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**Drinking Water
Engineering and Science
Discussions**

Interactive comment on “Hydraulic modelling of drinking water treatment plant operations” *by* G. I. M. Worm et al.

G. I. M. Worm et al.

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Response on review of DWESD 1, 155–172, 2008: DWESD 2, S3–S5, 2009

We would like to thank the referee for his or her comments. The referees' questions (Q) have been replied to with answers (A).

Q: In page 157, line 19 I find some confusion with the terms “head” and pressure, and their relation with the PSV usage. The authors say that “[...] a PSV maintains a fixed pressure at the upstream junction [...] by adding a specific head difference to the elevation [...]” and it is not really in that way. If we name head as H and pressure as p, the relation between both magnitudes in a junction is given by the more scientific equation:

$$H = \frac{p}{\gamma} + z$$

In this expression, z is the elevation of the junction, and p/γ is the pressure term. I would substitute the line 19 (page 157) by the equation shown above.

The usage of the PSV is as described by the authors in their reply to referee 1 (pages S82 and S83). I must disagree with referee #1 at this point, but must also state that the original explanation of PSV was poor. It is better explained in the reply mentioned above.

A: Since the suggestion of the referee is valid for junctions in general the following text has been added in to the introduction of junctions:

The total head in a junction is the elevation added up to the pressure in the junction according

$$H = \frac{p}{\rho \cdot g} + z$$

Where H is the total head (mwc), p is the pressure (N/m^2), ρ is the density of the fluid (kg·m^{-3}), g is the acceleration due to gravity (m·s^{-2}) and z is the elevation of the junction on a chosen level.

Q: I don't share the model the authors propose for wells. The authors model the drawdown in the well through a general purpose valve (GPV) with a linear relationship. There are 16 wells which supposedly are very close one to each other. The linear relation between flow and drawdown, as proposed by Thiem, corresponds to an isolated well with constant extracted flow. For the situation described for this paper, a second nonlinear term must be added, obtaining the following equation, due to Rorabaugh (1953):

$$\Delta z = \frac{Q}{2\pi T} \ln \frac{R}{r_w} + kQ^n$$

In the equation above, Q is the extracted flow, T is the soil conductivity, R the influence well radius, rw the distance to well, k a coefficient to be determined, and n an exponent ranging between 1 and 2.

Anyway, the description of this model for wells is unnecessary since it is not used. Finally, as described in page 160, lines 10 to 12, “[...] the water level measurement inside the well has been used instead of the groundwater level minus the groundwater estimation [...]”.

A: The revised paragraph on wells that replaced the lines 11–13 p158 of the original has been modified again to:

The water level of a freatic aquifer is modelled with a reservoir. Wells can be equipped with a submerged pump or can be part of a vacuum-gravity system to extract the water from the aquifer. As Thiem proposed (Thiem, 1906), for isolated wells with a constant extracted flow the relation between extracted flow and drawdown can be assumed to be linear. For pumped wells, a second non linear term must be added, leading to the following empirical relation (Rorabaugh, 1953) between drawdown and extracted flow

$$\Delta z = \frac{Q}{2\pi T} \cdot \ln \frac{R}{r_w} + k \cdot Q^n$$

Where Q is the extracted flow, T is the soil conductivity, R the influence well radius, r_w the distance to the well, k a coefficient to be determined and n an exponent ranging between 1 and 2. For any situation where the relation between extracted flow and draw-down is known the well draw-down is modelled with a GPV.

Although neither of the two ways to calculate the drawdown was used in the Harderbroek model, authors appreciate the referee’s suggestions, believe in the value of this paragraph and chose not to remove it.

Q: “[...] the speeds [...] were set manually to match the flow of the historic data [...]” (page 162, lines 3 to 5), which is like including a constant negative demand (interpreted as a constant inflow by EPANET solver).

A: Authors agree the yield of the pump can be realised by adding a negative base demand to a junction. However, for use of the model in practice where the speeds are

available from the process automation system and for use of the model after integration in a drinking water treatment plant simulator, the original solution will be used.

Q The model layout shown in Figure 1 is redundant and unclear. The model of each element in the plant was described in the text and in Table 1. So, a simpler sketch of plant’s layout with the elements (wells, cascades, rapid sand filters, tower aerators, and clear water reservoirs) is easy to understand.

A: The figure has been replaced by a treatment scheme and a description:

The model represents a ground water treatment plant with a normal production of 1000 m^3/h. The model contains presentations of the 16 wells, each with a submerged pump, the 4 cascade aerators, the 8 rapid sand filters, each with a pump in the effluent pipe of the filter and the 3 tower aerators. The model contains 344 pipes, 528 junctions and 207 valves.

Q: Independently from scale, the plots in Figures 2 and 5 show some obvious deviations. In Figure 2, measured flows from wells are mainly bigger than calculated. On the other hand, in Figure 5 almost all measured effluent flows in the rapid sand filters seem to be smaller than the calculated ones. In fact, only 3 measures are bigger than calculated flows. The updated figures shown in the reply by authors seem to be mistaken, since the three figures are the same.

A: The right, different, figures have been sent to the Publisher in response to the comments of the first referee, but during typesetting one figure was copied three times. Again the three new figures are given below and hopefully will end up in the typ set of this reply. From the reply to referee 1:

Referee 1 mentions the sand filters have the calculated flow consistently greater than the measured flow. This was further analysed by the authors. Obviously the pumps deliver more water than would be expected. Authors consider it’s likely the formula used to calculate the pump speed (technical specification current frequency controller) is not accurate. For the percentage of the speed control 0% equals an electricity frequency of 13 Hz in stead of 15 Hz and 100% equals an electricity frequency of 56 in stead of 58 Hz. As can be seen in Figure 5 model results are more balanced and have a higher accuracy as well.

Interactive comment on Drink. Water Eng. Sci. Discuss., 1, 155, 2008.

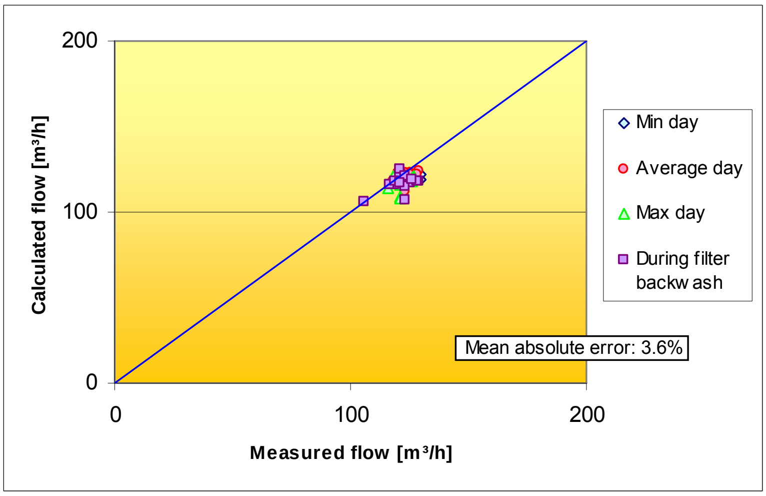

Fig. 2. (NB. this will be fig 3 in the revised paper). Validation of flows from wells.

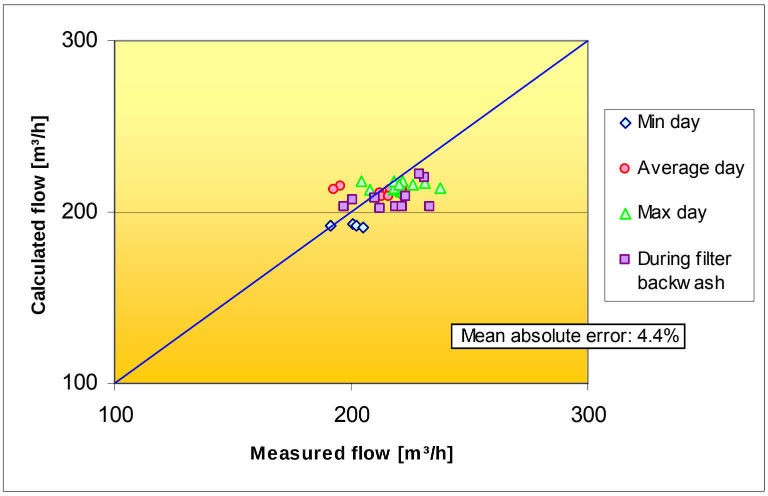

Fig. 4. (NB. this will be fig 5 in the revised paper). Validation of influent flows rapid sand filters.

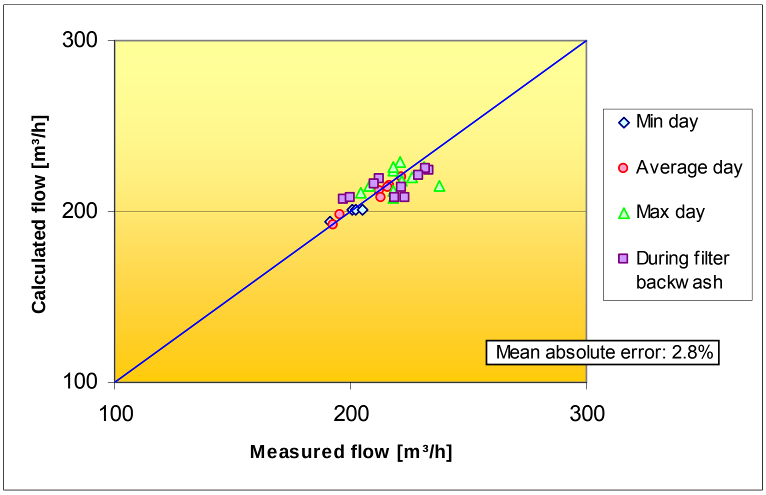

Fig. 5. (NB. this will be fig 6 in the revised paper). Validation of effluent flows rapid sand filters.