Groundwater Exchange Pools and Urban Water Supply Sustainability: Modeling Directed and Undirected Networks

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Abstract: Groundwater basins are important sources of water supply and storage for many cities. Groundwater exchange pools offer additional opportunities for utilizing these common pool resources, but their potential role in urban water management is not clear, and modeling such exchanges can be challenging. This paper presents an analysis of the potential for groundwater basin exchange pools to contribute to urban water supply sustainability. Building on an existing model of urban water management in Los Angeles, the analysis assesses the potential for groundwater exchange pools to reduce scarcity and demonstrates a method for modeling two-way (undirected) flows within a directed-network model using linear programming. Results indicate that exchange pools can help alleviate shortages from operational changes (reduced imported water) in Los Angeles, but providing more parties with access to storage improves their effectiveness. Exchange pools could potentially provide 6–12% of total supplies and reduce shortages as much as 86%. Considerations for organizing exchange pools are discussed to explore policy implications for managing common pool resources. The analytical method for embedding undirected network flows within a larger directed-network model has wide applicability for water resource systems analysis applications, including modeling water markets and interbasin transfers. **DOI: 10.1061/(ASCE)WR.1943-5452.0000949.** *© 2018 American Society of Civil Engineers.*

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Introduction

Groundwater is an important resource for many cities (Foster et al. 2010; Howard 2015). Groundwater basins provide both clean water supply and local storage capacity. Managing groundwater resources conjunctively with other available supplies supports their long-term preservation (Blomquist et al. 2001, 2004; Hill et al. 1946; Todd and Priestadt 1997; Trelease 1982). But urban watersheds are also connected to upstream water resources outside their jurisdictions when utilities import water from distant watersheds. Better management of local groundwater resources in cities can have widespread effects for connected landscapes and watersheds.

Organizing the sustainable use of water resources, including groundwater, across local or regional systems is a complicated management challenge with significant implications (Blomquist 1992; Brown and Farrelly 2009; Kiparsky et al. 2013; Marsalek et al. 2001; Wolfe and Brooks 2003). Groundwater is often considered a common pool resource (CPR). CPRs have several key defining characteristics. First, they are nonexcludable but rival. All users are affected when one or more users overexploit the resource (Hardin 1968). Second, many CPRs are renewable but can be depleted (Ludwig et al. 1993; Ostrom 1990). Third, they can be managed through cooperative, noncooperative, or external governance structures (Madani and Dinar 2012; Ostrom et al. 1994). CPRs can be openly accessible, or access can be controlled by government agencies and other organizations. Management agreements allocate access and usage rights, but codified arrangements may exclude some entrants and convert a CPR into the property of certain participants (Ostrom and Hess 2000; Wade 1986). Managing CPRs sustainably often requires both controlling the appropriation of the resource and taking actions to protect and improve its yield.

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