

Application of a residential end-use model for estimating cold and hot water demand, wastewater flow and salinity

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Abstract

The structure and data requirements of an end-use model for residential water demand and return flow are presented in a companion paper. This paper focuses on the practical application of the model. The model is first applied to confirm a few commonly observed water demand patterns: Seasonal variation in demand, the positive correlation between average annual daily water demand and stand size, and the increase in water demand, hot water demand and wastewater flow with an increase in household size. The convergence between the predicted model results and independently observed values by others encourages practical use of the model. Secondly, the effects of some specific water demand management measures are evaluated by adjusting selected model parameters. The measures include xeriscaping, the installation of dual-flush toilets and low-flow showerheads, pool ownership and pool cover use. The model provides a rapid means to obtain first estimates of the likely effects of different water demand management measures.

Keywords: water consumption - mathematical models, water salinisation, hot water supply

Introduction

An end-use model for water demand and sewer flow analysis is discussed in a companion paper (Jacobs and Haarhoff, 2004).

In this paper the authors demonstrate the practical application of the model. Some definitions, abbreviations and acronyms used in the companion paper are not repeated here, as they are common to both papers.

The residential end-use model (REUM) enables the analyst to estimate the indoor- and outdoor water demand, hot water demand, wastewater flow, and concentration of total dissolved solids (TDS) in the wastewater flow for an individual residential stand and a given set of input parameters. This makes the model unique – although other end-use models have been developed, applied and studied in South Africa (Van Zyl et al., 2004) none combine these five components into one model.

In this paper REUM is verified by investigating the convergence between the predicted model results and independently observed values by others. The paper also illustrates how a few specific water demand management (WDM) measures could be evaluated in detail with the use of REUM.

Factors influencing the model results

Numerous factors influence the indoor and outdoor water demand, hot water demand, wastewater flow and salinity. In REUM provision is made for 79 parameters, each varying over 12 months, to completely describe these five components. Table 1 indicates those parameters that require adjustment in this present investigation. For a full list of model parameters, reference could be made to Jacobs and Haarhoff (2004). Some of these parameters are briefly discussed below.

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Household size

The notation used to describe the so-called quantity parameter in REUM is n . The parameter n is equal to the household size for most indoor end-uses. For the purpose of this investigation the household size is considered to be measured in units of people per household (PPH). In other words, it is the number of water consumers on the stand.

Many values for household size have been published. The 51 published values that could be obtained from the literature vary between 2.6 and 4.7 PPH for suburbs, with a typical value of approximately 3.3 PPH for South African suburbs.

As could be expected, the value is higher (and less predictable) for township stands, ranging from 3.8 to 8.2 PPH for the seven published values obtained; no typical value is apparent. Up to 27 PPH have been reported (Simpson, 1983), but these higher values include more than one household, or tenants, on a single stand; such stands are not included in the present investigation.

It has been reported that *per capita* water use decreases substantially with an increase in the household size. The reduction in *per capita* water demand from 1 to 4 PPH, recorded in a detailed study by Edwards and Martin (1995), was about 40%. This value pertains almost exclusively to indoor demand, because the reported outdoor demand represents less than 5% of the total. Morgan (1973) presents similar findings regarding reduced *per capita* water demand with an increase in the household size.

However, for the illustration of **differences** due to different WDM measures in this paper (which cannot affect the household size) it was decided to maintain a constant *per capita* demand.

Blended water temperature

The desired “hot” water temperature is a blend of hot and cold water, thus it is termed blended water temperature. The value appears to be linked to the human body temperature (about 38°C). Relatively small variation around this value has been reported in