Flow Routing in Ephemeral Arid Rivers under the Influence of Transmission Losses and Groundwater Recharge Dams

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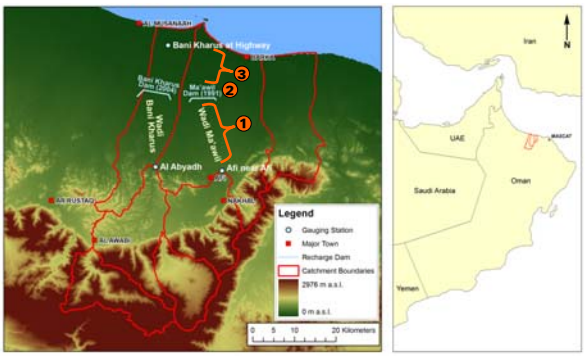
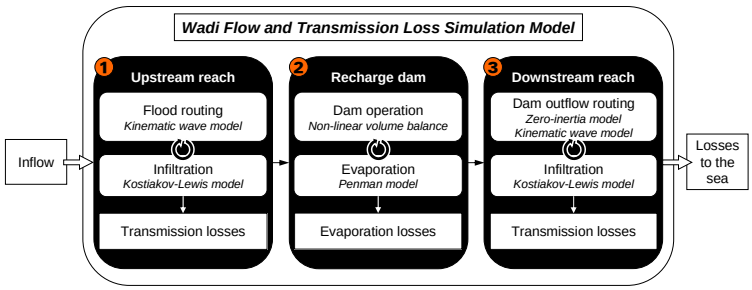
Motivation

The coastal aquifer in Oman's Batinah plain is affected by saltwater intrusion due to excessive groundwater withdrawal for irrigated agriculture. To account for a more sustainable water resources management, a sound groundwater recharge assessment is needed. The estimation of infiltration in ephemeral streambeds (or Wadis) during flood events is important for quantifying total groundwater recharge. However, flash floods caused by convective rainstorms lead to substantial freshwater losses to the sea. In order to minimize these losses and to promote artificial recharge of the coastal aquifer system, several recharge dams have recently been constructed in the wadi beds. The proposed model accounts for the quantification of transmission losses in the upstream wadi reaches as well in the downstream reaches, where flow dynamics are significantly weakened by dam operation. The sound modelling of such weak process dynamics (which can include standing wave effects if dam release rates equal transmission loss rates) is carried out with a novel analytical solution of the zero-inertia equations.

Investigation Area



Modelling System – Wadi Ma'awil

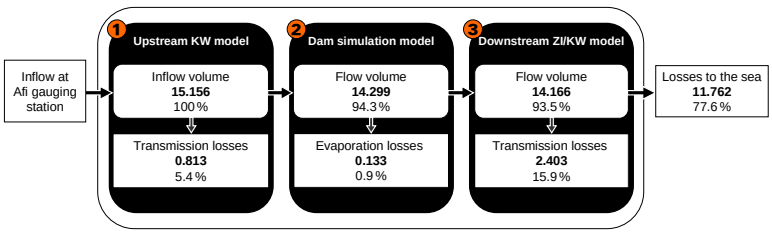


- Robust sub-models
- Optimal exploitation of available data
- No numerical issues during weak wave advance/recession downstream of dam due to analytical solution (PHILIPP et al., 2010)

Data Demands and Availability

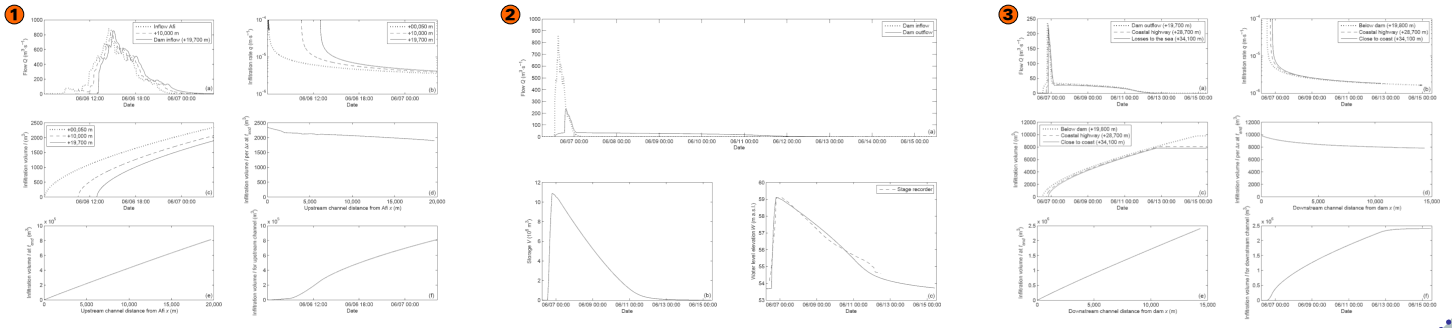
Data	Parameter(s)	Assessment	Notes
Wadi cross-sectional data	$\bar{A}(x,h)$, $\bar{R}(x,h)$; resp. $p_1(x)$, p_2, $p_3(x)$, p_4	Obtained from digital elevation model (ASTER DEM) and aerial imagery	Cross-sectional data included via specific profile functions
Longitudinal profile	S_0^*, K^*	S_0 obtained from ASTER DEM, K from field assessment and calibration (based on flow observations)	S_0 calculated from talweg of cross sections
Infiltration characteristics	k_a^*, k_k^*, k_c^*	Infiltrometry testing and calibration (based on observed transmission losses)	Infiltration modelled with empirical Kostiakov-Lewis model
Dam characteristics	$V = f(W)$, $A_r = f(W)$, $\alpha_{c,s}$, $H_{c_{1,2},s}$, L_s, D	Engineering report of the dam	Outflow characteristics determinable a priori
Inflow data	$Q(t)$	Obtained at Afi gauging station	Daily and sub-daily values, peak values
Dam water level over time	$W(t)$	Water level recorder	Timely-resolved data are scarce
Climate data	$T(t)$, $e(t)$, $G(t)$, $w(t)$	Seeb climate station	Evaporation is modelled with Penman model

Mass Balance for Cyclone Gonu Event



- Infiltration parameters were calibrated for well-monitored neighboring catchment of Wadi Bani Kharus (PHILIPP and GRUNDMANN, 2012)
- Calibrated model was used to simulate the most extreme observed event, caused by cyclone Gonu (06/07/2007)
- Model parameterization turned out to be feasible for Wadi Ma'awil since available dam stage recordings were soundly met (② in results box)

Modelling Results for Cyclone Gonu Event



References

PHILIPP, A., G. H. SCHMITZ, and R. LIEDL (2010): An Analytical Model of Surge Flow in Non-Prismatic Permeable Channels and Its Application in Arid Regions, Journal of Hydraulic Engineering 136(5).
PHILIPP, A. and GRUNDMANN, J. (2012), Flow Routing in Ephemeral Arid Rivers Under the Influence of Transmission Losses and Groundwater Recharge Dams, Journal of Hydraulic Engineering, subm.