Groundwater-Lake Interactions and their Impact on Water Quality

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Georgetown Lake is a 1489 ha lake situated in the Pintler Mountains, MT. The lake is highly recreated and was classified as mesotrophic to eutrophic. Throughout the winter ice cover season, dissolved oxygen concentrations continually decrease from high biological oxygen demand. Several previous water quality studies have been conducted but no detailed groundwater investigation and the role of groundwater on water quality has previously been conducted. This study presents a geochemical investigation coupled with streamflow and other physical water measurements to enhance our understanding of how groundwater interacts with the lake. Radon, water isotopes, major ions, and nutrients were collected spatially throughout the at the lake bottom in over 130 locations during late winters of 2011 and 2013 prior to ice melting. Major ions and water isotopes were also collected bi-monthly at all major inflows and outflows from September 2012 until December 2013. Water isotopes, major ions, and ^{222}Rn were also collected in several groundwater wells and springs located near the perimeter of the lake and in springs discharging further down the mountain slope from the lake. The purpose of this study was to i) investigate locations where groundwater enters the lake, ii) characterize the role of groundwater in controlling lake water quality, iii) identify locations where lake water recharges regional groundwater, iv) conduct an annual water balance focusing on the quantities of groundwater inflow and groundwater outflow.

Georgetown lake is separated by a westward dipping thrust fault consisting of a Precambrian metasedimentary rock lower plate to the west and a Paleozoic carbonate upper plate to the east. Spatial variations of water chemsitry (particulary ^{222}Rn) show that groundwater discharges to the lake from the east through the carbonates. During the late winter, S and N species are reduced and mostly in the form of H_2S and NH_4, but S is mostly SO_4^{2-} with no detectable N species along the eastern shores where well-oxygenated groundwater enters the lake. Water isotopes show highly evaporated lake water in the western portion of the lake but groundwater with little to no evaporation replaces lake water to the east. Springs located downslope to the west of the lake show a similar evaporation signal as lake water suggesting that lake water recharges groundwater through the metasedimentary rock to the west. Temporal records of water chemistry were incorporated into a water balance which allowed separation of groundwater inflows from outflows.