Time frame: 2040-2060 compared to 1950-1999
Region: Gunnison River Basin, Colorado
IPCC SRES Emissions Scenario: A2 ("medium-high emissions")

Rationale: The hydrologic scenarios were chosen to be consistent with the climate change scenarios identified by Linda Mearns. Hydrologic scenario 1 (moderate change) is developed from the average of the modeled hydrologic projections. Scenario 2 (extreme change) is developed from an individual simulation that has seasonal temperature a precipitation changes that are similar to the climate change scenario.

Scenario #1: Moderate change
Climate: Increased annual temperatures (2+°C), no substantial change in annual precipitation, but increased cool season precipitation and decreased warm season precipitation.

Parameter	**Impacts**
Streamflow Amount	5-10% decrease
Snowpack Accumulation and Melt	later fall accumulation, earlier spring melt, high elevation midwinter accumulation may be similar to present
Streamflow Timing	earlier by 7 days
Soil Moisture	significantly less during summer

Streamflow Amount: Annual natural streamflow will decrease under a scenario of increased temperature, even in precipitation remains the same. The shift of precipitation from summer to winter somewhat counteracts the drying tendency somewhat leading to a moderate decrease (5-10%) in annual flows.
Snowpack Accumulation and Melt: Warming temperatures lead to a later accumulation of snow in the fall, and an earlier snowmelt in the spring. However, because of the increased precipitation in winter, and the generally cold, high-elevation nature of the Upper Gunnison Basin, the mid-winter snowpack may be similar to the present.
Streamflow Timing: Snowmelt-driven streamflow will occur earlier in the spring, by about 7 days on average.
Soil Moisture: The earlier melt along with decreased summer precipitation and increased summer temperatures results in significantly lower amounts of water stored in the soils during summer.

Scenario #2: Extreme change
Climate**:** Increased annual temperatures (3+°C), ~10% decrease in annual precipitation, with greater decreases in warm season precipitation

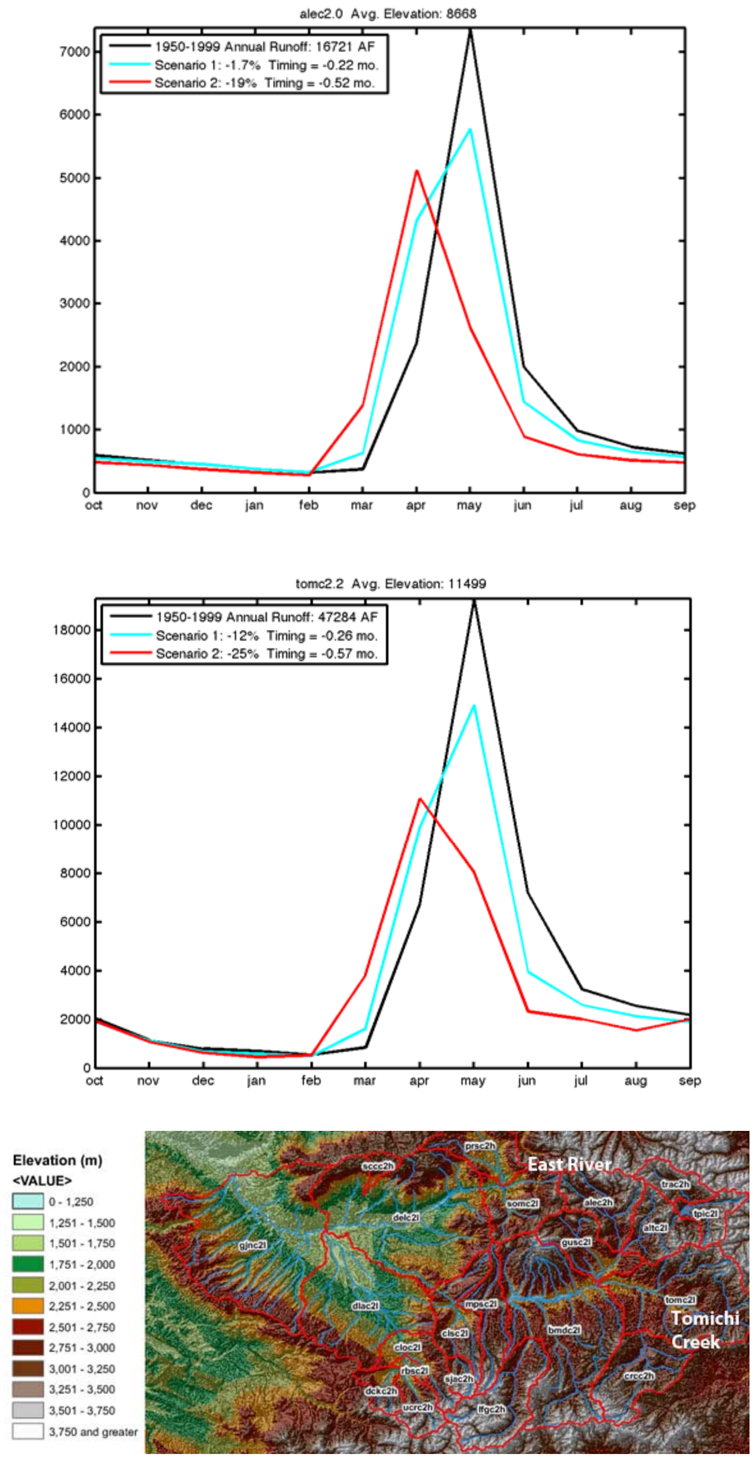
Parameter	Impacts
Streamflow Amount	20-25% decrease
Snowpack Accumulation and Melt	later fall accumulation, earlier spring melt, potential for substantial early melt and decreased yield if high dust deposition
Streamflow Timing	earlier by 14+ days
Soil Moisture	extremely low in summer and fall

Streamflow Amount: Decrease in precipitation and increase in temperature both act to reduce annual streamflow totals. Projected streamflow decreases are in the range of 20-25%
Snowpack Accumulation and Melt: Warming temperatures lead to a later accumulation of snow in the fall, and an earlier snowmelt in the spring. Because this likely represents a hot/dry scenario for much of the West, the potential exists for more frequent dust deposition events, which also may lead to an earlier melt and to reduced water yield from the snowpack.
Streamflow Timing: Snowmelt-driven streamflow will peak about two or more weeks earlier in the spring.
Soil Moisture: The much earlier melt, along with decreased summer precipitation and increased summer temperatures, results in extremely low amounts of water stored in the soils during summer and fall.

General note on Hydrologic Variability and Extremes:
Hydrologic *variability* will continue even in the face of human-caused (anthropogenic) climate change. The basin has experienced episodic drought and wet periods in the past. Paleoclimate reconstructions indicate that the potential exists for longer and deeper droughts than experienced in the historic record. Projected warming would exacerbate the impact of precipitation deficits on streamflows, soil moisture and snowpack. The potential for lower low-flows in summer and fall also exists, particularly in the extreme change scenario. There is also the potential for occasional higher peak flows in summer, because individual thunderstorms may be stronger even if total precipitation decreases.

Scenario Information Sources

- Naturalized Flows from Jim Prairie (U.S. Bureau of Reclamation). Data: http://www.usbr.gov/lc/region/g4000/NaturalFlow/index.html. (Prairie and Callejo, 2005).
    - Prairie, J., and R. Callejo, 2005. Natural flow and salt computation methods, U.S. Dep. of Interior, Salt Lake City, Utah. http://www.usbr.gov/lc/region/g4000/NaturalFlow/Final-MethodsCmptgNatFlow.pdf
    - Data: http://www.usbr.gov/lc/region/g4000/NaturalFlow/index.html
- Paleoclimate Reconstruction from http://treeflow.info/upco/gunnisoncrystal.html (Woodhouse et al. 2006) (TreeFlow home page - http://www.treeflow.info).
    - Woodhouse, C.A., S.T. Gray, and D.M. Meko, 2006. Updated streamflow reconstructions for the Upper Colorado River basin. Water Resources Research 42(5): W05415
- Hydrologic projections from simulations of the hydrology of the Gunnison River Basin under climate change by Levi Brekke (U.S. Bureau of Reclamation; unpublished).
- The basis for the hydrologic scenarios is shown in the figures of projected flows, snowpack, and soil moisture from these simulations. Shaded bands on these figures indicate the 25th and 75th percentiles of the projections from different models. Preliminary results from the Colorado River Water Availability Study was also used to inform the descriptive scenarios, as these used a different methodology that showed greater reductions in flow for the median scenario than did the work by Levi Brekke.



Top: Comparison of the observed (1950-1999 average) and projected annual water year (Oct.-Sep.) runoff hydrograph for East River, in the lower elevation band (8,000-9,000 ft.). **Middle:** Comparison of the observed and projected annual water year runoff hydrograph for Tomichi Creek, in the upper elevation band (11,000-12,000 ft.). **Bottom:** map of approximate locations of streams mentioned above. In graphs, observed is shown in black, moderate change scenario in light blue, and extreme change scenario in red.