U.S. Department of the Interior
Bureau of Reclamation

San Juan Recovery Implementation Program

RECLAMATION
Managing Water in the West

U.S. Department of the Interior
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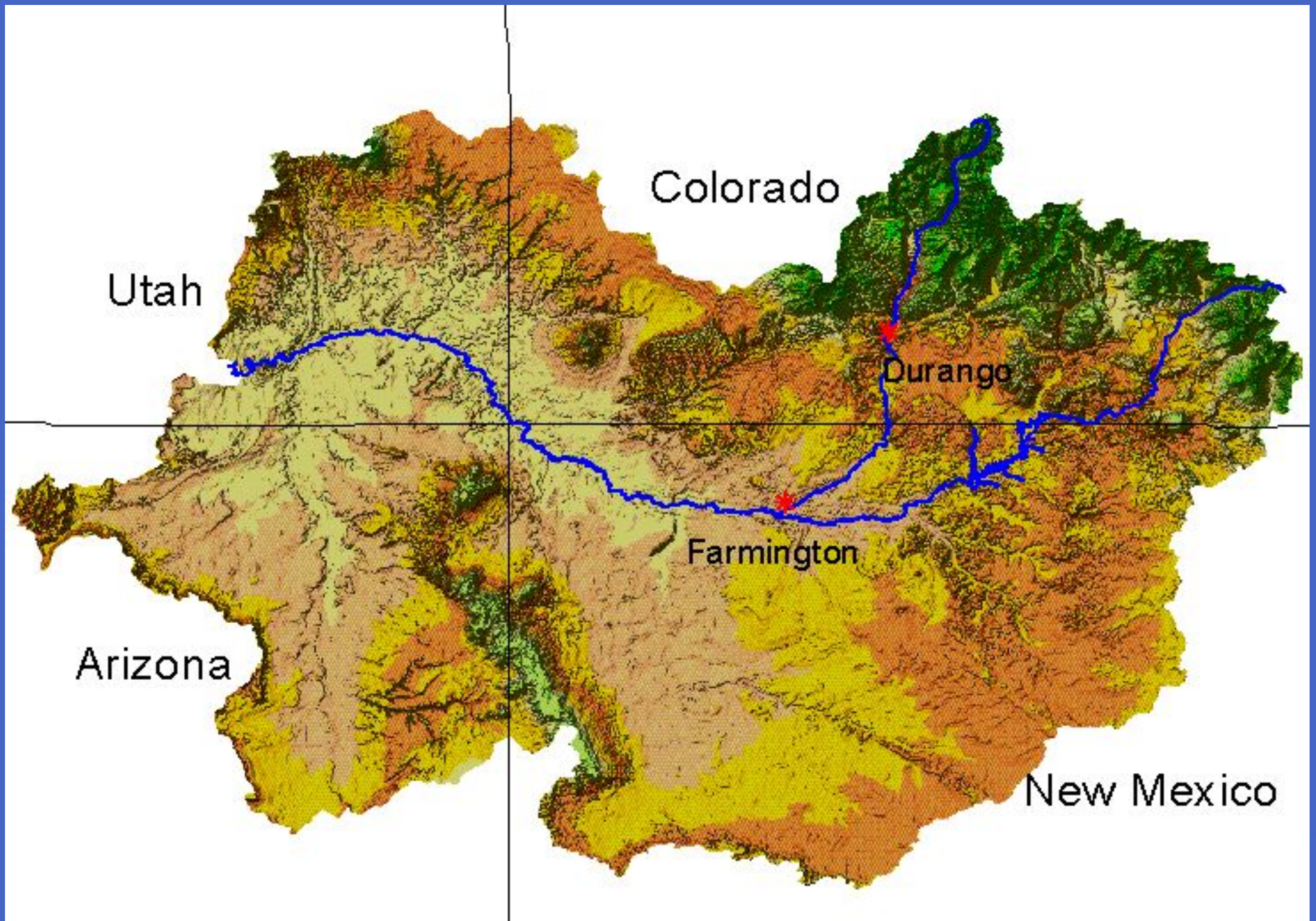
San Juan Basin Hydrology Model

RECLAMATION
Managing Water in the West

San Juan River Basin



SJRIP Overview

- Program to Recover Endangered Fisheries
  - Pike Minnow
  - Razorback Sucker
- Data Collection
  - Sediment transport and other physical processes data
  - Biological data
- Formulation of Flow Recommendations

SJRIP Overview

- Coordination Committee
- Biological Committee
- Hydrology Committee
- Tech Team
  - Keller-Bliesner Engineering
  - Reclamation
  - Colorado Water Conservation Board
- Links
  - http://southwest.fws.gov.sjrip/
  - http://www.usbr.gov/uc/wcao/envprog/sjrip/

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SJRIP Overview

- Flow Recommendations
  - Baseflow
  - Primary flushing flows – Maximum return periods between events
  - Secondary flushing flows – Flow Duration Frequencies

Maximum Return Periods

Flow Criteria - Max Duration	Allowed
9700 cfs for 5-days - 10-years	10
7760 cfs for 10-days - 6-years	6
4850 cfs for 21-days - 4-years	4
2450 cfs for 10-days - 2 years	2

Flow Duration Statistics – 10,000 cfs

Duration	Frequency
1 days	30.00%
5 days	20.00%
10 days	10.00%
15 days	5.00%
20 days	0.00%
21 days	0.00%
30 days	0.00%
40 days	0.00%
50 days	0.00%
60 days	0.00%

Flow Duration Statistics – 8,000 cfs

Duration	Frequency
1 days	40.00%
5 days	35.00%
10 days	33.00%
15 days	30.00%
20 days	20.00%
21 days	0.00%
30 days	10.00%
40 days	0.00%
50 days	0.00%
60 days	0.00%

Flow Duration Statistics – 5,000 cfs

Duration	Frequency
1 days	65.00%
5 days	60.00%
10 days	58.00%
15 days	55.00%
20 days	0.00%
21 days	50.00%
30 days	40.00%
40 days	30.00%
50 days	20.00%
60 days	15.00%

Flow Duration Statistics – 2,500 cfs

Duration	Frequency
1 days	90.00%
5 days	82.00%
10 days	80.00%
15 days	70.00%
20 days	65.00%
21 days	0.00%
30 days	60.00%
40 days	50.00%
50 days	45.00%
60 days	40.00%

SJRIP Overview

- Roles of Hydrologic Model
  - Gage impacts of meeting flow recommendations
    - Baseline conditions
    - Proposed conditions
  - Section 7 Consultations
  - Hydrology studies associated with EIS work

SJBHM Overview

- First generation model
  - Monthly timestep
  - Implicit ALP
  - Reclamation natural flows
- Second generation model
  - Operating ALP with interaction with Navajo Reservoir
- Third generation model
  - Daily timestep in decision model
  - StateMod natural flows

SJBHM Overview

- Previous generation problems
  - Inconsistent and poorly documented natural flows
  - Lack of return flow lagging in RiverWare
  - Inability to split return flows in RiverWare
  - Monthly timestep
    - Required significant post-processing
    - Model had no knowledge of downstream daily flows

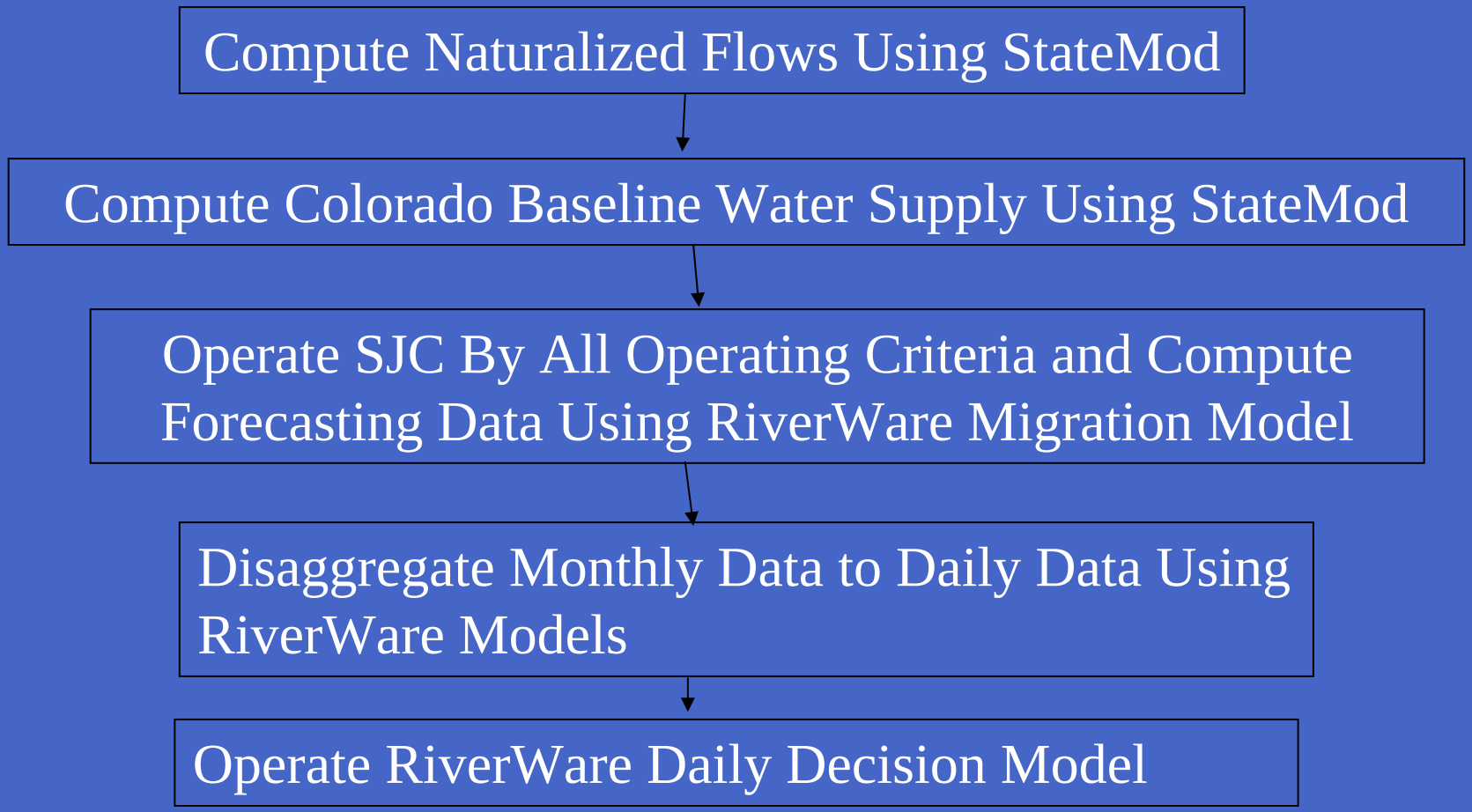
SJBHM – 3rd Generation Overview

- Mix of StateMod and RiverWare Hydrologic Models
- Several Supporting Models
  - Mixed Stations Model
  - Blaney-Criddle Evapotranspiration Model
  - Hargreaves-Samani Evapotranspiration Model
  - StateCU Evapotranspiration Model
- Numerous data stores and DMI's
  - Hydrologic Database (HDB)
  - CDSS Hydrobase
  - TSTool
  - DemandTS

SJBHM – Modeling System

- StateMod Natural Flow Model
- StateMod Monthly Baseline Model
- RiverWare Daily Gains Model
- RiverWare Monthly Migration Model
- RiverWare Daily Decision Model

SJBHM Modeling Steps



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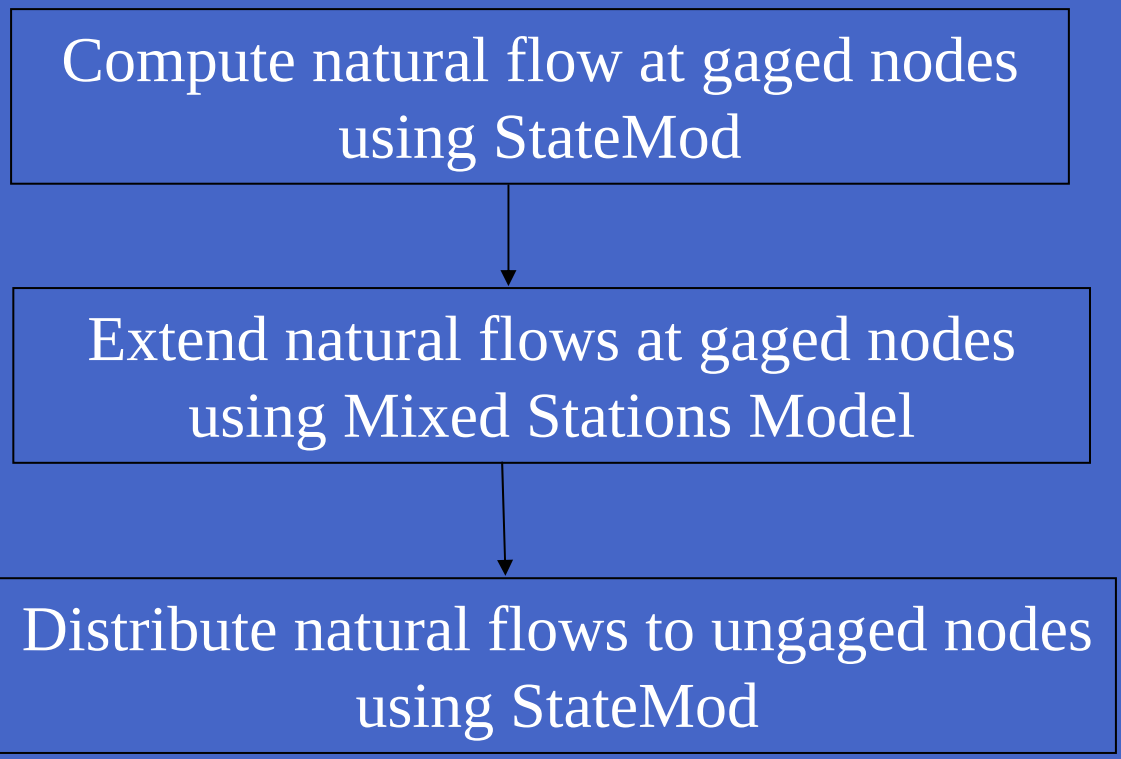
SJBHM Natural Flow Computations

- StateMod Advantages
  - Automatic management of missing data
  - Use of Mixed Stations Model to extend natural flows
  - Ability to spatially distribute flows to ungaged areas

SJBHM – StateMod Natural Flow Steps

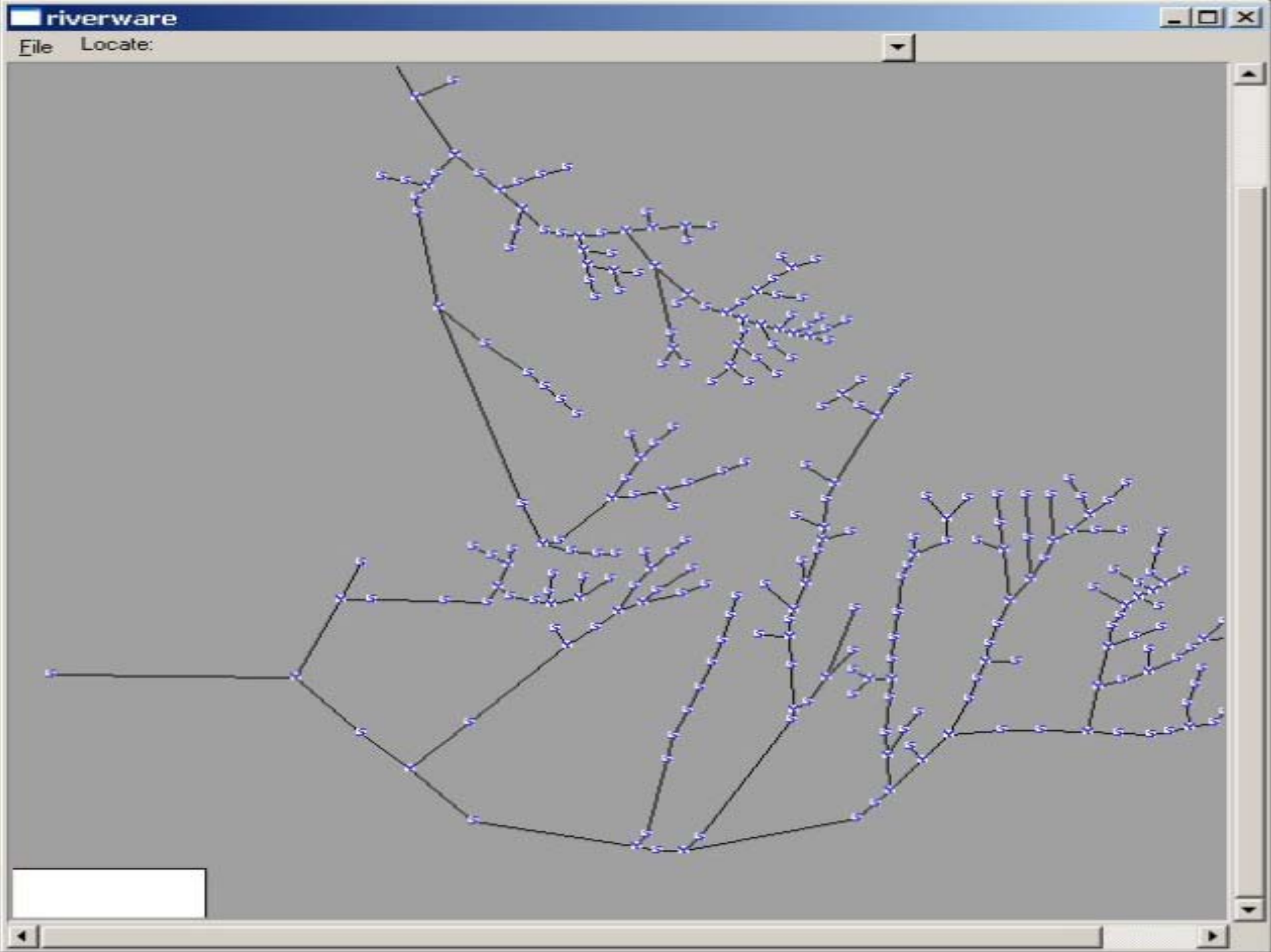


SJBHM - Configuration

- StateMod to RiverWare node correspondence
  - 1 to 1 to extent possible
  - Automated creation of initial RiverWare model
- Data Management
  - StateMod to RiverWare via StateMod (stm) format
  - Other formats as appropriate

SJBHM Nodes

- Hydrology Nodes
- Monthly Migration Model
- Daily Decision Model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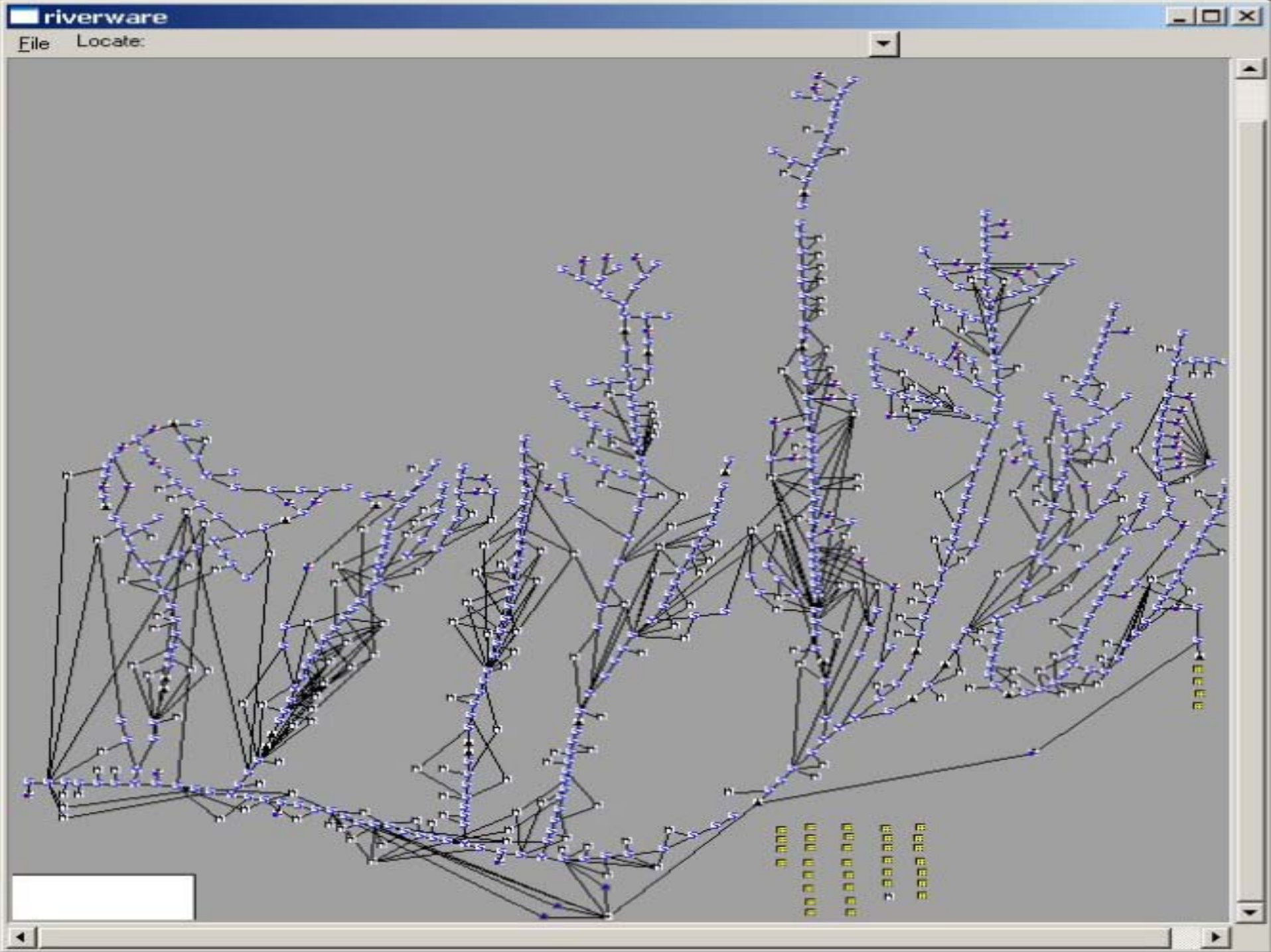
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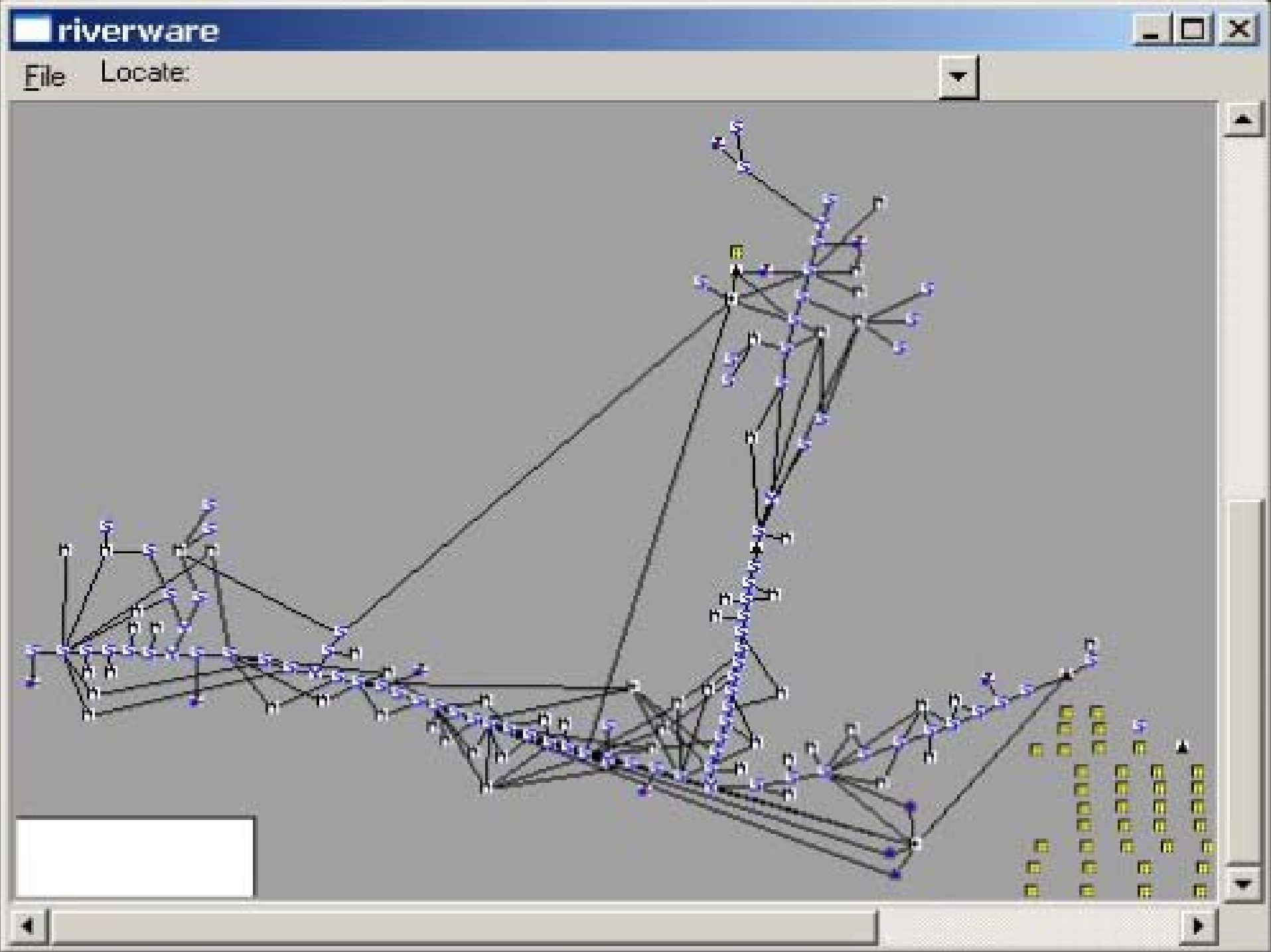

riverware
File
Locate:

SJBHM – Operations

- Water supply forecasting
  - Emulation of NWS unregulated inflow forecasts
  - Short-term flood control forecasts
- Decision variables
  - Predicted Spill; aka surplus volume; aka op volume
  - Available water
- Forecast error
- Interim forecasts

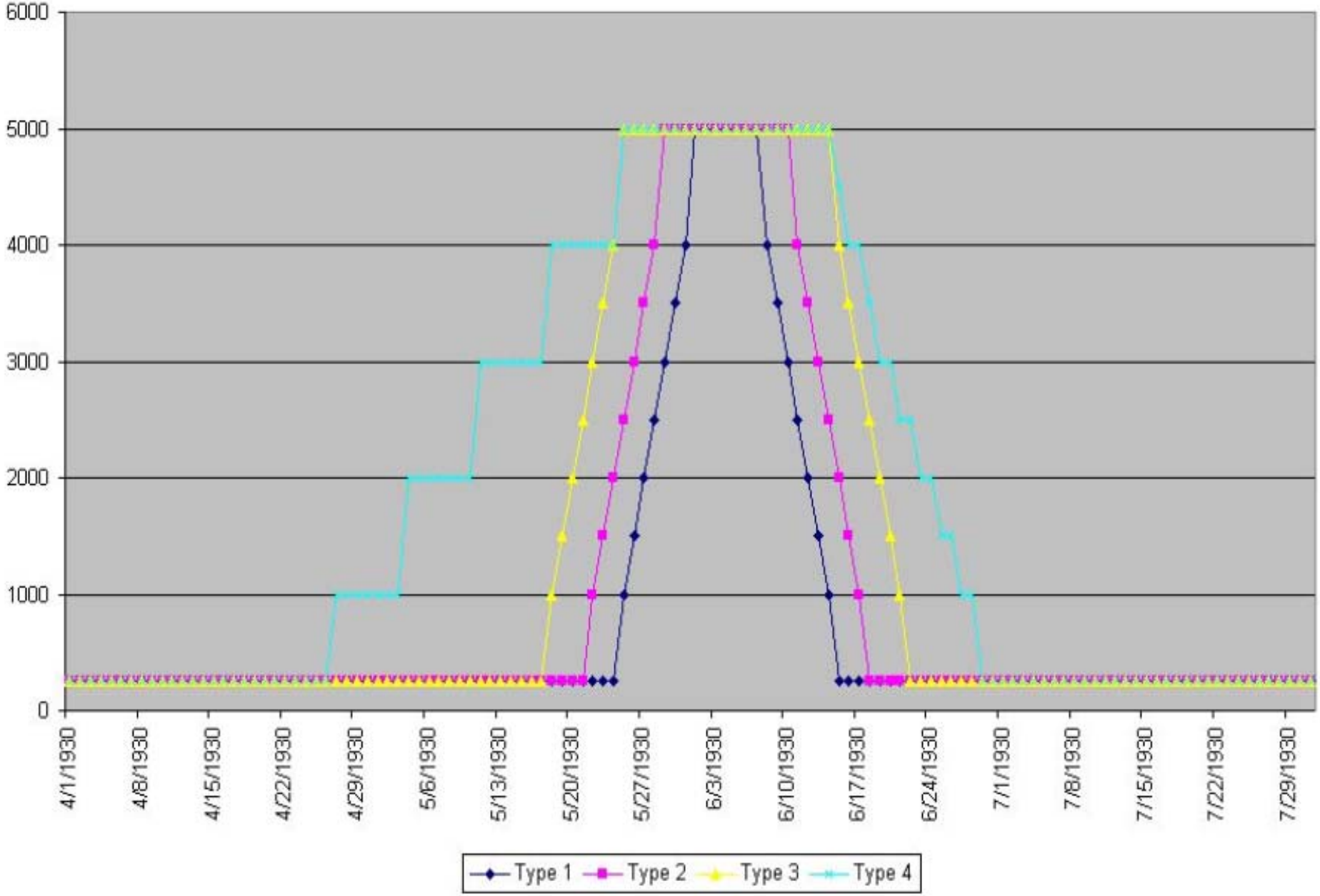
SJBHM – Non RIP Operations

- StateMod Baseline Operation
  - Water rights solver
  - Modified Direct Solution Algorithm
  - Standard operations
  - Special operations – La Plata Compact
  - Establishes water supply for most Colorado water users
- San Juan Chama
- Animas La Plata Project
  - Normal operations
  - Mitigation Operations
- Navajo Normal Operations
  - NIIP
  - Downstream Demands
  - Fill and Not Spill
  - Flood Control

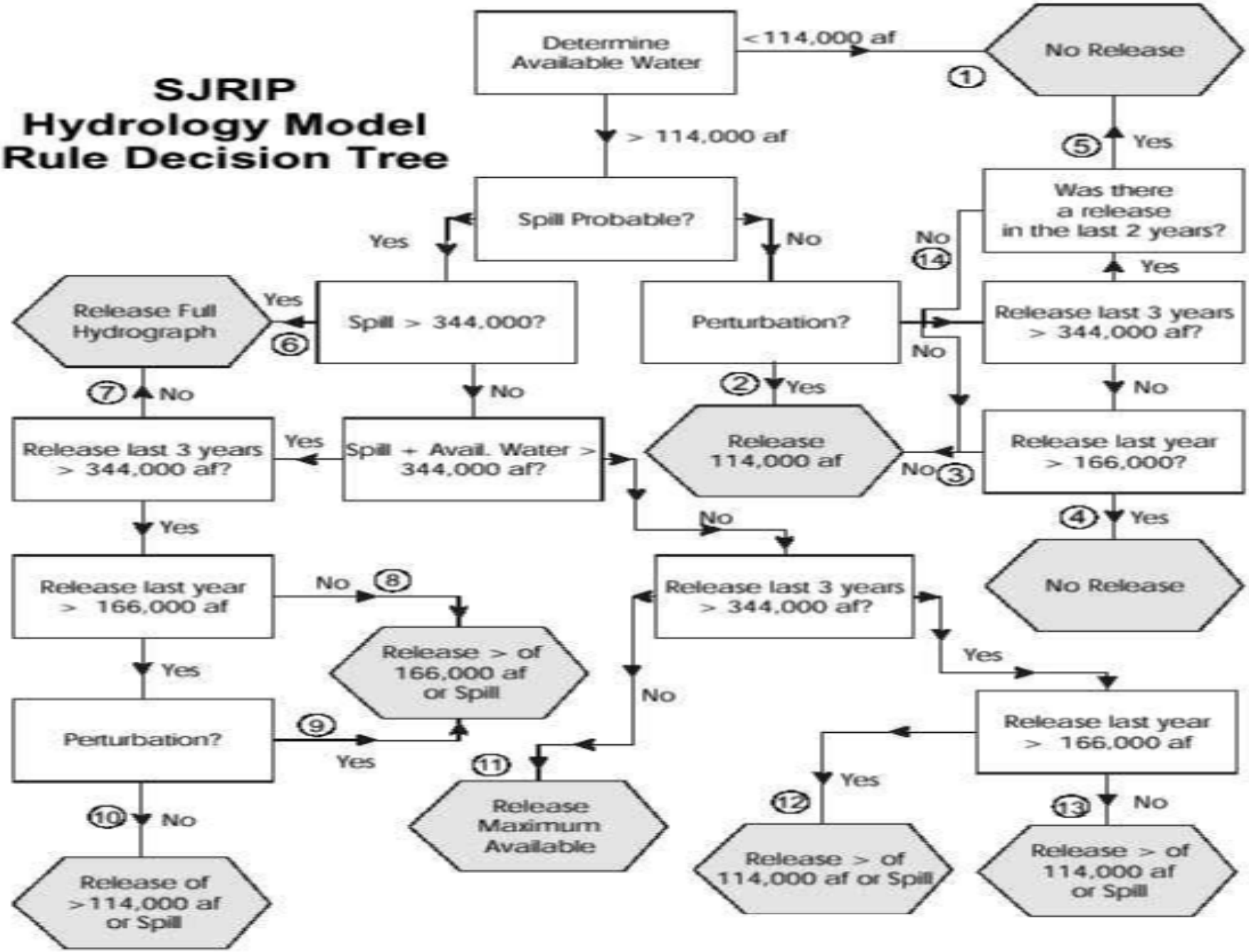
SJBHM – RIP Operations

- Baseflows – 7 Day running average of 500 cfs at combination of gages
  - Three Gage
  - Two Gage Maximum
  - Two Gage Minimum
- Flushing Flows
  - Event types targeted toward primary criteria
  - Decision tree used to make and track decisions

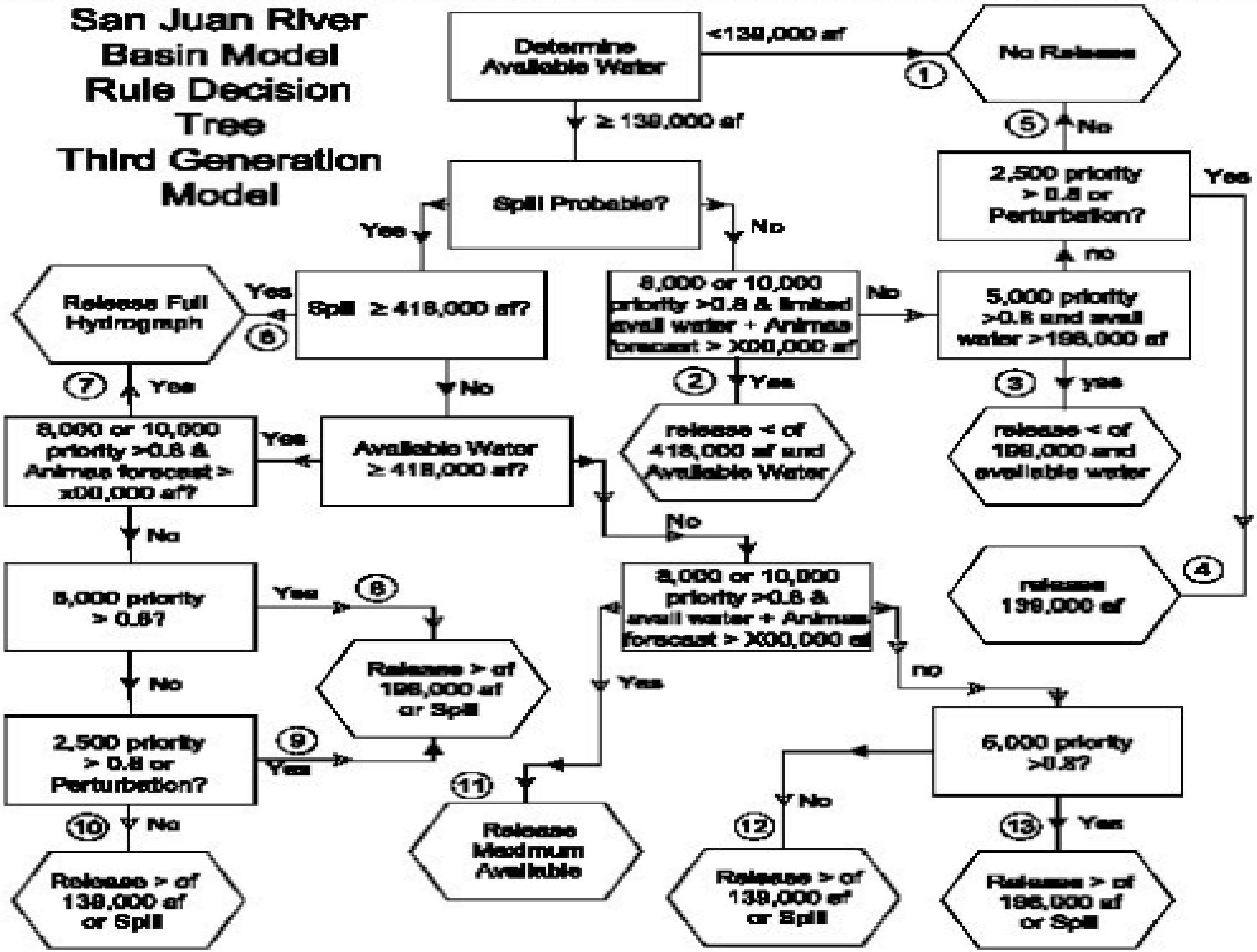
Figure 1. Flushing Release Hydrographs



SJRIP Hydrology Model Rule Decision Tree



San Juan River Basin Model Rule Decision Tree Third Generation Model



Available Water = predicted inflow + current storage - carryover storage
Limited available water is the lesser of 418,000 af and available water

SJBHM RIP Operations

- Third Generation Objectives
  - Optimize flushing releases
    - Avoid unnecessary releases to conserve for future use
    - Curtail releases that have met target
  - Better interaction with ALP
  - Meet actual baseflow criteria
  - Provide water for future development while maintaining flow recommendations

SJBHM RIP Operations

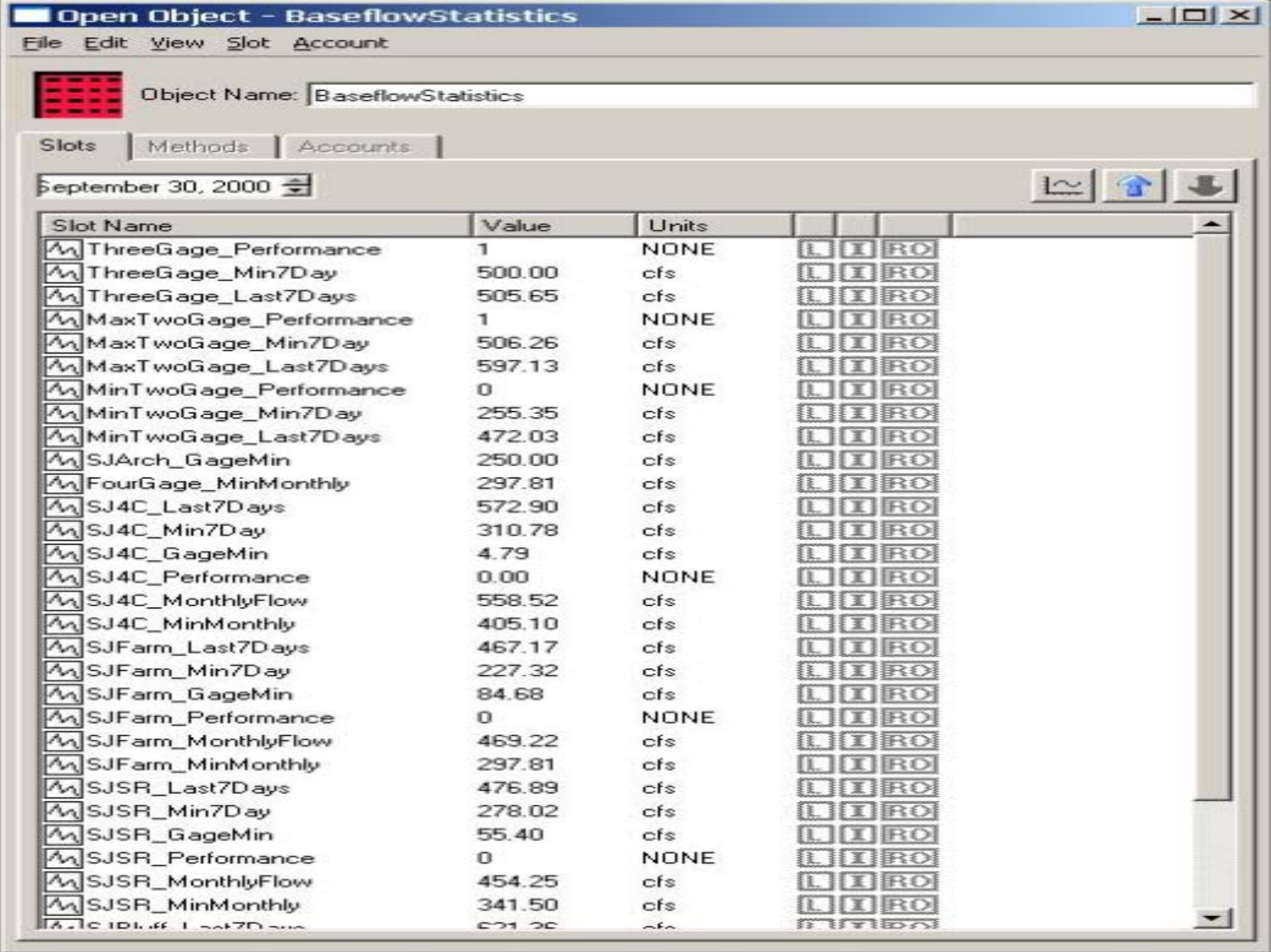
- Third Generation Enhancements
  - Completed
    - Ability to look back at actual events rather than releases
    - Prioritization of target events
    - More frequent decision dates
    - Inclusion of Animas forecast in decision process
  - Proposed
    - Alternative adjustments (in lieu of nose adjustments)
    - Release curtailments or extensions based upon realized conditions
    - Additional interaction with ALP
    - Better Animas peak matching

SJBHM RIP Operation

- Release priority =
  - Years since last occurrence of event
  - / maximum years allowed for event
- Example
  - 8 years since last event
  - 10 years allowed between events
  - Priority = 8/10 = 0.8

SJBHM Fun Stuff

- Performance statistics available at end of run
- Decision dates specification
- Macro aggregations of rdf output in Excel
- Migration to PC during development
- Batch scripts to facilitate updating
- RPL functions to count events
  - AnnualEventCount
  - AnnualEventLastOccurrence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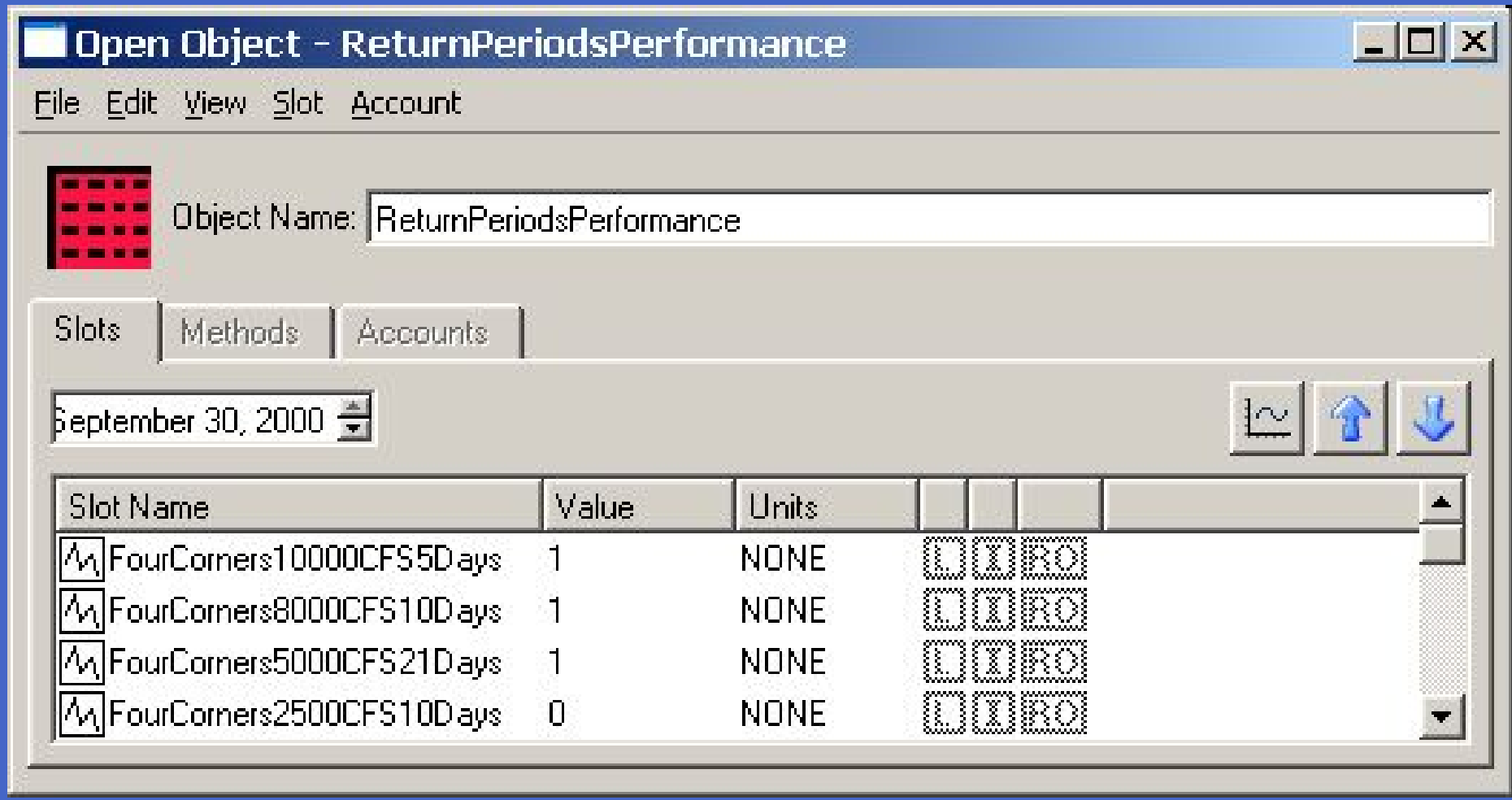
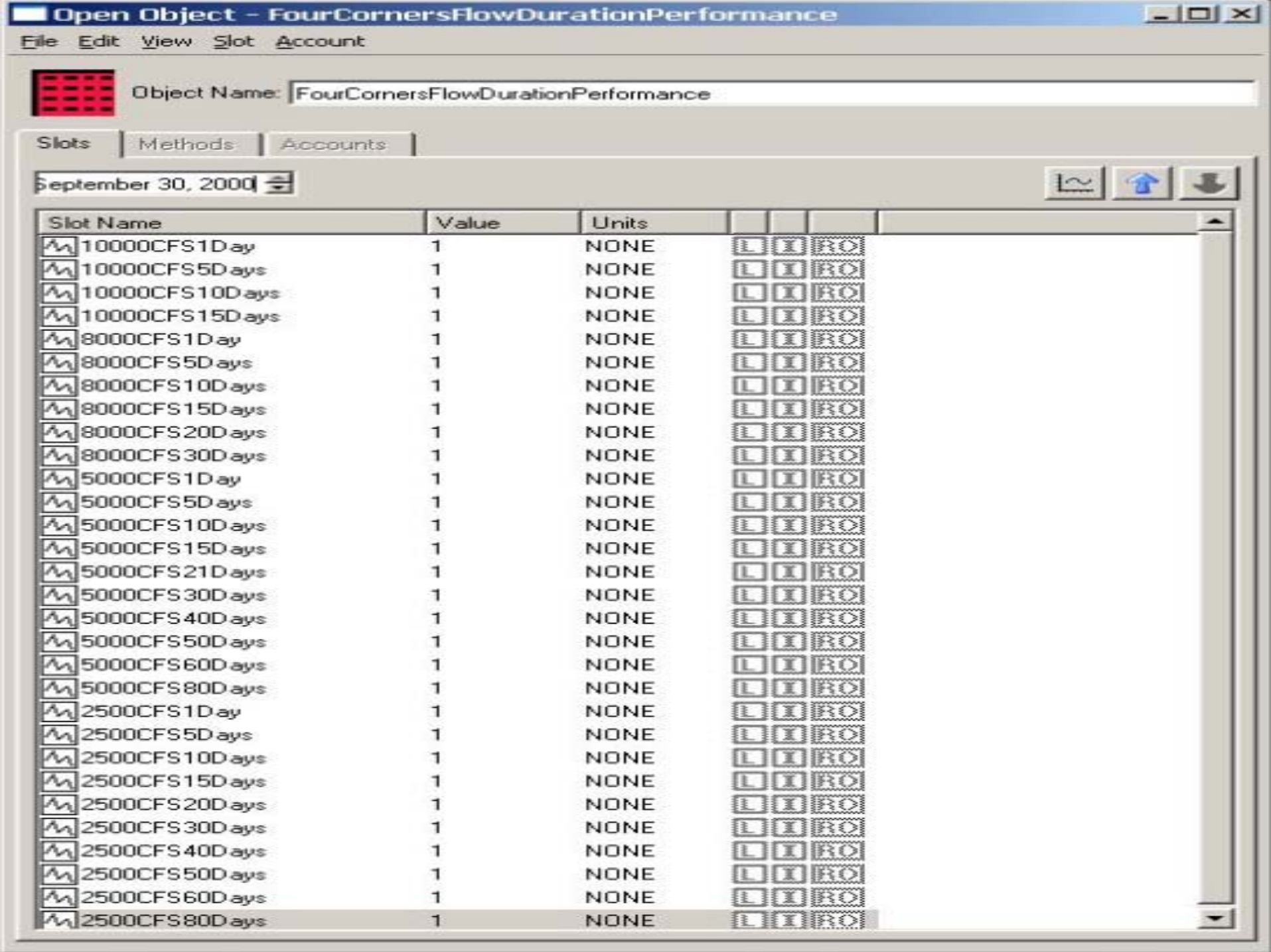
ThreeGage_Last7Days 505.65 cfs
MaxTwoGage_Performance 1 NONE
MaxTwoGage_Min7Day 506.26 cfs
MaxTwoGage_Last7Days 597.13 cfs
MinTwoGage_Performance 0 NONE
MinTwoGage_Min7Day 255.35 cfs
MinTwoGage_Last7Days 472.03 cfs
SJArch_GageMin 250.00 cfs
FourGage_MinMonthly 297.81 cfs
SJ4C_Last7Days 572.90 cfs
SJ4C_Min7Day 310.78 cfs
SJ4C_GageMin 4.79 cfs
SJ4C_Performance 0.00 NONE
SJ4C_MonthlyFlow 558.52 cfs
SJ4C_MinMonthly 405.10 cfs
SJFarm_Last7Days 467.17 cfs
SJFarm_Min7Day 227.32 cfs
SJFarm_GageMin 84.68 cfs
SJFarm_Performance 0 NONE
SJFarm_MonthlyFlow 469.22 cfs
SJFarm_MinMonthly 297.81 cfs
SJSR_Last7Days 476.89 cfs
SJSR_Min7Day 278.02 cfs
SJSR_GageMin 55.40 cfs
SJSR_Performance 0 NONE
SJSR_MonthlyFlow 454.25 cfs
SJSR_MinMonthly 341.50 cfs
L I RO

Return Period Performance

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September 30, 2000
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8000CFS1Day 1 NONE
8000CFS5Days 1 NONE
8000CFS10Days 1 NONE
8000CFS15Days 1 NONE
8000CFS20Days 1 NONE
8000CFS30Days 1 NONE
5000CFS1Day 1 NONE
5000CFS5Days 1 NONE
5000CFS10Days 1 NONE
5000CFS15Days 1 NONE
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2500CFS20Days 1 NONE
2500CFS30Days 1 NONE
2500CFS40Days 1 NONE
2500CFS50Days 1 NONE
2500CFS60Days 1 NONE
2500CFS80Days 1 NONE

Edit Slot: NavajoData.ForecastAndDecisionDates

File Row Column View

ForecastAndDecisionDates

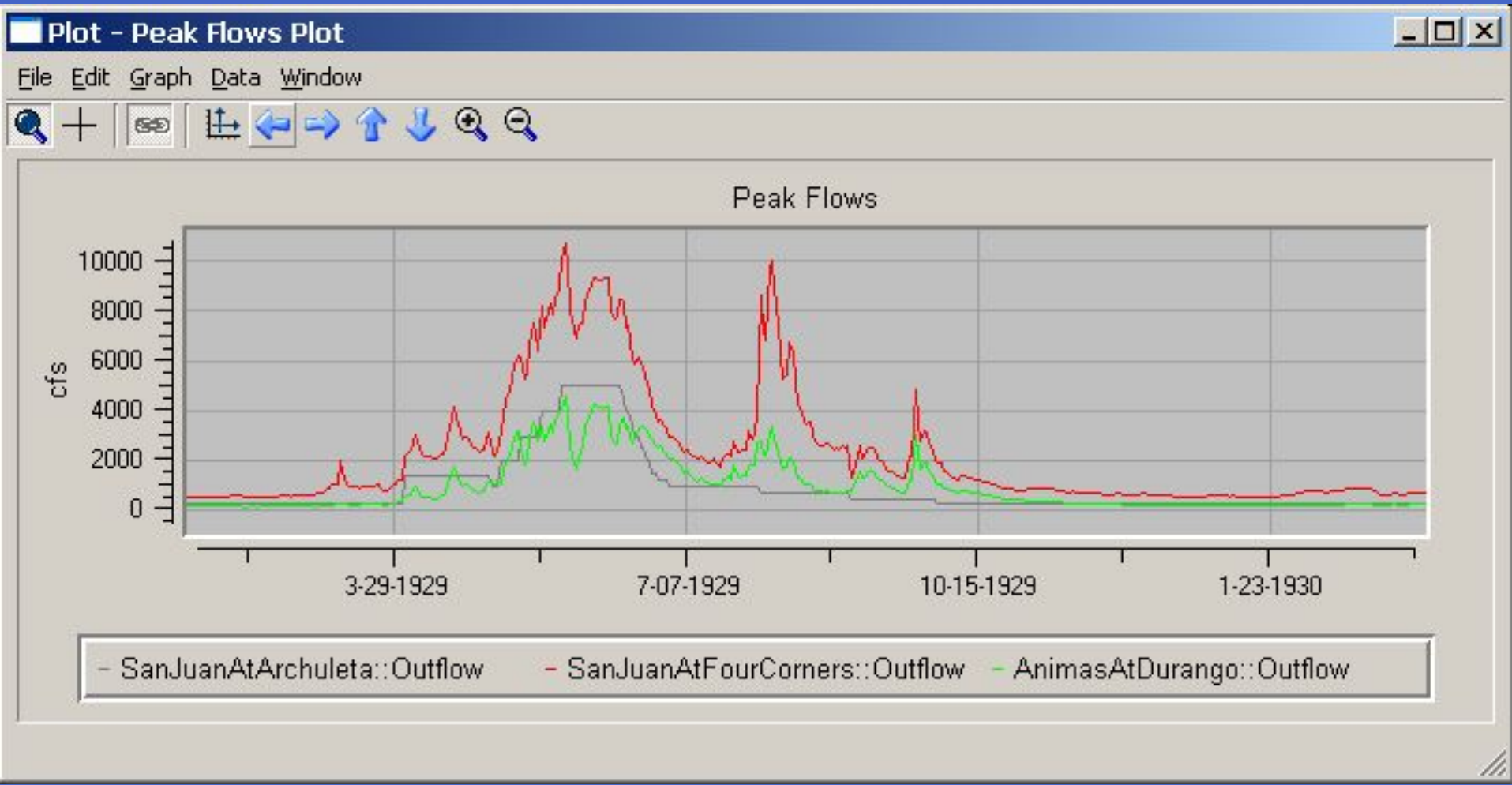
Units: NONE

	Forecasts	RIP	FloodControl	Normal
0:00 March 1	1	0	0	1
0:00 March 2	0	0	0	0
0:00 March 3	0	0	0	0
0:00 March 4	0	0	0	0
0:00 March 5	0	0	0	0
0:00 March 6	0	0	0	0
0:00 March 7	0	0	0	0
0:00 March 8	0	0	1	0
0:00 March 9	0	0	0	0
0:00 March 10	0	0	0	0
0:00 March 11	0	0	0	0
0:00 March 12	0	0	0	0
0:00 March 13	0	0	0	0
0:00 March 14	0	0	0	0
0:00 March 15	0	1	1	1
0:00 March 16	0	0	0	0
0:00 March 17	0	0	0	0
0:00 March 18	0	0	0	0
0:00 March 19	0	0	0	0
0:00 March 20	0	0	0	0
0:00 March 21	0	0	0	0
0:00 March 22	0	0	1	0
0:00 March 23	0	0	0	0
0:00 March 24	0	0	0	0
0:00 March 25	0	0	0	0
0:00 March 26	0	0	0	0
0:00 March 27	0	0	0	0
0:00 March 28	0	0	0	0
0:00 March 29	0	0	1	0
0:00 March 30	0	0	0	0
0:00 March 31	0	0	0	0
0:00 April 1	1	1	1	1
0:00 April 2	0	0	0	0
0:00 April 3	0	0	0	0
0:00 April 4	0	0	0	0

Interpolate Lookup

Annual Period, Irregular Interval

Peak Flows Flow



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