

A Simulation Model to generate the Demand Hydrographs in Large-scale Irrigation Systems

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The study reports the development of a model for the generation of daily volumes and hourly discharge hydrographs, withdrawn from on-demand pressurised irrigation systems. The model is based on the simulation of the water budget at the level of each single hydrant. Under the hypothesis that the initial soil moisture is at field capacity, once the soil water reserve falls down a pre-defined limit value, irrigation occurs. The farmer's management strategy was simulated using a stochastic approach allowing for the generation of the initial time of each irrigation at each hydrant. The aggregation of the hydrant hydrographs generates the discharge hydrographs at the upstream end of the network. The calibration of the model was carried out comparing the generated and measured hydrographs at the upstream end of an irrigation network in Southern Italy. The results obtained are satisfactory even though they require further verifications. The comparison has generally shown a good correspondence, particularly for daily withdrawn volumes. The simulated hourly discharges showed, sometimes, hourly peaks higher than the measured ones. The proposed model, when well calibrated, can be used for the design of new irrigation systems as well as for the analysis of existing ones.

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1. Introduction

Large pressurised irrigation systems allow for better services and higher distribution efficiency as compared to open channel systems. Systems operating on-demand offer the greatest opportunity to meet irrigation requirements as farmers decide when and how much water to take from the network (Labye *et al.*, 1988; Lamaddalena & Sagardoy, 2000). A number of preliminary conditions have to be satisfied: (i) an adequate water tariff of withdrawn volumes, (ii) delivery devices equipped with flowmeter, flow limiter, pressure control and gate valve, and (iii) an adequate design for conveying the demand discharge during the peak period by delivering the minimum pressure head at hydrants for on-farm irrigation equipment.

One of the most important uncertainties in an on-demand system is the calculation of the discharges from the network. As farmers control the irrigation, it is impossible to know, *a priori*, the hydrants operating simultaneously. In such systems, the nominal discharge

attributed to each hydrant is much greater than the expected share, so that the hydrant operates for less than 24 h. As a result, the probability of all hydrants being open simultaneously is very low. Thus, it would not be reasonable to design the network for a discharge equal to the sum of the hydrants capacities. These considerations have justified the use of probabilistic approaches for computing the discharges in on-demand systems. However, variabilities related to the discharges flow occur in such systems in relation to scheduling decisions over time depending on the cropping pattern, crops grown, meteorological conditions, on-farm efficiency and management strategy. These variabilities may produce failures related to the design options. Therefore, designers and managers should have an adequate knowledge of the hydraulic behaviour of the system.

The advent of on-demand large-scale irrigation systems in the early 1960s, in France, fostered the development of statistical models to compute the design flows. Examples of such models are the first and the second formula of Clément (1966). Although these

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