Category I - Hydrology, Climatology & Hydraulics

Application of a New Model for Groundwater Age Distributions: Modeling and Isotopic Analysis of Artificial Recharge in the Rialto-Colton Basin, California

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Executive Summary:

The "banking" of water in aquifers has drawn much interest lately as a strategy for managing the water reserves. The ability of any given aquifer to serve as reservoir and filter for such waters, in particular, reclaimed wastewater is indicated by the groundwater residence time, or age. Banking is being considered at the Rialto-Colton basin aquifer, via infiltration through the Linden ponds (Figure 1). Age serves as a useful indicator of ground water renewability and the feasibility of using aquifers for water storage, and equally importantly, it is a measurable parameter.

The ability of any aquifer to serve as reservoir and filter for such water …….. is indicated by the groundwater residence time, or age. Carbon-14 (C^{14}) isotope is normally used as a tracer to compute the ground water ages. A comprehensive reactive transport with established set of geochemical reactions over the entire aquifer is being developed to estimate the age of groundwater in the Riato-Colton basin aquifer which is being considered for banking water imported from Northern California.

Carbon-14 (C^{14}) isotope is normally used as a tracer to compute the ground water ages. To determine age at a point in space and time in an aquifer, one measures the C^{14} activity there and with known activity in influent, calculates age as the time required for the radioactive decay to reduce the activity of the influent to that of the measured, with corrections for geochemical reactions. This projectcharacterizes these reactions in the Rialto-Colton basin aquifer in Southern California and quantifies their effects on C^{14} data by simulating reactive transport in the aquifer over several thousand years. The information is then used to estimate the groundwater age directly by solving the age equation (Ginn, 1999).

In the aquifer, the geochemical reactions may alter the initial C^{14} content of the influent through gain, loss or dilution of the dissolved inorganic carbon as the water travel through the system. The impacts of geochemical reactions on the C^{14} activity of the influent water in the aquifer has been accomplished by employing the geochemical codes PHREEQC (Parkhurst, 1995) which simulates the chemical reactions of water and NETPATH (Plummer and others, 1994) which simulates the flow paths through the aquifer.

For the initial study, the Rialto-Colton aquifer is divided into 4 primary flowpaths that follow the general direction of groundwater flow from NW to SE (Figure 1): 1) A-A' middle water bearing unit, 2) A-A' lower water bearing unit, 3), B-B' middle water bearing unit, and 4) B-B' lower water bearing unit . We found that the most dominant reactions that affect C^{14} activity of the influent water, and hence ground water ages, are silicate weathering, clay precipitation, cation exchange, calcite precipitation/dissolution, and organic matter oxidation. For the A-A' lower unit flowpath that runs parallel to and east of an unnamed fault, the age of the water ranges approximately between 3,000 to 16,000 years with ages increasing from 3,000 years at the beginning of the flowpath, to 13,000 years at the end of the flowpath. For the B-B' lower unit flowpath that lies on the west of the unnamed fault, the ground water age ranges approximately between 500-14,000 years from the beginning to the end of the flowpath. Both of the lower water bearing units do not demonstrate the effects of mixing with younger waters from the Linden pond and the nearby creeks, e.g. Lytle Creek, which is expected. For the A-A' middle unit, the mixing of the native ground water with the Lytle Creek water is discovered between the first 3 and 6 miles downgradient along the flowpath. The ground water age ranges between 200-1,300 years with the start location of the flowpath having the oldest water. The effect of mixing between the native water with the younger Lytle Creek water exhibited such that the ages of the water farther than 3 miles downgradient are younger than that at the beginning flowpath and the youngest water is located approximately 5-6 miles downgradient. For the B-B' middle unit, the range of ground water ages is about 300-8000 years. There is no apparent mixing of the native ground water with any other recharge source. The mixing of the native water with the imported water from Linden pond is however expected particularly somewhere on the A-A' middle water bearing flowpath. We hope to resolve this anomaly as described next.

The preliminary investigation involves sophisticated chemical reaction modeling, along with highly simplified flow path simulation. To treat both reactions and transport realistically, we will develop a comprehensive reactive transport model with the established set of geochemical reactions over the entire aquifer, instead of only the 4 independent flowpaths. This will be accomplished by employing HBGC123D (Gwo et al., 2001) implemented with isotopic calculation step following Wigley et al. (1978) for computing C^{14} and stable C^{13} contents of the water. Computed carbon contents will be calibrated with the measured carbon contents to assess the amount of imported recharge into the Linden pond. Future research will also develop a the RAFT (Chilakapati, 1997) flow and reactive transport code for generating steady state and transient ground water age distributions by using the age equations formulated by Ginn (1999).