Large scale quantification of aquifer storage and volumes from the Peninsula and Skurweberg Formations in the southwestern Cape

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Abstract

The Western Cape Province of South Africa is a relatively water-scarce area as a result of the Mediterranean climate experienced. Due to the increased usage of groundwater, and the requirement to know how much water is available for use, it is imperative as a 1st step to establish an initial estimate of groundwater in storage. The storage capacity, namely, the total available storage of the different aquifers, and the storage yield of the fractured quartzitic Peninsula and Skurweberg Formation aquifers of the Table Mountain Group (TMG), are calculated with a spreadsheet and Geographic Information System (GIS) model. This model is based on the aquifer geometry and estimated values (based on measured data) for porosity and specific storage (calculated using the classic Jacob relation). The aquifer geometry is calculated from 1:50 000 and 1:250 000 geological contacts, faults and major fractures, with dips and aquifer formation thickness calculated through structural geology 1st principles using a Digital Elevation Model (DEM). Balanced geological cross-sections constructed through the model areas provide an important check for the aquifer top and bottom surface depth values produced by the GIS model. The storage modelling undertaken here forms part of the City of Cape Town TMG Aquifer Feasibility Study and Pilot Project, with modelling focusing on the 3 main groundwater target areas at Theewaterskloof (Nuweberg), Wemmershoek and Kogelberg-Steenbras. In the storage models, the Peninsula and Skurweberg Formation aquifers have confined pore volumes ranging from approximately 29 bn. to 173 bn. m^3 and 4 bn. to 26 bn. m^3, respectively (based on using different porosity values ranging from 2.5% to 15%). Using an average head decline of 1 m across the confined aquifer areas across all 3 groundwater exploration areas, and confined pore volumes based on a porosity of 5%, 6.9 Mm^3 and 1.1 Mm^3 of groundwater, from the Peninsula and Skurweberg Formation aquifers, respectively, is available. The aquifer storage model intentionally makes use of low, geologically reasonable values for porosity and aquifer compressibility, so as to provide minimum large-scale 1st estimates of potential yields; however, when new data become available these initial porosity and compressibility assumptions will probably be revised upward. The storage yield approach is also very conservative, as it does not take into account the annual replenishment of the aquifer, and constitutes the yield potential during drought conditions (zero recharge) from the confined portion of the aquifer only. The yield model therefore provides a quantitative perspective on the common public and decision-maker perception that groundwater abstraction from the deep confined Peninsula Formation aquifer will significantly dewater the system, with (often unspecified) adverse ecological consequences. Even where the regionally-averaged decline in hydraulic head approaches 20 m, the volume released by aquifer compression generally remains in the order of 0.24% of the total volume in slow circulation within the deep groundwater flow system. A vastly greater volume of groundwater is essentially non-extractable by any practical and/or economical means.

Keywords: Table Mountain Group, Peninsula Formation, Skurweberg Formation, hydrogeology, aquifer, storage modelling, storage yield