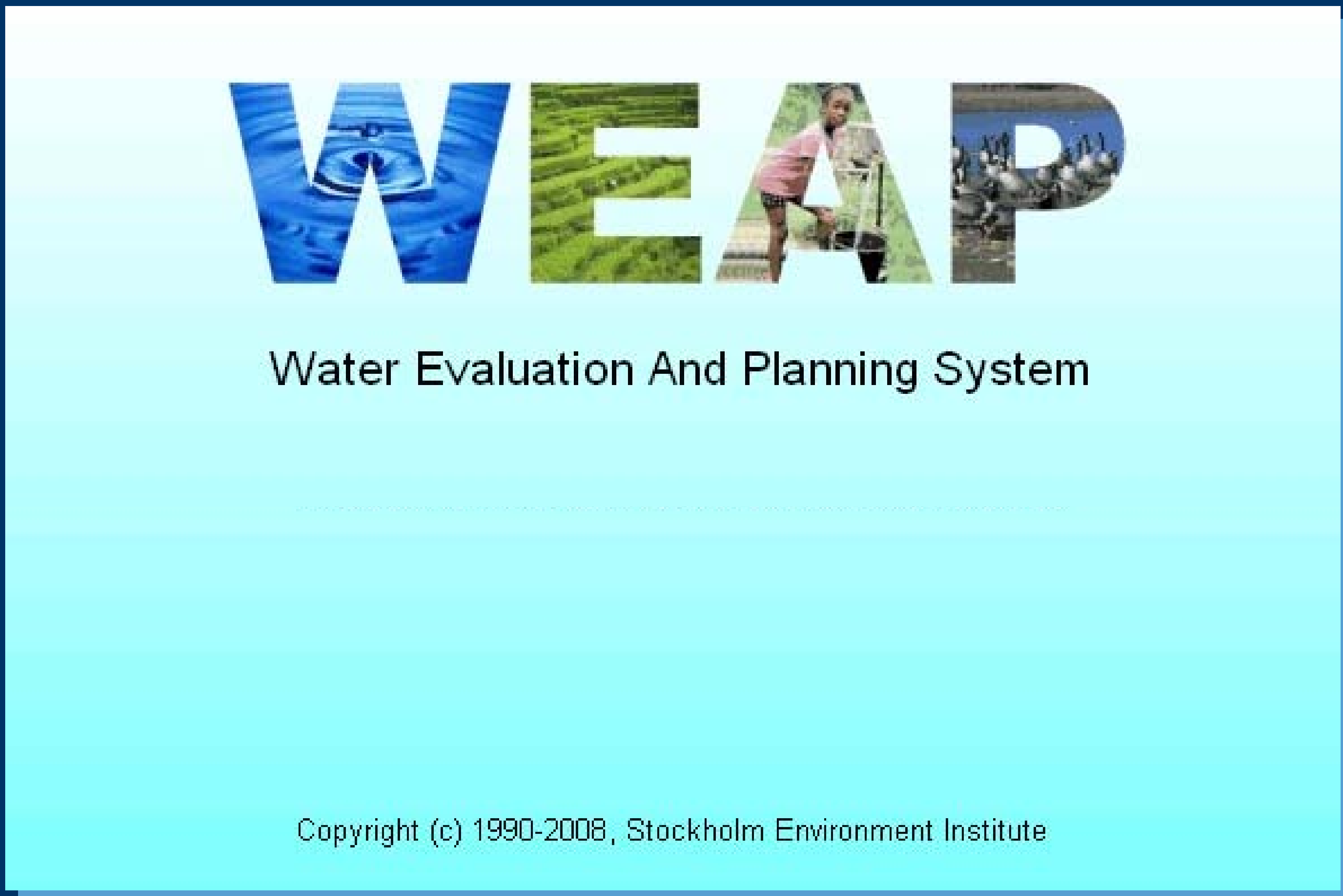
Overview of WEAP



WEAP in Planning

- Provides a common framework and a transparent set of data that can be explored by all stakeholders and decision-makers

- Scenarios can be easily developed to explore options for the future

- Implications of various policies can be evaluated

A New Planning Uncertainty

POLICYFORUM

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1]* Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, waterworks, and floodplains; annual global investment in water infrastructure exceeds U.S.$500 billion (*1*).

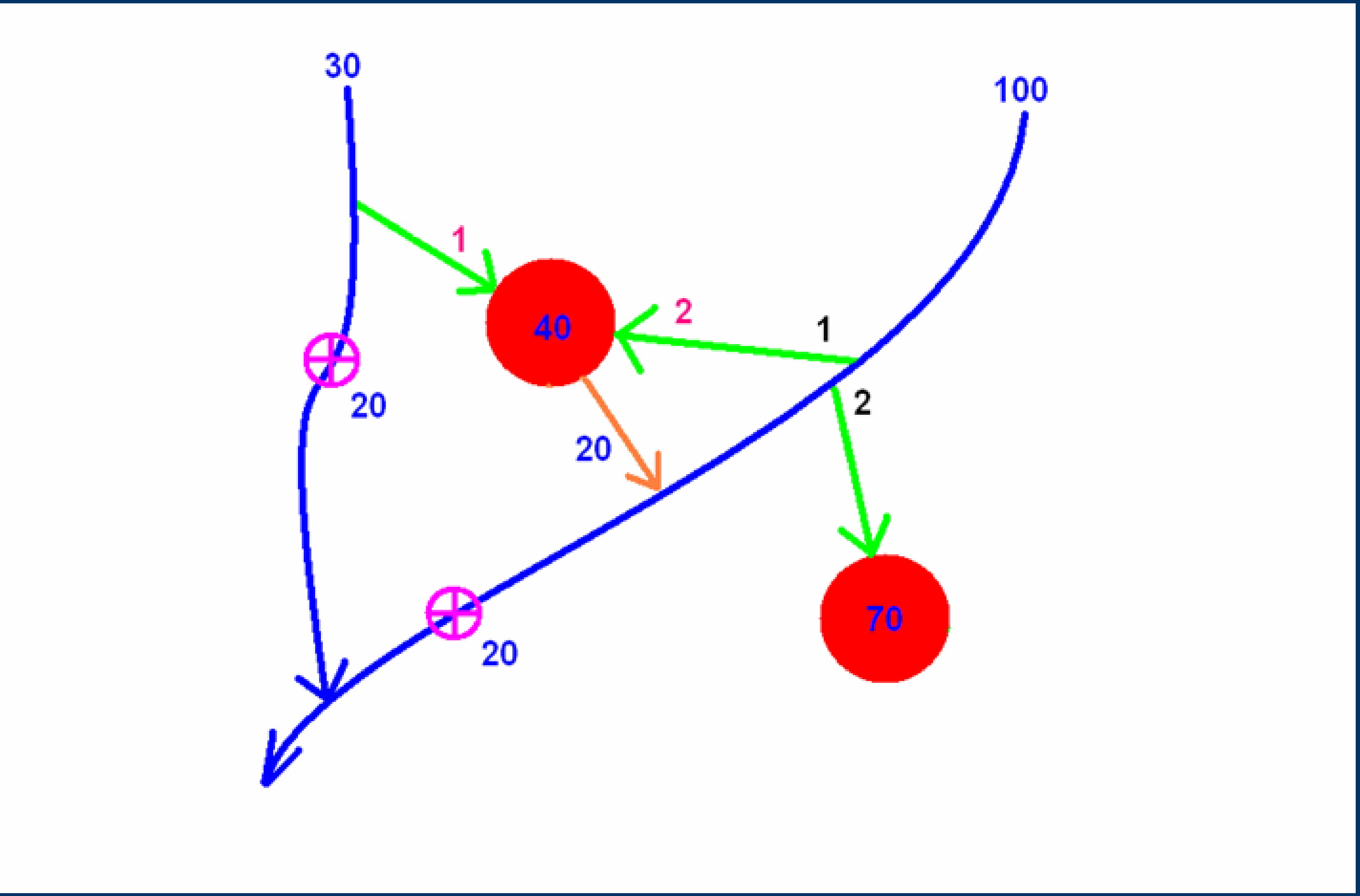
An uncertain future challenges water planners.

In view of the magnitude and ubiquity of the hydroclimatic change apparently now that has emerged from climate models (see figure, p. 574).

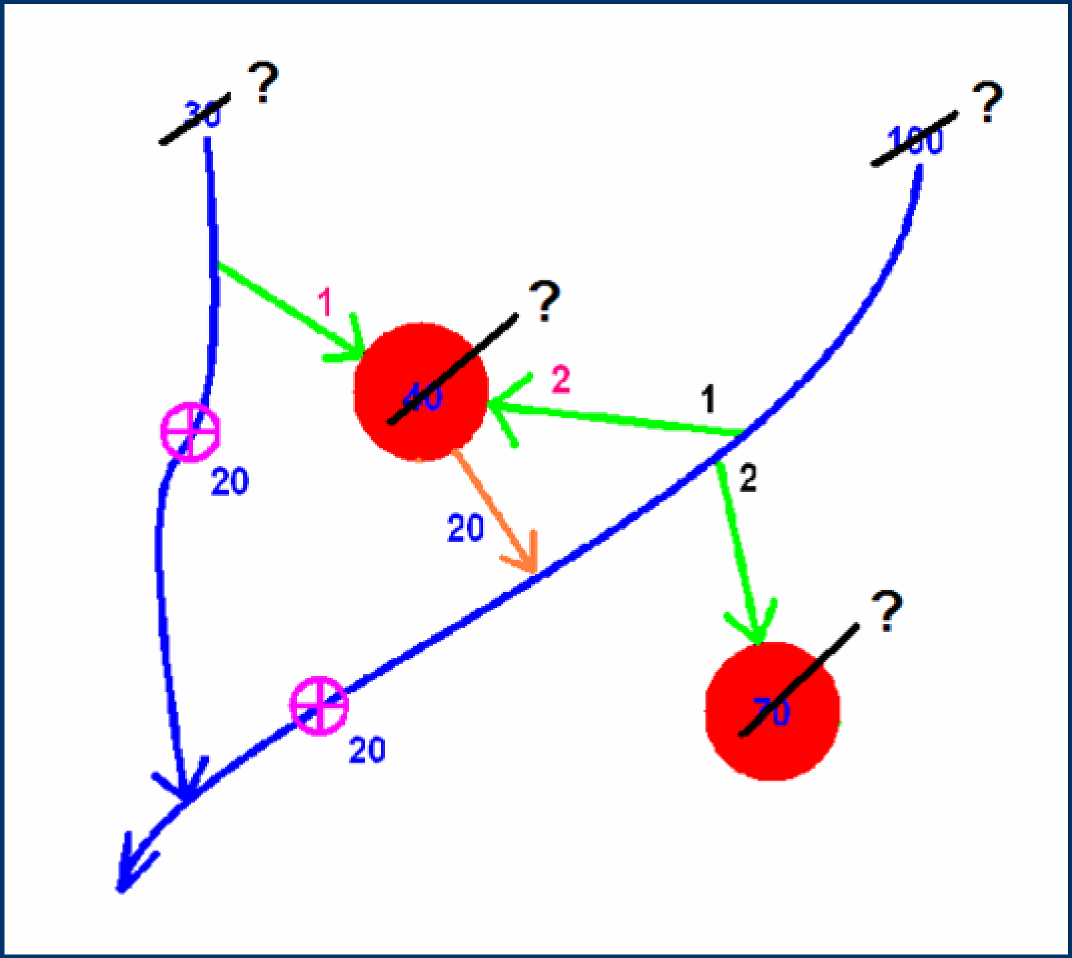
Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short records (*13*) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (*12*, *14*).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of climate models. The global pattern of observed annual streamflow trends is unlikely to have

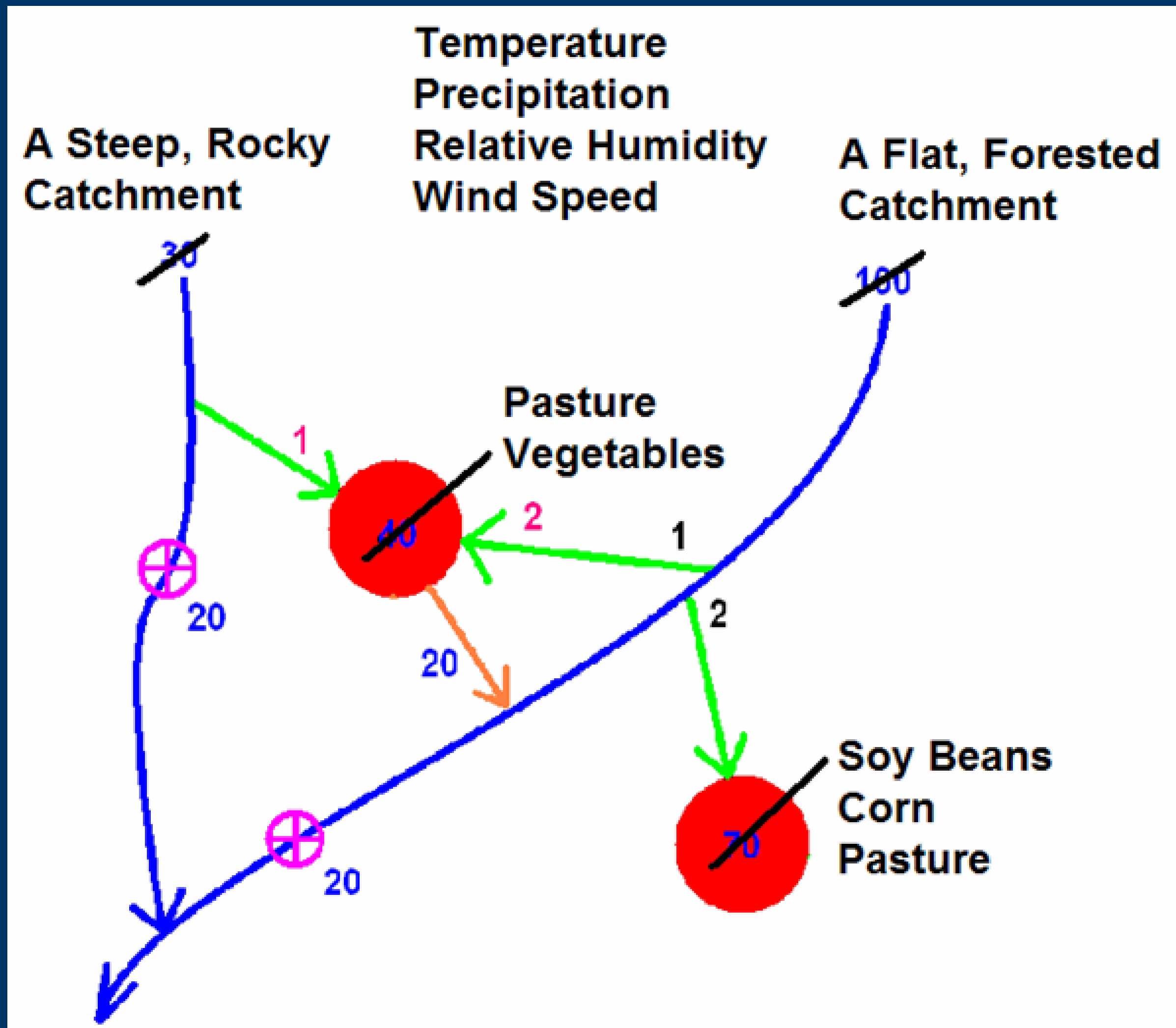
WEAP enhancement to address this uncertainty explained by examining a simple planning model

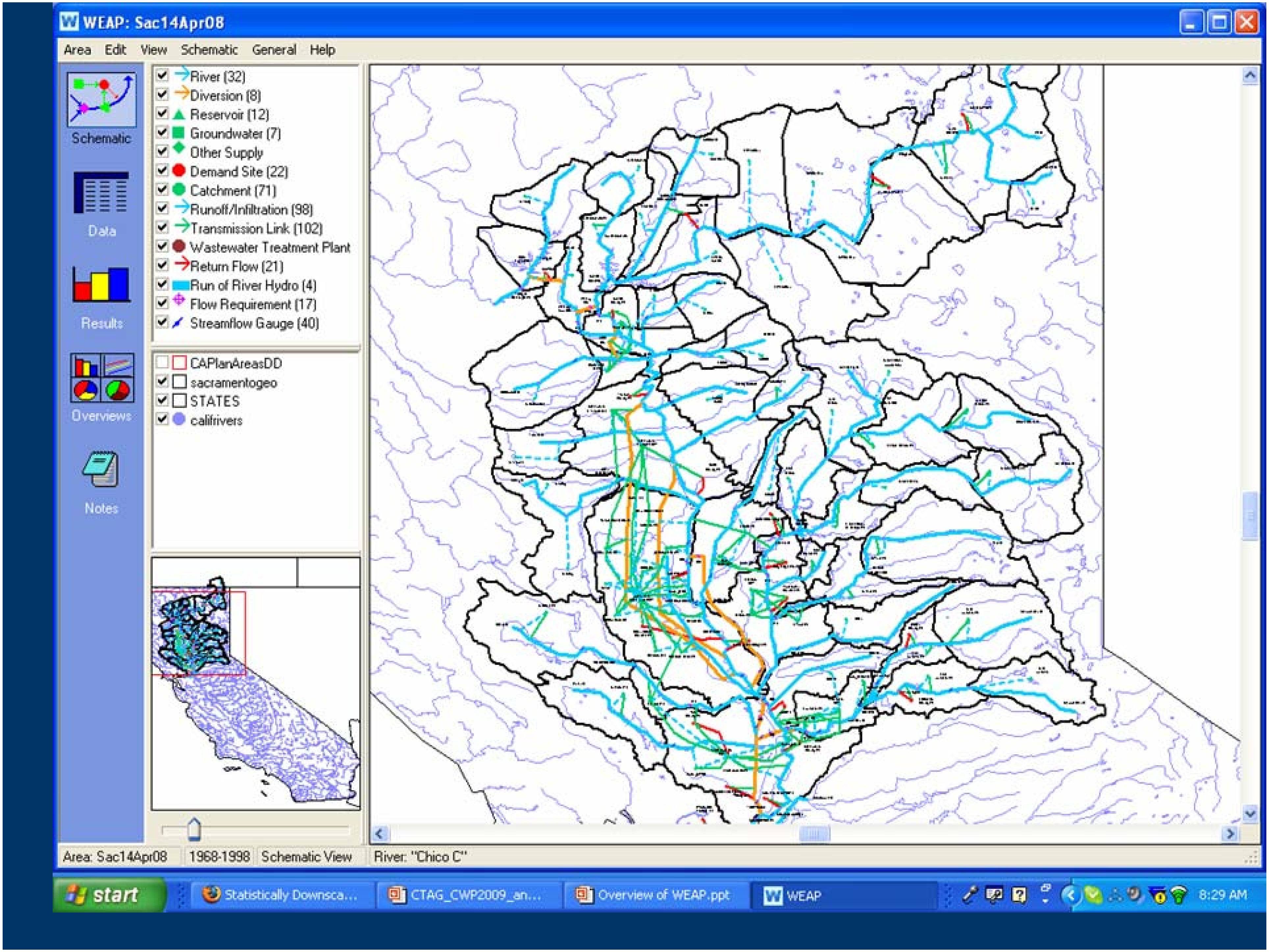


What do we do now?



ADD HYDROLOGY!

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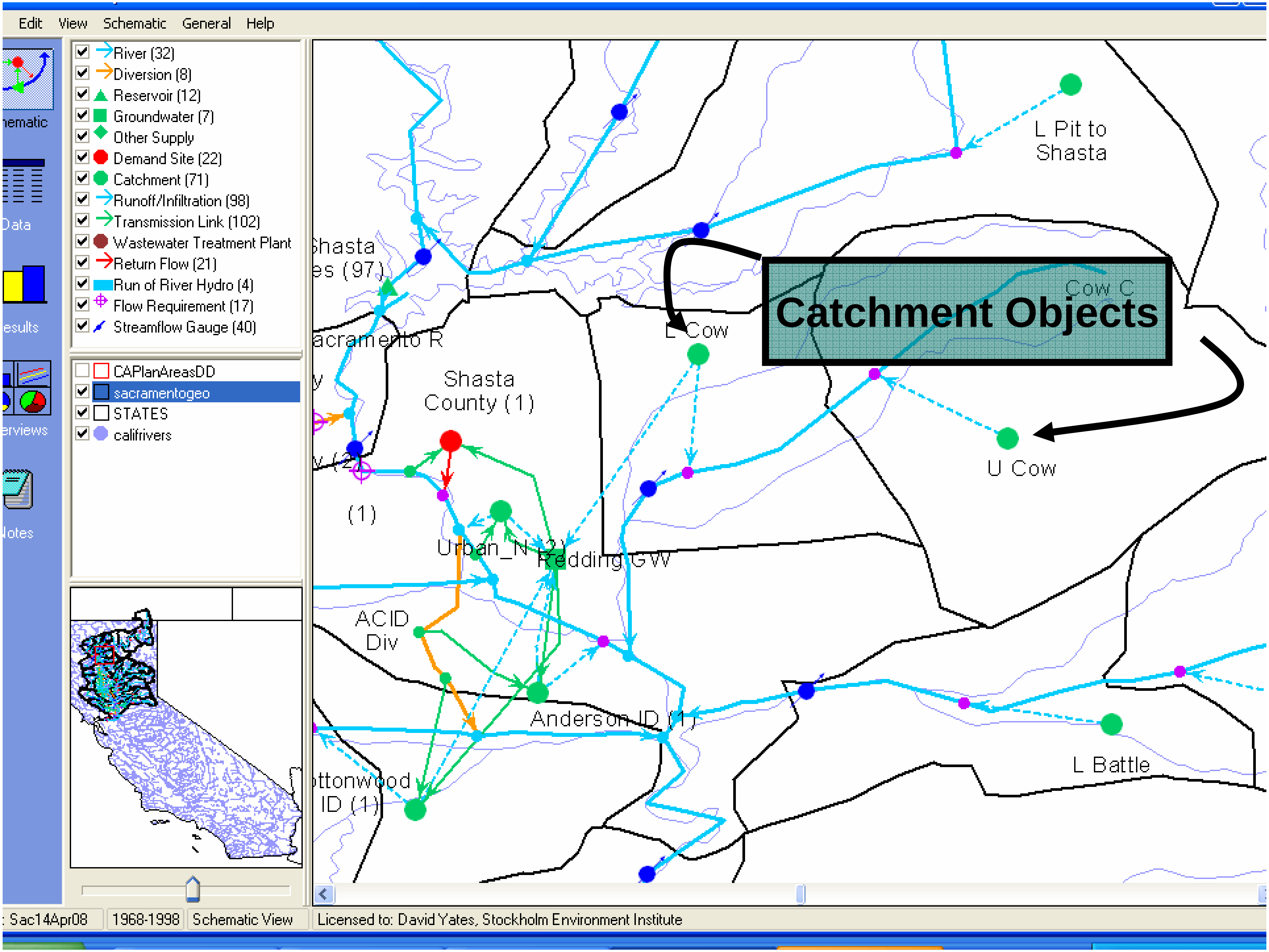

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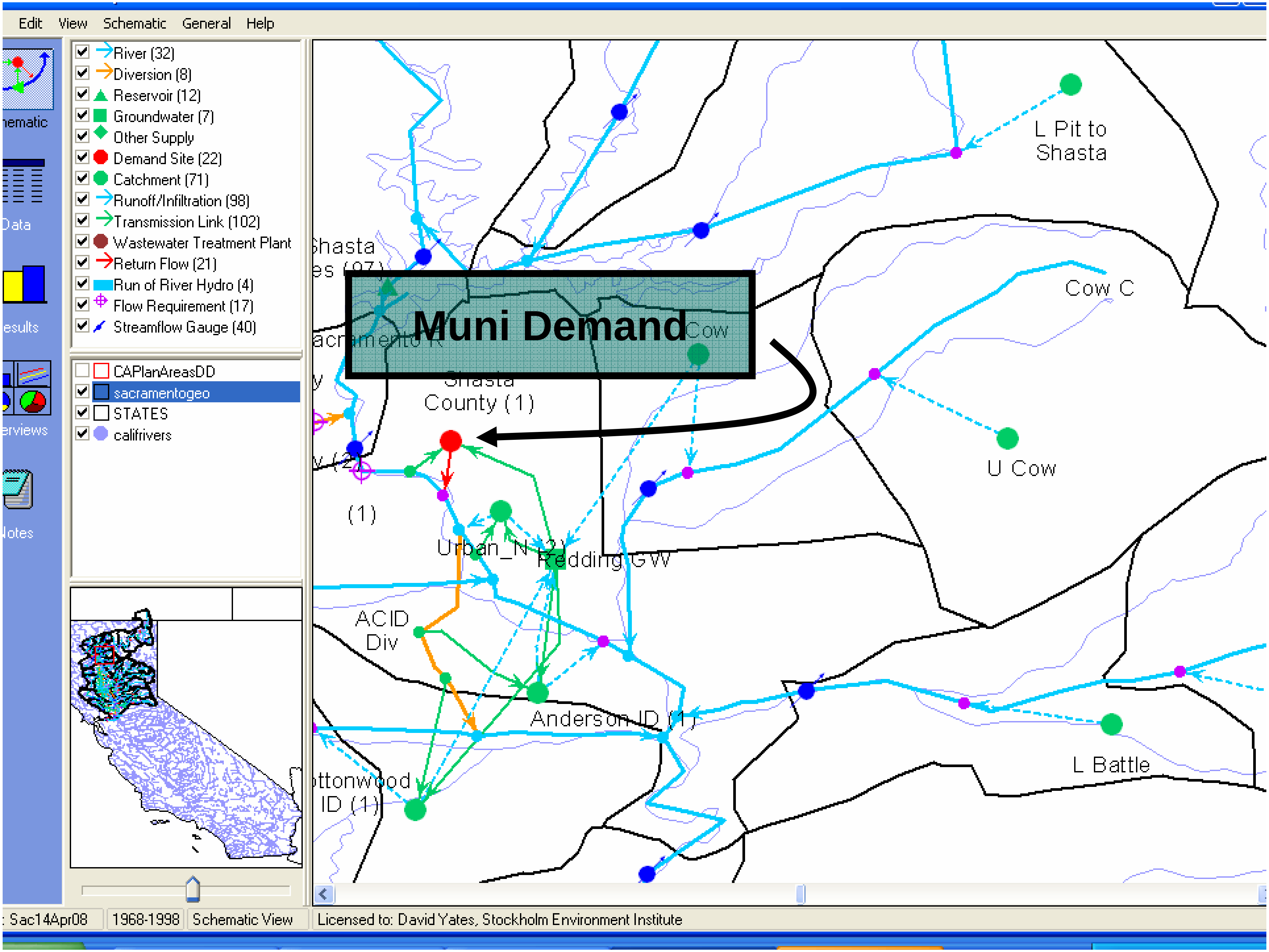

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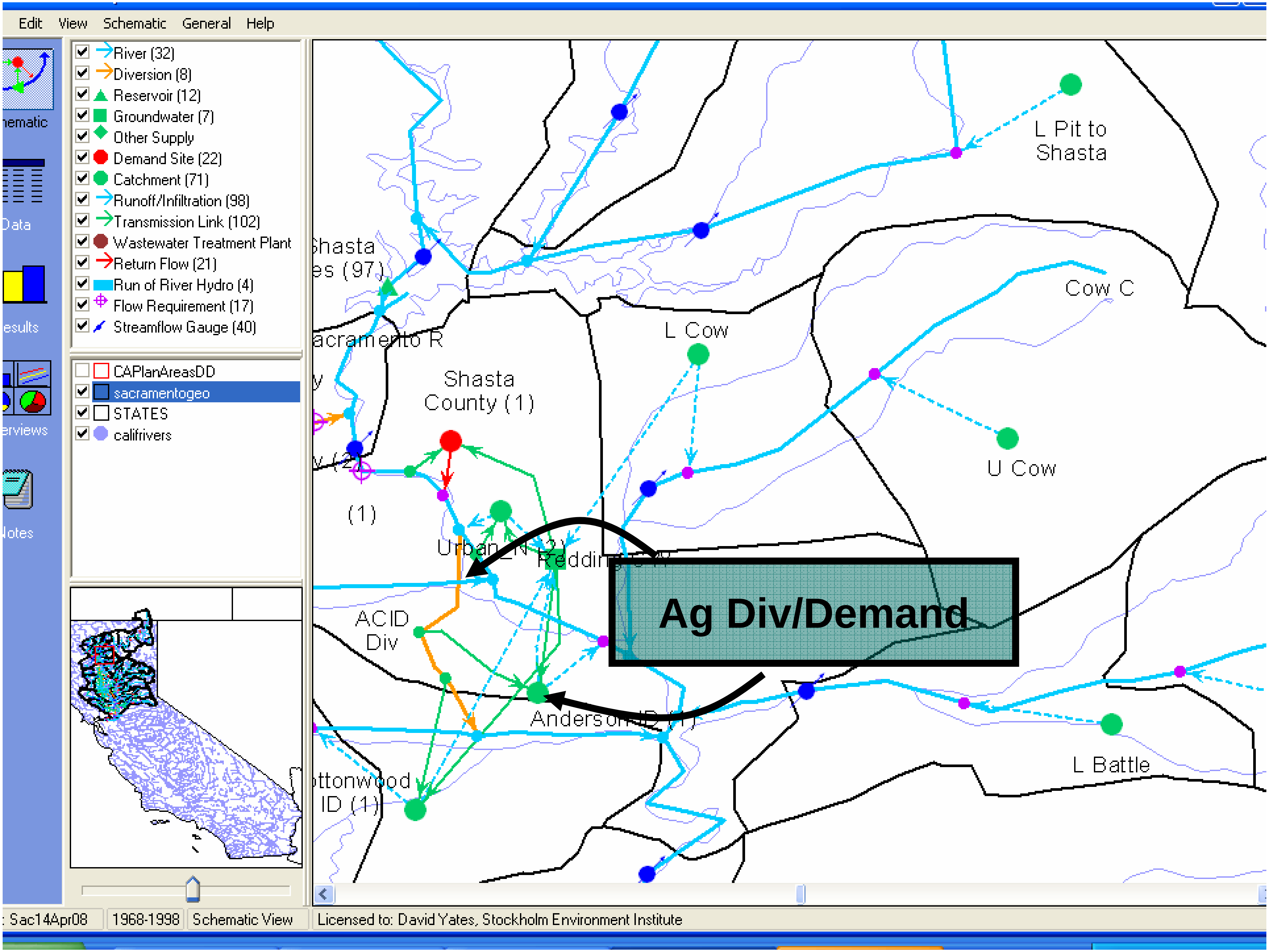

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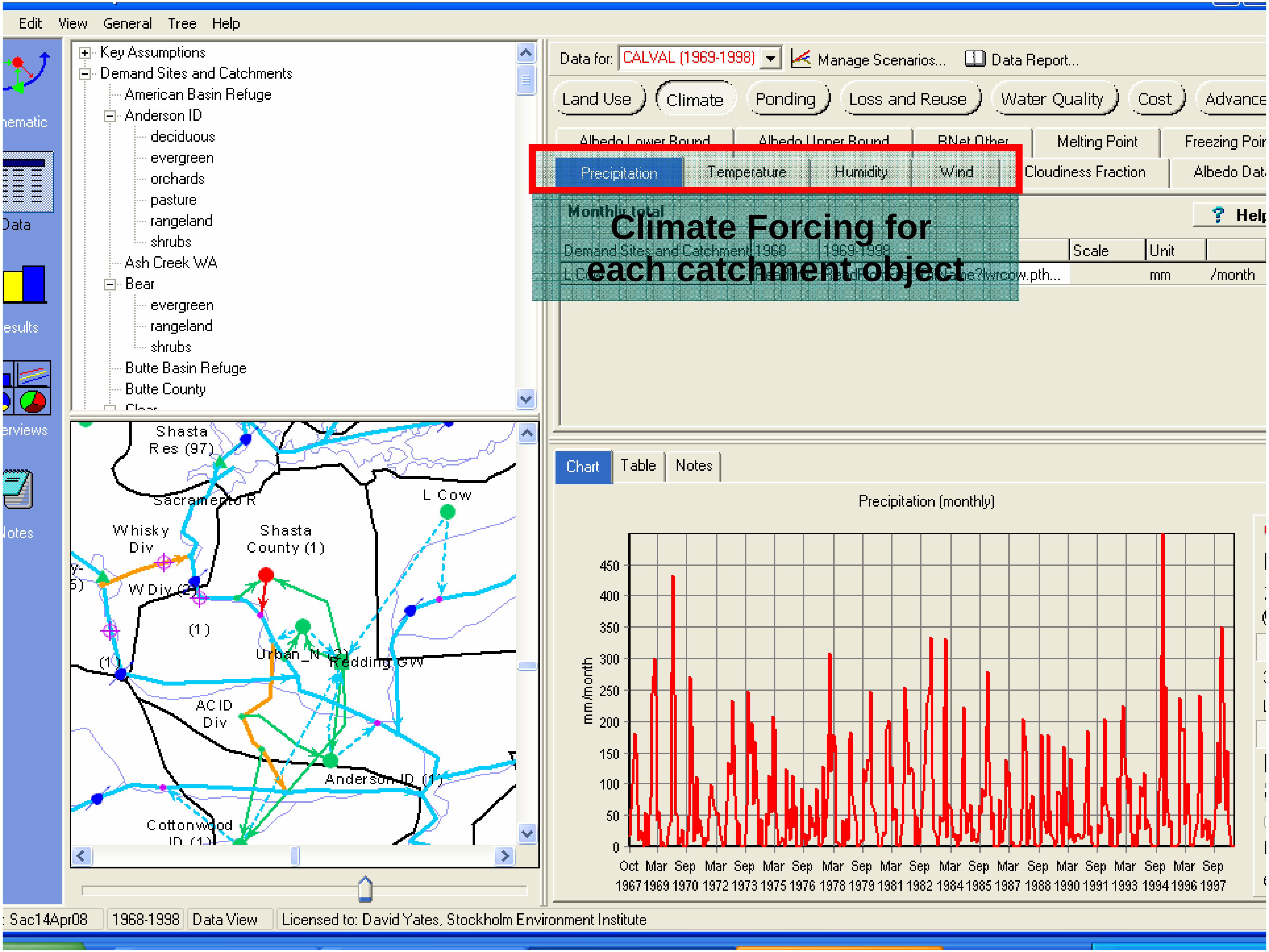
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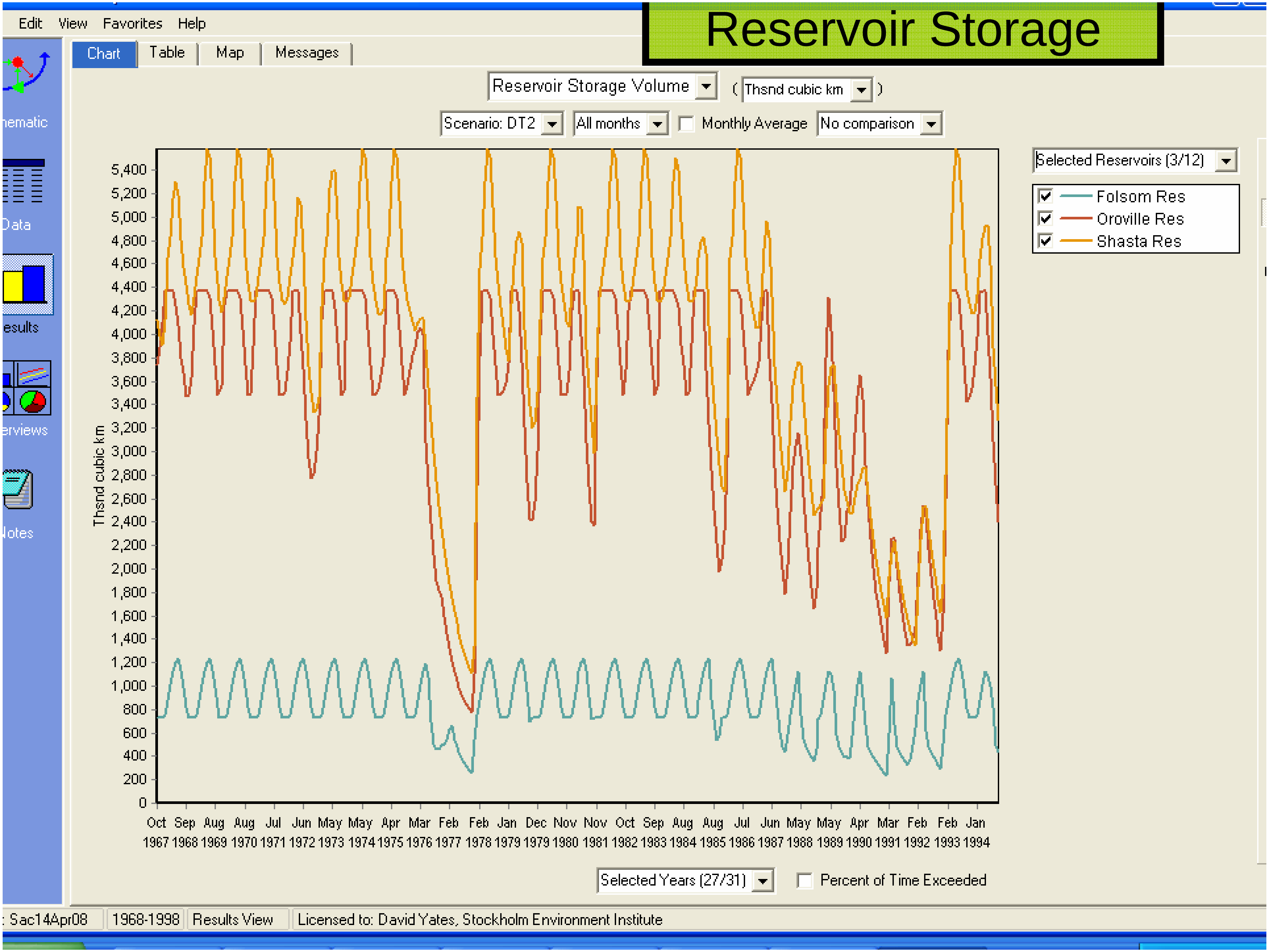
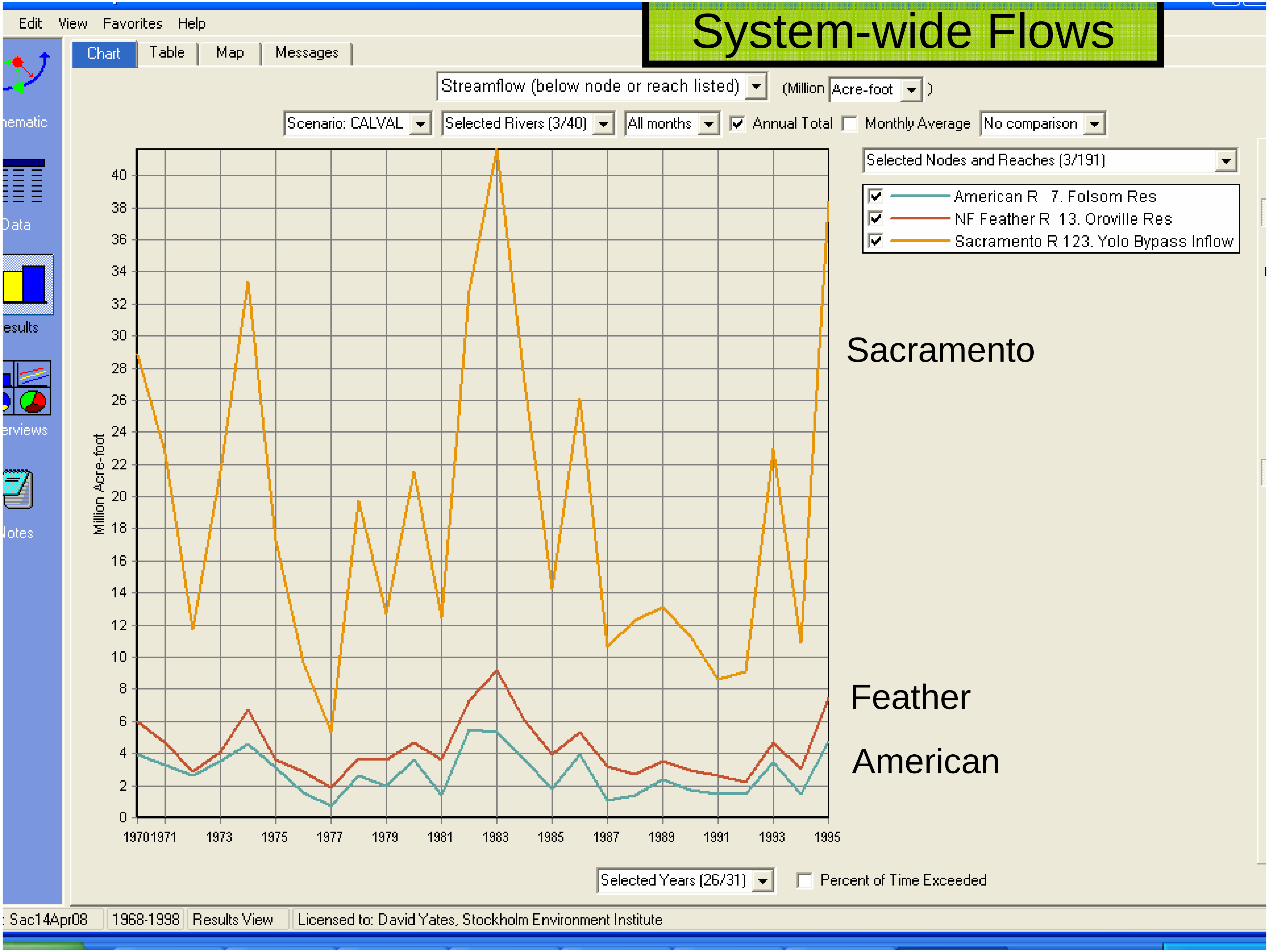
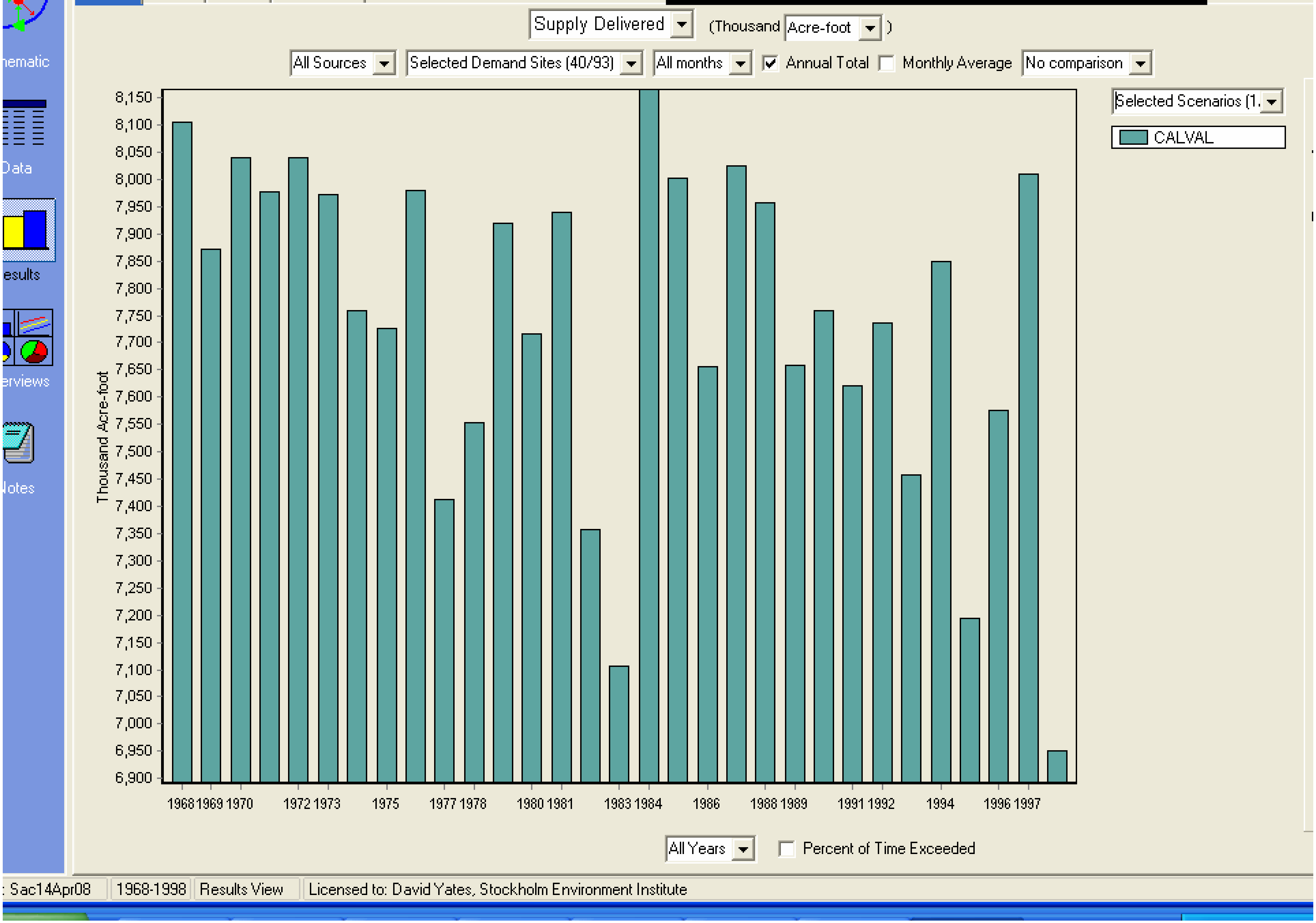
Reservoir Storage



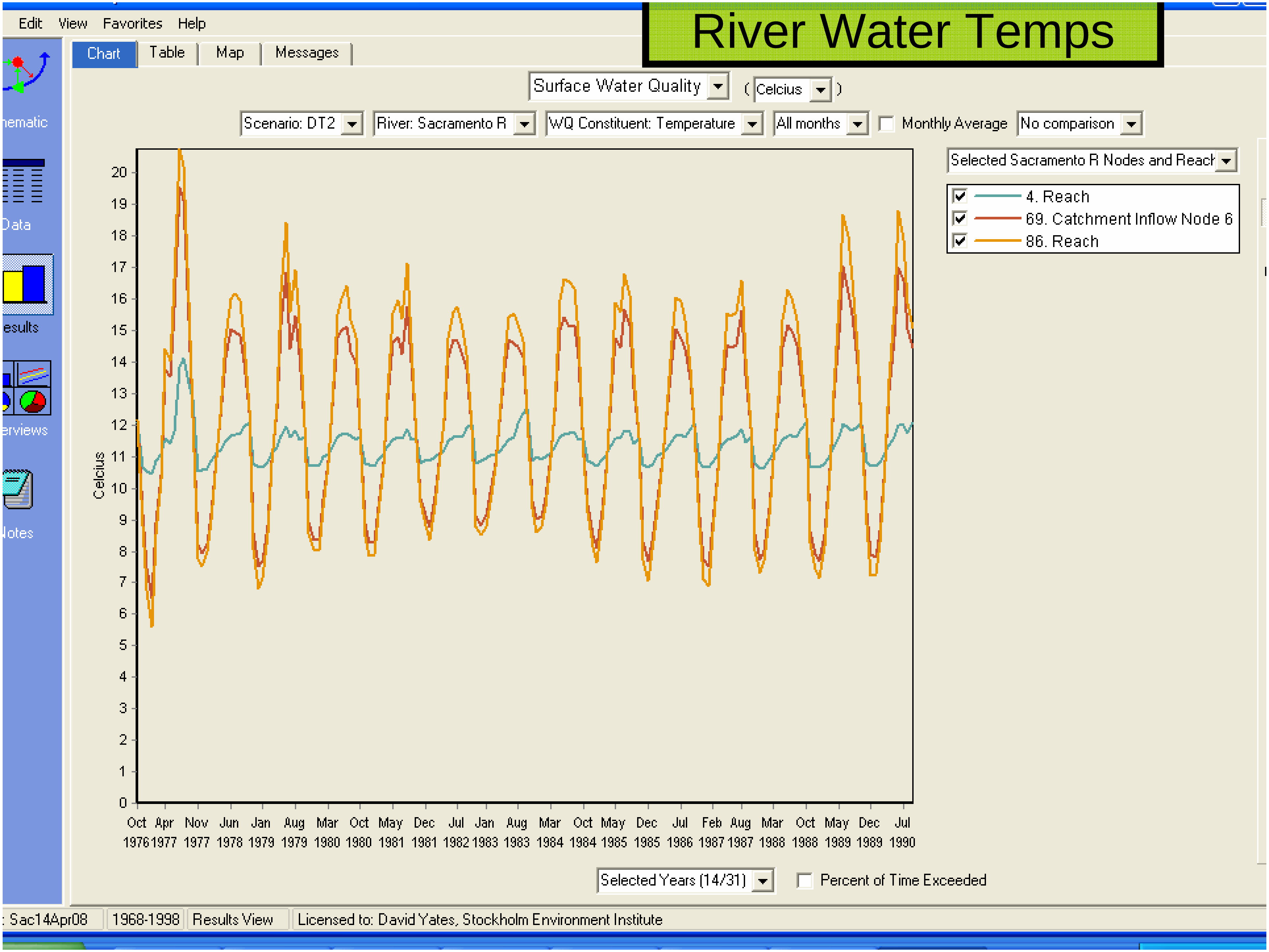
System-wide Flows



Agricultural Deliveries



River Water Temps



Outline

- Scenario framework for Water Plan Update 2009
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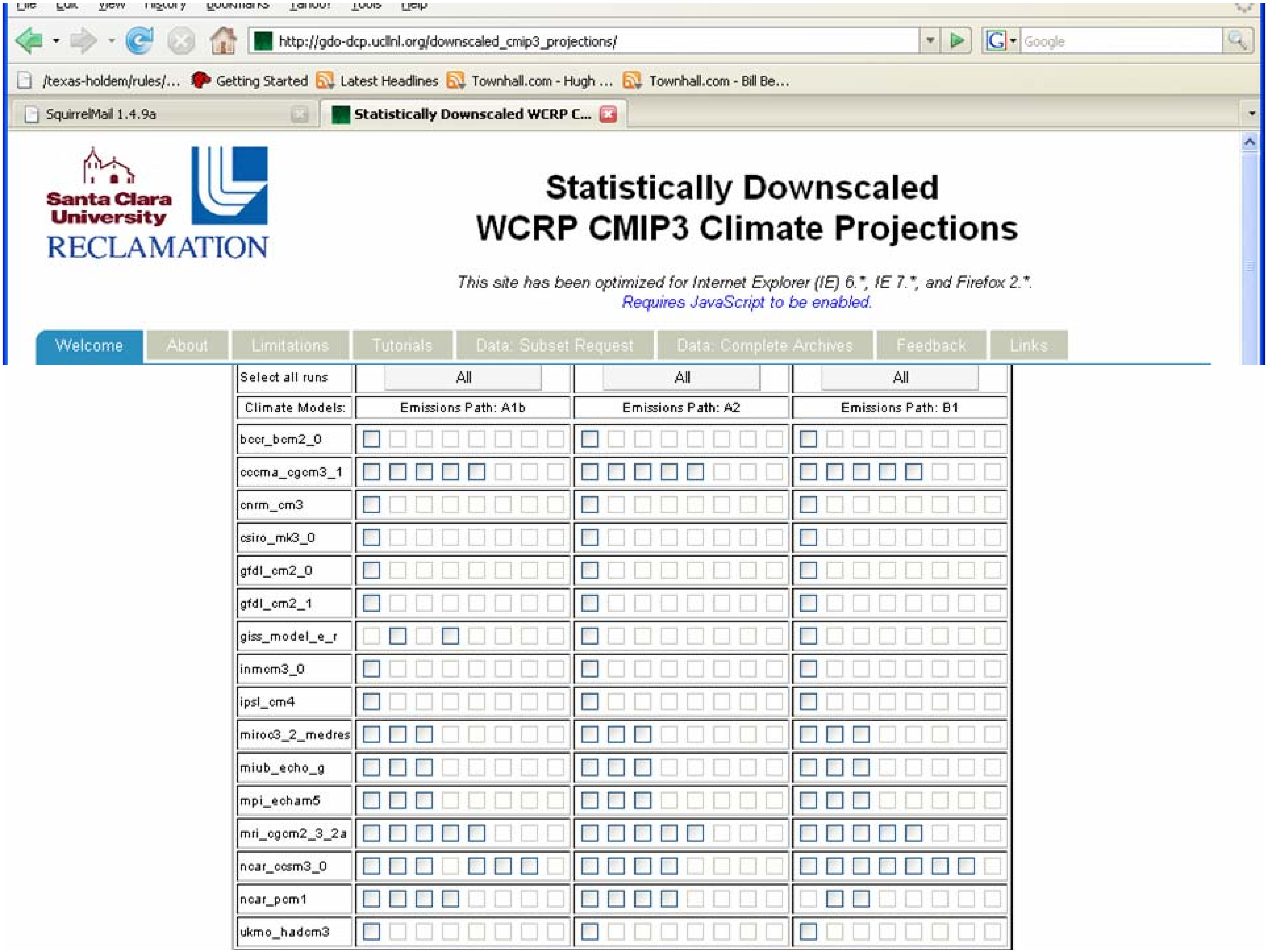
Climate Scenarios

- **What climate scenarios will we use?**
- **Make use of the CEC/Pier/Maurer/LNLN Datasets☺**
- **Which ones to use and would these be the only scenarios?**
- **Would we also do “simple” climate change scenarios? Delta T’s and %P’s.. Or “expert elucidated scenarios” Drought spells w/warming?**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Water Plan Update 2009 Analysis

"Analysis looks to the past and to the future"

Future Uncertainties

- Economic & Financial
- Institutional & Political
- Natural System (including climate change)
- Technological
- Lifestyle & Cultural Practices

Management Responses

- Reduce water demand
- Improve op. efficiency
- Increase water supply
- Improve water quality
- Resource stewardship
- Improve flood management
- Others

Narrative Scenarios
Describe Plausible Futures

Past | Present | Future

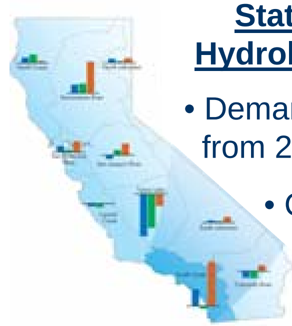
Water Portfolios ***Describe Past Conditions***

- Past water balances by hydrologic region (1998-2005)

?

- How much water was used by each sector?
- What sources were used to meet demand?
- What was the flow of water in and out of region?

Quantitative Scenario Analyses ***Evaluate Response Packages in an Uncertain Future***



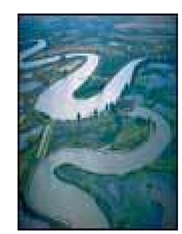
Statewide by Hydrologic Region

- Demand and supplies from 2005 to 2050
- Coarse assessment of response packages

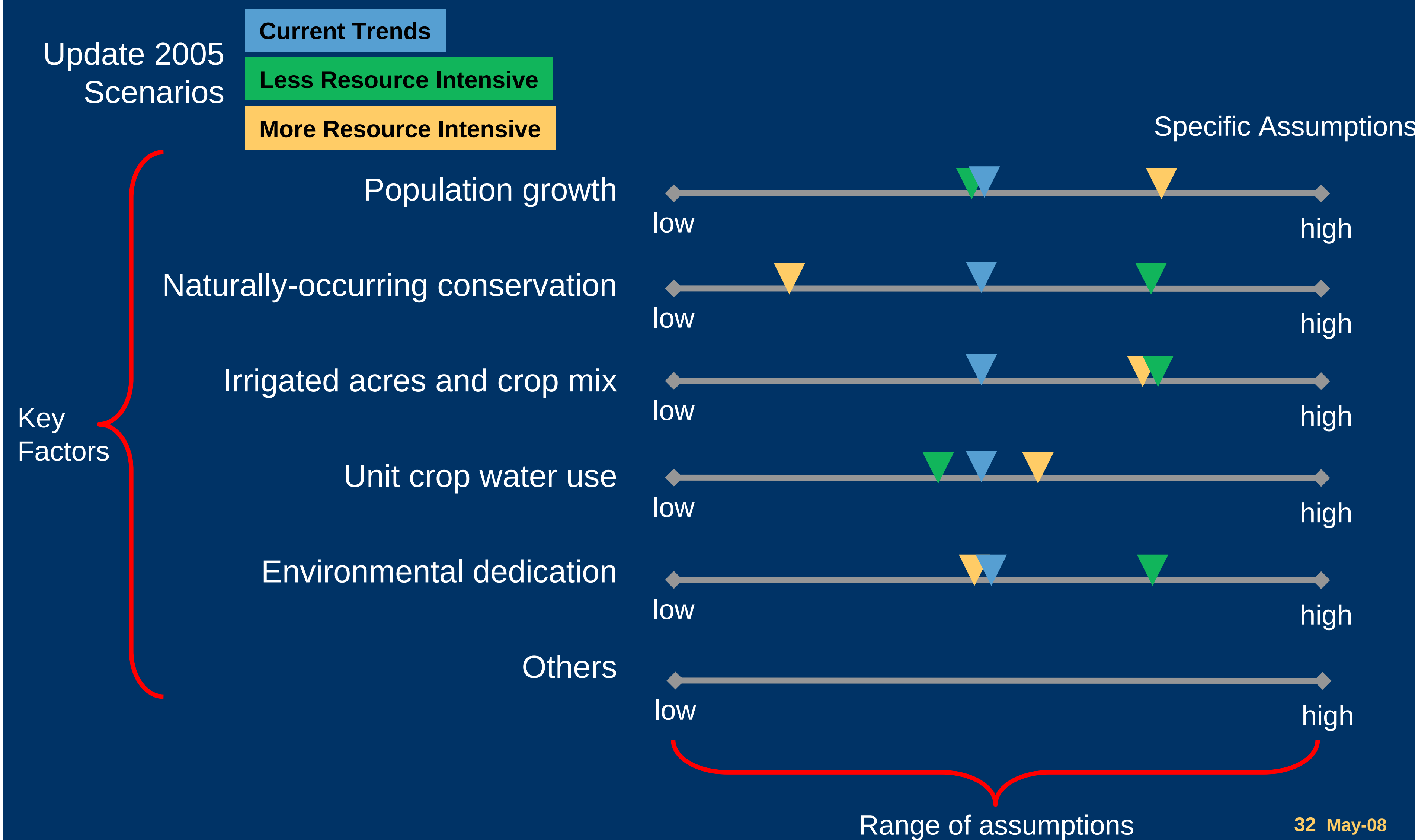
? TBD

Planning Areas for Sacramento and San Joaquin River Regions

- Integrated scenarios reflecting supply, demand, water quality, and flooding issues
- WEAP modeling platform



A Single Scenario is Defined by Assumptions about the Key Factors



Extreme Events Will Be Evaluated For Each Scenario

- **Climate-related trends treated as uncertain factors and form a basis for "scenarios"**
  - **Precipitation and temperature trends**
  - **Trends in frequency of severe storms and droughts**
  - **Mean sea level rise**

- **Performance of the system during specific types of "events" evaluated for each scenario**
  - **Average year**
  - **Single drought year**
  - **Recent historical drought / flood**
  - **Extreme drought / flood**
  - **Severe earthquake or infrastructure interruption**
  - **Others…**

X L
R M

Plenary Meeting in October Added to, Refined, and Augmented the 2005 Response Packages

Reduce Water Demand

- Agricultural Water Use Efficiency
- Urban Water Use Efficiency

Improve Operational Efficiency & Transfers

- Conveyance
- System Reoperation
- Water Transfers

Increase Water Supply

- Conjunctive Management & Groundwater Storage
- Desalination –Brackish & Seawater
- Precipitation Enhancement
- Recycled Municipal Water
- Surface Storage – CALFED
- Surface Storage - Regional/Local

Improve Water Quality

- Drinking Water Treatment and Distribution
- Groundwater/Aquifer Remediation
- Matching Quality to Use
- Pollution Prevention
- Urban Runoff Management

Practice Resource Stewardship

- Agricultural Lands Stewardship
- Economic Incentives (Loans, Grants, and Water Pricing)
- Ecosystem Restoration
- Floodplain Management
- Recharge Areas Protection
- Urban Land Use Management
- Water-Dependent Recreation
- Watershed Management

X L R M

Evaluation Criterion Are Under Development

- Criterion could include measures of:
  - Water needs
    - Urban
    - Agricultural
    - Environment
  - Water supply reliability over various hydrologic sequences and conditions
    - Frequency of water rationing
    - System performance during droughts of differing strength and duration
  - Performance of flood control system during wet periods
  - Water quality metrics

X L
R M