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Simulating impacts of oil shale production and climate change with the WARMF model

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Oil shale is one of the largest fossil energy resources in the western United States. Reserves of recoverable shale oil are estimated at 1.8 trillion barrels (at greater than 15 gallons per ton) for the Green River formation, which spans Wyoming, Utah, and Colorado. A production goal of 2.5 million barrels per day of shale oil has been often cited. However, oil shale development is energy intensive and may require as much as 5 to 10 barrels of water per barrel of upgraded shale oil produced. We investigated the impacts of shale oil production, climate variability, and climate change on surface water resources in the White and Upper Colorado Rivers using the Watershed Analysis Risk Management Framework (WARMF) model. WARMF is a decision support system built around a physically-based basin hydrology model. A critical advantage of WARMF is its ability to simulate reservoir and river diversion operations. This capability enables us to assess how the operations of water infrastructure may be modified to optimize flows to meet supply needs as water demand grows and climate variability and change intensify. In particular, we focused on Colorado's Piceance Basin to assess the impact of shale oil production rates of between 100,000 and 1.5 million barrels of oil per day. Without considering climate change or transfers of existing water rights, our analysis suggests that new water demand from shale oil production could be met by diverting flows from the White and Upper Colorado rivers (during periods of medium to high flows) into a regionally expanded reservoir with a capacity of about 200,000 acre feet for a production rate of 1.2 million barrels of oil per day at a water to oil ratio of 3-to-1. When we impose climate change scenarios the model results show a significant reduction in snowpack in the Colorado Mountains, which in turn leads to significant decreases in river flows. However, if some existing water rights are transferred to the oil shale industry, the impacts on river flows are decreased.