THE EFFECTS OF CLIMATE CHANGE ON LAKE TAHOE IN THE 21st CENTURY: METEOROLOGY, HYDROLOGY, LOADING AND LAKE RESPONSE

Abstract

The 21st Century global climate is expected to experience long-term changes in response to anthropogenic greenhouse gas emissions. Discussions on the potential impacts of climate change on water resources in the Lake Tahoe basin have only recently begun and our scientific understanding to date has focused on identifying existing impacts and trends in the historic data. Water resource managers need to know the potential effects of changing meteorologic conditions on a variety of topics such as expected future air temperature, amount and type of precipitation, stream discharge, sediment and nutrient loading characteristics, BMP performance, lake mixing and water quality response. In this study we examined all these topics using existing water resource models already developed for the Lake Tahoe TMDL. A sophisticated statistical downscaling methodology was applied to the model outputs of the of the Geophysical Fluid Dynamics Laboratory Model (GFDL) and the Parallel Climate Model (PCM) given the A2 and B1 emissions scenarios, to produce simulated data records at a 12 km grid scale in the Tahoe basin for the 21st Century (2000-2099).

The results show:

1) Upward trends in T_{max} and T_{min}, with trends for the GFDL > PCM, and trends for the A2 > B1,
2) No strong trends in annual precipitation amount, except for declining precipitation for the GFDL A2 case toward the end of the century,
3) A continuing shift from snowfall to rain, toward earlier snowmelt and runoff during the water year, for both scenarios,
4) A downward shift in the hydrologic flow-duration curve for the A2 scenario in the last third of the century,
5) Some increases in drought severity, especially toward the end of the century,
6) Dramatic increases in flood magnitude in the middle third of the century, especially with the B1 scenario,
7) Sediment and nutrient loading to Lake Tahoe should not increase, to any meaningful level, as a result of climate change and may actually decrease due to the estimated decline in water yield,
8) That while climate change will result in a modest decline in BMP performance for fine sediment particle load reductions (i.e. increase in average pollutant load), any diminished performance will be relatively small and load reduction should still be significant,
9) That by the middle of the 21st Century (after about 2050) Lake Tahoe could cease to mix to the bottom. This will in turn result in complete oxygen depletion in the deep waters and an increase in sediment release of nitrogen and phosphorus,
10) That annual loading of soluble reactive phosphorus under sustained conditions of lake stratification (no deep mixing) and anoxic sediments could be twice the current load from all other sources. Loading of ammonium under these conditions could increase the amount of biological available nitrogen that enters the lake by 25 percent. This effect on the Lake Tahoe's nutrient budgets could have a dramatic and long-lasting impact on the food web and trophic status of Lake Tahoe,
11) That the resulting annual Secchi depth in the later portion of the 21st Century could be in the range of 15-20 m as compared measured values of 21-22 m since 2000 and,
12) Climate change will drive the lake surface level down below the natural rim after 2086 for the GFDL A2 but not the GFDL B1 scenario.

http://www.fs.fed.us/psw/partnerships/tahoescience/documents/final_rpts/
P030Climate_Change_Project_Final_Report_2010_Aug.pdf