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An operating strategy for run-of-river abstractions for typical rural water supply schemes using Siloam Village as a case study

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ABSTRACT

The study focuses on the development of an operating strategy for optimum scheduling of run-of-river abstractions in typical rural water supply schemes in accordance with the quantitative and qualitative requirements of the rural water demand sectors using Siloam Village as a case study. The operating strategy has been generalized to enable its use in any river system. Since Nzhelele River at Siloam Village is ungauged and no daily streamflow data was available in the nearby Mutshedzi River sub-quaternary catchment (SQC), within the same quaternary catchment A80A, a water balance model was used to compute the inflow into Mutshedzi Dam. The Mike 11 NAM and Australian Water Balance Model (AWBM) used in rainfall-runoff modelling of the Mutshedzi River SQC were calibrated and the results verified using the computed inflow hydrograph. Each of the model's performance was assessed based on the overall root mean square error, Nash Sutcliffe coefficient of efficiency, percentage bias, correlation coefficient and overall water balance error. The availability and suitability of Nzhelele River water for domestic use and the environment were assessed using the unregulated river water yields and water quality respectively. The results of the water resources assessment were used to derive operating rules for Nzhelele River at Siloam Village. The Mike 11 NAM model underestimated most of the peak flows while AWBM overestimated most of the small to medium peak flows and underestimated the major peak flows for both calibration and verification runs. Both models estimated the low flows reasonably well for the calibration and the verification runs, except in a few cases where they underestimated the low flows. The Mike 11 NAM and AWBM performances were good and comparable though the latter performed relatively better than the former. Both models were therefore used in the simulation of the streamflow hydrograph for Nzhelele River SQC at Siloam Village and the results compared. The model parameters were transferred based on the nearest neighbour regionalization technique. The simulated runoff was used to derive unregulated river water yields at different levels of assurance of supply (LAS) for Nzhelele River SQC at Siloam Village using 1 day flow duration curves. The results of the water resources assessment show that Nzhelele River water can meet the low flow and domestic water requirements for the survival, standard and high levels of supply services at a LAS of approximately 90% (1:10). The domestic water requirements cannot be supplied at the recommended LAS of 99.5% (1:200), 99% (1:100), 98% (1:50) and 95% (1:20). High levels of turbidity make Nzhelele River water unsuitable for domestic use unless treated at household level to reduce turbidity and microbiological risks to acceptable levels. The derived operating rules for Nzhelele River at Siloam Village are that the river water can be scheduled daily for LFR and domestic use at approximately 90% LAS, and other sources of water should be used to optimize the supply of domestic water requirements to or towards 99.5% LAS on daily scale. The development of an operating strategy integrating run-of-river abstractions, groundwater and rainwater to ensure that the domestic use, environmental flow requirements and possibly food security and irrigation are met at the required LAS has been recommended. The generic operating strategy for run-of-river abstractions has been derived by summarizing the procedure used in developing the operating rules for Nzhelele River at Siloam Village and can be applied to any river system to fully or partially supply the community with water.