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Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Applying SWAT to predict orthophosphate loads and trophic status in four reservoirs in the upper Olifants catchment, South Africa" *by* J. M. Dabrowski

J.M. Dabrowski

jdabrowski@csir.co.za

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Author Response to Reviewer 1:

Important Points:

The approach adopted in the calibration procedure was to continue to run SUFI-2 iterations until a further improvement in one calibration station was not possible without a deterioration in another. The parameter ranges of the last iteration were then used in subsequent model analyses. The current parameter ranges as published in the manuscript were achieved after two iterations. We did perform an additional iteration

in an attempt to improve the calibration. However, we found that while an additional iteration resulted in a slight improvement in objective functions for some calibration stations, there was a deterioration in B2H014. This fact, and the fact that statistics for this station were not that good (Table 3) indicate that hydrological processes in this catchment may be fundamentally different from other parts of the catchment and a separate calibration for this part of the catchment may have been more appropriate. This aspect has been addressed in the Conclusion section (Page 18, Line 25 – Page 19, Line 11 – specific reference to B2H007 and B2H014 has been made in this section of the conclusion in the revised version). This section also elaborates on challenges associated with multi-site calibration approaches as adopted in this study. Multi-site calibration results in data from multiple sites across the catchment being used in the calibration process which results in better catchment representation in the calibration process. However, a drawback of this method is that calibration using multiple sites introduces more constraints on the process, which means that fewer iterations will be possible before a calibration iteration will result in an improvement at some sites and a deterioration in other sites.

The poor performance at B2H007 and B2H014 may also be related to the fact that this part of the catchment had a relatively poor weather data record and therefore had to rely on the SWAT weather generator for simulations (this has been discussed in the manuscript – (from Page 11, Line 19). Based on this response I have not performed additional iterations as suggested by the reviewer, however a more detailed explanation of the rationale behind the number of iterations in the calibration procedure has been included in the revised version of the manuscript.

2. The SWAT model does not simulate the effect of management of sewage treatment works (STWs). The only manner in which improved management of STWs can be simulated is simply by reducing the point source loading associated with each of the STWs (with the assumption being that improved management improves the quality of effluent released). In this respect SWAT was indeed used to simulate changes in

STWs management, by reducing effluent concentrations from 4 mg/l (estimated current conditions) to 1 mg/l and 0.1 mg/l in the tested scenarios.

3. A warm-up period was included in the model runs. This warm-up period was for the year 1999 to 2001 (i.e. 3 years). Model data was only analysed for the years 2002 to 2010. This explanation has now been included in the text of the manuscript under section 2.3 (Model Calibration).

4. Various aspects in the Conclusion have been elaborated upon in the revised version of the manuscript so as to address this specific comment.

Specific Comments:

Page 1363, Line 9: Naish, replaced with Nash

Page 1363, Line 23: ‘a’ has been deleted.

Page 13630, Line 18: Dryland agriculture is commercial. This has been included in the revised manuscript.

Page 13641, Line 11: The model is likely to be very sensitive to fluctuations in OP effluent concentrations. This can be seen in the large reduction in OP loads when adopting a 1 mg L-1 effluent scenario. Improved model performance would be achieved through more rigorous monitoring of effluent concentrations at STWs. However considering the expense of monitoring a compromise needs to be made between increased monitoring or relying on a combination of limited measured data and modelled data (as in this study). The fact that OP loads were well predicted in catchments with and without STWs would indicate that the 4mg L-1 effluent concentration was a fairly accurate assessment of STWs throughout the catchment. This point was emphasised in Page 13645, Line 18-22 and has been further emphasised by including the following sentence: “This further indicates that 4 mg L-1 was a reasonable estimate of current effluent concentrations from STWs.”

Page 13641, Line 21: The author followed the recommendation of the reviewer (“. . ..

to estimate daily weather.”

Page 13461, Line 25: A reference has been included in the revised version of the manuscript (DWA, 2011b).

Page 13642, Line 22: These parameters were obtained from the literature. The sentence has been modified to accurately reflect this: “For flow calibration, sensitive parameters influencing peak and base flow were obtained from the literature (Neitsch et al., 2002; White and Chaubey, 2005) and used to calibrate flow simulations for the calibration stations.”

Page 13642, Line 24: See response to “Important Points” above.

Page 13643, Line 2: Naish replaced with Nash

Page 13643, Line 3: R2 were not in fact used. The author used the incorrect notation for the Nash-Sutcliffe coefficient. The sentence has been corrected as follows: “The NS coefficients range from infinity to 1. If the NS coefficients values are less than or close to 0, the model simulation is taken as an indication of poor or unacceptable performance.”

Page 13644, Line 1: A warm-up period was included in the model runs. This warm-up period was for the year 1999 to 2001 (i.e. 3 years). Model data was analysed for the years 2002 to 2010.

Page 13644, Line 23: This sentence has been changed as recommended by the reviewer: “In general, flow simulations at calibration stations compared well to measured flow records and simulated monthly maximum flow volumes were similar to maximum volumes measured at flow gauging stations across the catchment (Fig. 2).

Page 13645, Line 6: This aspect is dealt with later on in the discussion (Page 13645, Line 25 to Page 13646, Line 2).

Page 13645, Line 11: This sentence has been corrected: “With the exception of

B2H014, NS statistics for the validation stations were slightly lower than for calibration stations across (Table 3)."

Page 13645, Line 17: This reference has now been included in the revised manuscript. The sentence has been updated as follows: "The SWAT model has been successfully applied to simulate hydrology in other African countries (Baker and Miller, 2013; Schuol et al., 2008), as well as at the catchment (Andersson et al., 2011; Govender and Everson, 2005) and national scale (Andersson et al., 2012) in South Africa."

Page 13645, Line 20: This reference has been included in the revised manuscript.

Page 13645, Line 25: abscent corrected to absent.

Page 13646, Line 10: More detail on the manner in which average loads were calculated has been provided: "In this context, the difference between mean annual measured and predicted loads was considered to be an acceptable form of evaluating model performance. Mean annual loads were calculated by summing monthly loads for a year and determining the annual average for the years 2002 to 2010."

Page 1346, Line 28: The map has been revised to indicate mean annual OP loads generated per sub-catchment (as opposed to accumulated loads from upstream to downstream). This has the effect of clearly identifying which sub-catchments are responsible for generating high OP loads.

Page 1347, Line 6: This is simply because some STWs are smaller and release lower volumes of effluent (and therefore smaller loads of OP) on a daily basis. While the same concentration of OP in effluent was used for all WWTWs (i.e. 4 mg/L or 1 or 0.1 mg/L for the effluent reduction scenarios), the specific effluent discharge rates for each WWTW were incorporated into the model. This means that OP loads generated by each WWTW will vary according to the discharge rate of the specific WWTW. This was described under section 2.2 (Page 13641, Line 12-13 of the HESSD pdf).

Page 13647, Line 7: The author feels that this paragraph emphasises the point that

very few studies have applied SWAT in predicting OP loads and concentrations in rivers and especially reservoirs. This emphasises that the results from this study represent a relatively new contribution to the application of SWAT, within the South African and global context.

Page 13467, Line 25: While the author concedes that there are large discrepancies at the monthly resolution, the PBIAS statistics nevertheless do indicate that the range of simulated OP concentrations fall within an acceptable range of measured concentrations, indicating that the model was able to make realistic simulations of OP concentrations at the monthly time-step. However falling within a range is not the same as an accurate simulation as would be indicated by a good NS statistic (i.e. while the concentrations are within a similar range they do not necessarily correspond well along a monthly time resolution). For this reason the first sentence of this section has been deleted and the following sentence has been modified as follows: "PBIAS statistics indicated that simulated OP concentrations in the four reservoirs were within an acceptable range of measured concentrations, particularly in the Witbank and Bronkhorstspruit reservoirs (Fig. 5)."

Page 13649, Line 24: This would include factors such as riparian buffer strips, conservation tillage, fertilizer management etc.. This has been explicitly stated in the revised version of the manuscript.

Page 13651, Line 9: It would not be possible to simulate this with SWAT as currently the model does not simulate the cycling of nutrients within a reservoir system. Thus the study focussed on predicted OP concentrations and associated trophic status associated with the three STW scenarios. These are presented in Figure 8.

Page 13652, Line 3: Under prediction changed to under-prediction.

Page 13652, Line 17: Undoubtedly has been changed to "most likely".

Table 2: Capacity has been corrected.

Table 3: The caption has been modified to reflect the fact that these statistics are for monthly simulations. B1H004 was not spaced differently in the original submission. This has obviously occurred during the type-setting process. The comment related to the poor statistics for B2H014 has been dealt with in my response to point 1 under "Important Points".

Figure 4: The actual figure and the figure caption have been updated as per the reviewers comments.

Figure 5: For all reservoirs, measured OP concentrations were not well simulated by the model from 2008 onwards, with measured concentrations being considerably lower than simulated predictions. No obvious modelling errors could be detected that could account for this difference. The discrepancy could possibly be related to the inability of the model to simulate nutrient cycling associated with the production of algal blooms in the reservoir. For example the first large algal bloom recorded in Loskop Reservoir was in 2007, after which time blooms have re-occurred on an annual basis (Dabrowski et al., 2013). Subsequent monitoring in the reservoir revealed very low concentrations of OP associated with algal blooms – presumably due to uptake of OP to facilitate growth of algae (Dabrowski et al. 2013). The fact that these blooms occurred near the inflow of the reservoir (in the lacustrine zone) and that monitoring takes place at the dam wall could suggest that algal blooms may intercept OP concentrations and deplete levels before they reach the dam wall. None of the other reservoirs were studied in as sufficient detail to determine whether similar processes occur. (This explanation has been included in the revised version of the manuscript).

Figure 8: The figure caption has been updated to address the reviewers comment.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 13635, 2013.

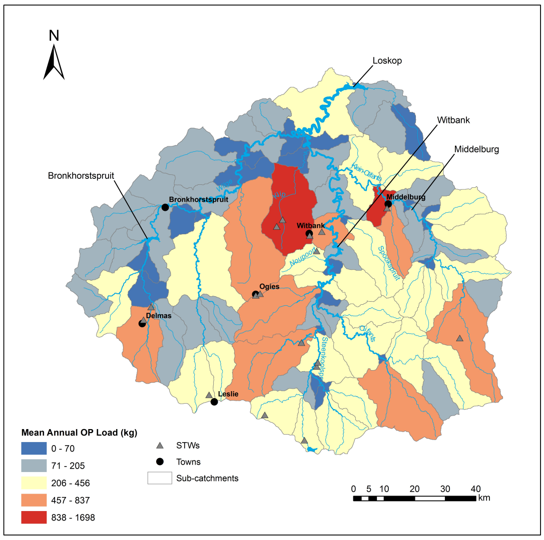

Fig. 1. Revised version of figure 4