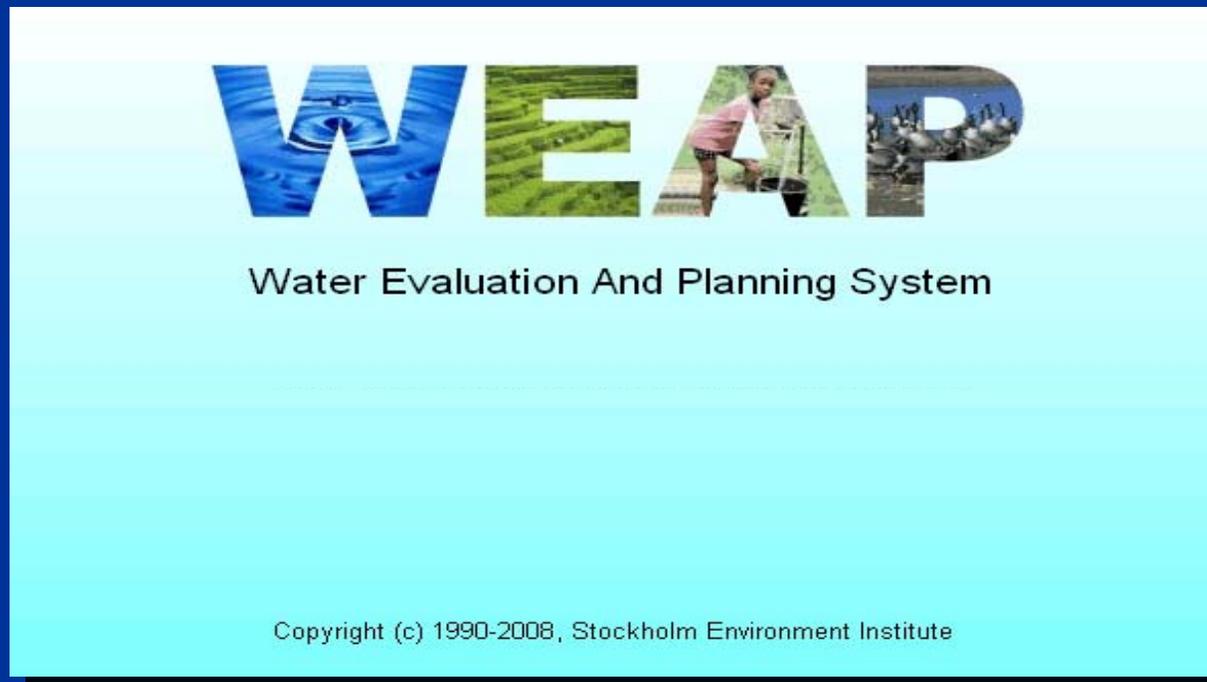


Quantifying Resource Management Strategies within WEAP

Brian Joyce - Stockholm Environment Institute

Water Evaluation and Planning System

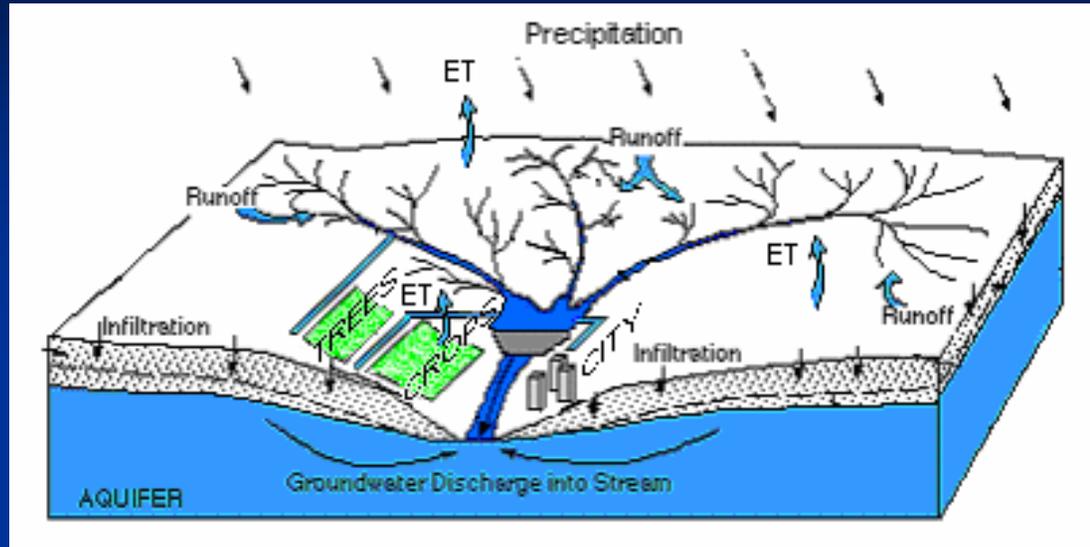
- A generic, object-oriented, programmable, integrated water resources management modeling platform



Examples of Analyses

- Sectoral demand analyses
- Water conservation
- Water rights and allocation priorities
- Financial analyses
- Groundwater and streamflow simulations
- Reservoir operations
- Hydropower generation
- Pollution tracking
- Ecosystem requirements

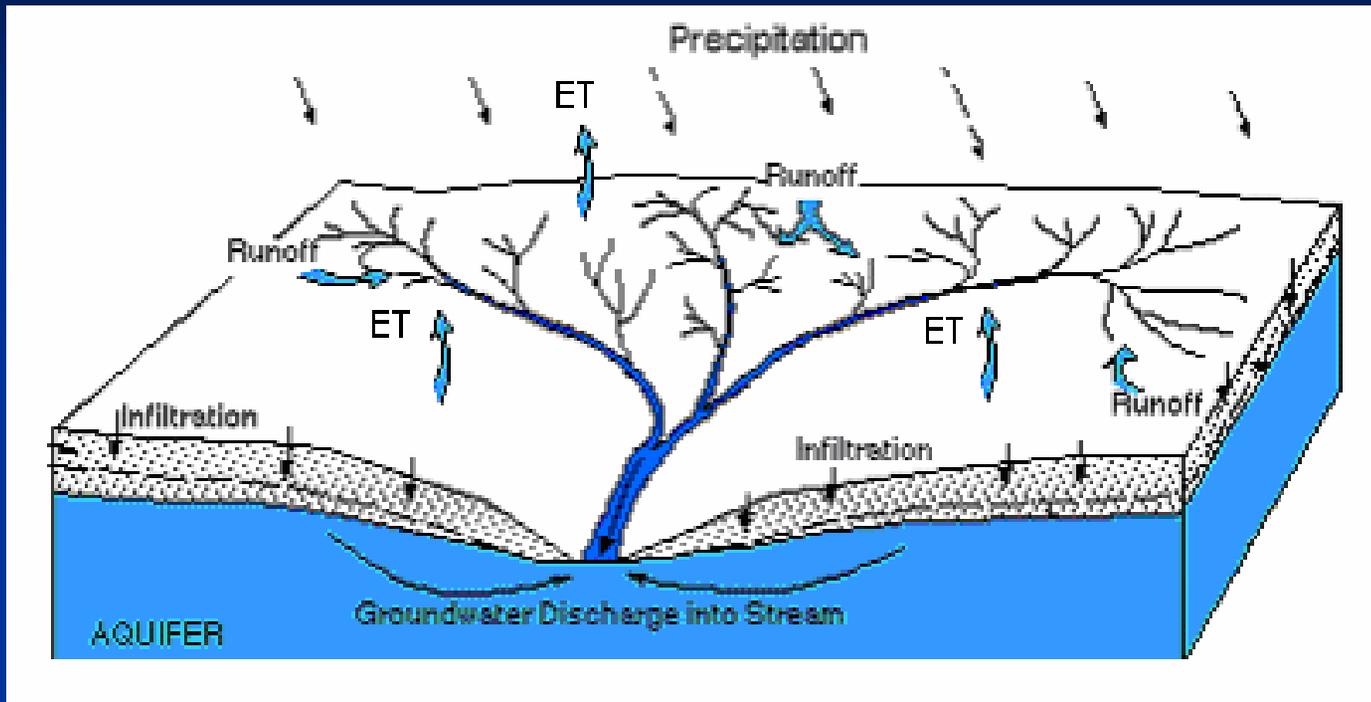
Planning Model



Critical questions:

- How should water be allocated to various uses in time of shortage?
- How can these operations be constrained to protect the services provided by the river?
- How should infrastructure in the system (e.g. dams, diversion works, etc) be operated to achieve maximum benefit?
- How will allocation, operations and operating constraints change if new management strategies are introduced into the system?

Hydrology Model

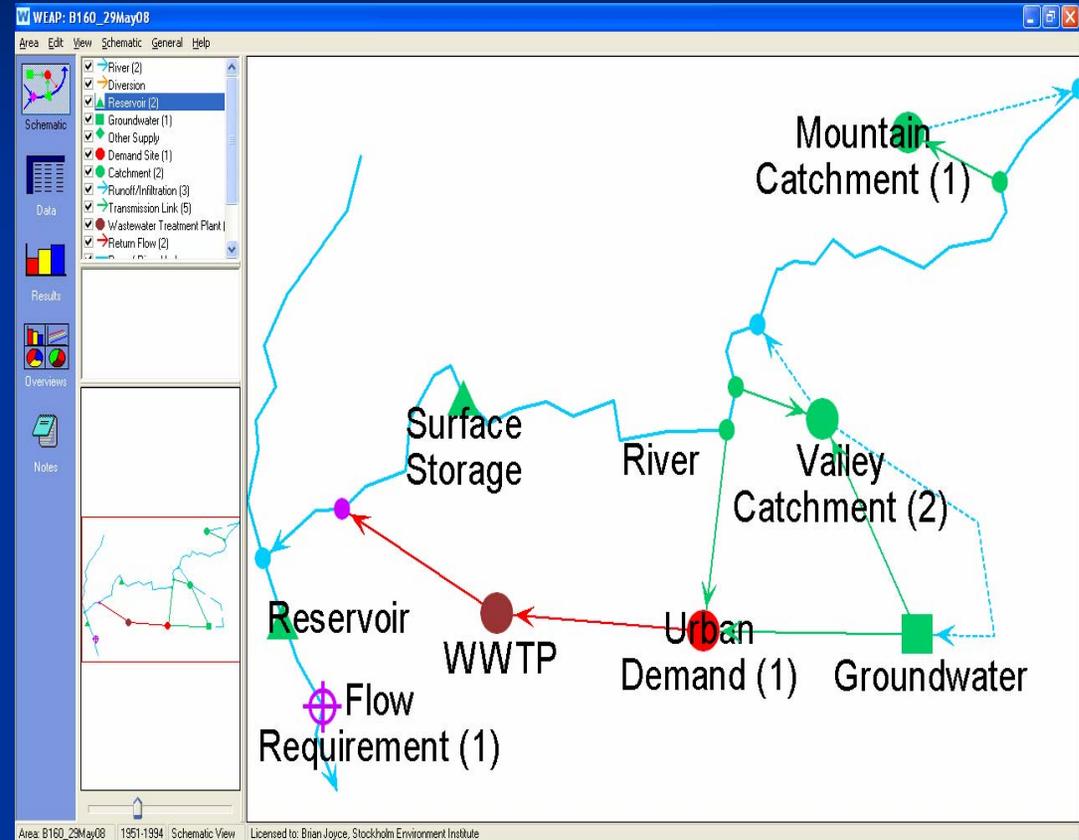


Critical questions:

- How does rainfall on a watershed translate into flow in a river?
- What pathways does water follow as it moves through a watershed?
- How does movement along these pathways impact the magnitude, timing, duration and frequency of river flows?

WEAP Structure

- Node-link architecture connects water supplies to demands
- Each demand is assigned a priority and a preferences among available supplies
 - Determines order in which demands are met
 - Determines order in which sources are used
- Constrained by link capacities



Resource Management Strategies

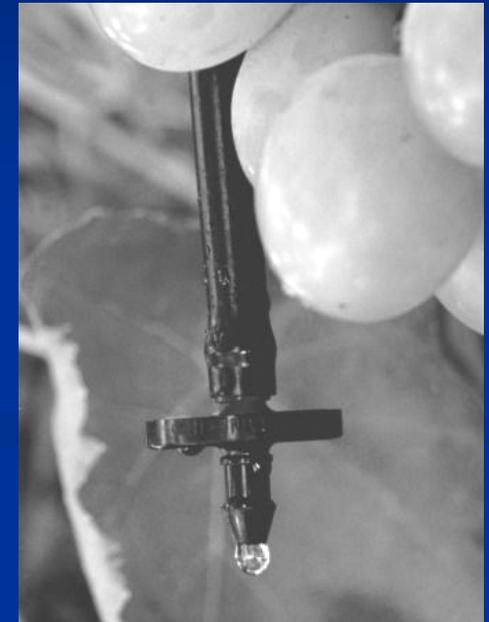
STRATEGIES TO REDUCE WATER DEMAND	
Agricultural Water Use Efficiency	YES*
Urban Water Use Efficiency	YES*
STRATEGIES TO IMPROVE OPERATIONAL EFFICIENCY	
Conveyance	YES
System Reoperation	YES
Water Transfers	YES
STRATEGIES TO INCREASE WATER SUPPLY	
Conjunctive Management & Groundwater Storage	YES*
Desalination	YES*
Precipitation Enhancement	YES*
Recycled Municipal Water	YES*
Surface Storage -- CALFED/State	YES*
Surface Storage -- Regional/Local	YES*
STRATEGIES TO IMPROVE WATER QUALITY	
Drinking Water Treatment and Distribution	SOME
Groundwater Remediation/Aquifer Remediation	SOME
Matching Water Quality to Use	SOME
Pollution Prevention	NO
Urban Runoff Management	NO
STRATEGIES TO PRACTICE RESOURCE STEWARDSHIP	
Agricultural Lands Stewardship	NO
Economics Incentives Policy	SOME
Ecosystem Restoration	NO
Floodplain Management	NO
Forest Management	NO
Recharge Area Protection	YES
Urban Land Use Management	YES
Water-Dependent Recreation	NO
Watershed Management	NO
STRATEGIES TO IMPROVE FLOOD MANAGEMENT	
Modify Flooding	SOME
Modify Impacts of Flooding	NO
Modify Susceptibility to Flooding	SOME
Preserve and Restore Natural Floodplain Functions	NO

	Modeled in WEAP
	Partially Modeled in WEAP
	Not Modeled in WEAP

Reducing Water Demand

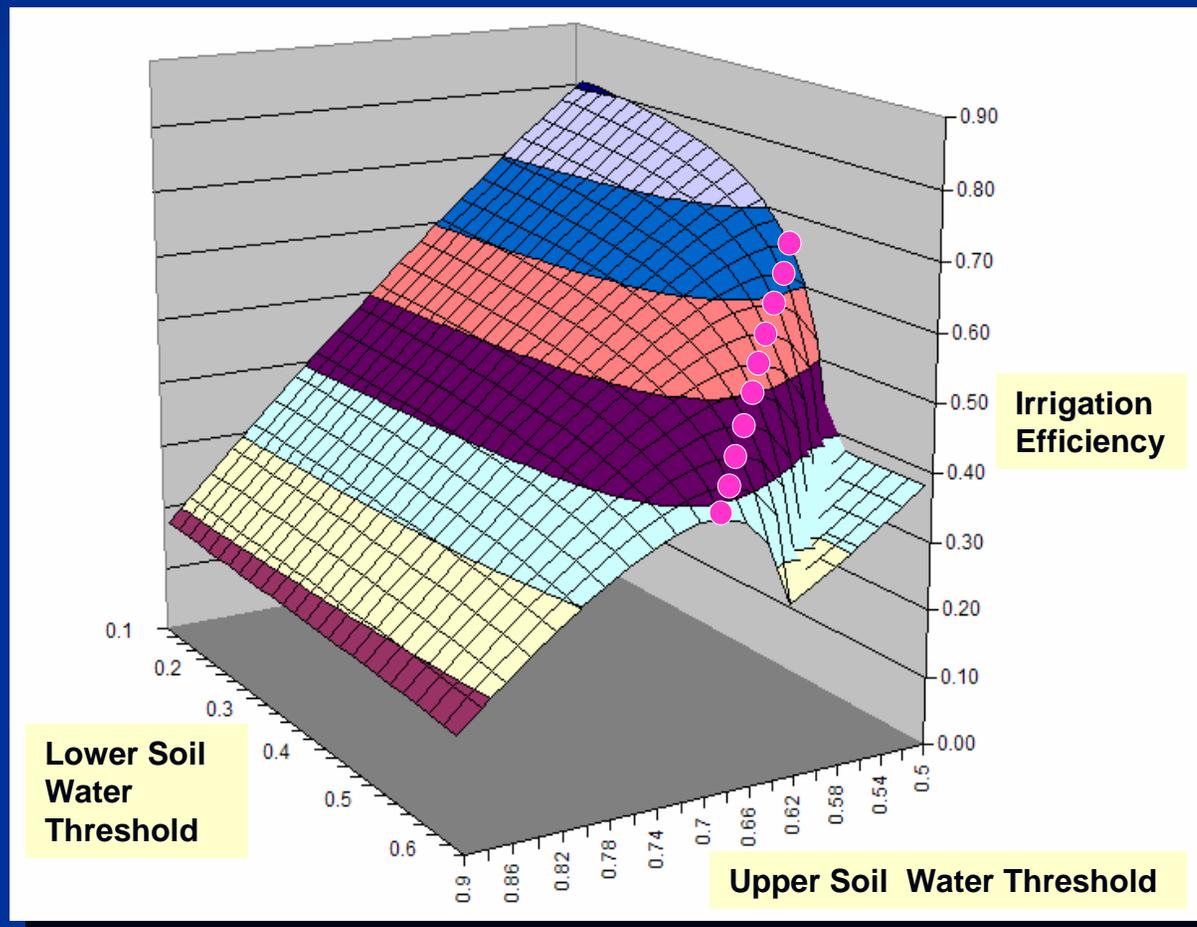
Agricultural Water Use Efficiency

- Improvements in technologies and management of agricultural water
 - Hardware (on-farm irrigation equipment)
 - Crop and farm water management practices, and
 - Improvements to water supplier distribution systems



Managing Irrigation Efficiency in WEAP

- Irrigation efficiency is determined by controlling soil moisture
- Highest when soils are managed in dry range



Managing Irrigation Efficiency in WEAP

WEAP: B160_29May08

Area Edit View General Tree Help

Schematic

Data

Results

Overviews

Notes

- Key Assumptions
- Demand Sites and Catchments
 - Valley Catchment
 - Irrigated Agriculture
 - Row Crop
 - Oil Crop
 - Rice
 - Pasture
 - Cereals
 - Orchards
 - Fallow
 - Non Irrigated
 - Urban
 - Mountain Catchment
 - Urban Indoor Demand
 - Single Family
 - Multiple Family
- Hydrology
- Supply and Resources
 - Linking Demands and Supply

Data for: Agricultural Water Use Efficiency (1951-1994)

Land Use Climate Ponding Irrigation

Irrigated Area Lower Threshold Upper Threshold

Irrigate when soil moisture falls below

Irrigated Agriculture	1951	1952-1994
Row Crop	Key\Irrig...	Key\Irrig Ag\Low
Oil Crop	Key\Irrig...	Key\Irrig Ag\Low
Rice	Key\Irrig...	Key\Irrig Ag\Low
Pasture	Key\Irrig...	Key\Irrig Ag\Low
Cereals	Key\Irrig...	Key\Irrig Ag\Low
Orchards	Key\Irrig...	Key\Irrig Ag\Low
Fallow		

Chart Table Notes

Area: B160_29May08 | 1951-1994 | Data View | Licensed to: Brian Joyce, Stockholm Environment Institute

ControlPanel

Response Packages

Apply Changes Show Results

Reference	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Agricultural Water Use Efficiency	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Urban Water Use Efficiency	<input type="checkbox"/>	<input type="checkbox"/>
Conveyance	<input type="checkbox"/>	<input type="checkbox"/>
System Reoperation	<input type="checkbox"/>	<input type="checkbox"/>
Conjunctive Management and Groundwater Storage	<input type="checkbox"/>	<input type="checkbox"/>
Desalination	<input type="checkbox"/>	<input type="checkbox"/>
Precipitation Enhancement	<input type="checkbox"/>	<input type="checkbox"/>
Recycled Municipal Water	<input type="checkbox"/>	<input type="checkbox"/>
Surface Storage	<input type="checkbox"/>	<input type="checkbox"/>
Modify Flooding	<input type="checkbox"/>	<input type="checkbox"/>

Irrigation Thresholds - Row Crops

Lower Soil Water Threshold(%)

Upper Soil Water Threshold(%)

Irrigation Thresholds - Oil Crops

Irrigation Thresholds - Rice

Irrigation Thresholds - Pasture

Irrigation Thresholds - Cereals

Irrigation Thresholds - Orchards

Run Close

Help

Row Crop
Oil Crop
Rice
Pasture
Cereals
Orchards
Fallow

All
3-D
Log
Grid
Print
Search

Urban Water Use Efficiency

- Technological or behavioral improvements in indoor and outdoor residential, commercial, industrial and institutional water use that lower water demand, lower per capita water use, and result in benefits to water supply, water quality, and the environment.



Urban Demand Management in WEAP

WEAP: B160_29May08

Area Edit View General Tree Help

Schematic

- Key Assumptions
- Demand Sites and Catchments
 - Valley Catchment
 - Mountain Catchment
 - Urban Indoor Demand
 - Single Family
 - Multiple Family
- Hydrology
- Supply and Resources
- Water Quality
- Other Assumptions

Data

Results

Overviews

Notes

Data for: Current Accounts (1951) Manage Scenarios...

Water Use Loss and Reuse Demand Management

DSM Savings DSM Cost

% reduction in total monthly demand due to demand side management

Demand Sites and Catchment	1951	Scale
Urban Indoor Demand	5	Percent

Chart Table Notes

Area: B160_29May08 1951-1994 Data View Licensed to: Brian Joyce, Stockholm Environment Institute

ControlPanel

Response Packages

Apply Changes Show Results

Reference	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Agricultural Water Use Efficiency	<input type="checkbox"/>	<input type="checkbox"/>
Urban Water Use Efficiency	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Conveyance	<input type="checkbox"/>	<input type="checkbox"/>
System Reoperation	<input type="checkbox"/>	<input type="checkbox"/>
Conjunctive Management and Groundwater Storage	<input type="checkbox"/>	<input type="checkbox"/>
Desalination	<input type="checkbox"/>	<input type="checkbox"/>
Precipitation Enhancement	<input type="checkbox"/>	<input type="checkbox"/>
Recycled Municipal Water	<input type="checkbox"/>	<input type="checkbox"/>
Surface Storage	<input type="checkbox"/>	<input type="checkbox"/>
Modify Flooding	<input type="checkbox"/>	<input type="checkbox"/>

Demand Management

Demand Side Management Savings (%) 5

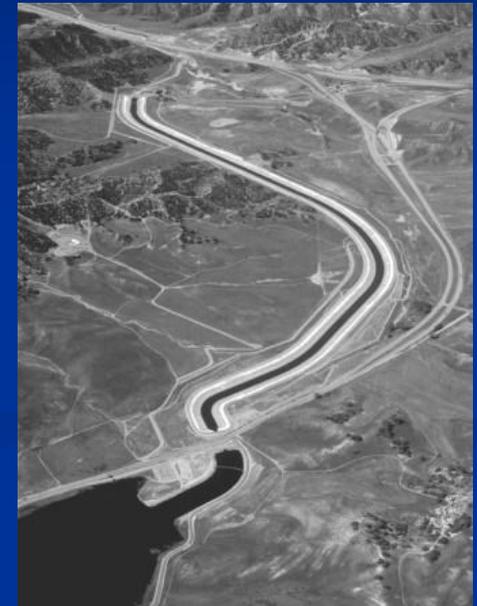
Demand Side Management Cost (\$/acre-foot) 80

Run Close

Improving Operational Efficiency

Conveyance

- Design water transmission systems with adequate water capacity to efficiently distribute imported or locally produced water to storage or the end users, so that system bottlenecks do not occur.



Adjusting Conveyance Capacities in WEAP

The screenshot displays the WEAP software interface with the ControlPanel dialog box open. The dialog box is titled "ControlPanel" and has a "Response Packages" section with checkboxes for various packages. Below this is a section for "Conveyance Capacities (CFS)" with sliders for different types of pumping and diversion.

Response Packages

Package	Apply Changes	Show Results
Reference	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Agricultural Water Use Efficiency	<input type="checkbox"/>	<input type="checkbox"/>
Urban Water Use Efficiency	<input type="checkbox"/>	<input type="checkbox"/>
Conveyance	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
System Reoperation	<input type="checkbox"/>	<input type="checkbox"/>
Conjunctive Management and Groundwater Storage	<input type="checkbox"/>	<input type="checkbox"/>
Desalination	<input type="checkbox"/>	<input type="checkbox"/>
Precipitation Enhancement	<input type="checkbox"/>	<input type="checkbox"/>
Recycled Municipal Water	<input type="checkbox"/>	<input type="checkbox"/>
Surface Storage	<input type="checkbox"/>	<input type="checkbox"/>
Modify Flooding	<input type="checkbox"/>	<input type="checkbox"/>

Conveyance Capacities (CFS)

Urban Indoor Groundwater Pumping	250
Urban Indoor Surface Water Diversion	300
Agriculture Groundwater Pumping	250
Agriculture Surface Water Diversion	500

Buttons: Run, Close

Background WEAP Interface:

- Title Bar:** WEAP: B160_29May08
- Menu Bar:** Area Edit View General Tree Help
- Left Panel:** Schematic, Data, Results, Overviews, Notes
- Tree View:**
 - Key Assumptions
 - Demand Sites and Catchments
 - Valley Catchment
 - Mountain Catchment
 - Urban Indoor Demand
 - Single Family
 - Multiple Family
 - Hydrology
 - Supply and Resources
 - Linking Demands and Supply
 - to Valley Catchment
 - from Withdrawal Node 4
 - from Groundwater
 - to Mountain Catchment
 - to Urban Indoor Demand
 - from Withdrawal Node 1
 - from Groundwater
 - River
 - Groundwater
 - Return Flows

- Data Table:**

Linking Rules	Losses	Cost		
Maximum Flow	Volume	Maximum Flow	Percent of Demand	...
Maximum monthly flow (as a volume), due to physical ca				
to Valley Catchment	1951	1952-1994		
from Withdrawal Node 4	500	500		
from Groundwater	250	250		
- Chart:** A bar chart showing flow in ft³/second over time from 1950 to 1968. The y-axis ranges from 0 to 500. The chart shows a red bar at the bottom (0-250) and a green bar on top (250-500).
- Bottom Status Bar:** Area: B160_29May08 | 1951-1994 | Data View | Licensed to: Brian Joyce, Stockholm Environment Institute

System Reoperation

- Changing the existing operation and management procedures for such water facilities as dams and canals to meet multiple beneficial uses.



Adjusting Operational Priorities in WEAP

The screenshot displays the WEAP software interface with the ControlPanel dialog box open. The background shows a schematic of a water system with various components like Reservoirs, Rivers, and Groundwater. The ControlPanel dialog box is titled "ControlPanel" and has a "Response Packages" tab selected. It contains a table of response packages and a section for "Operational Priorities".

Response Packages

Response Package	Apply Changes	Show Results
Reference	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Agricultural Water Use Efficiency	<input type="checkbox"/>	<input type="checkbox"/>
Urban Water Use Efficiency	<input type="checkbox"/>	<input type="checkbox"/>
Conveyance	<input type="checkbox"/>	<input type="checkbox"/>
System Reoperation	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Conjunctive Management and Groundwater Storage	<input type="checkbox"/>	<input type="checkbox"/>
Desalination	<input type="checkbox"/>	<input type="checkbox"/>
Precipitation Enhancement	<input type="checkbox"/>	<input type="checkbox"/>
Recycled Municipal Water	<input type="checkbox"/>	<input type="checkbox"/>
Surface Storage	<input type="checkbox"/>	<input type="checkbox"/>
Modify Flooding	<input type="checkbox"/>	<input type="checkbox"/>

Operational Priorities

Carryover Storage - Reservoir 1 (TAF)	500
Carryover Storage - Reservoir 2 (TAF)	760
Storage Priority - Reservoir 1	95
Storage Priority - Reservoir 2	98

Buttons: Run, Close

Increasing Water Supply

Conjunctive Management and Groundwater Storage

- Coordinated operation of surface water storage and use, groundwater storage and use, and conveyance facilities to meet water management objectives.



Possible Approaches in WEAP

- Adjust supply preferences in wet and dry years
 - For example, Pump groundwater first in dry years, Divert surface water first in wet years
- Operate groundwater object as a bank
 - Track storage accounts, Limit puts/takes to bank

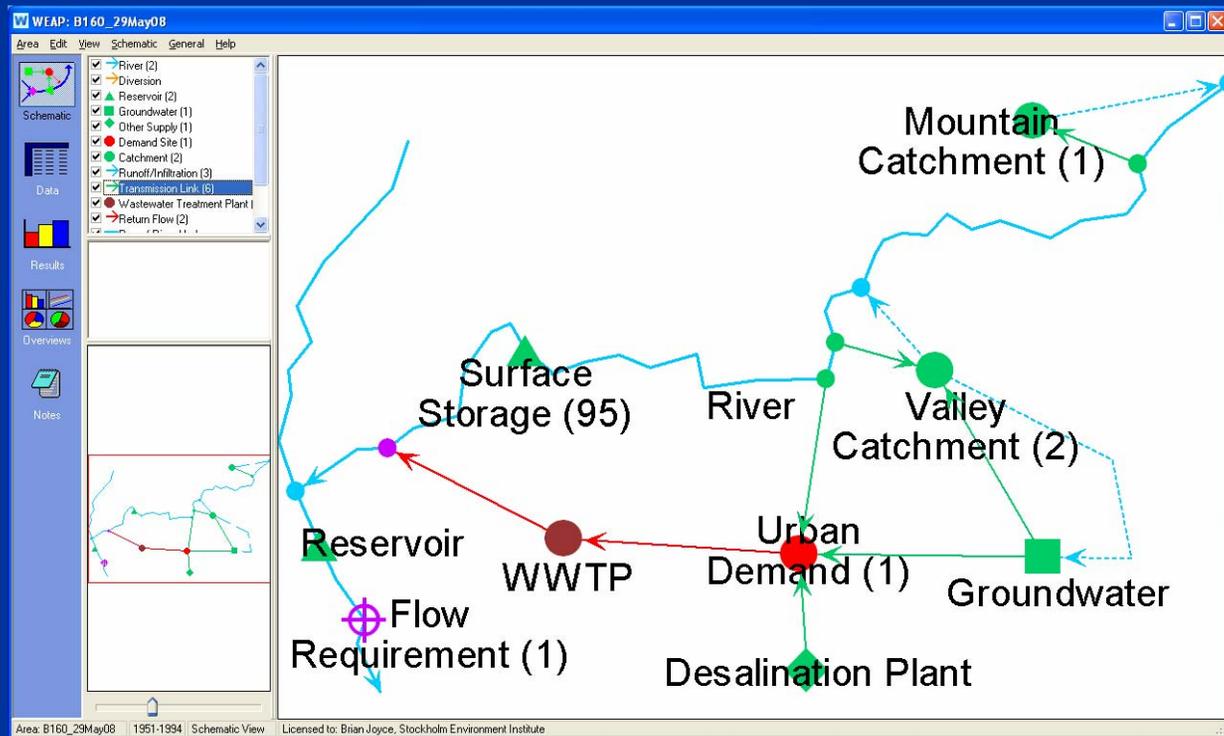
Desalination

- In California, the principal method for desalination is through reverse osmosis technology. There are two primary types of desalination:
 - Brackish (low-salinity) surface or groundwater
 - Ocean water.



Desalination in WEAP

- Add desalination plant as new water supply model object
- Fixed and variable costs/benefits considered



Precipitation Enhancement

- Precipitation enhancement projects are intended to increase surface water supplies or hydroelectric power. Projects increase the amounts of water produced (~2-15%) by artificially stimulating clouds to produce more rainfall or snowfall than they would naturally.



Adjusting Precipitation in WEAP

The screenshot shows the WEAP software interface with the 'ControlPanel' dialog box open. The dialog is titled 'ControlPanel' and has a 'Data for:' dropdown set to 'Current Accounts (1)'. The 'Key Assumptions' section shows 'Key Assumption' as 1951 and 'PrecipFactor' as 2. The 'Response Packages' section is a table with two columns: 'Apply Changes' and 'Show Results'. The 'Precipitation Enhancement' section has a slider for 'Precipitation Increase (%)' set to 2. The 'Run' and 'Close' buttons are at the bottom of the dialog.

Response Package	Apply Changes	Show Results
Reference	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Agricultural Water Use Efficiency	<input type="checkbox"/>	<input type="checkbox"/>
Urban Water Use Efficiency	<input type="checkbox"/>	<input type="checkbox"/>
Conveyance	<input type="checkbox"/>	<input type="checkbox"/>
System Reoperation	<input type="checkbox"/>	<input type="checkbox"/>
Conjunctive Management and Groundwater Storage	<input type="checkbox"/>	<input type="checkbox"/>
Desalination	<input type="checkbox"/>	<input type="checkbox"/>
Precipitation Enhancement	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Recycled Municipal Water	<input type="checkbox"/>	<input type="checkbox"/>
Surface Storage	<input type="checkbox"/>	<input type="checkbox"/>
Modify Flooding	<input type="checkbox"/>	<input type="checkbox"/>

Precipitation Increase (%)

Run Close

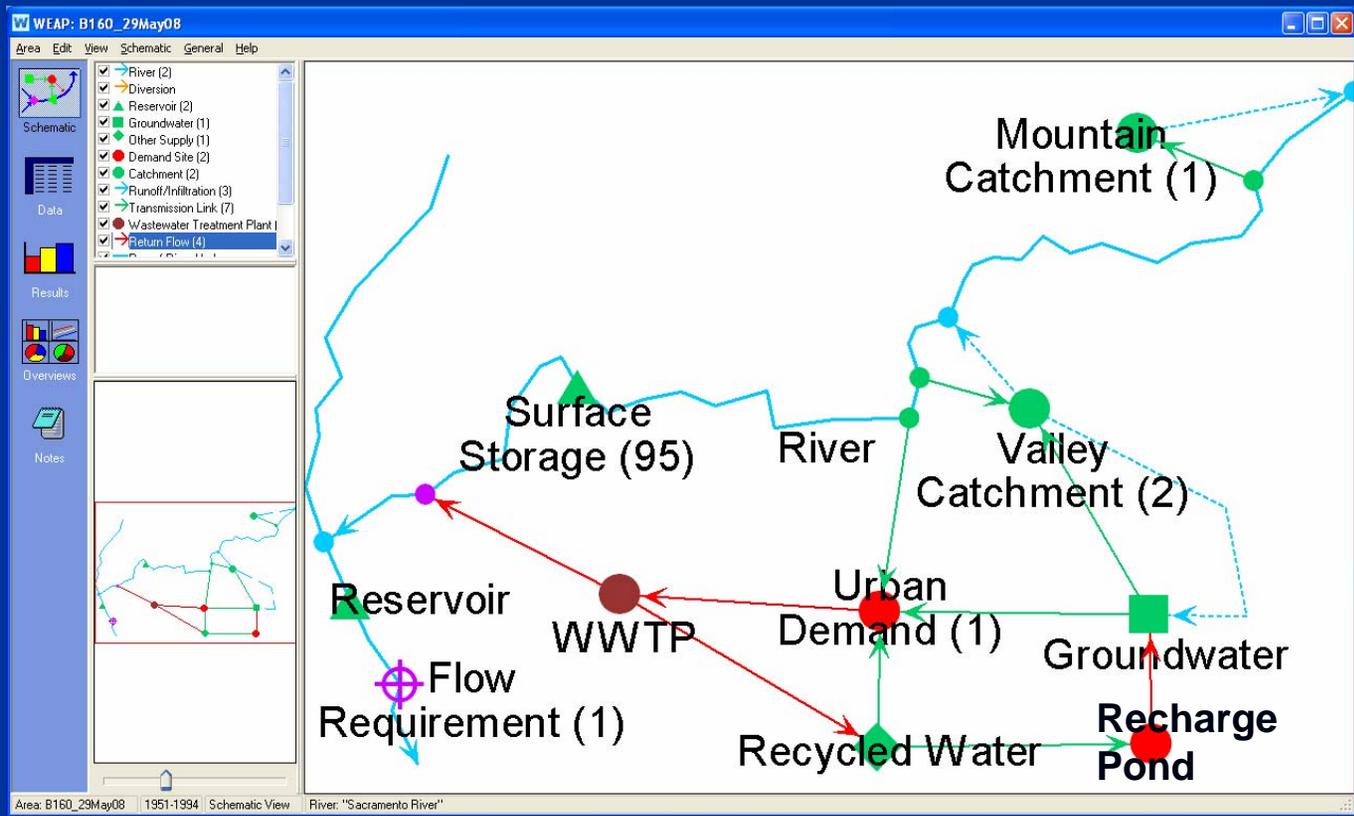
Recycled Municipal Water

- Water recycling is the process of treating wastewater from previous uses, and then storing, distributing, and using this recycled water to meet demands. Reclaimed water used for:
 - Golf courses
 - School yards
 - Residential landscape
 - Parks
 - Industrial uses



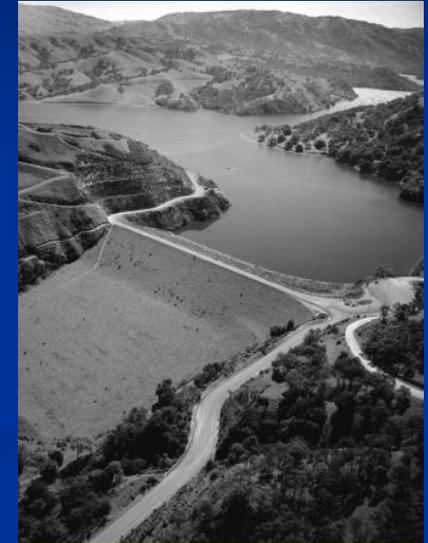
Wastewater Recycling in WEAP

- Outflows from WWTP are temporarily stored as supplemental water supply



Surface Storage

- The CALFED Record of Decision (2000) identified five potential surface storage reservoirs that are being investigated by the California Department of Water Resources, U.S. Bureau of Reclamation, and local water interests.
 - Shasta Lake Water Resources Investigation
 - North-of-the-Delta Offstream Storage
 - In-Delta Storage Project
 - Los Vaqueros Reservoir Expansion
 - Upper San Joaquin River Basin Storage Investigation



Possible Approaches in WEAP

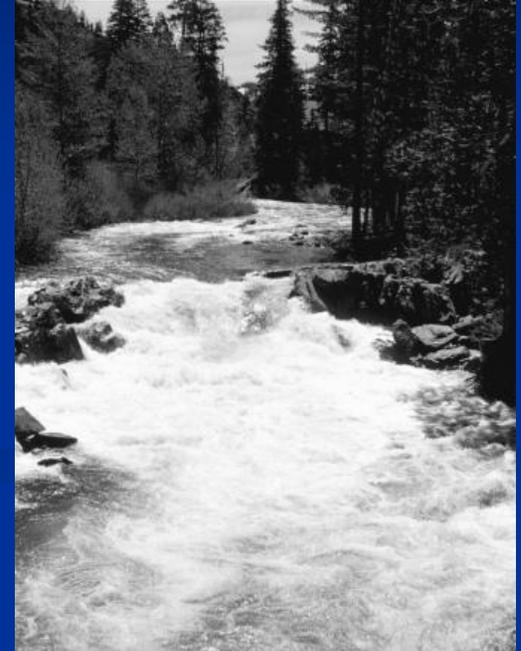
- Modify existing storage
 - Increase storage capacity
 - Adjust reservoir operating rules (e.g. flood control storage)
- Add new facilities
 - Incorporate proposed operations and engineering specifications
 - Indicate date reservoir comes online

Improving Flood Management

The background of the slide is a solid dark blue color. In the lower right quadrant, there is a subtle graphic of light blue, wavy lines that resemble ripples on water, extending from the bottom right towards the center.

Flood Management

- Projects and programs that detain or divert floodwaters or improve the ability of channels to accommodate floodwaters.



Possible Approaches in WEAP

- Adjust reservoir rule curves
 - Allow additional flood storage in certain months
- Adjust weir diversions
 - Increase amount of spilled water that is diverted to bypasses

Questions

Thank You