Colorado River Water Availability Study

CWCB Workshop

Centennial Water & Sanitation District / Metro District of Highlands Ranch

April 8, 2010

Consulting Team

AECOM

AMEC Earth & Environmental

Canyon Water Resources

Leonard Rice Engineers

Stratus Consulting

BOYLE | AECOM

Objectives

"How much water from the Colorado River Basin is available to meet Colorado's water needs?"

- What is a reasonable base of existing uses for Phase I of the CRWAS?
- How does historical hydrology compare to paleohydrology?
- What is a reasonable projection for hydrology affected by climate change?
- How much water is available to Colorado under certain compact assumptions?

Objectives

"How much water from the Colorado River Basin is available to meet Colorado's water needs?"

- **Phase I**
  Water Availability under current infrastructure, currently perfected water rights, and current levels of consumptive and non-consumptive water demands

- **Phase II**
  Water Availability under projected demands from existing, conditional, and new water rights and for additional consumptive and non-consumptive water demands

Technical Approach

"How much water from the Colorado River Basin is available to meet Colorado's water needs?"

- Update / expand CDSS based on stakeholder input through BRTs
- Assess water availability using historical hydrology
- Assess water availability using paleohydrology
- Assess water availability using climate-adjusted hydrology
- Compare water availability from historical and climate-adjusted hydrology
- Estimate water available to Colorado under certain compact assumptions

Public Outreach

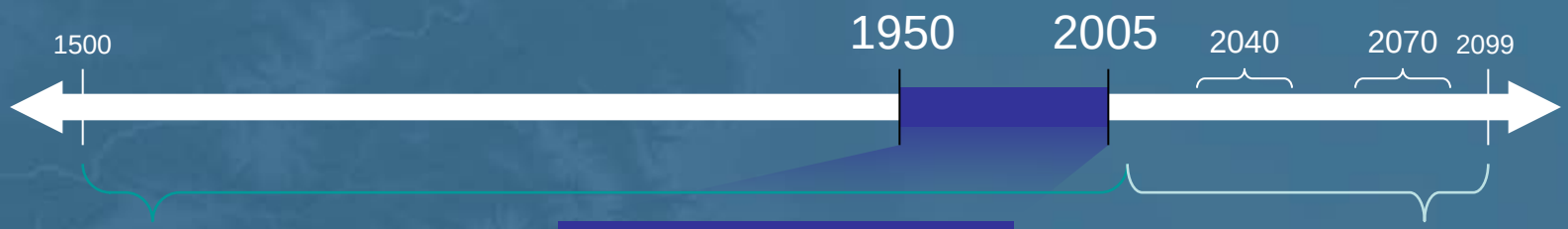
~30 public meetings / workshops / peer reviews

- CWCB Board
- CWCB, DWR, and AG Staff
- CWCB Climate Change Technical Advisory Group (CCTAG)
- Interbasin Compact Committee (IBCC) and Basin Roundtables (BRTs)
- Joint Front Range Climate Change Vulnerability Study Program (JFRCCVS)
- Centennial Water & Sanitation District / Metro District of Highlands Ranch
- NOAA Regional Integrated Sciences and Assessments Program (RISA)
- University of Colorado's Western Water Assessment Program (WWA)
- Northern Colorado Water Conservancy District (Water User Meeting)
- Colorado River Water Conservation District (Annual Seminar)
- Colorado House-Senate Joint Agriculture Committee
- Front Range Water Council
- Colorado Water Congress

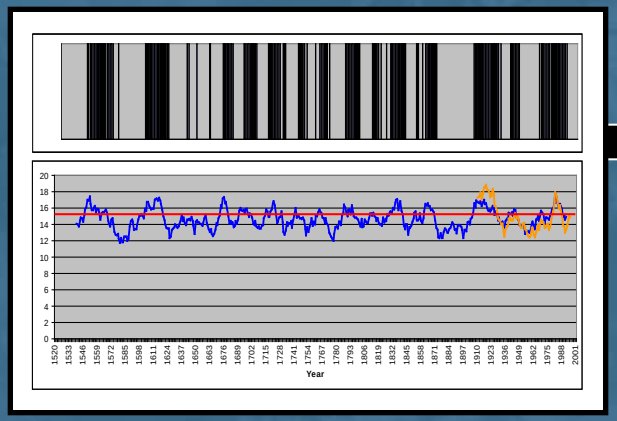
Analysis Tools

- Variable Infiltration Capacity (VIC) Hydrology Model
- Colorado Decision Support System (CDSS)
- Colorado River Simulation System (CRSS)
- Hydrologic Determination Mass Balance Analysis

Overall Hydrology Approach

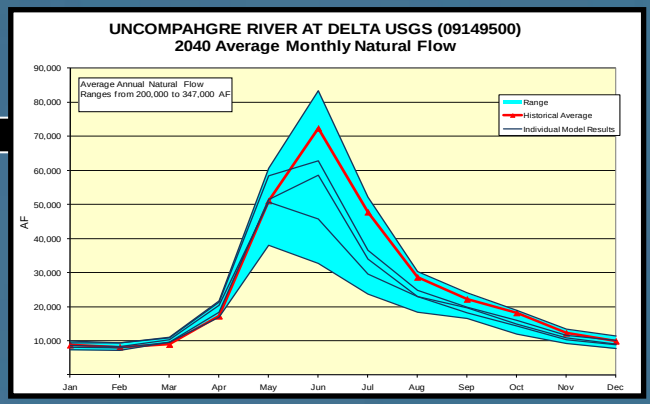


Paleohydrology

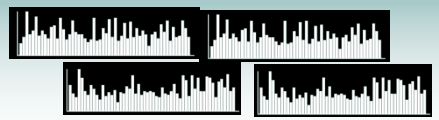


Observed Hydrology

GCM's & Hydrology



Statistical Models



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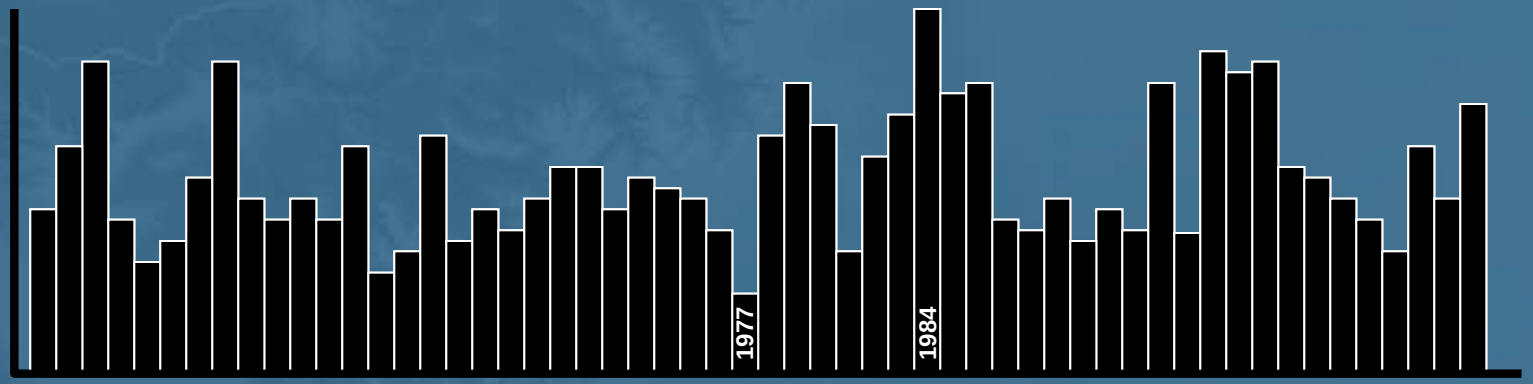
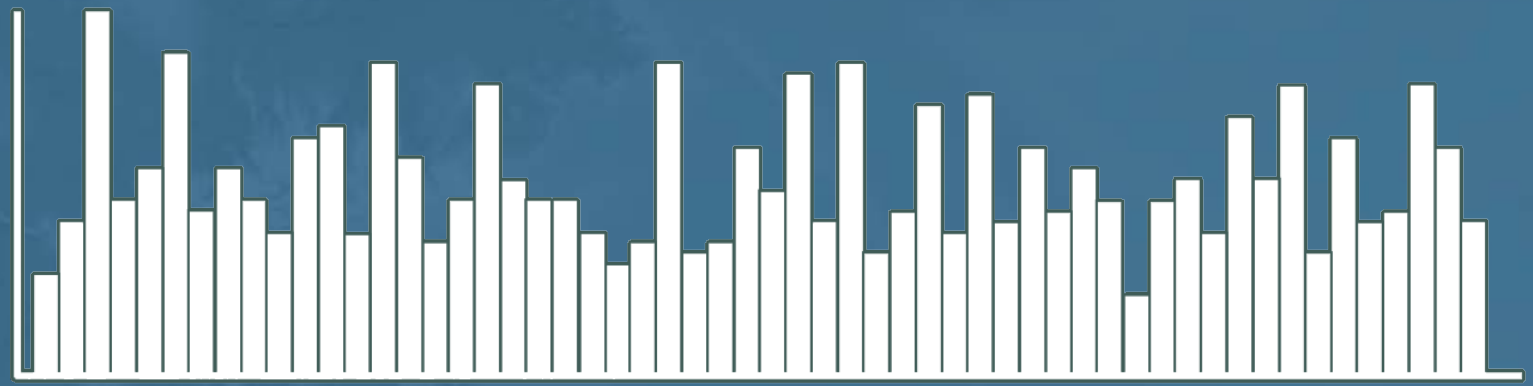
Paleohydrology – Re-sequencing





1950 Years 2005

1.

Repeat 100x

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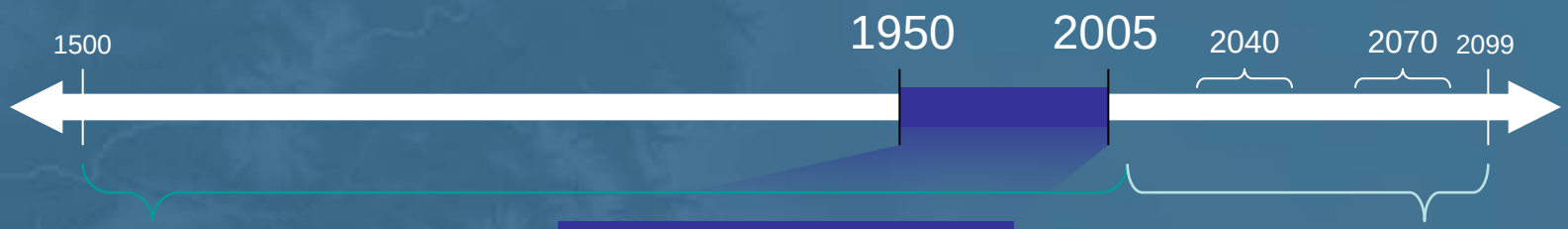

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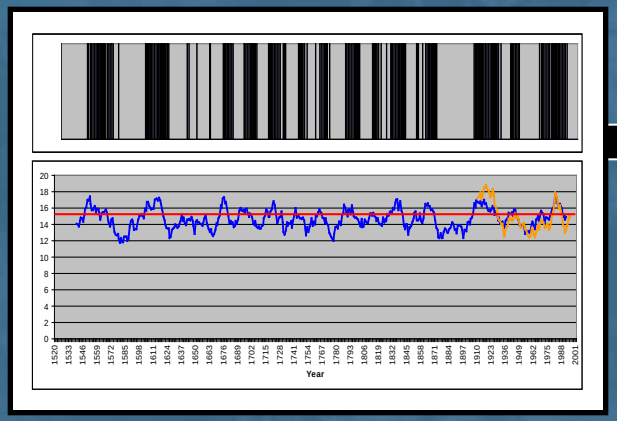

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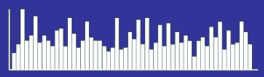

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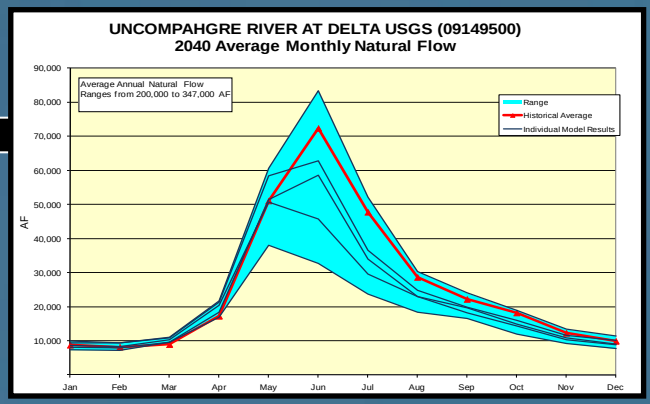

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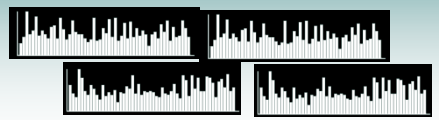

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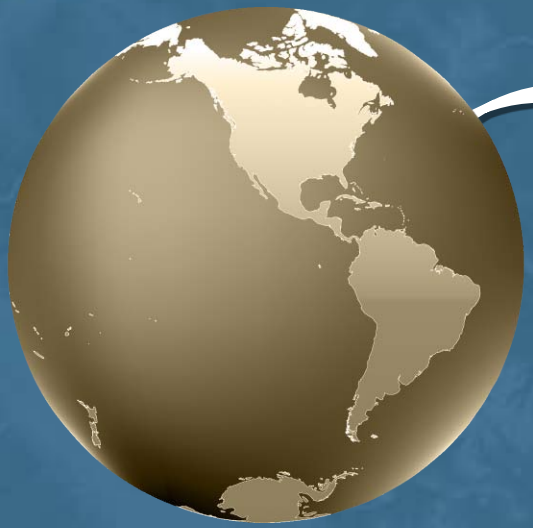
GCMs and Hydrology



Earth

- Emissions Scenarios
- Global Climate Models

Result: *Altered Temperature and Precipitation*

Colorado River Basin

- "Down-Scaled" Projections
- Revised Basin-Wide Hydrology

Result: *Altered Stream Flows*

State of Colorado

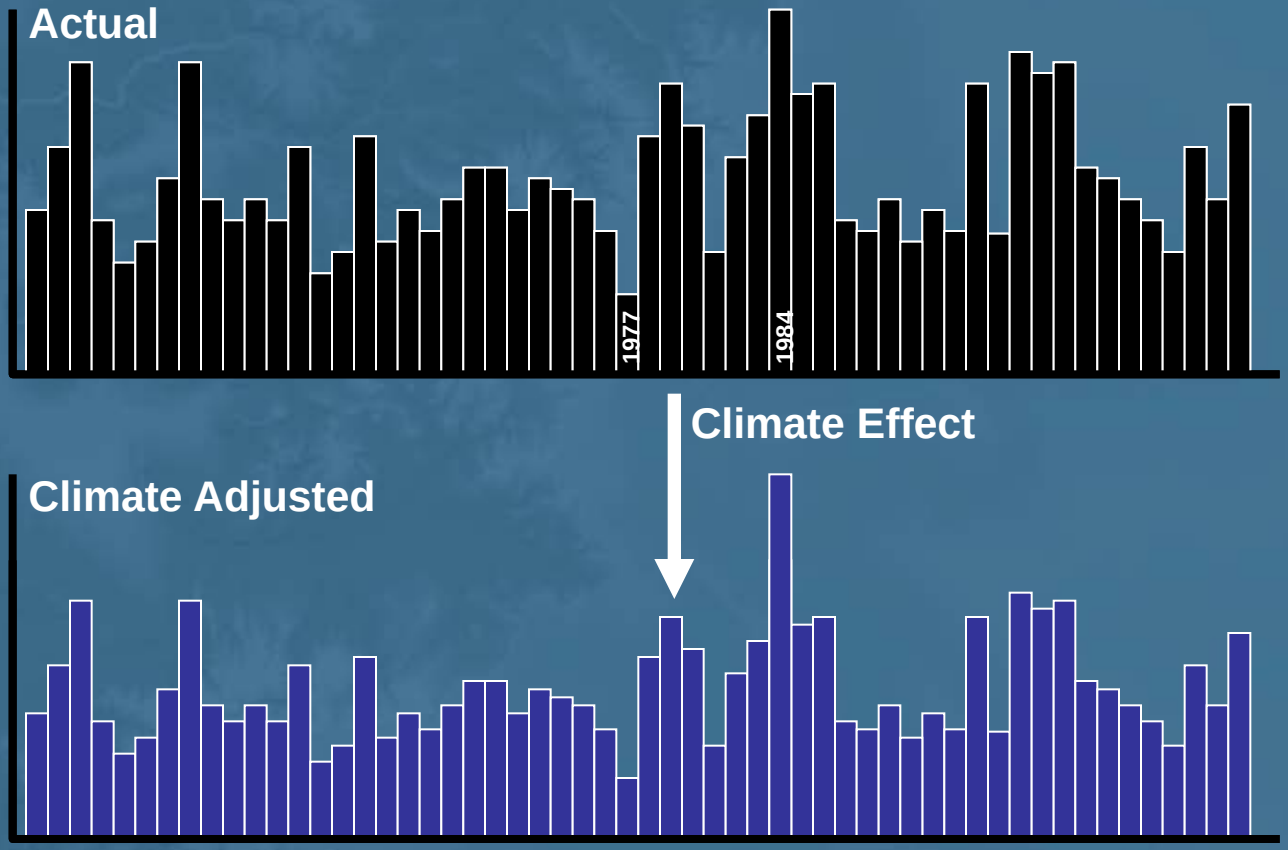
- CDSS Modeling

Result: *Water Availability*

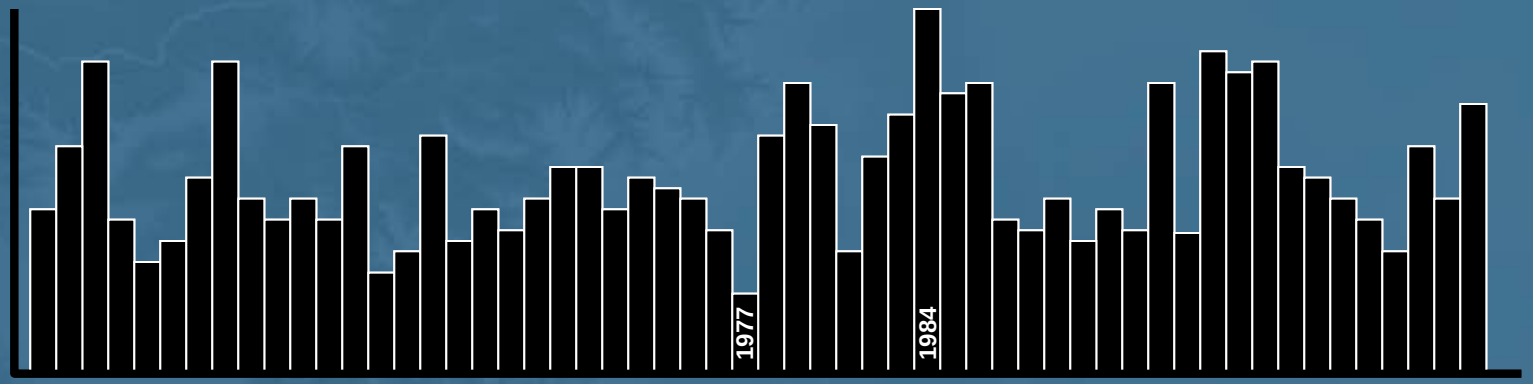
Climate Change: Selection of Projections

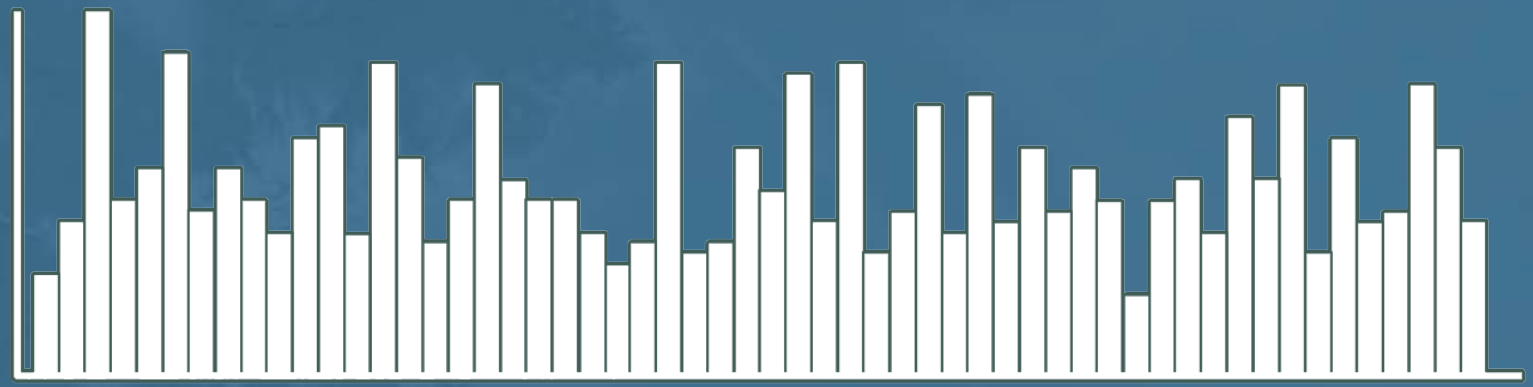
- CRWAS coordinated with Front Range Study
- Two time frames jointly selected (2040 / 2070)
- Five projections jointly selected to characterize projected climate for each time frame

GCM Hydrology Process



Re-sequencing Climate Adjusted Hydrology





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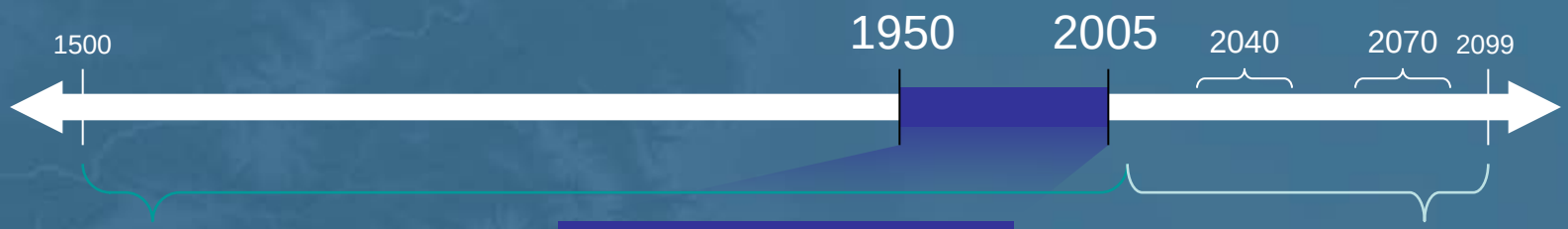

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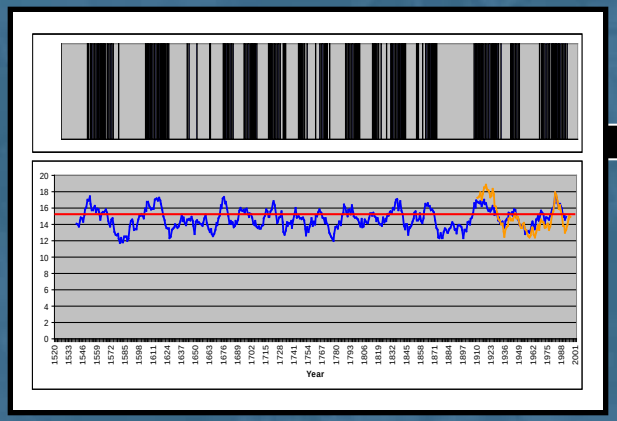

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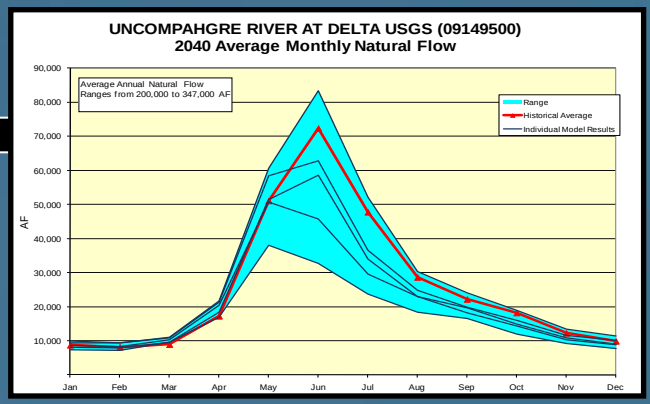

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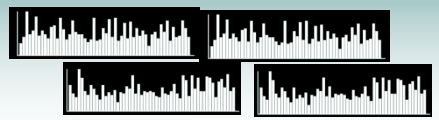

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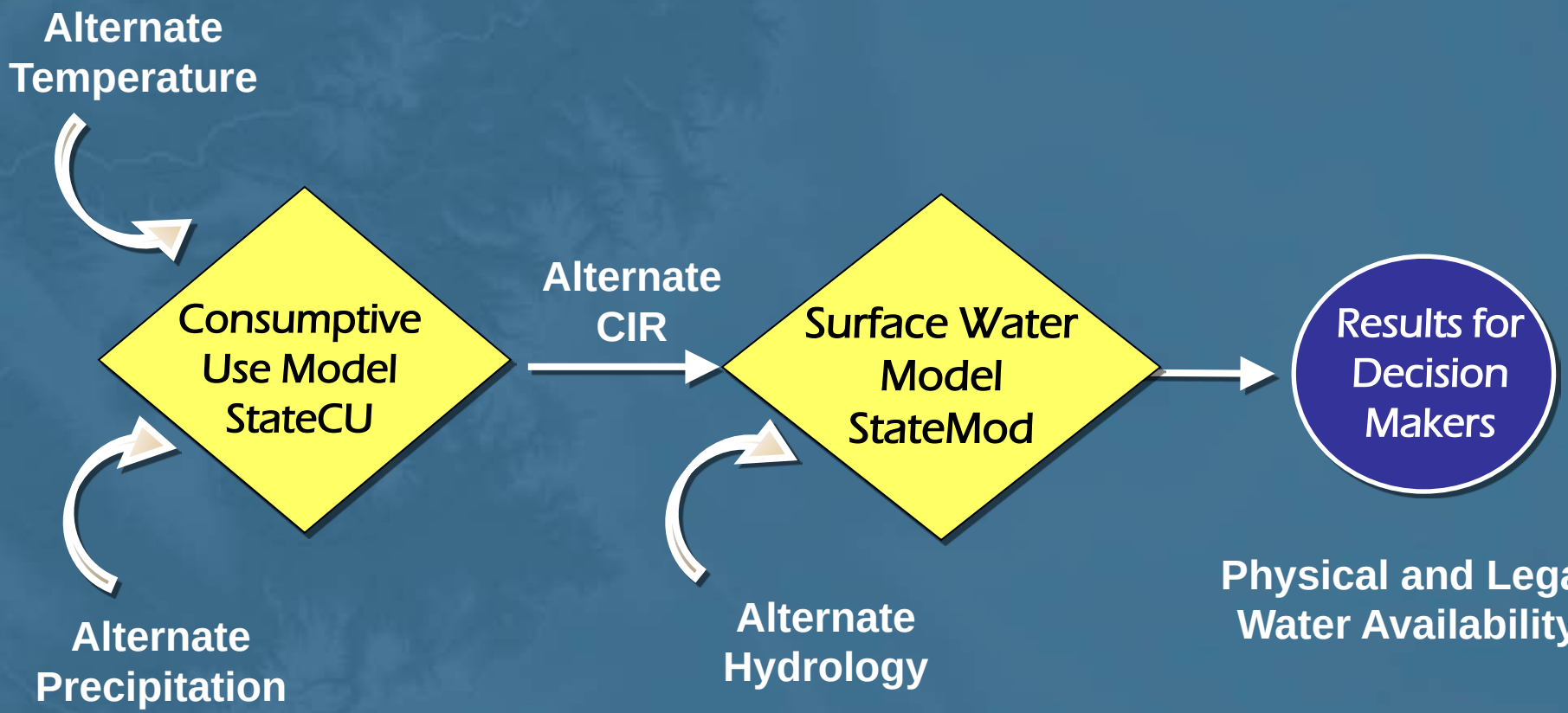
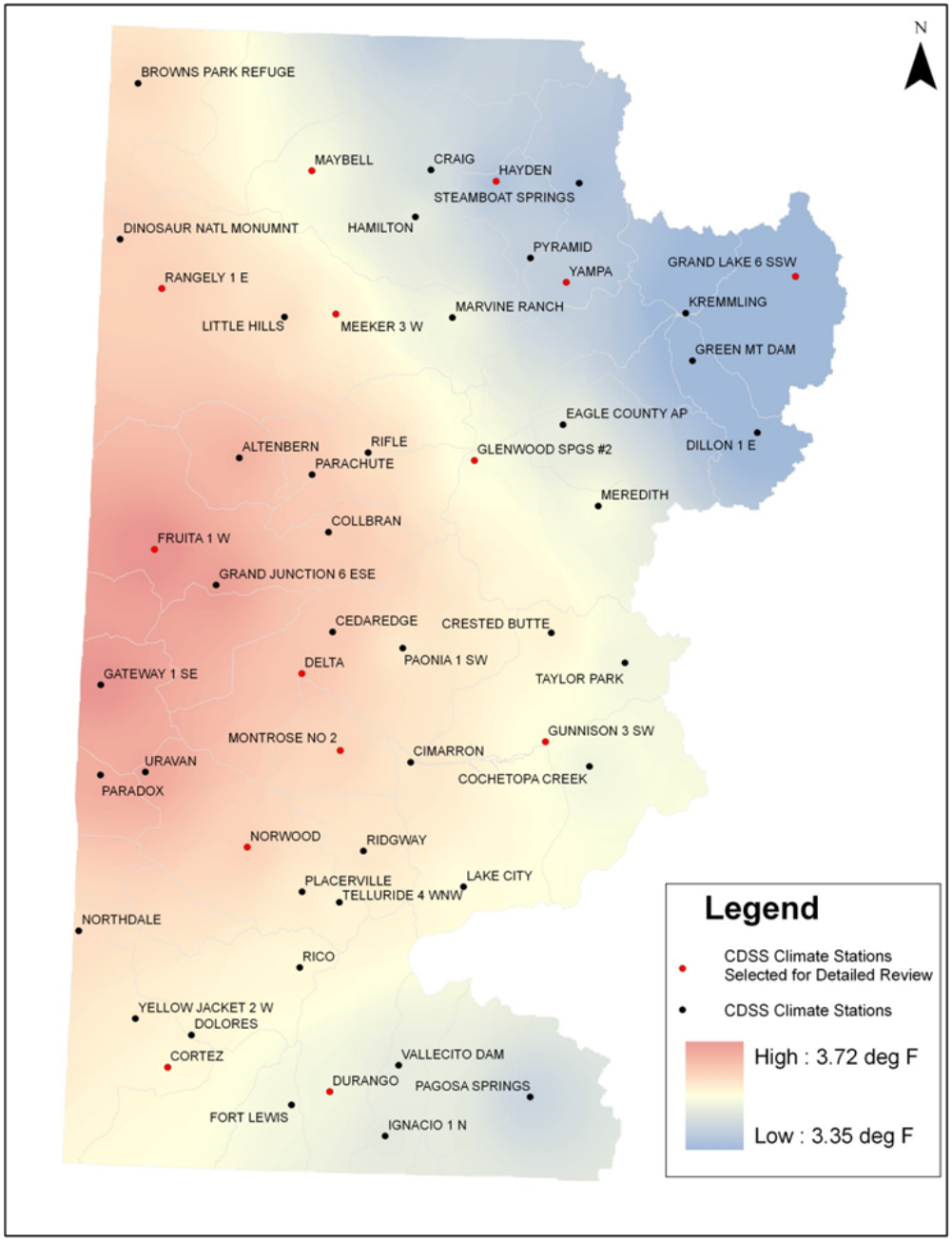
Final Step – Estimating Water Availability



Findings - Temperature

- Increases basin-wide by 3.3 to 3.7 degrees F
- Lower elevations show largest increase
- Increase occurs each month of the year



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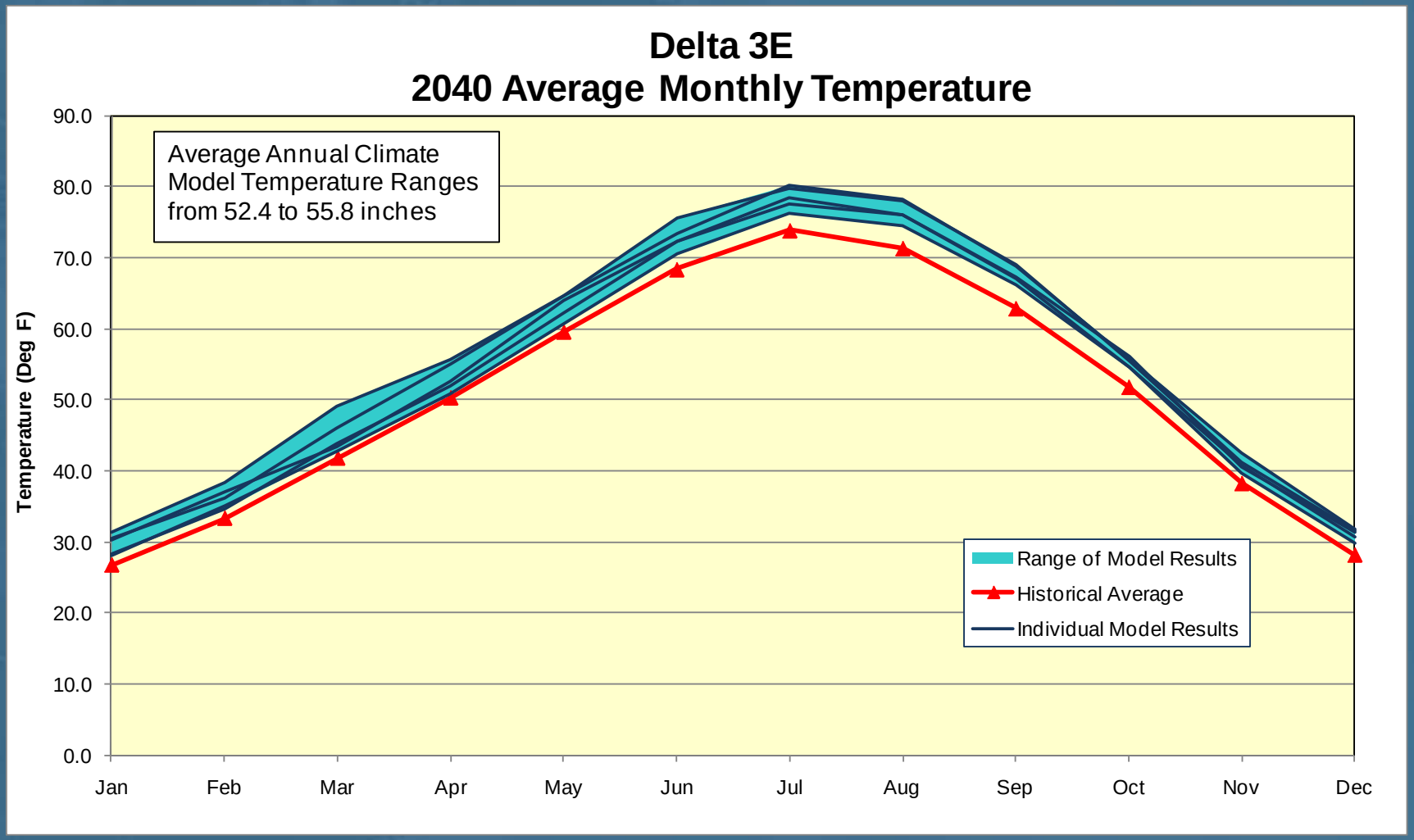
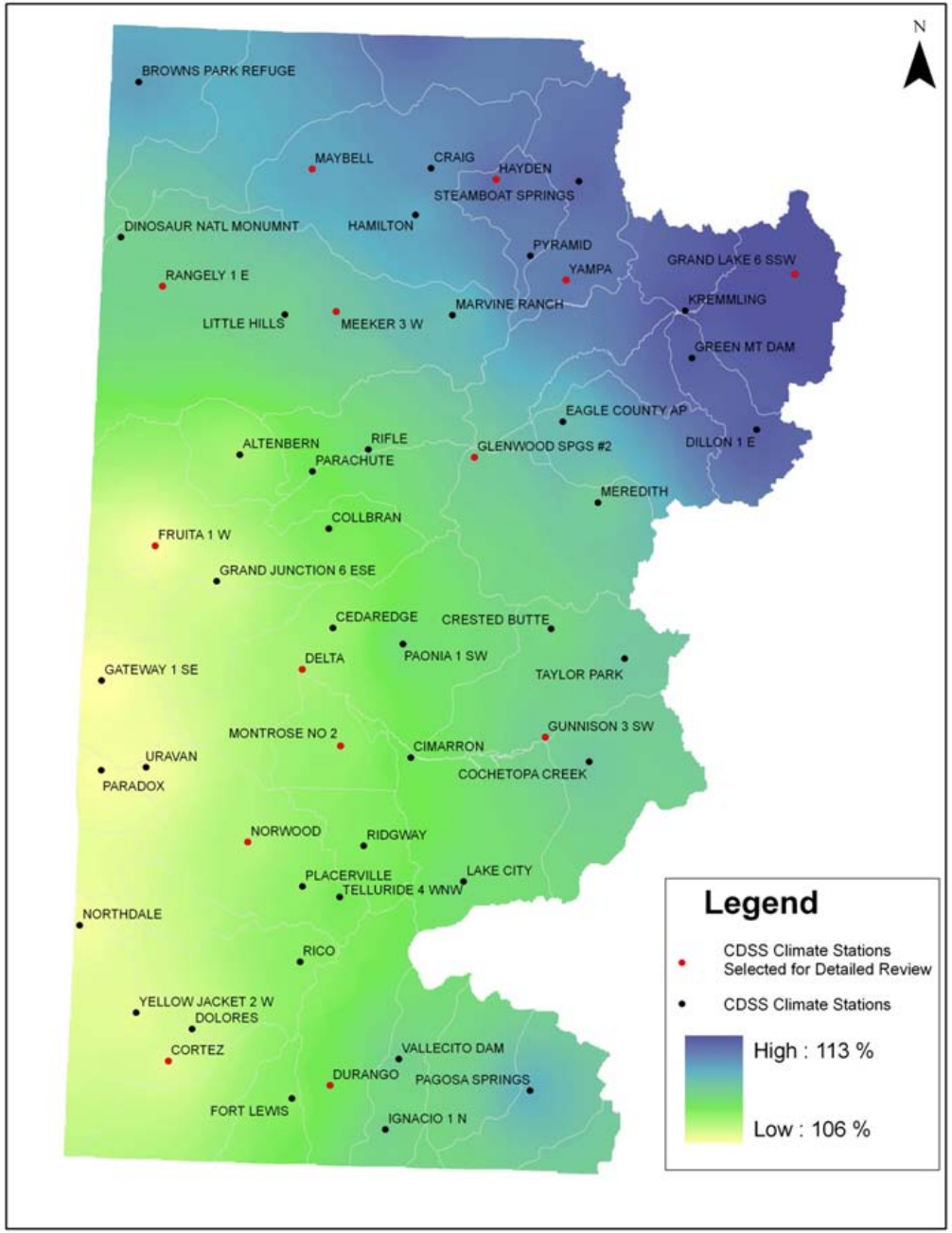


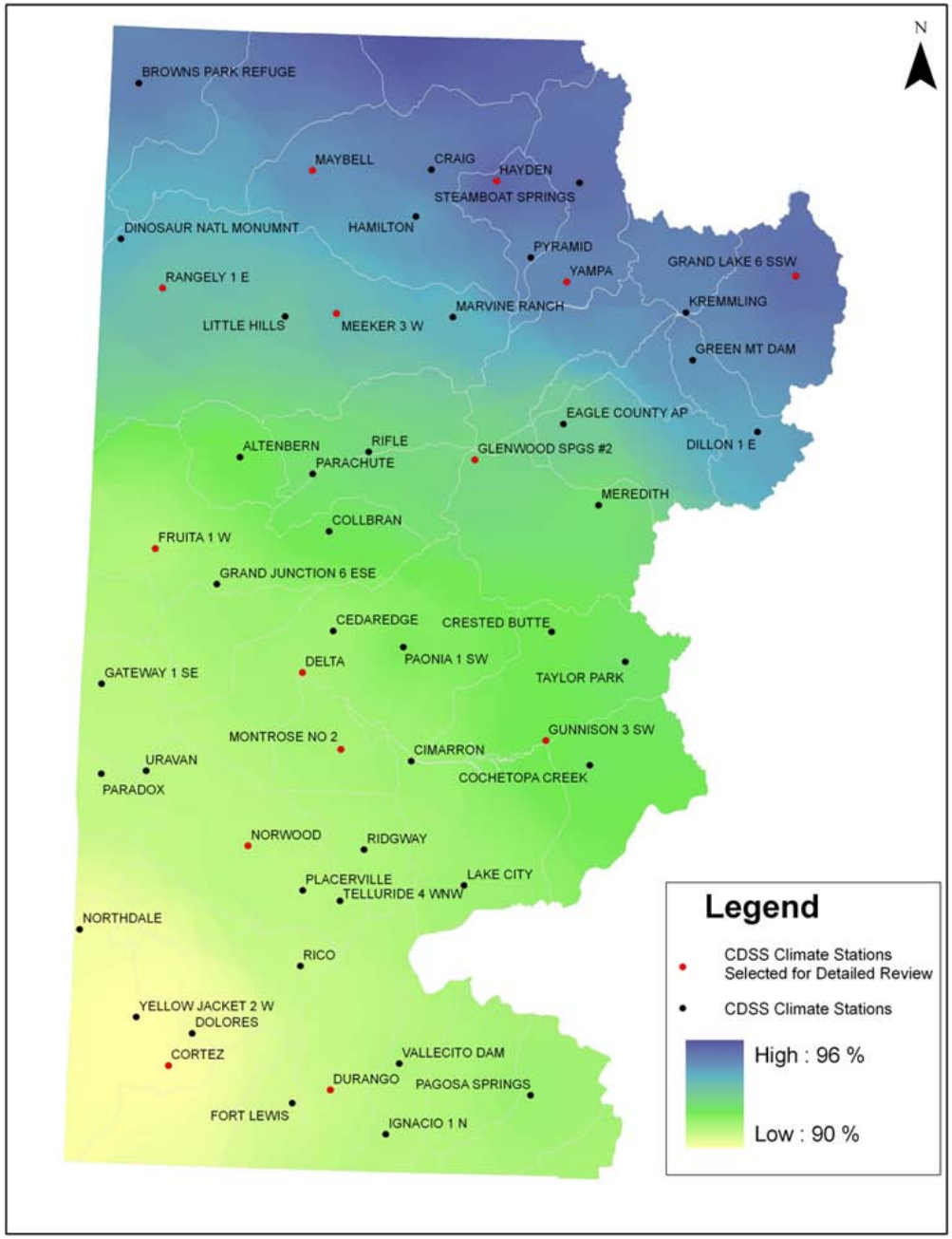
Findings - Winter Precipitation (Nov-Mar)

- Increases basin-wide by 6 to 13 percent
- Increases more in the northern part of the river basin
- Increases more at higher elevations
- Shifts from snow to rain in the shoulder months



Findings - Summer Precipitation (Apr-Oct)

- Decreases basin-wide by 4 to 10 percent
- Decreases more in the southern part of the basin
- Decreases less at higher elevations



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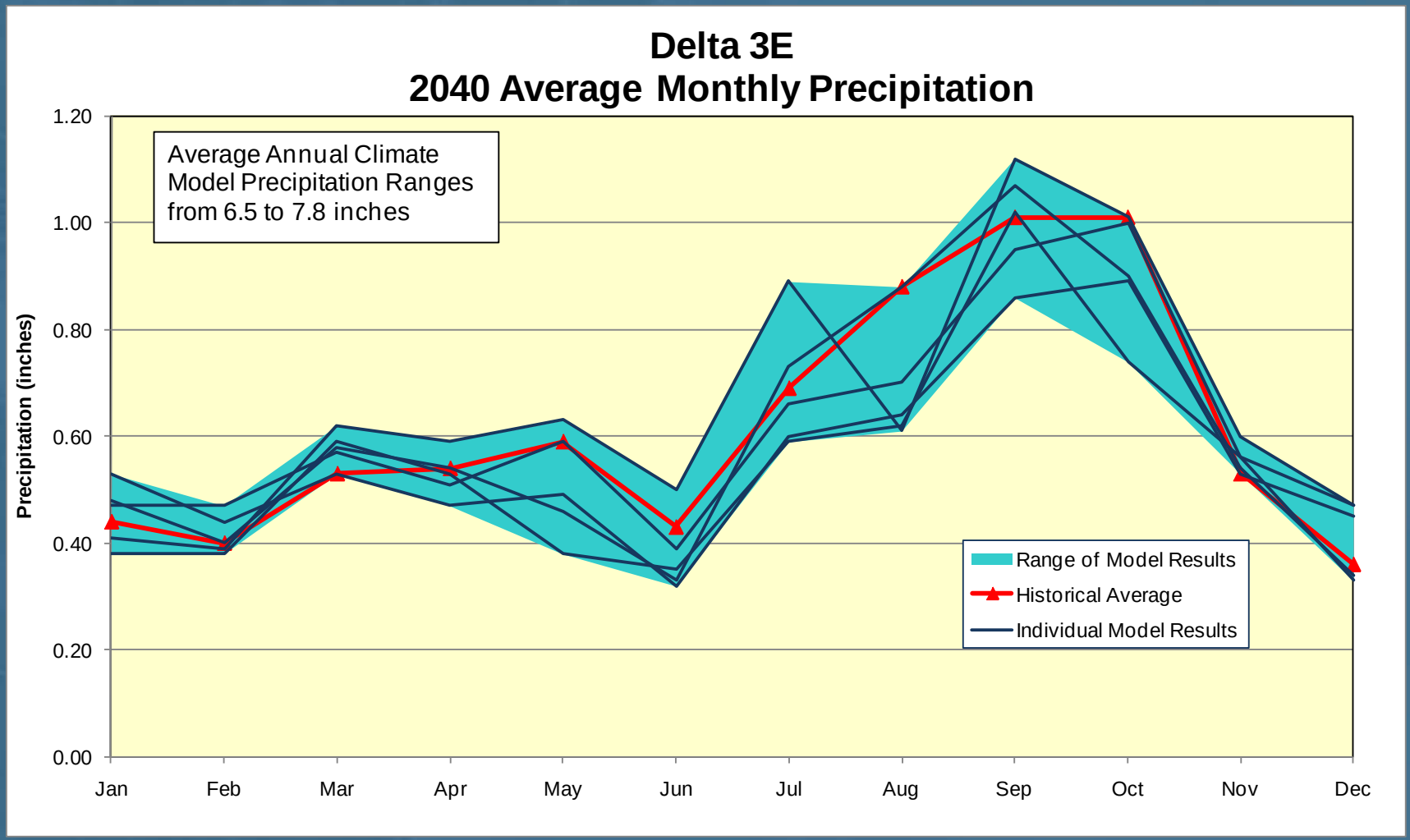
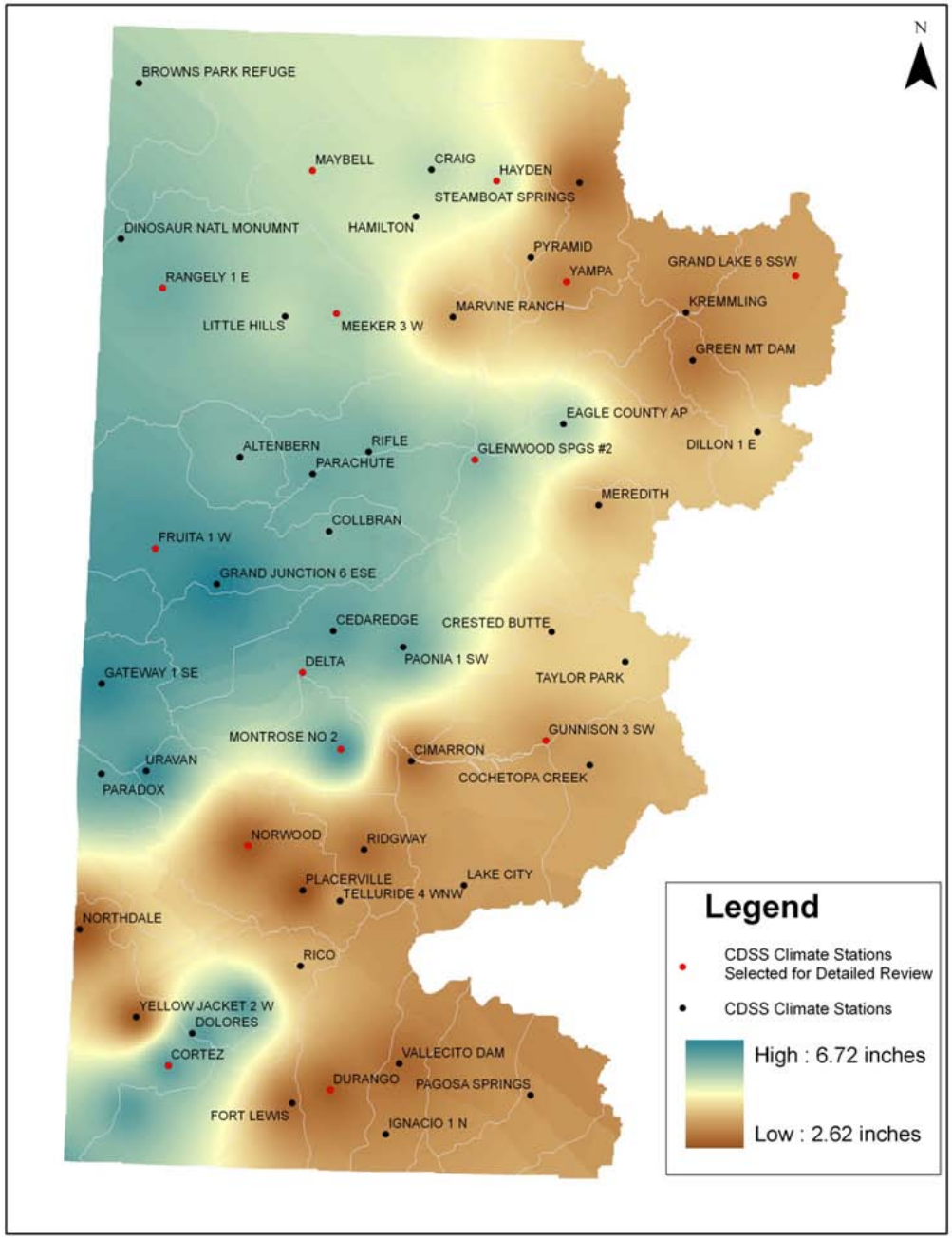


Findings - Crop Irrigation Requirement

- Increases basin-wide 2.6 to 6.7 in/yr for pasture grass
- Increases basin-wide by 20 %
- Growing season increases basin-wide by 15 to 22 days
- Increases more at lower elevations



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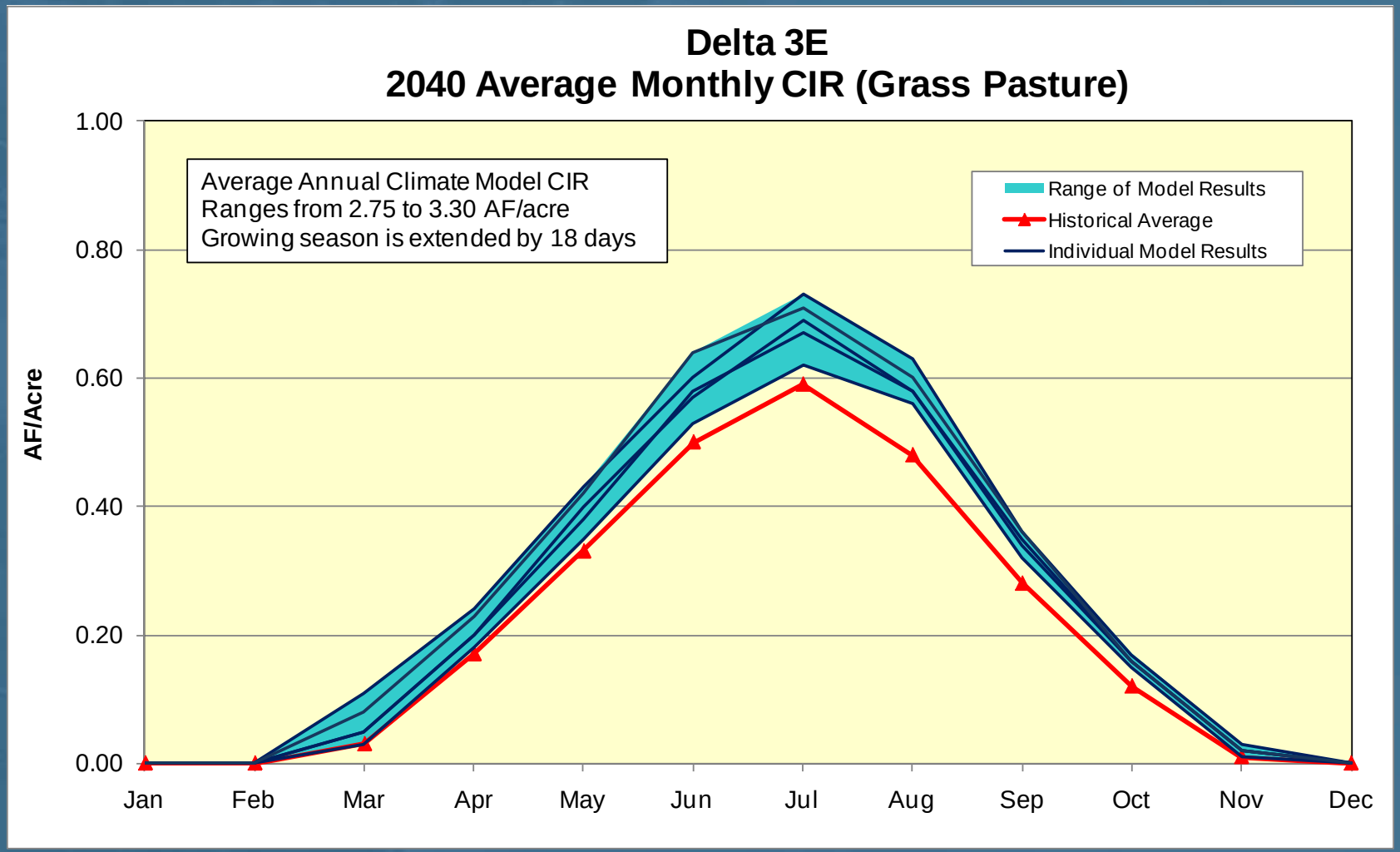
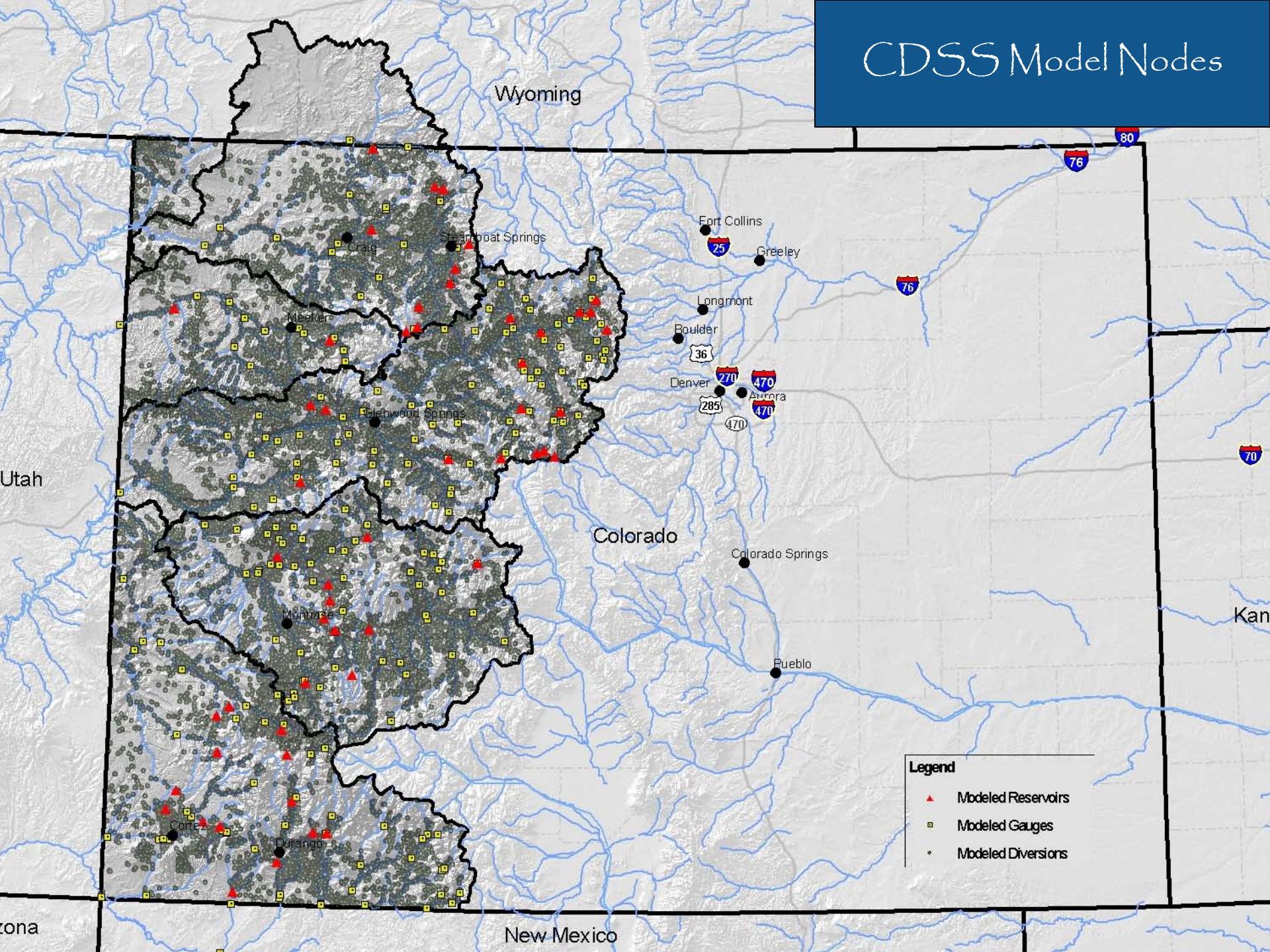
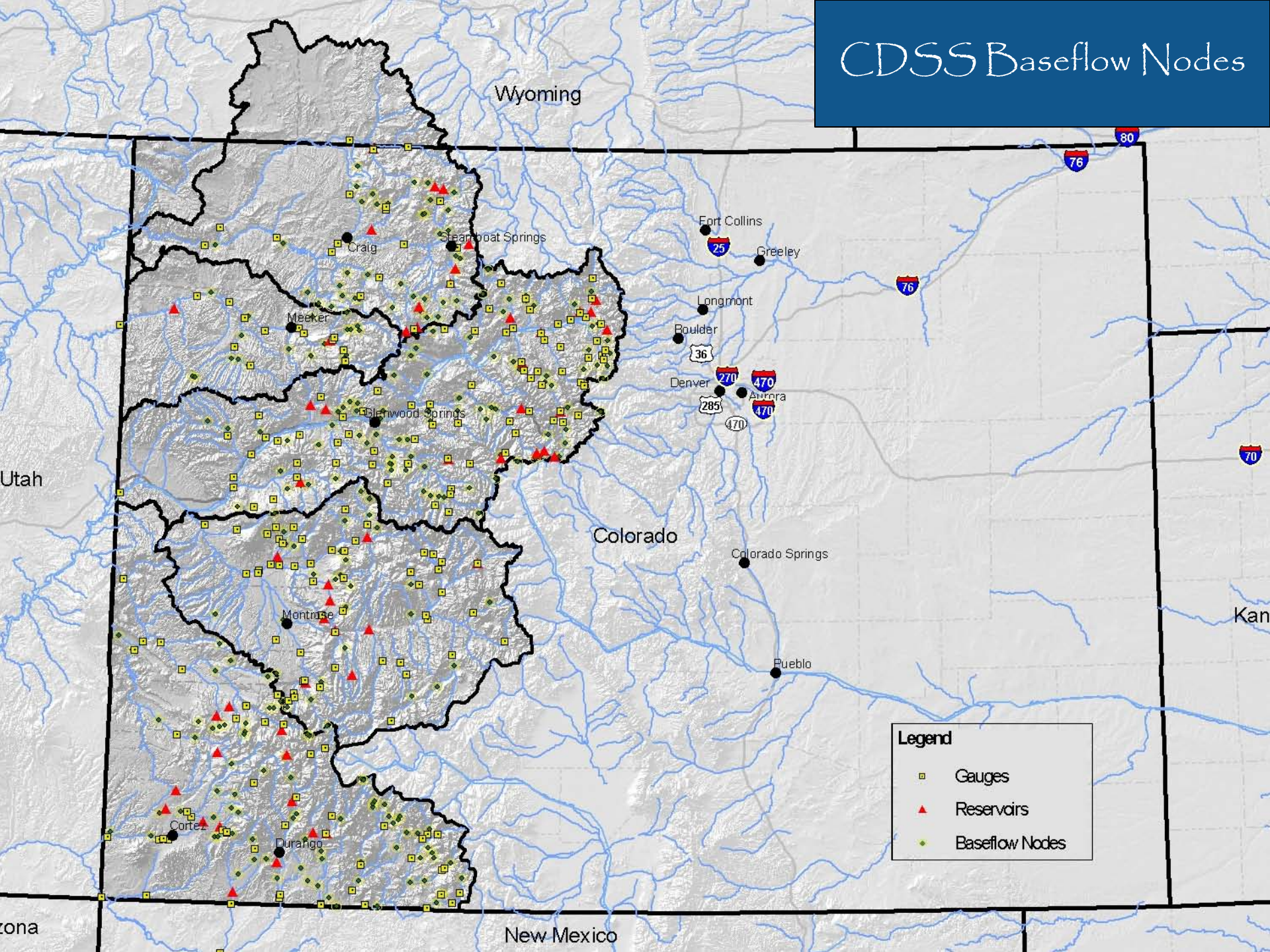


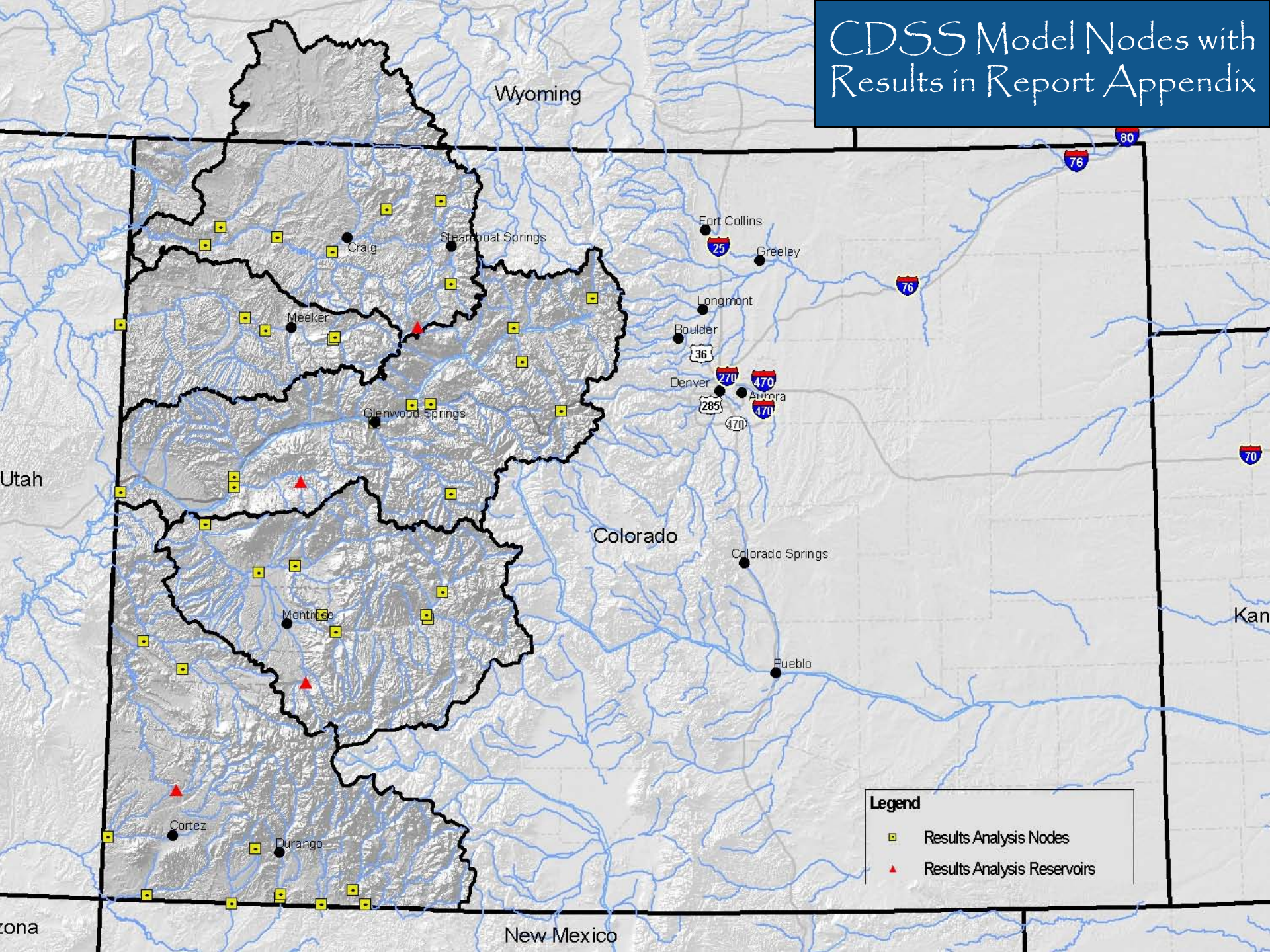
CDSS Model Nodes



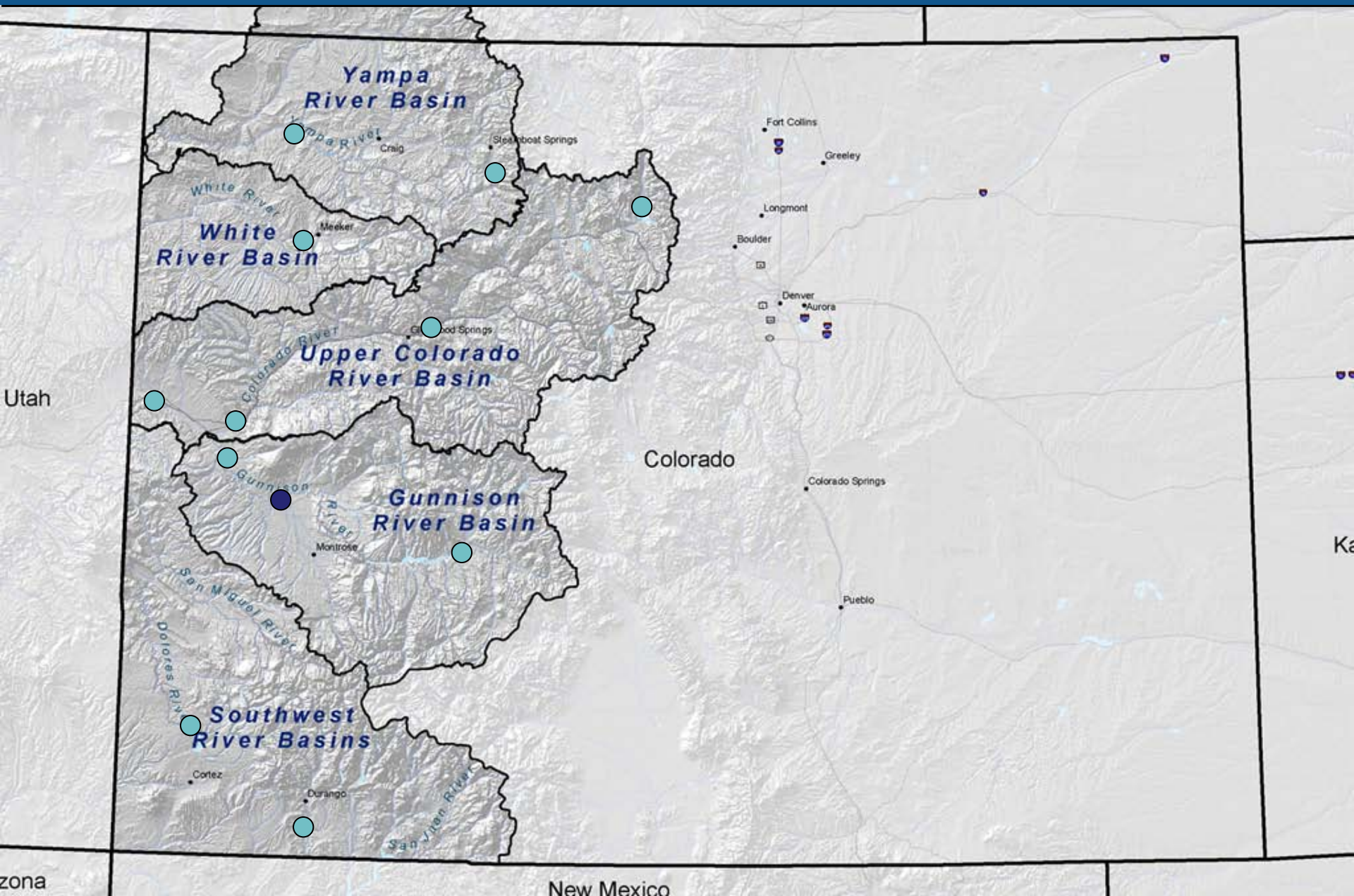
CDSS Baseflow Nodes



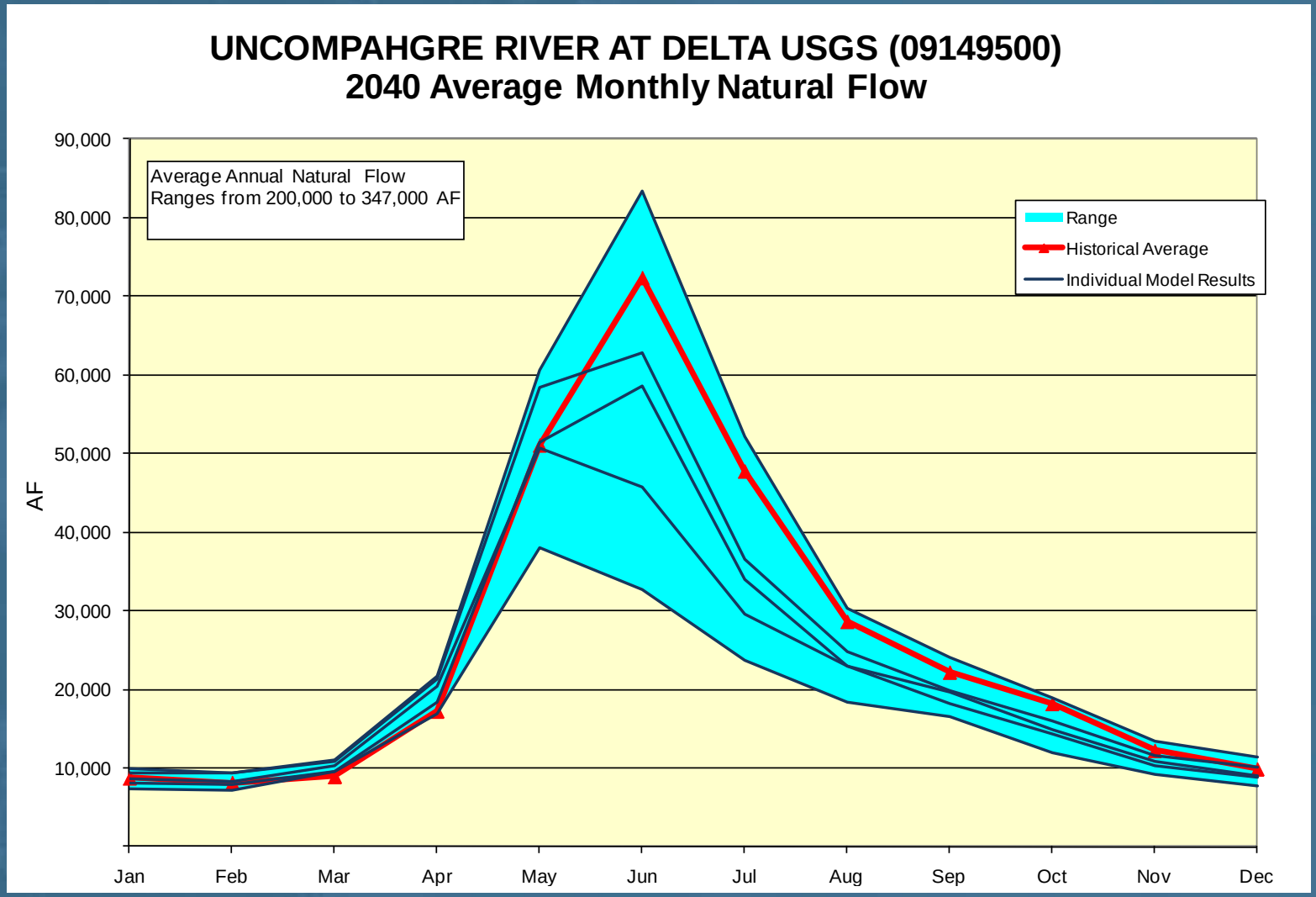
CDSS Model Nodes with Results in Report Appendix



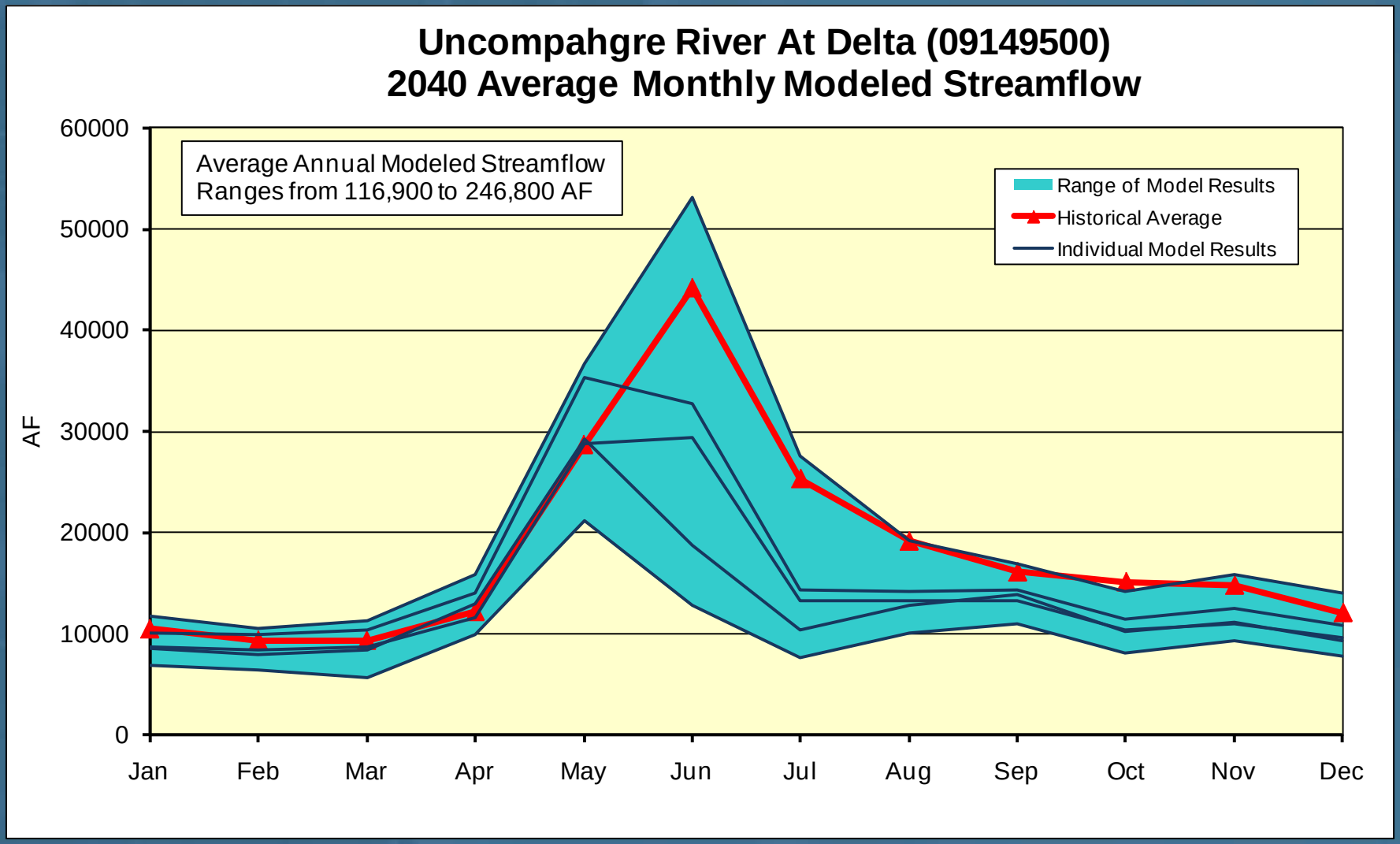
Sequence of Results: Uncompahgre River at Delta and Gunnison River Basin



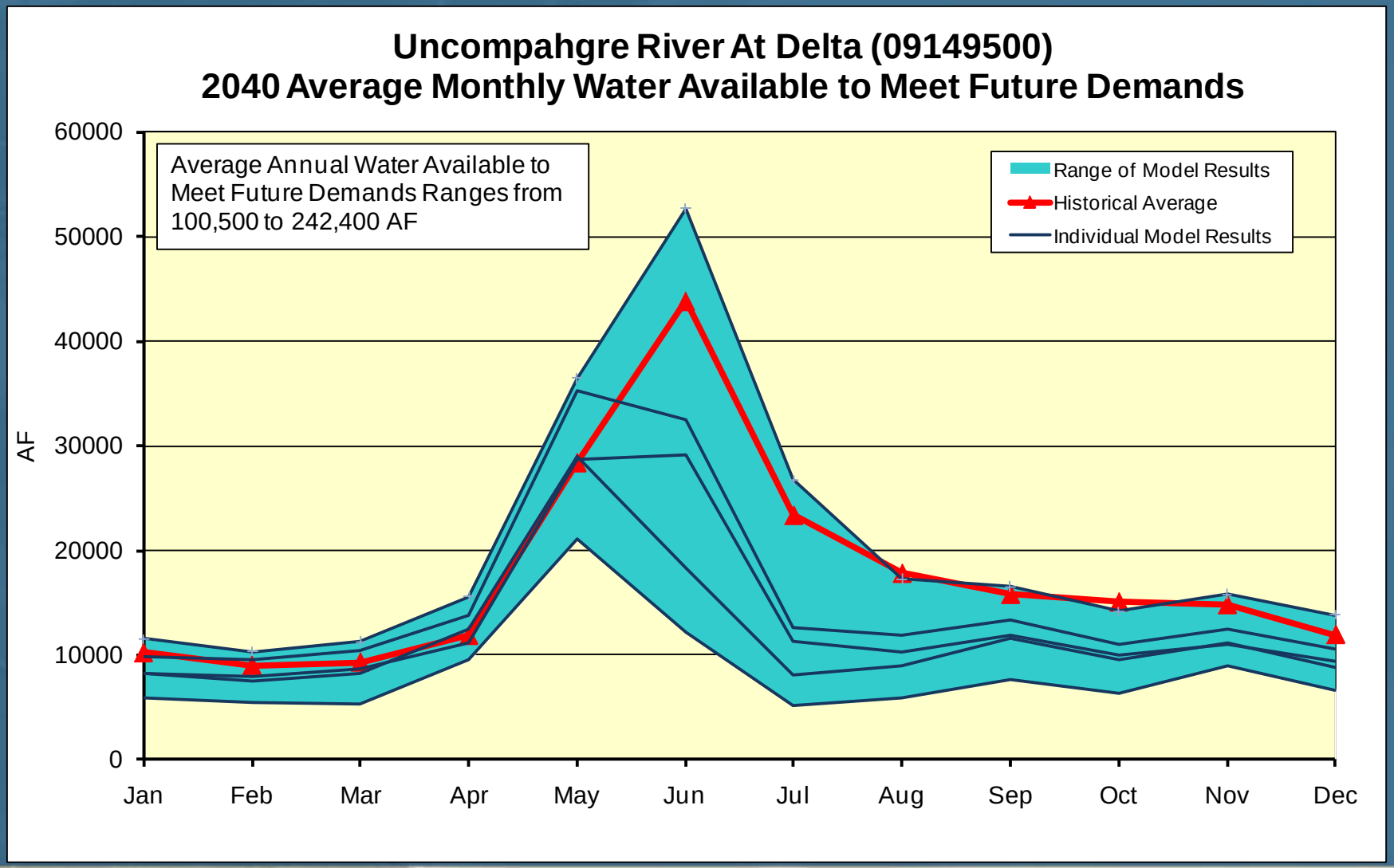
Natural Flow



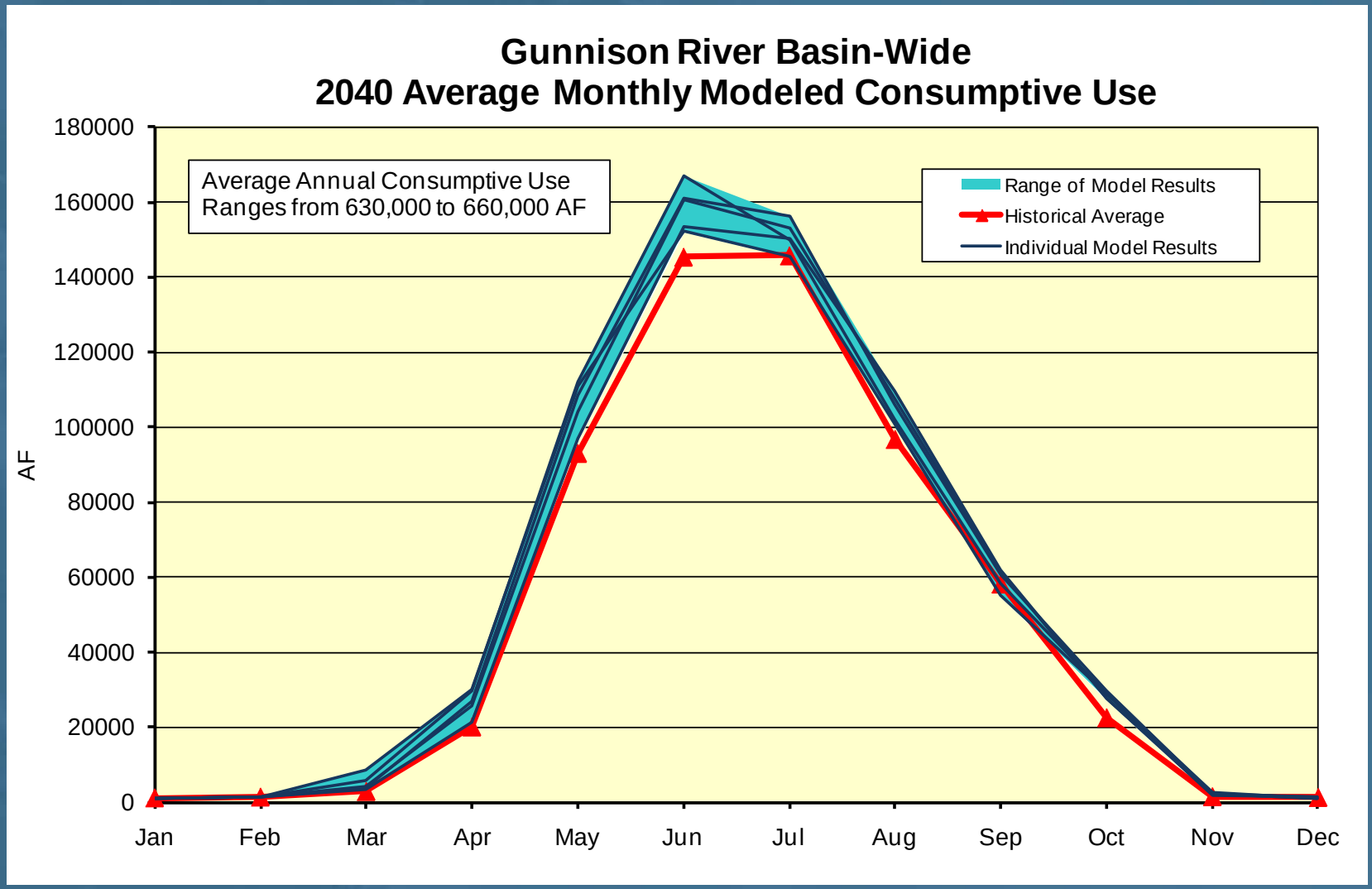
Modeled Streamflow



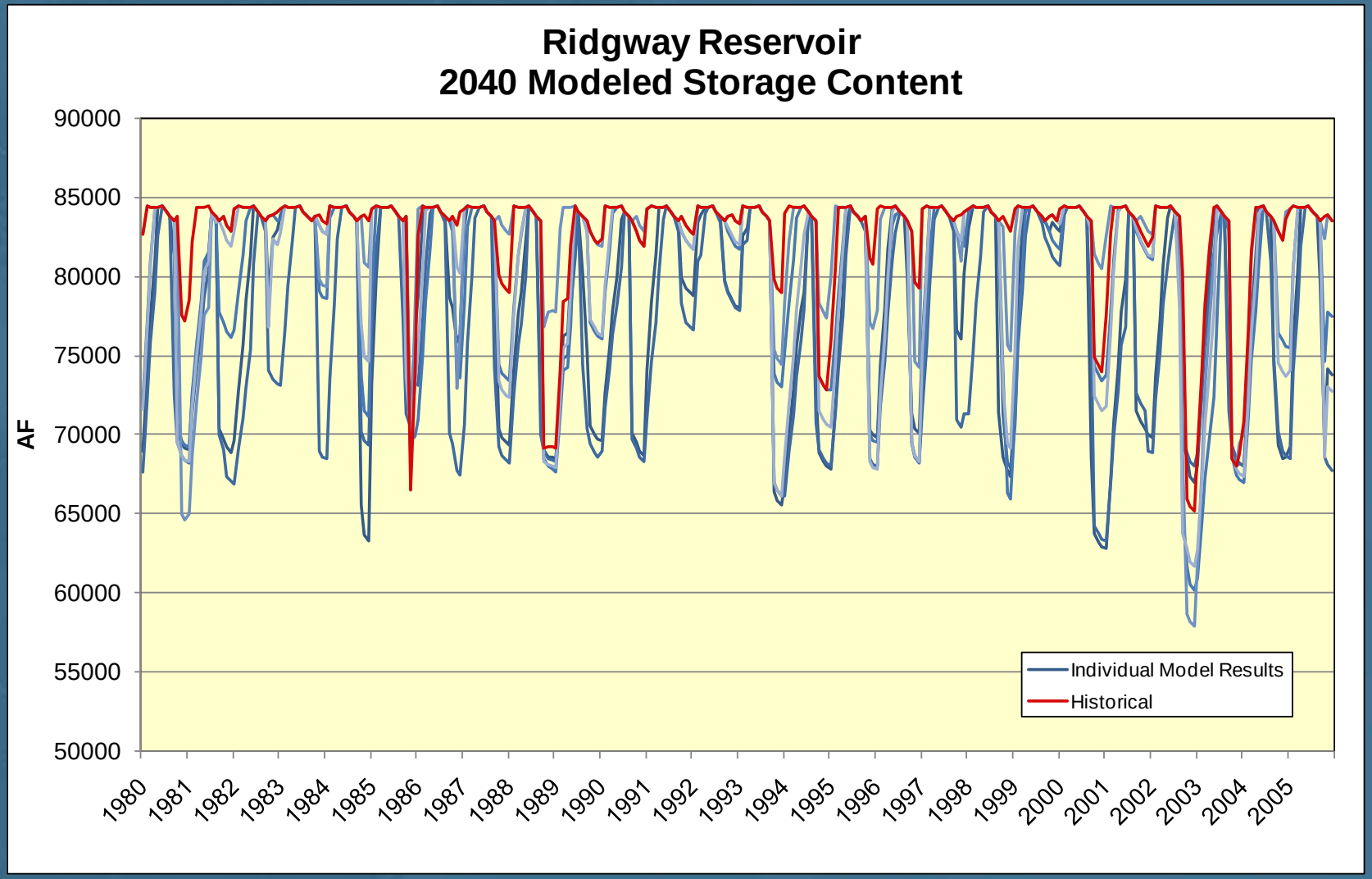
Water Availability



Modeled Consumptive Use



Modeled Reservoir Storage



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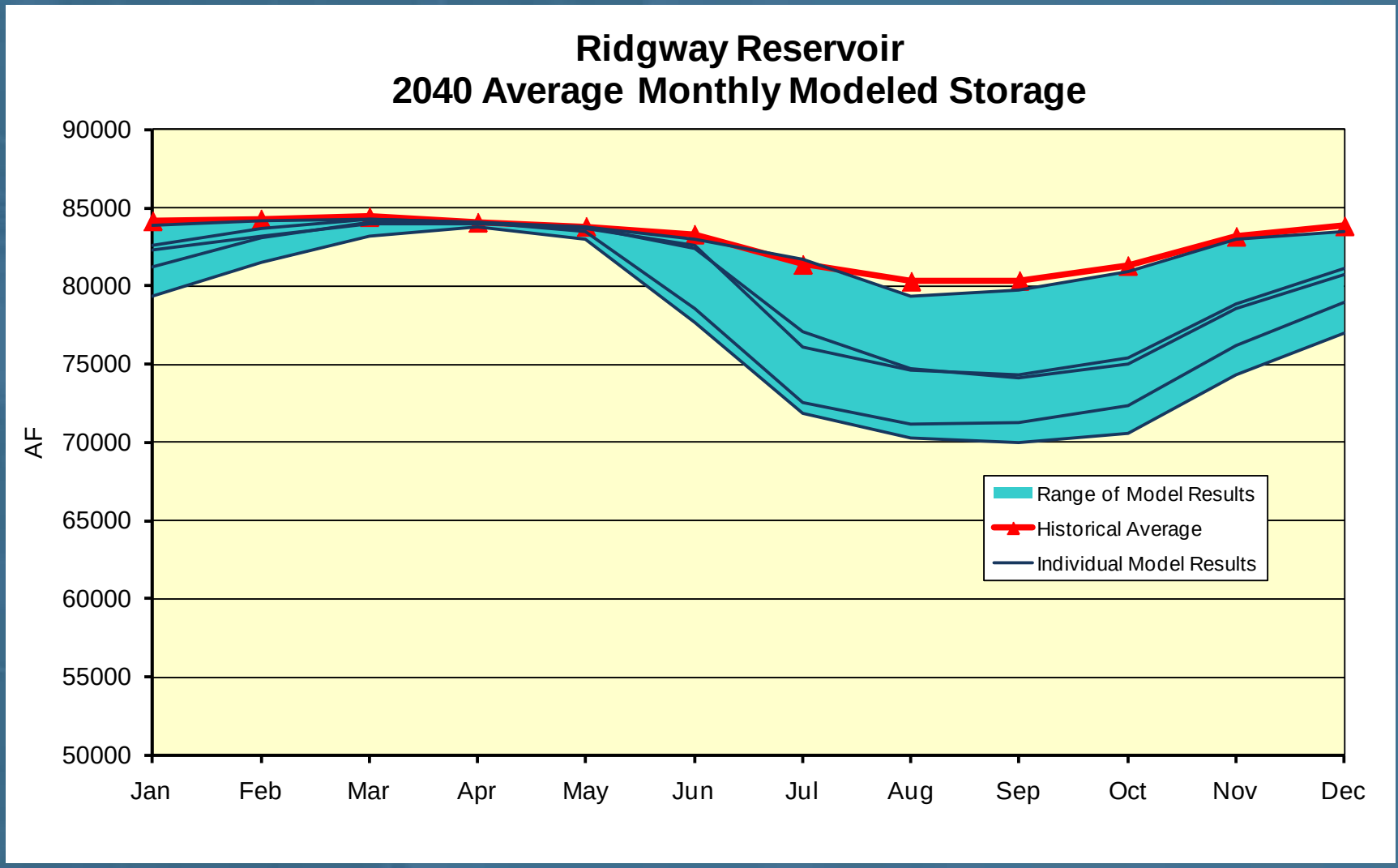

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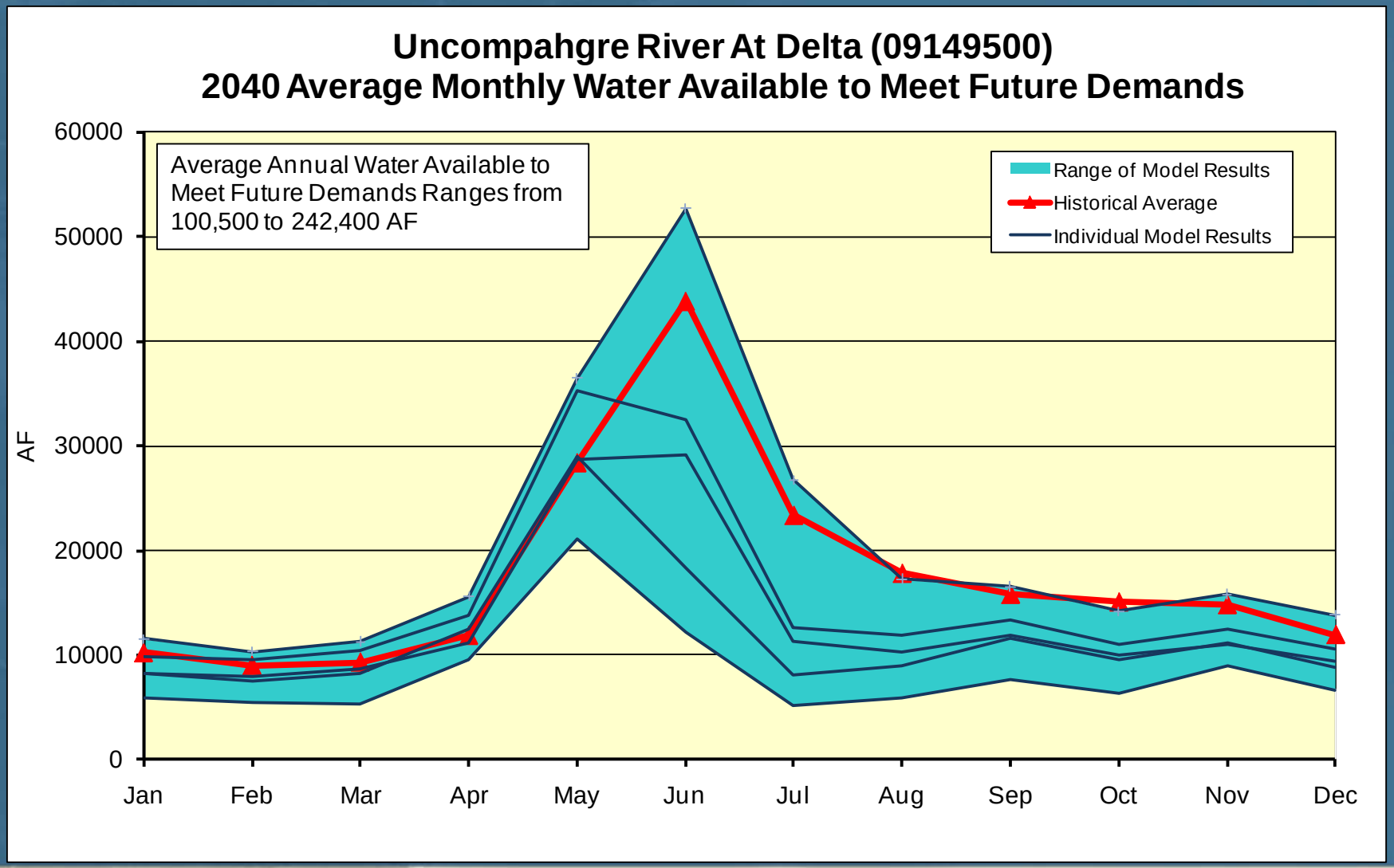
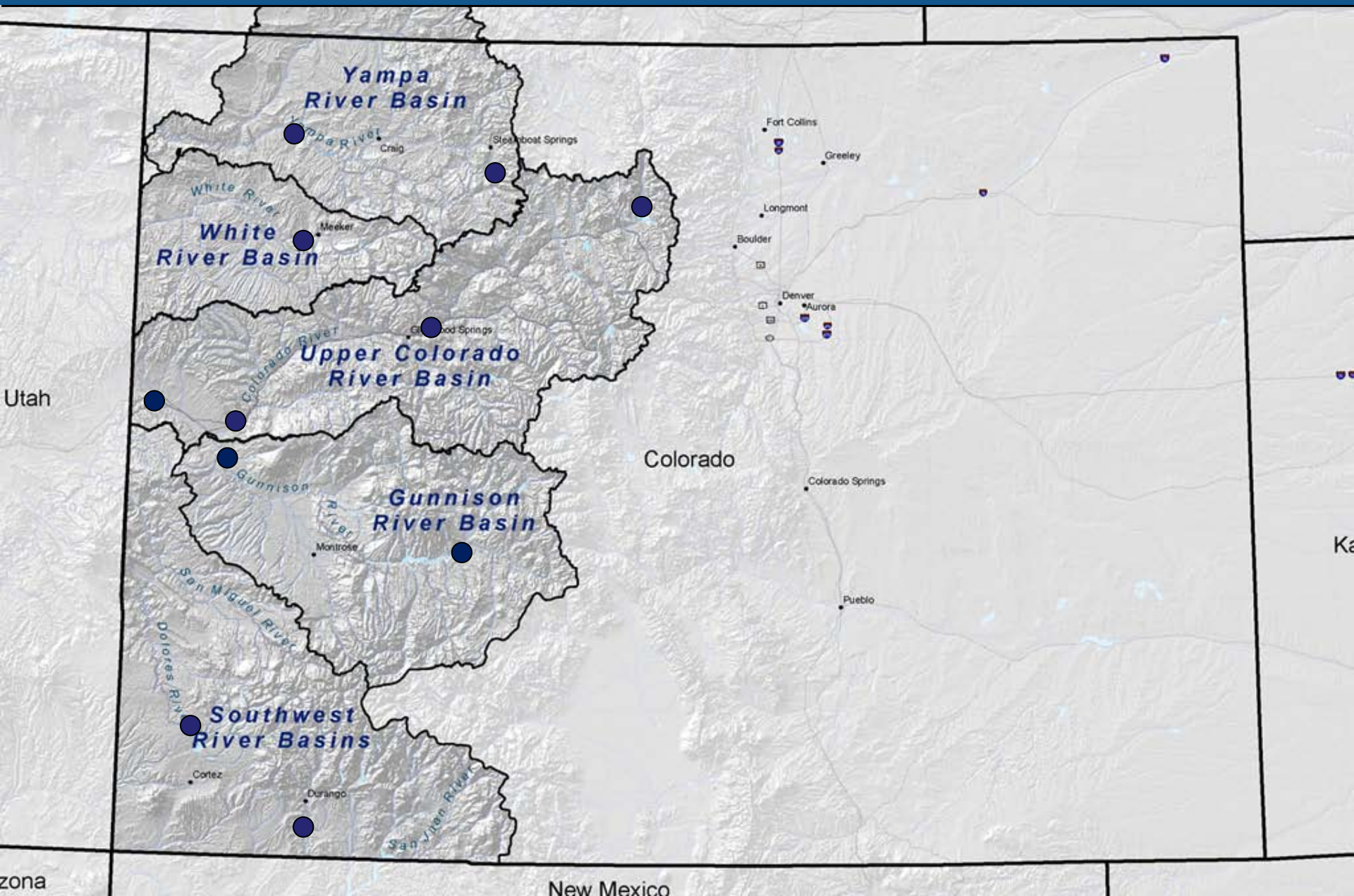


Result Summary: 5 West-Slope Basins



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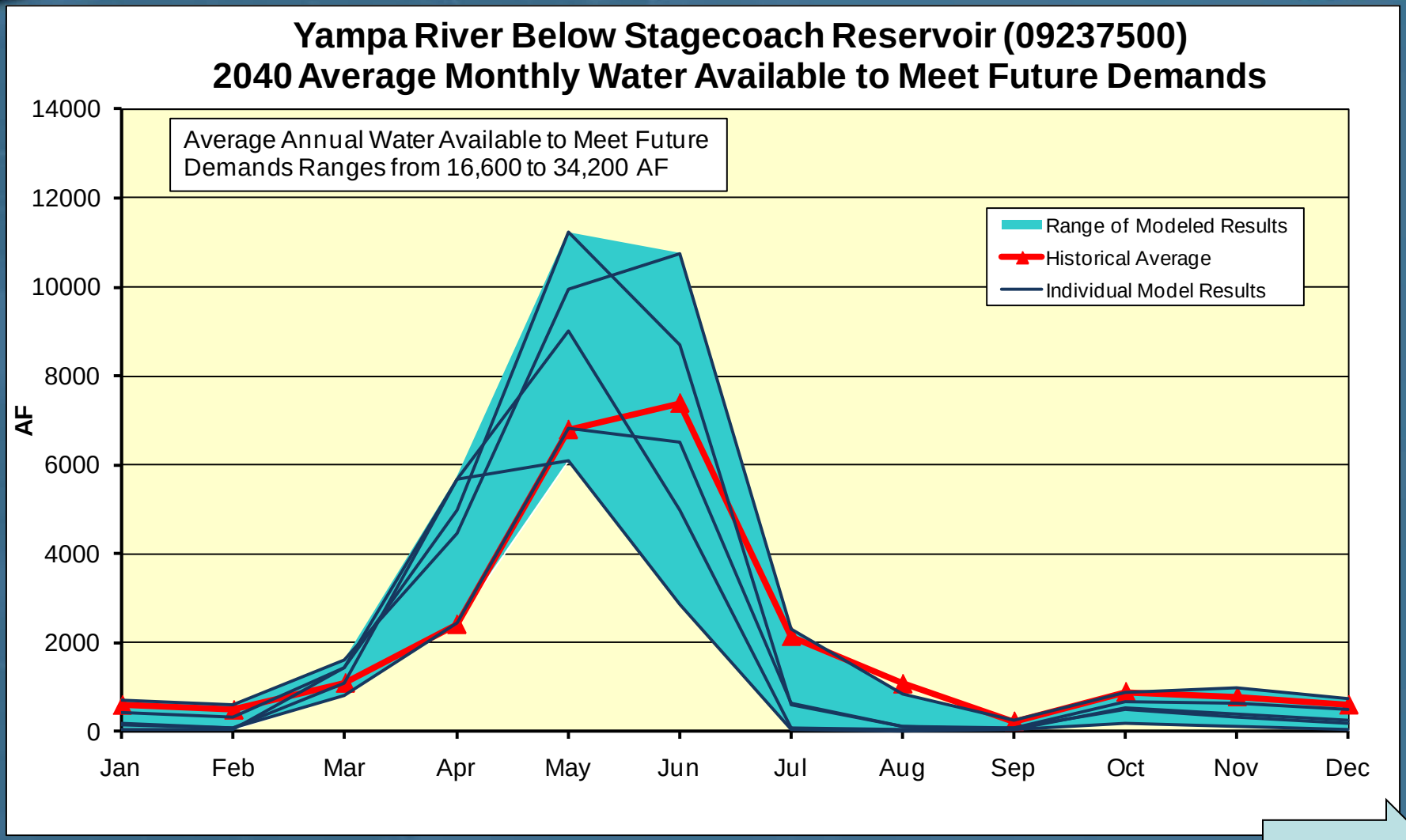

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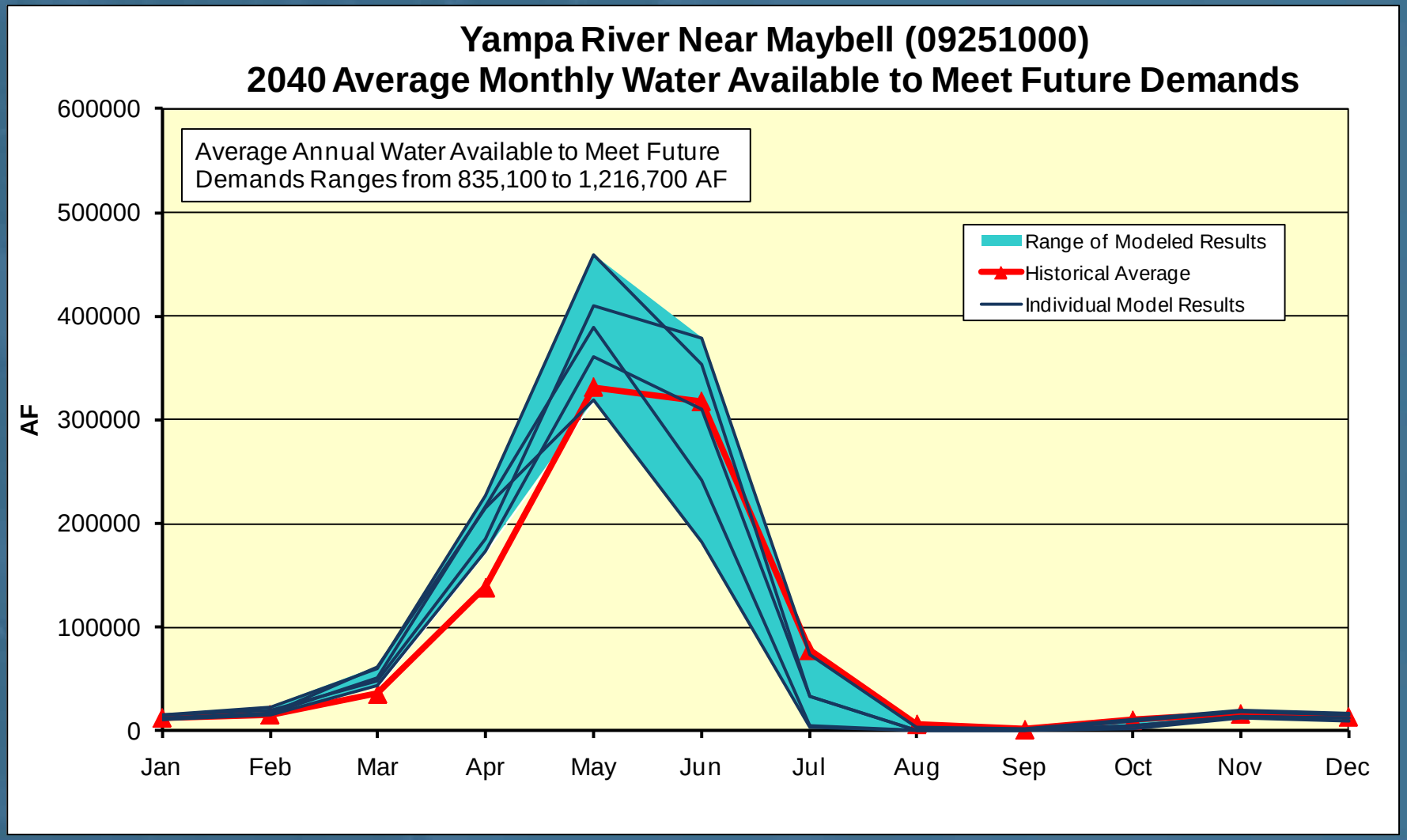

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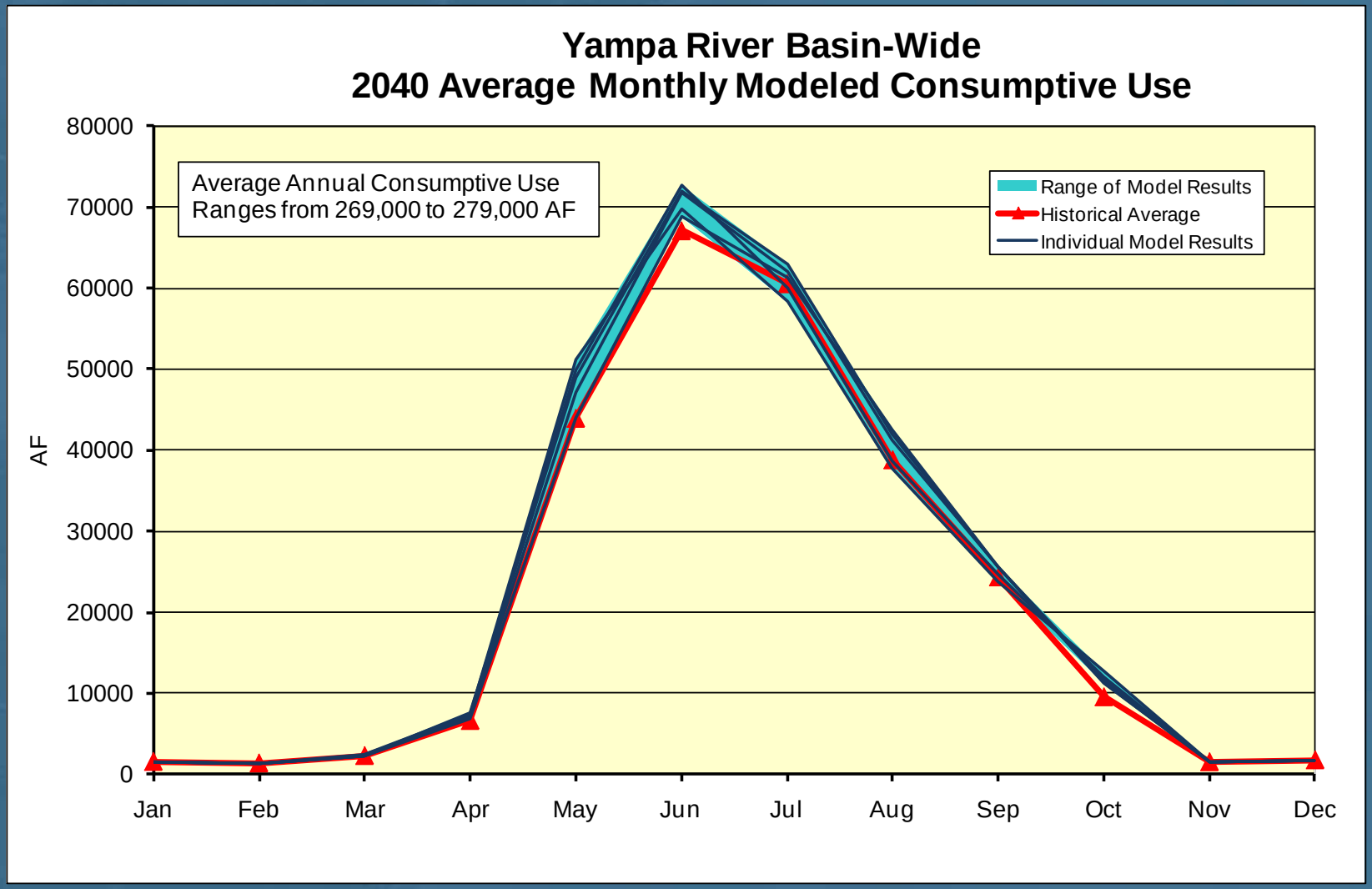

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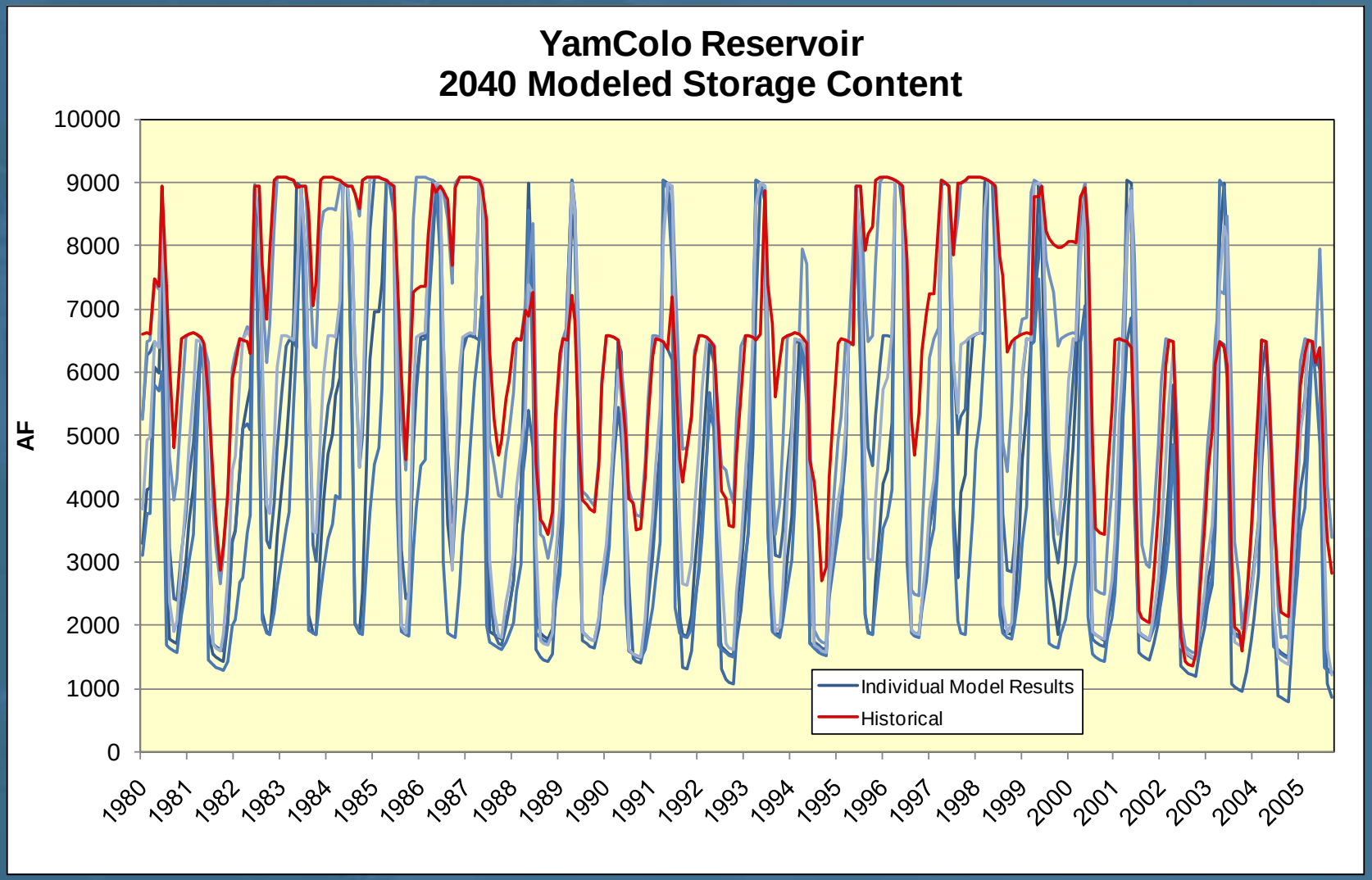

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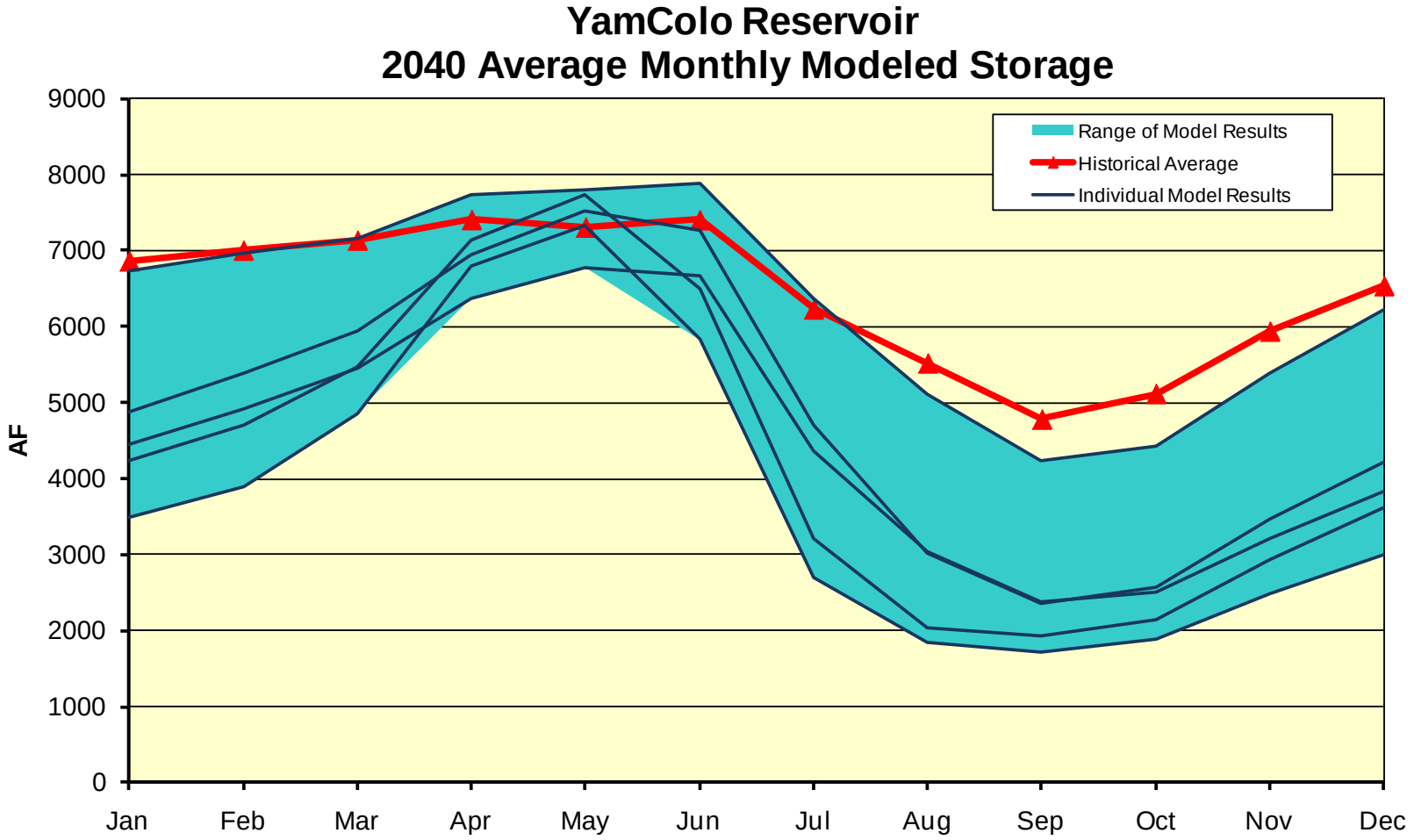

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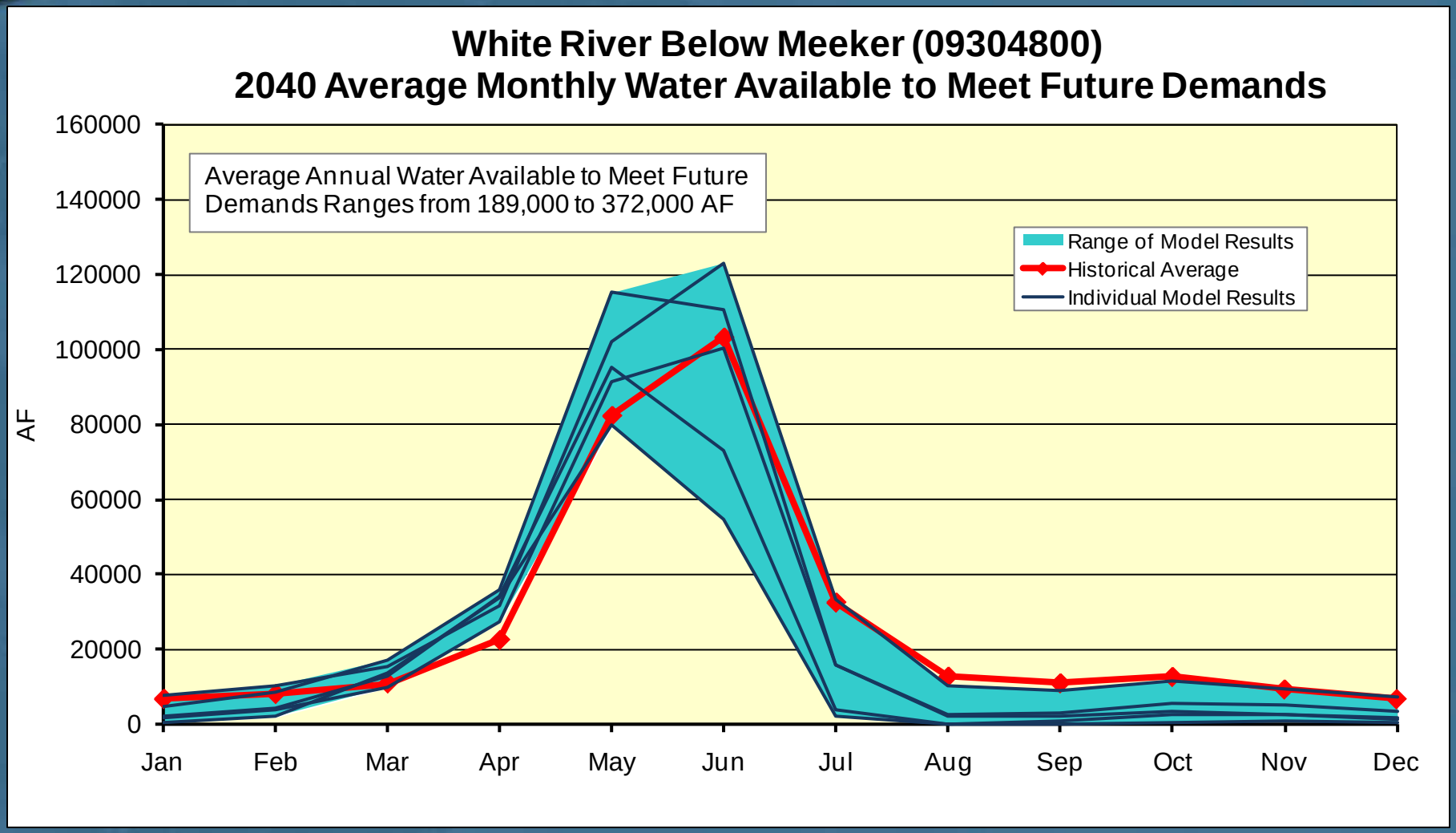

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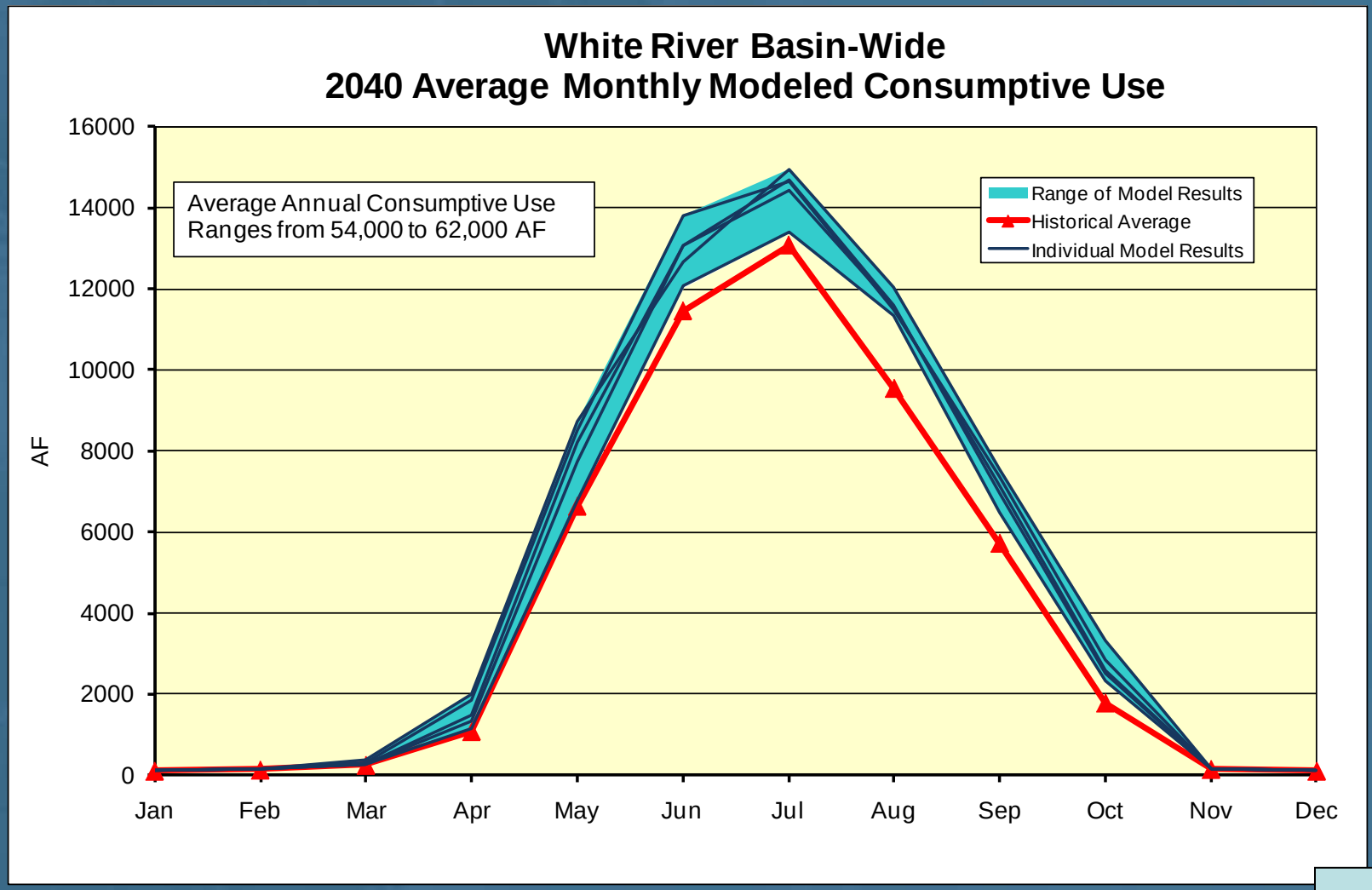

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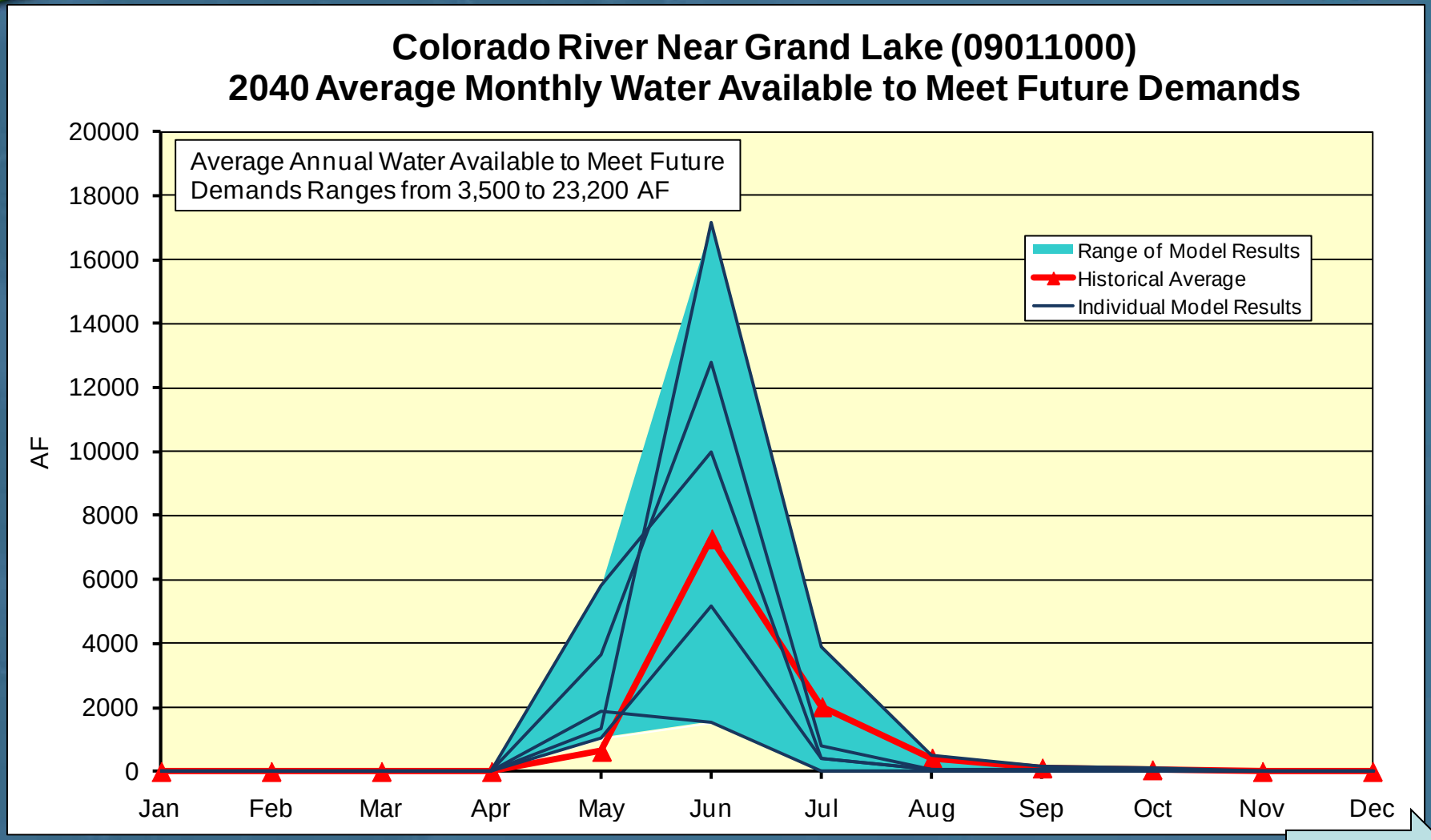

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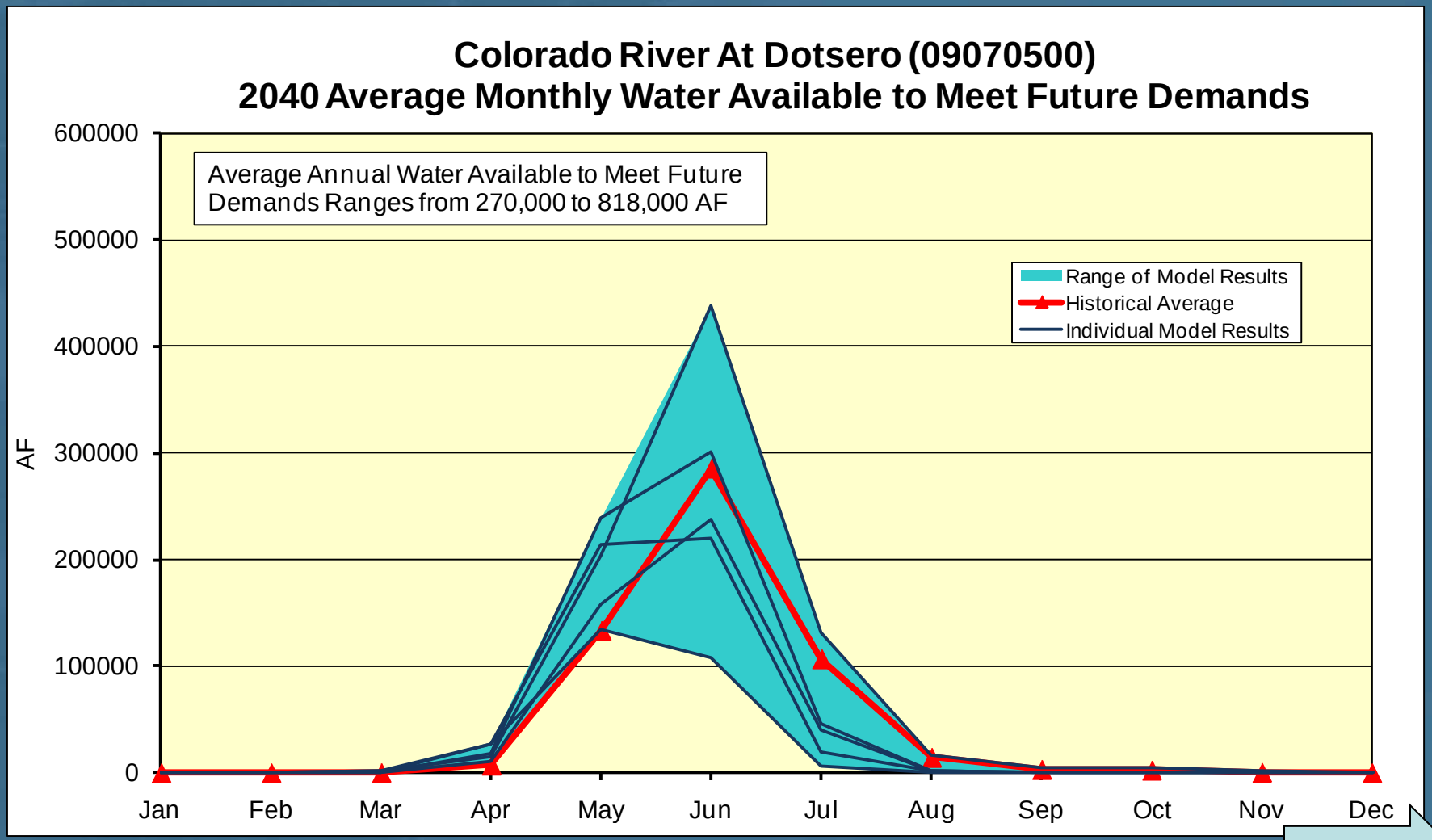

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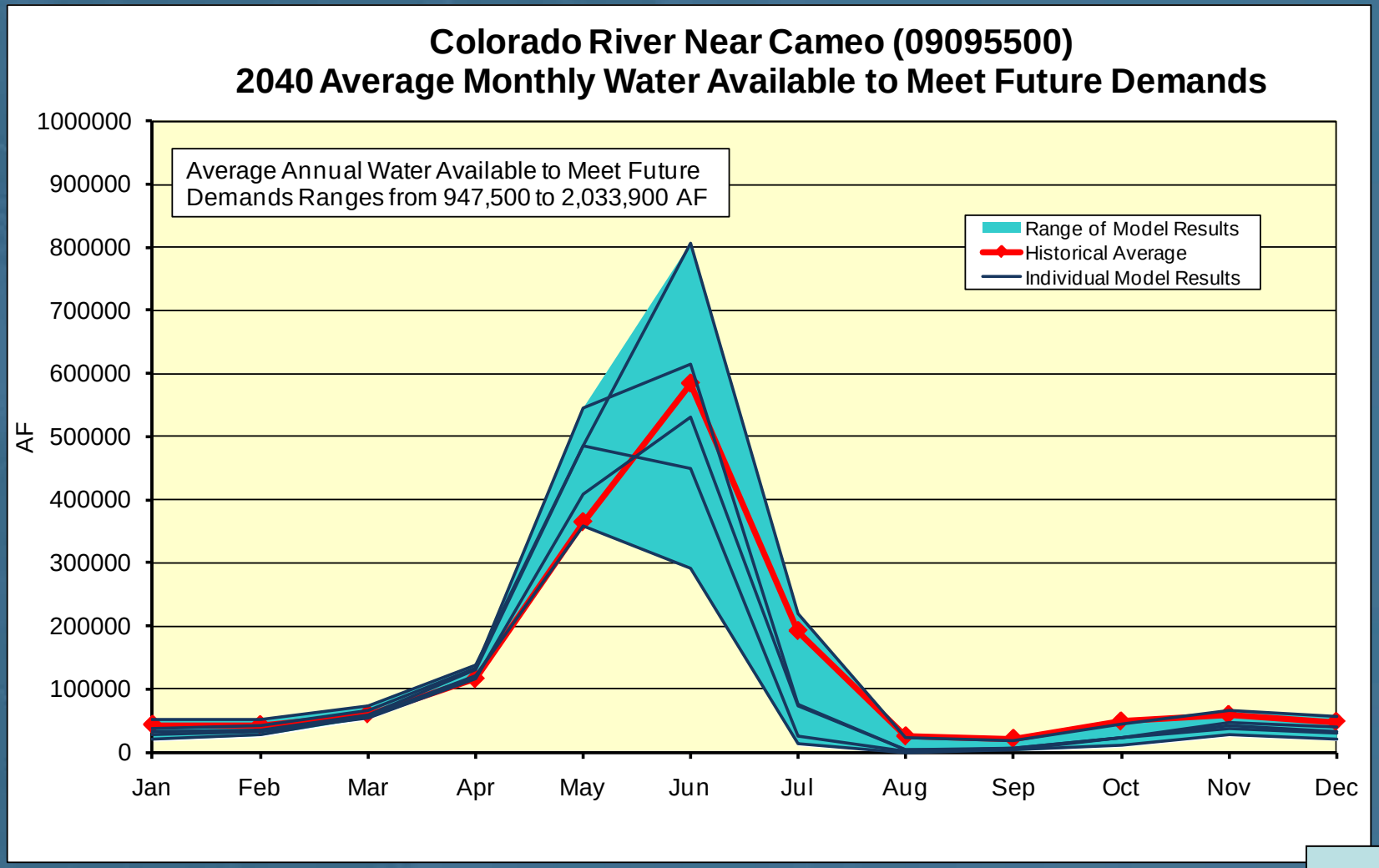

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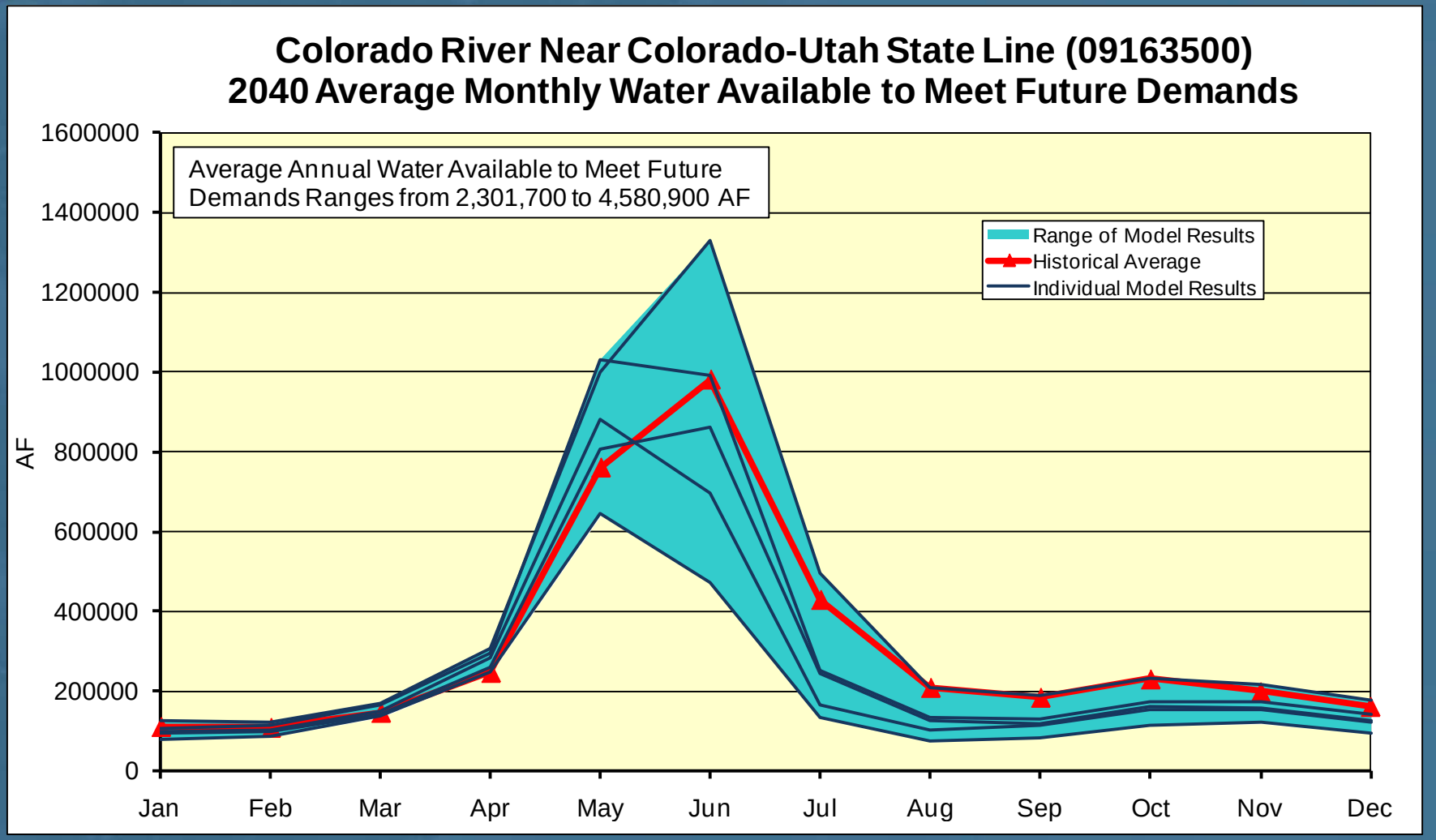

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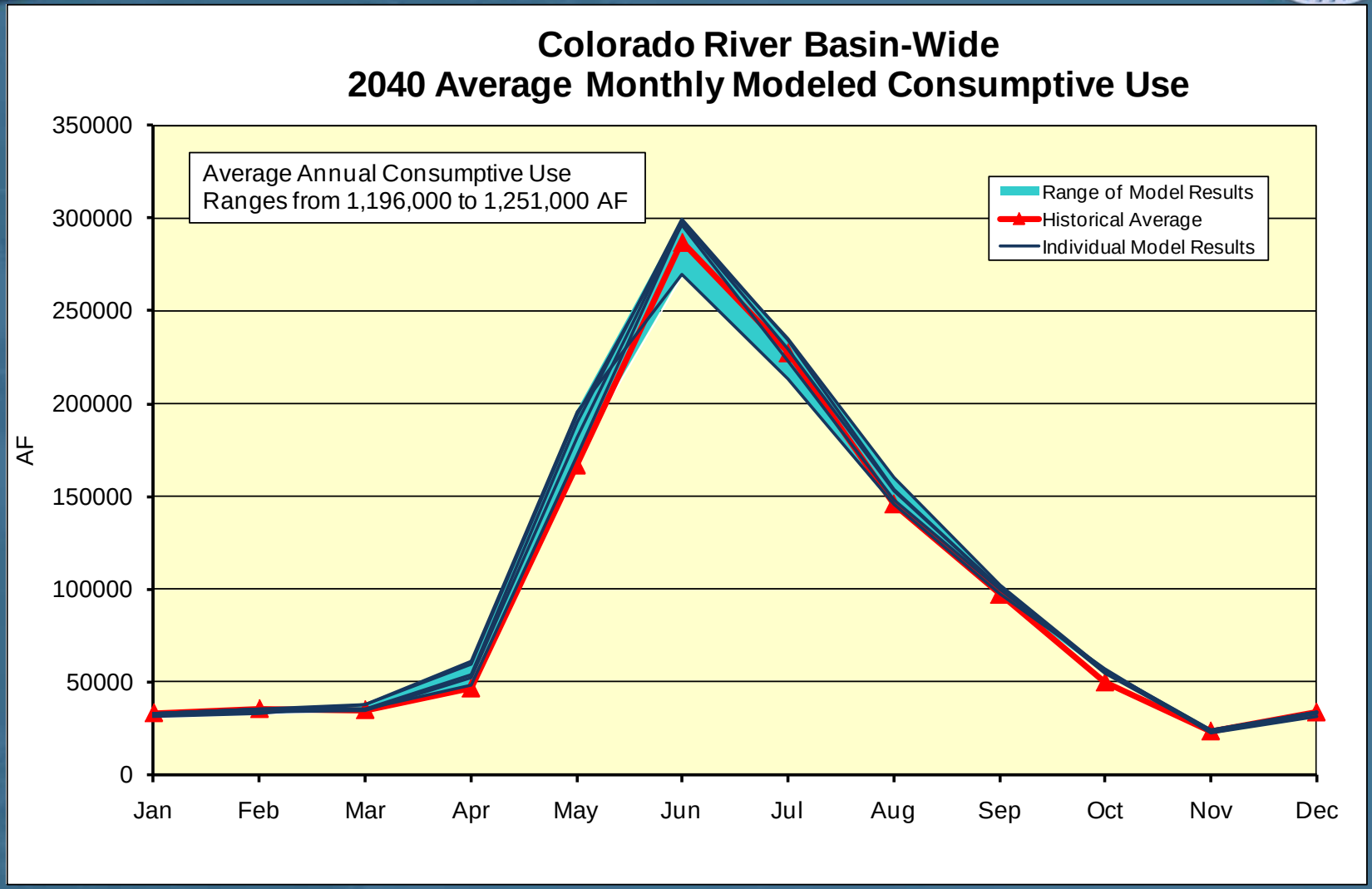

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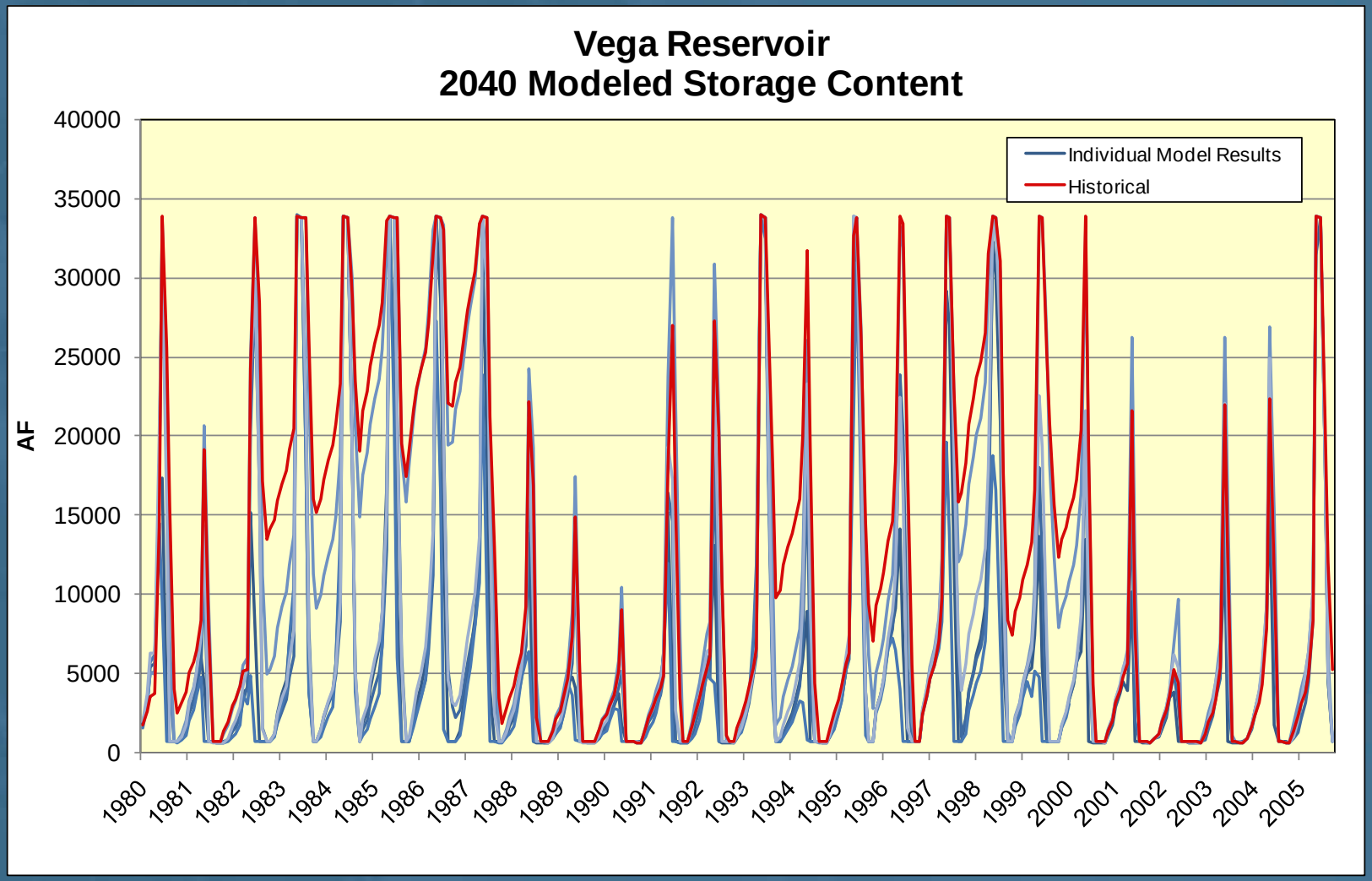
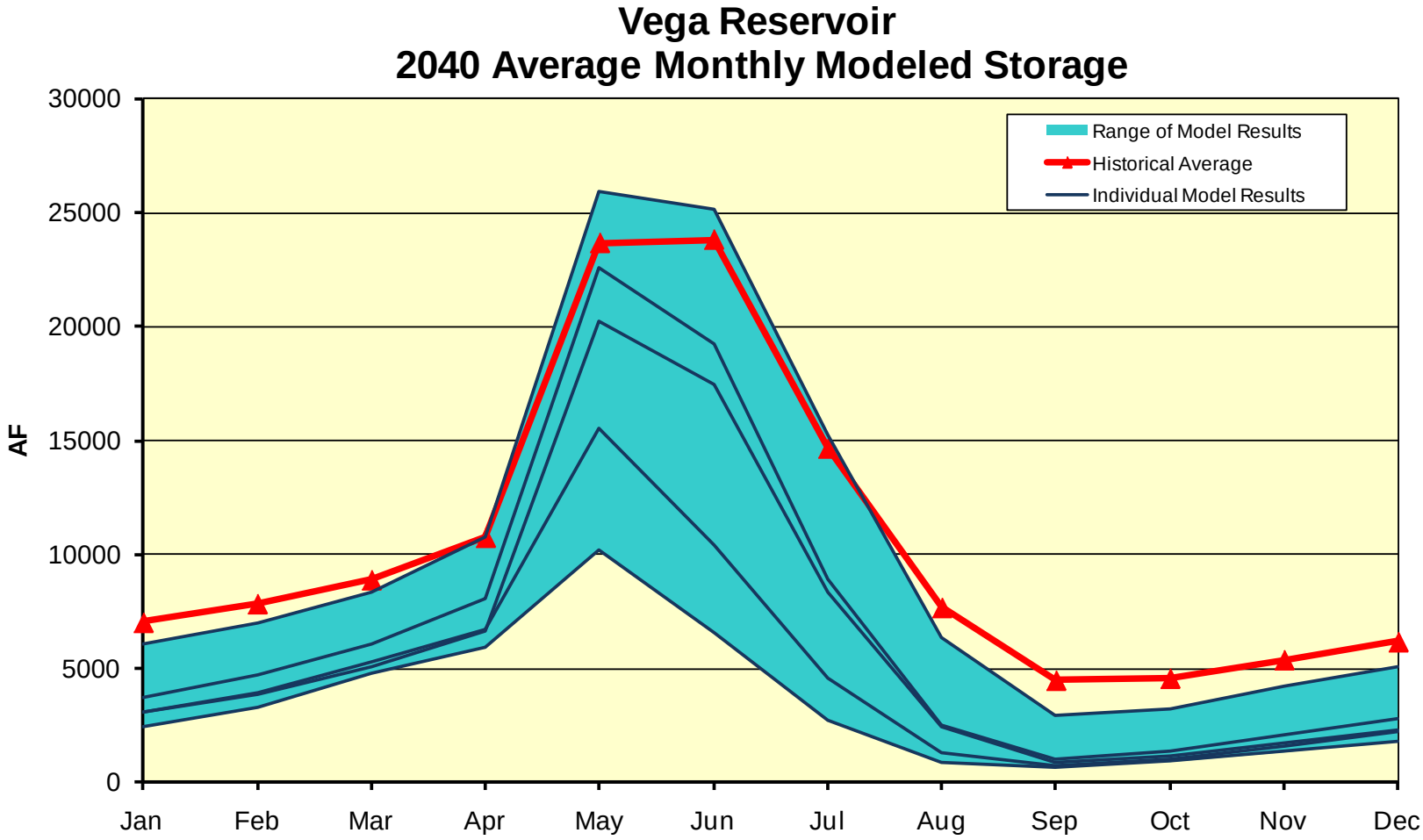
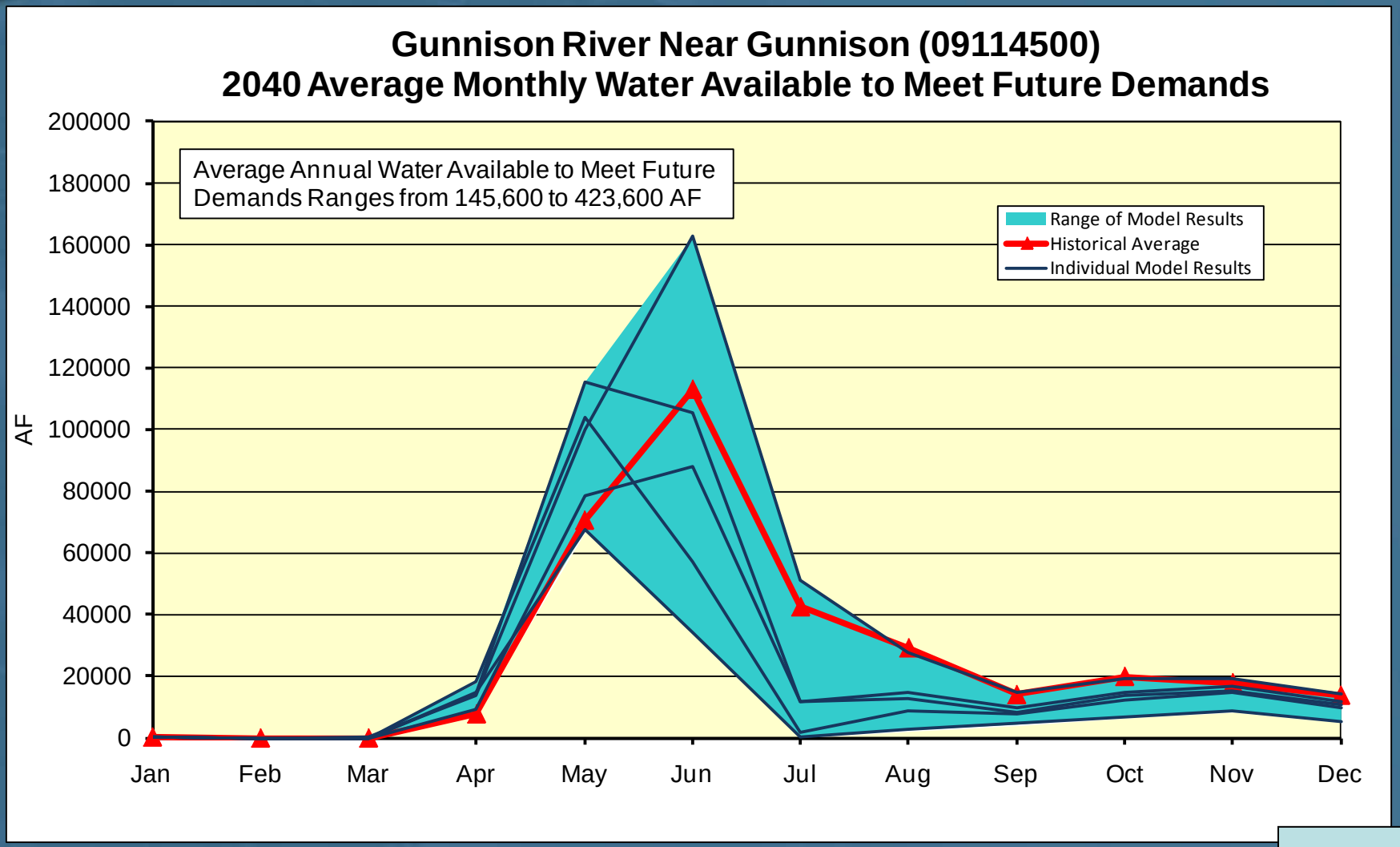


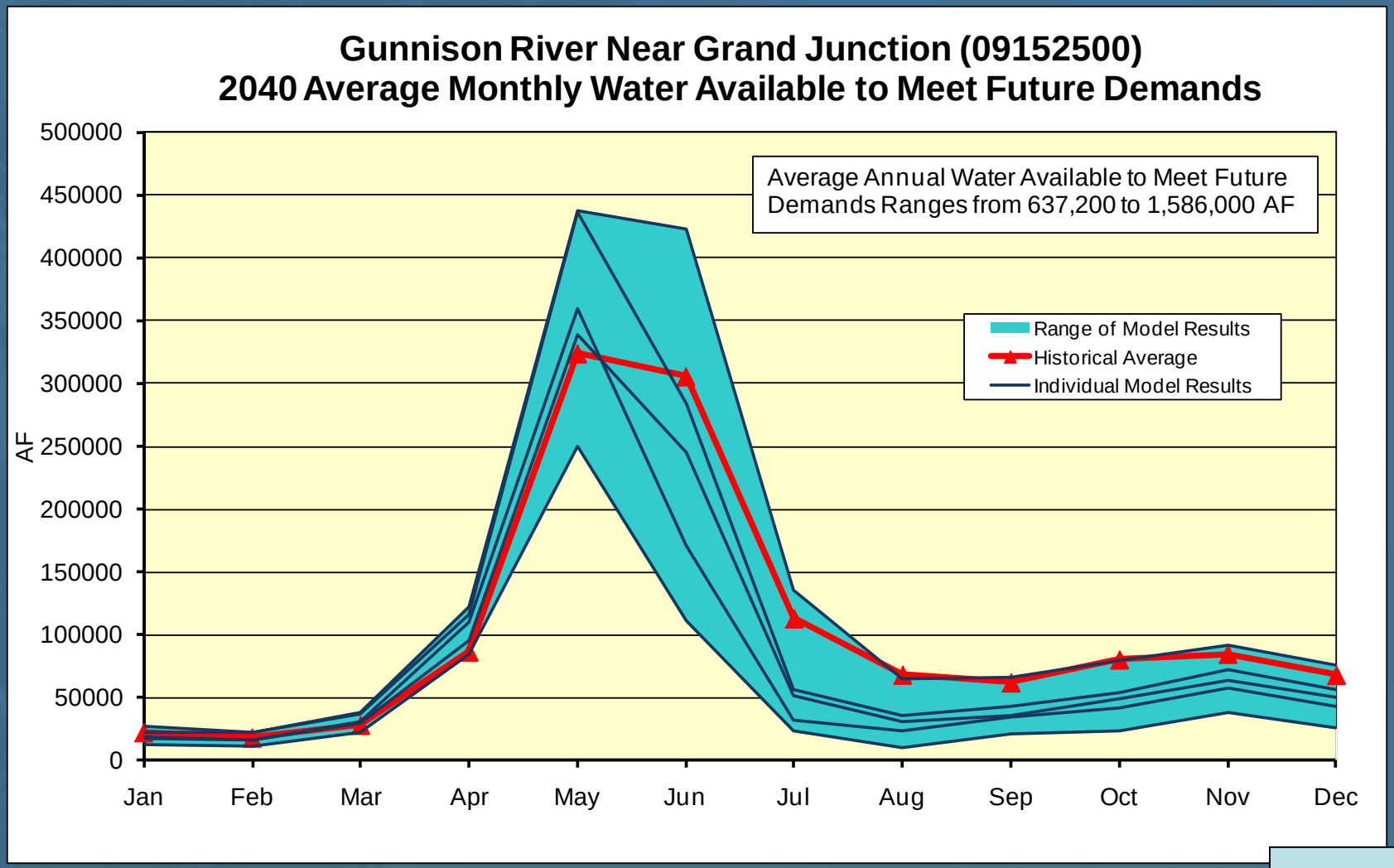
Modeled Reservoir Storage



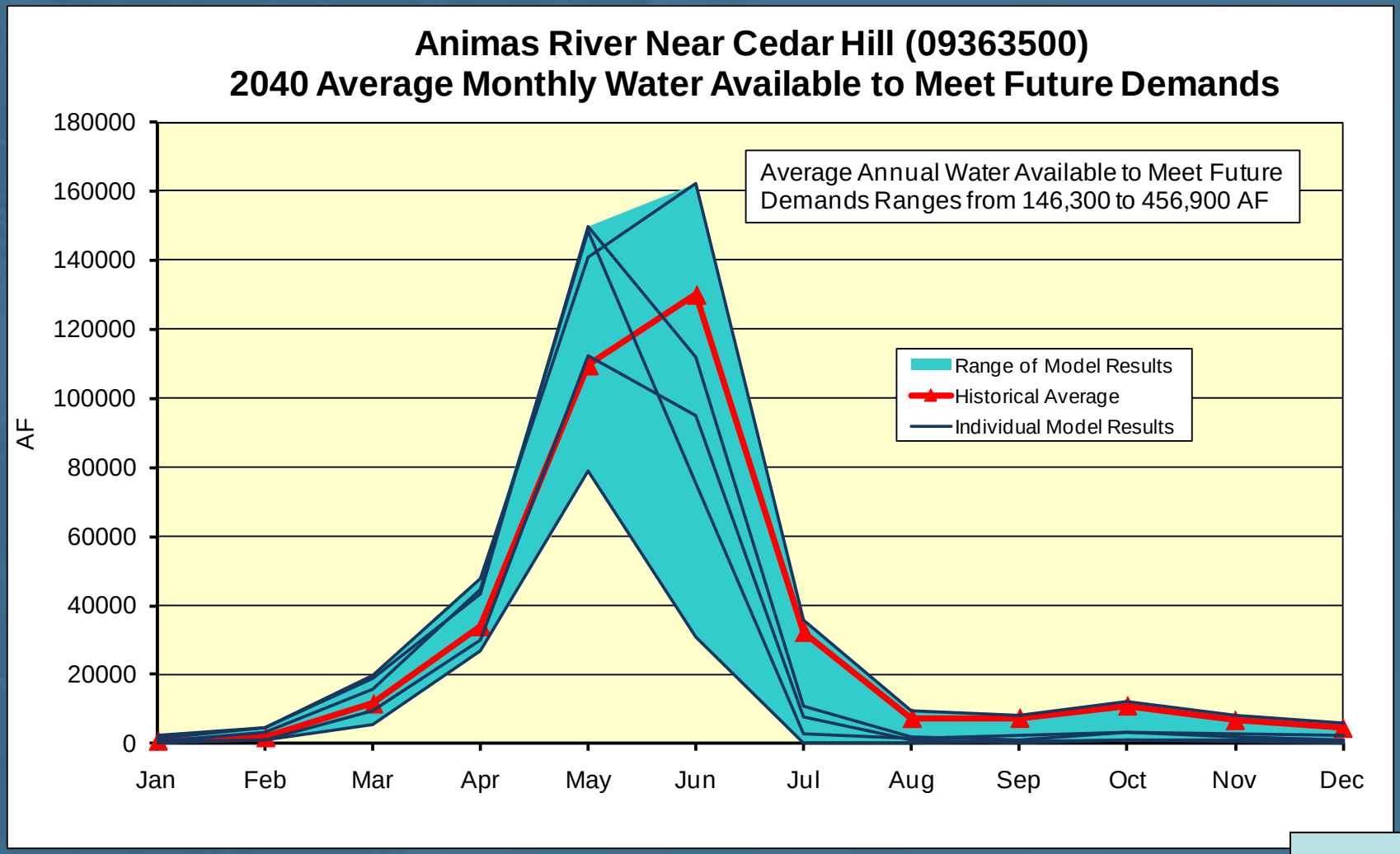
Water Availability



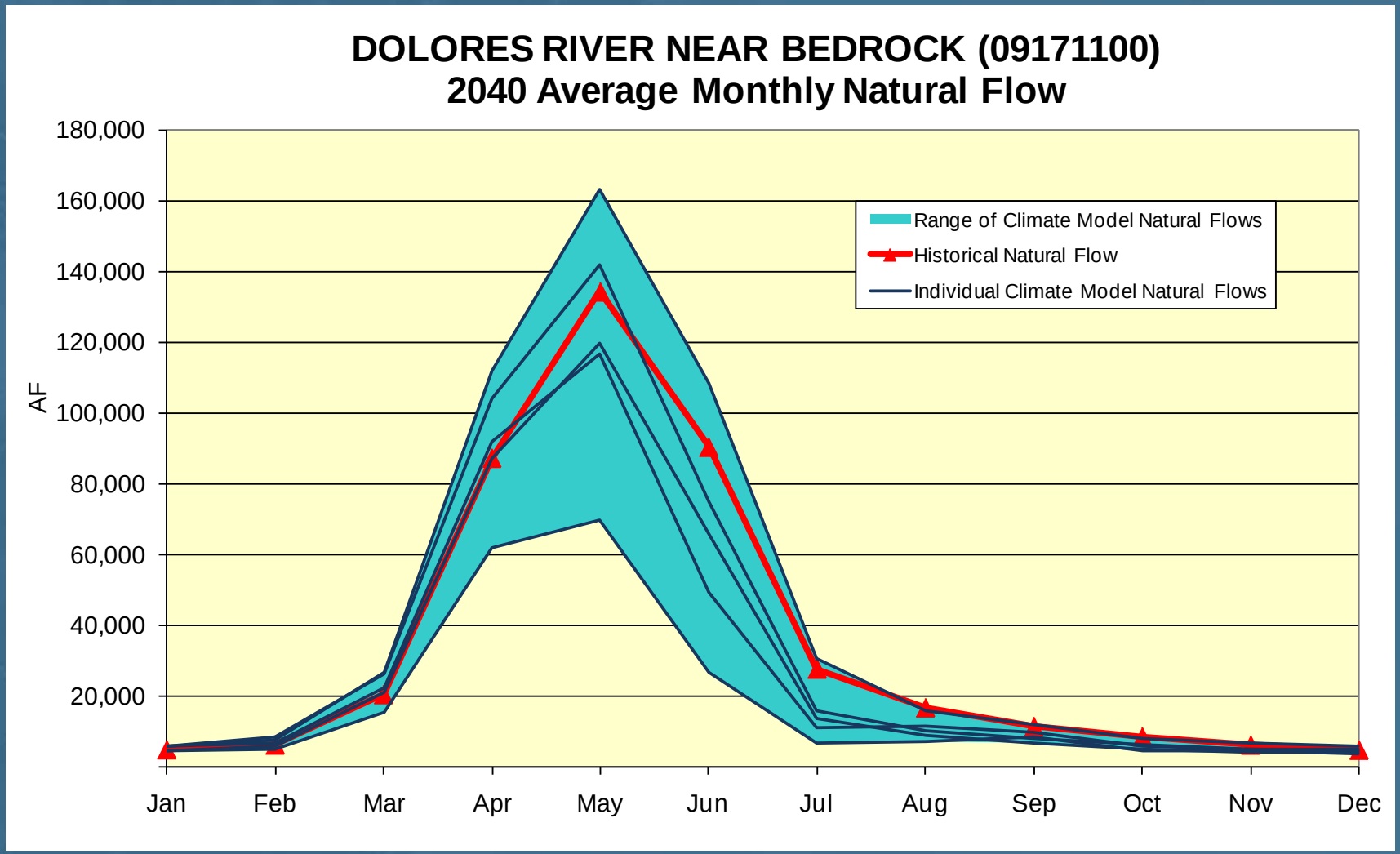
Water Availability



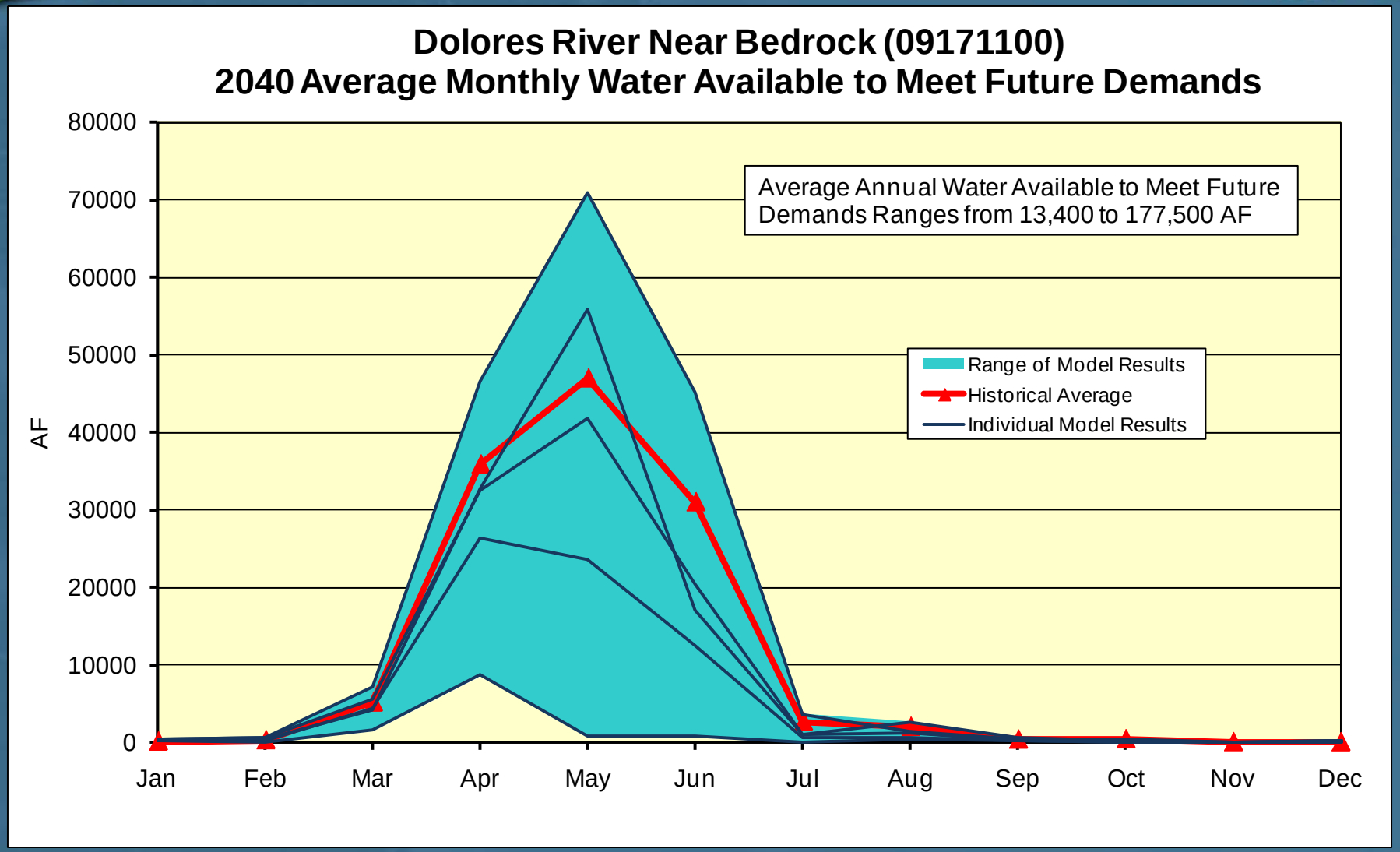
Water Availability



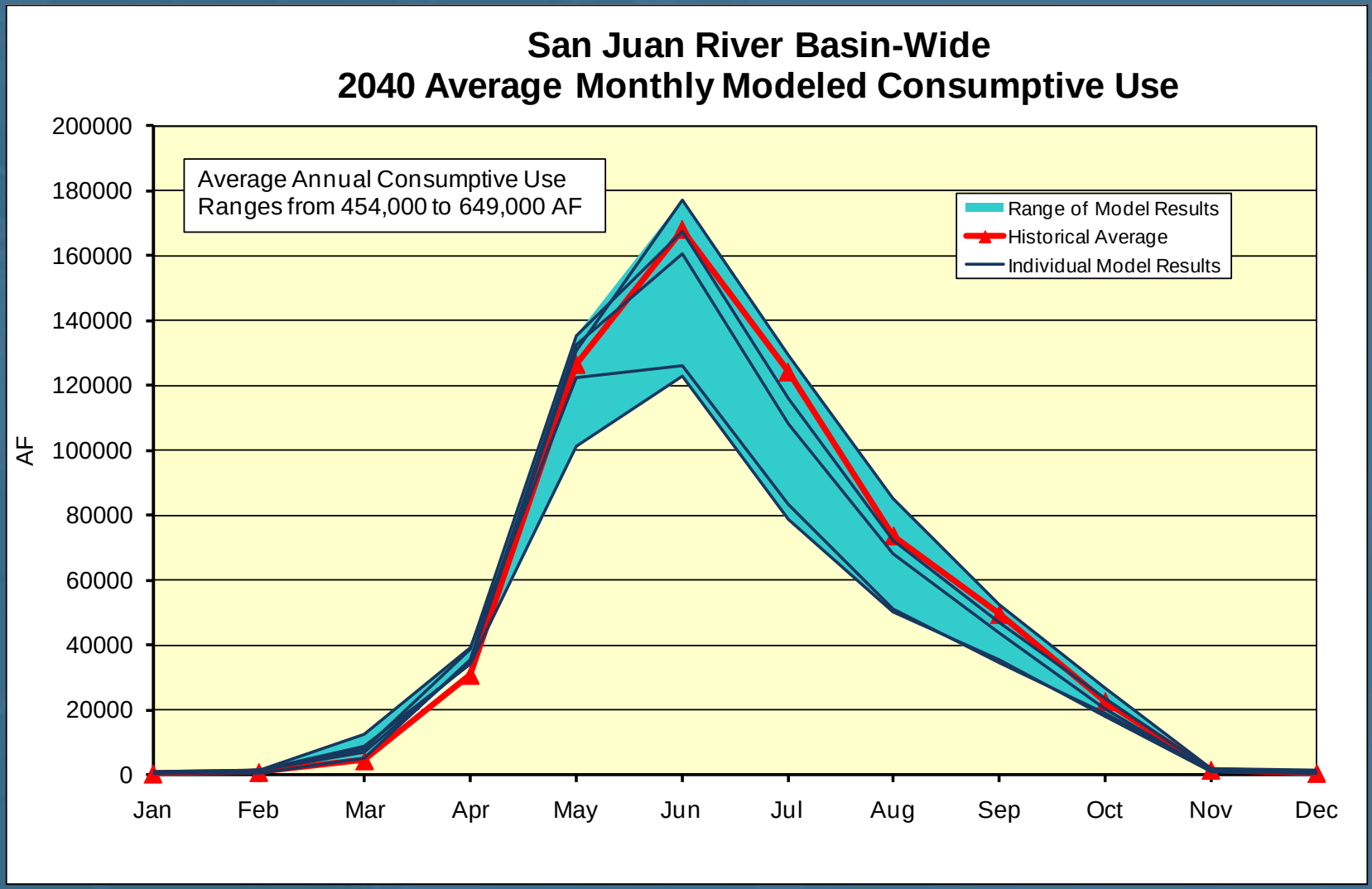
Natural Flow



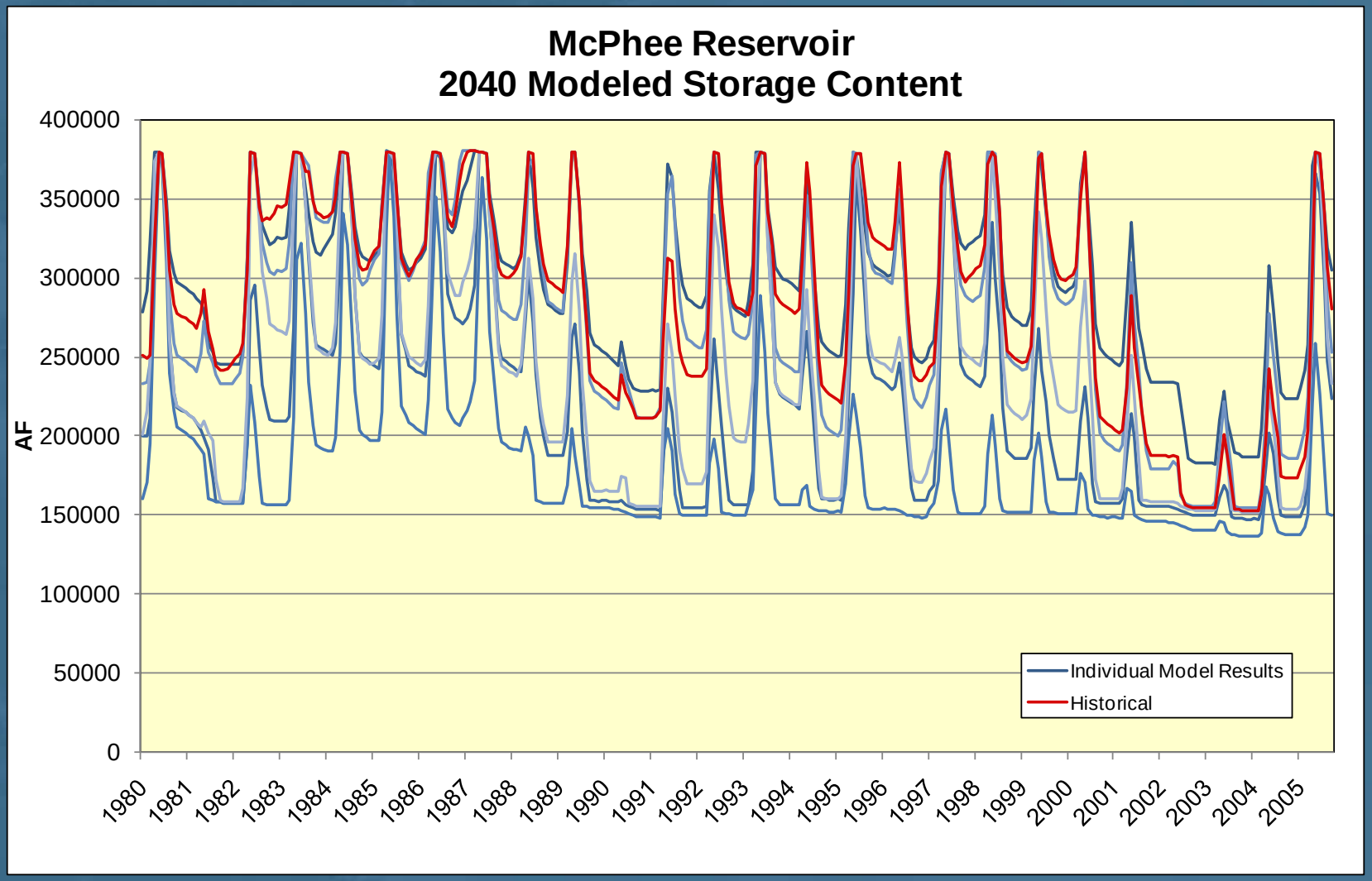
Water Availability



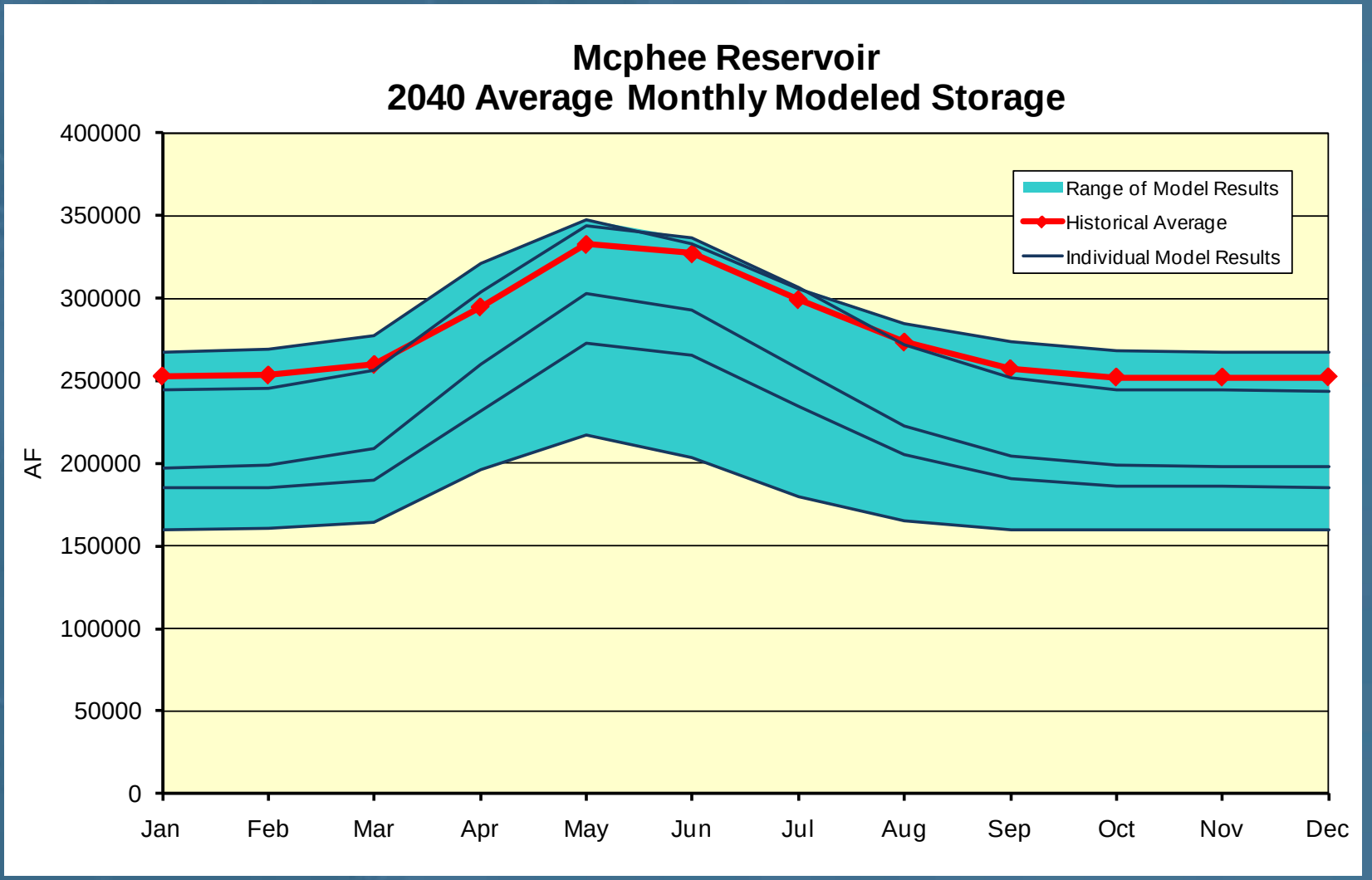
Modeled Consumptive Use



Modeled Reservoir Storage



Modeled Reservoir Storage



Result Summary – Natural Flow

- Annual flow increases in some possible futures and decreases in others
- Annual flow generally increases in parts of the Yampa River basin and at higher elevation watersheds
- Annual flow generally decreases in south-western watersheds and at lower elevations
- Shifts toward earlier peak runoff
- Flow decreases in late summer and early fall

Result Summary – Modeled Streamflow

- Annual modeled streamflow decreases basin-wide, except in the Yampa River basin, and higher elevation locations in the Upper Colorado River basin
- Modeled Flow increases in April and May and decreases in later summer and fall months

Result Summary – Modeled Consumptive Use

- Increases in Yampa, White, Upper Colorado, and Gunnison basins by 4 to 18 %
- Decreases in the San Juan and Dolores basins by 8 %

Result Summary – Use of Reservoirs

- Reservoirs show increased use
- Pool levels fluctuate more than historical

Result Summary – Water Available to Meet Future Demands

- Higher elevations generally have less annual flow available to meet future demands, as a percent of modeled streamflow
- Available flow generally increases in April and May, corresponding to the shift in natural flow hydrographs

Forest Change Hydrology

- Forest Change Due to Fire
  - Localized
  - Relatively small except for very rare cases.
  - Occurrence is substantially random over long periods.

- Forest Change Due to Insect Infestation
  - Data Availability
  - Forest Recovery Timeframe
  - Water Supply Impact Detection Threshold

Forest Change due to Insect Infestation

- Data Availability
  - Tree and beetle science is changing rapidly
  - USFS and participating agencies have ongoing studies in North Platte Basin
  - Re-growth, snow studies, and new hydrologic data

Forest Change due to Insect Infestation

- Forest Recovery Timeframe:
  - Re-growth begins immediately via immature trees and understory vegetation
  - ET reduction offset quickly by grass / shrub regrowth
  - Evaporation reduction offset by tree re-growth (before 2040)

Forest Change due to Insect Infestation

- Water Supply Impact Detection Threshold:
  - Most flow volume from sub-alpine forest (elevations >8,000 feet)
  - 20%-30% watershed must be cleared before detectable flow change
  - Stream flow impact from forest disturbance <<< Impacts from climate change

Colorado Water Availability for Future Consumptive Use

- Approach
  - Used mass-balance analysis at Lee Ferry (2007 Hydrologic Determination)
  - Simulated full-development water use requests in upper basin
  - Calculated 10-year cumulative flow at Lee Ferry.
  - Calculated upper basin consumptive use that could be maintained considering Compact provisions
- Hydrology adjusted for climate change
- NM, UT, WY fully developed
- All Upper Basin storage capacity fully used

- Applied Upper Basin water use requests used in 2007 Hydrologic Determination:

Potential Lee Ferry Obligation	Upper Basin Water Use
75 MAF	6.76 MAF
82.5 MAF	5.98 MAF

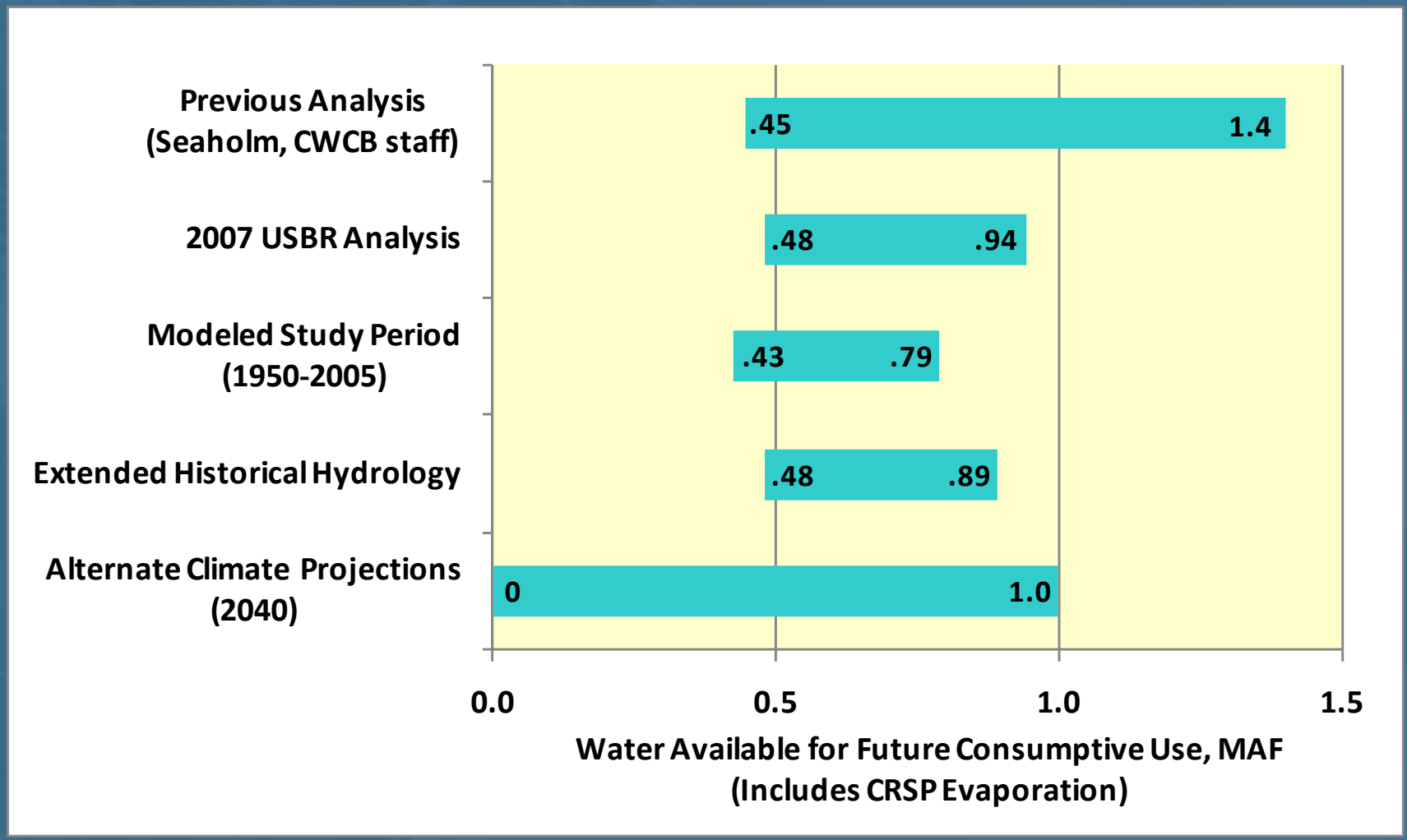
Colorado Water Availability for Future Consumptive Use

- 1906 – 2000 (Hydrologic Determination)
- 1950 – 2005 Study Period
- Extended Historical Hydrology
- Climate Impacted Hydrology
  - Focus on 2040 time frame
  - Five projections for the time frame

Colorado Water Availability for Future Consumptive Use
Phase I Assumptions on Current Consumptive Use

- Estimated by StateMod
  - 1950-2005 natural flows and weather
  - Current irrigated acreage
  - Current M&I demands
  - Simulates diversions, crop CU, evaporation
  - Excludes evaporation from Aspinall Unit and Navajo evaporation chargeable to New Mexico
  - Excludes exports to New Mexico
- Estimated CU = 2.6 MAF

Results – Water Available for Future Consumptive Use based on Specific Compact Assumptions



Conclusions

1. BRT interaction provided essential information to update and refine CDSS

Conclusions

2. Computer models proved appropriate for Phase I objectives

Conclusions

3. Phase I demonstrates broad range of water availability results
   - Inherent uncertainties in GCMs
   - Complexity of modeling atmospheric circulation
   - Down-scaling effects of changed temp/precip on natural flows in Colorado River basin

Conclusions

4. Phase I results based on current water demands
   - Stakeholders demonstrated strong interest to expand analysis to future demands / operating conditions

Recommendations

- Continue CDSS refinements
  - Baseflows in Plateau Creek
  - Aspinall Unit reservoir operations
  - Current release rules for flood control reservoirs
  - Alternative transbasin demands affected by climate change
  - Alternatives to representing USFWS fish flow recommendations
  - Remove New Mexico structures from San Juan / Dolores model

Recommendations

- Use CRWAS to support other CWCB / IBCC programs
- Incorporate new water management strategies
- Stakeholders to interpret findings:
  - From their own perspective
  - Considering their assessment of possible future conditions
  - Considering the resources they have available to adapt
  - Considering their role in water management
  - Considering their tolerance for risk

Comments and Questions?

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