Response to the comments

Date: Dec. 1, 2014
To: **A. L. Hojberg**"alh@geus.dk"
From: Samy Khalaf "samykhalaf2005@yahoo.com"
Subject: Response on comments for MS No.: hess-11, C4537–C4538, 2014
"Optimal well locations using Genetic Algorithm
for Tushki Project, Western Desert, Egypt "

I appreciate the insightful comments and suggestions, which greatly will improve this manuscript. Kindly, in the following is the response to these comments.

General comments

Comment (1): The language needs to be improved significantly. In its present form, several parts of the MS is difficult or not possible to understand.

Reply: OK, English language was reviewed.

Comment (2): The detail of the descriptions is very varying. Some aspects is devoted much space without providing much relevant descriptions, e.g. descriptions of GA starting with Darwin and genes, while other aspects is almost not described leaving the reader with questions, e.g. description of the model calibration. The length of the text describing the different aspects should be more balanced, reflecting what is relevant for the present study.

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Reply: The detail of the descriptions for all aspects is devoted much space, for model calibration described in pages 11 and 12 under title model calibration, and pages 15 and 16 under title Results and discussions to illustrate results of model calibration for steady and transit state.

Comment (3): The structure of the MS is generally good, but needs to be revised at some places to better guide the reader, especially where the calibration of MODFLOW and the optimization with OLGA is described

Reply: Thank you, for model calibration is divided two parts, first part to illustrate how to make the calibration model and the second for discussion of calibration results, Will be transfer of the second part with the first part to better guide the reader. But the optimization with OLGA is accepted described.

Comment (4): In the downloaded version of the MS the legends and text in the figures are very difficult to read..

Reply: OK, will be improved the legends and text in the figures.

Comment (5): There are 13 figures, some may be removed and some need improvements.
Reply: OK, will be improved the legends and text in 13 figures.

Specific comments

Comment (1): Introduction: The introduction includes a description of several previous studies on optimisation techniques, including a short list of the detailed results from these studies, such as number of wells, abstractions rates or costs. These results is not relevant for the present study and it is not explained how the present study builds on top of existing studies. It should be more clear how the present study utilise knowledge from previous studies and what is new in the present study. The introduction should thus be revised.

Reply: OK. The introduction was reviewed, line 5 in page 5 was edit "optimal location of operating wells since the effect each another be side drilling in straight line around highway. The solution of this problem is proposed in this study".

Comment (2): 1.3 Hydrological aspects
"General groundwater flow direction is from SW to NE direction" this cannot be seen from the figure. It is wrong or does it refer to a regional flow not visible in the figure?

Reply: OK. , The general groundwater flow Characteristics to the Nubian sand stone aquifer in western desert in from SW - NE while figure 4 chosen the local groundwater flow direction which reflect the recharge from river Nile to adjacent aquifer i.e. SE-NW.

Comment (3): "The groundwater flow rate was estimated as 0.044 m/day (near Nasser Lake) and decreased to 0.044 m/day towards northwestern parts (El-Sabri et al., 2010)" it is the same number twice.

Reply: OK. , was verified from reference (EL-Sabri) and was corrected statement as follows: "The groundwater flow rate was estimated as 0.054 m/day near Lake Nasser and decreases to 0.044 m/day towards southwestern and middle parts of the area".

Comment (4): "2. Materials and methods "The last paragraph is repetition and can be left out"

Reply: OK. , The last paragraph was deleted from Materials and methods.

Comment (5): "The groundwater flow rate was estimated as 0.044 m/day (near Nasser Lake) and decreased to 0.044 m/day towards northwestern parts (El-Sabri et al., 2010)" it is the same number twice.

Reply: OK. , was verified from reference (EL-Sabri) and was corrected statement as follows: "The groundwater flow rate was estimated as 0.054 m/day near Lake Nasser and decreases to 0.044 m/day towards southwestern and middle parts of the area".

Comment (6): “2.2 conceptual model

“The basement surface forms an impervious lower boundary for the aquifer and acts as a barrier to the lateral groundwater flow in some locations” What is meant by "some locations", what is the condition elsewhere?

Reply**: *OK.* *, some locations (NW direction where the basement rocks are out Detectors see Fig. 2)*.**

Comment (7): 2.4 Model calibration: This section is simply some textbook materials of little use in the MS. Instead the section should describe the calibration methodology used including:

Observation data: is it only calibrated to hydraulic heads? How many observations wells? (appears to be 9 from the figures). Where are they located?

Reply**: *OK.* *, Number of observation wells is 9 wells and their location shown in the below figure.***

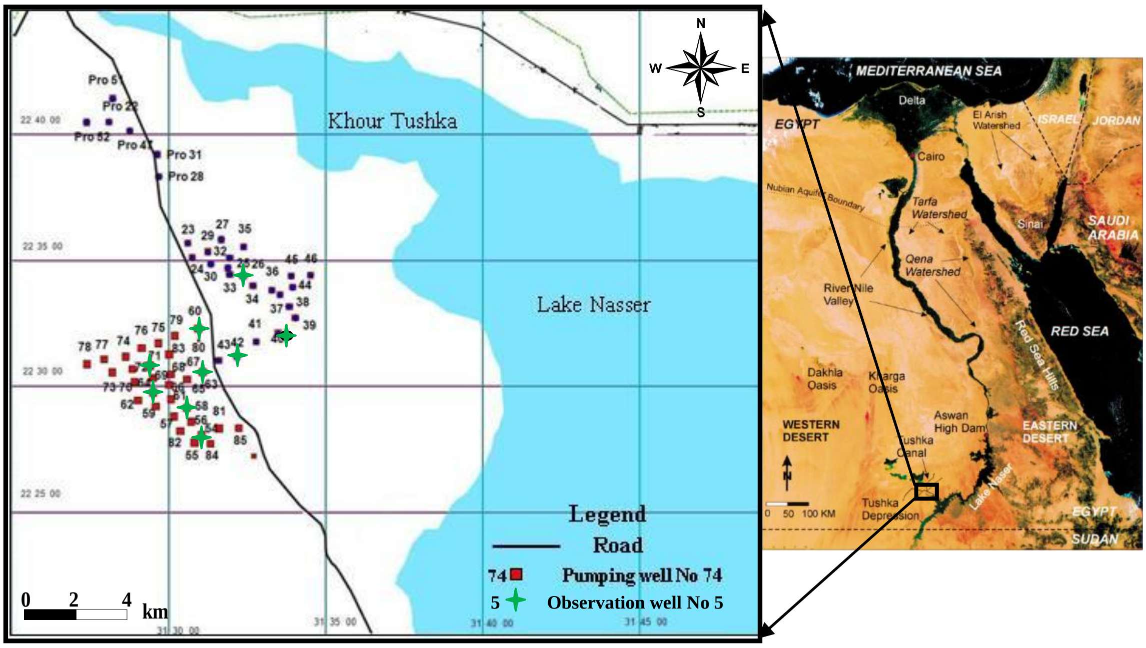

Fig. 1. Location map of the study area showing
the location of 48 flowing wells and 9 observation wells

Comment (8): How many parameters where included in the calibration? Horisontal/vertical conductivities – one for each geological units? What is the assumption with respect to the faults? What is the interaction with the lakes? Is the boundary conditions calibrated – how?

Reply**: *OK.* *, Number of parameters included in the calibration is hydraulic conductivity in steady state and specific yield in transit state. Horizontal/vertical conductivities were variable for each geological units. The assumption with respect to the faults appear on hydraulic conductivity. The boundary conditions is constant during calibration and simulation***

Comment (9): For the transient calibration what type of data is used – are there any time series of head from observation wells or is storage calibrated by first calibrating the heads to the 2008 data and then calibrating the storativities by running the model to 2010 and comparing to the 2010 data?

Reply: OK. , specific yield was used in the transient calibration; do not used any time series of head from observation wells.

Comment (10): Have any attempt been made to validate the model. It seems that little information is available on head data and the dynamics of the aquifer. The simulated drawdown in the scenarios are very dependent on the calibrated specific yields, thus uncertainty in these estimates will result in uncertainties in the simulated drawdown. What will this uncertainty mean for the final results and recommendations?

Reply: OK. , You are right, it first trial for optimal wells location and results need to be collection through continuous monitoring groundwater level.

Comment (11): 2.5 Optimisation technique + 2.6 Testing scenarios

The optimisation procedure and the test of scenarios is difficult to understand. What is e.g. meant by "After completing the stage of calibration, the output of the first round is used to replace the initial condition with the condition of implementing the exploitation policies."

Equation 3 – 6 list the constraints in the GA optimisation, but which values where used in the constraints

Values used in the constraints

pumping constraint

Q_{min} = 300 m3/day

Q_{max} = 1000 m3/day (first scenario)

Q_{max} = 1500 m3/day (2^{nd} and 3^{rd} scenario)

drawdown constraint

d_i = 30 m

water demand constraint

Q_D = 60000 m3/day (first scenario)

Q_D = 120000 m3/day (2^{nd} scenario)

Q_D = 900000 m3/day (3^{rd} scenario)

distance between wells constraint

D_{all} = 500 m

What is the actual objective function – how is drawdown and optimal Q weighted?

$$\sum_{j=1}^{N_w} r_j \le d_i \quad \text{at point } i$$

$$= r_{w1} + r_{w2} + r_{w3} + r_{w4} + r_{w5} + \dots\dots\dots \quad at \text{ point } 1$$

$$= r_{w1} + r_{w2} + r_{w3} + r_{w4} + r_{w5} + \dots\dots\dots \quad at \text{ point } 2$$

$$= \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$= r_{w1} + r_{w2} + r_{w3} + r_{w4} + r_{w5} + \dots\dots\dots \quad at \text{ point } N_c$$

Since every well has an effect on the adjacent wells due to the distance between wells is less than the radius of influence, and according to the presence of cone of interference, so it is logic to define the drawdown constraint in terms of sum of drawdowns at control points and the governing equation become: (there was an error in formulation the equation and replaced by)

Comment (12): 3 Results and discussion

The results from the calibration of the groundwater model and the results from the optimisation should be in individual sub-sections In table 4-6 and in the discussions I have problem understanding what variables are 1) results, and what are 2) constraints in the GA optimisation.

a. r(m): I guess it is a constraint during optimisation, but numbers in the tables are the final results – what constraint has then been used?

Drawdown constraint, this constraint normally meant to protect the ecosystem by avoiding excessive drawdown. In this work, the drawdown constraints were formulated to avoid mining

$$\sum_{j=1}^{N_w} r_j \le d_i \quad \text{at point } i$$

$$= r_{w1} + r_{w2} + r_{w3} + r_{w4} + r_{w5} + \dots\dots\dots \quad at \text{ point } 1$$

$$= r_{w1} + r_{w2} + r_{w3} + r_{w4} + r_{w5} + \dots\dots\dots \quad at \text{ point } 2$$

$$= \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$= r_{w1} + r_{w2} + r_{w3} + r_{w4} + r_{w5} + \dots\dots\dots \quad at \text{ point } N_c$$

In which: r_j is the drawdown at control point i caused by a pumping rate from pumping well j (value of r_j see table 4 to 6), di is the permissible drawdown at control point I equal = 30 m.

b. Qmin/well – as above

c. Qmax/well, is this only a constraint or has the optimisation resulted in this Qmax for some wells?

Pumping constraint

Q_{min} = 300 m3/day

Q_{max} = 1000 m3/day (first scenario)

Q_{max} = 1500 m3/day (2nd and 3rd scenario)

d. Qopt: I guess this is the total daily extraction for the optimised setup

Why do you end up with different Qopt in the different scenarios. Should Q_demand not be the same for scenario 1 and 2, while 3 should be larger to include the reclaimed land? The Qopt in scenario 3 is actually lower than in scenario 2?

Ok, The Qopt in scenario 3 is actually lower than in scenario 2 because the second scenario ***studies the optimal locations for these 68 productive wells and their optimal pumping rates.*** The third one proposes water exploitation policy aimed at increasing the ***present productive wells by 14 wells***. The predicted value of (r) based on the 3rd scenario is more or less similar to the results of the other two scenarios although the number of the operating wells is increased by 20%. This reflects the great importance to apply the optimal well location concept in any new reclamation projects.

Comment (13): Tables:

Table 1 and 2 is of little value. Instead the resulting values (transmissivity and storage) should be provided

Ok, the transmissivity distribution values show in figure 3 and was insert the storage value in table 1 and 2.

Table 4-6 may be combined to one table

Table 4-6 was separated because it's better guide the reader

Comment (14): Figures:

Figure 3, is not too relevant and can be excluded

Figure 3 show the transmissivity distribution values (right map), in case excluded of this figure must be insert transmissivity values.

Figure 5, what is the information of this? We do not need just the discretization. It should show the different types of internal and external boundaries, where are they located and what type is used? We can only see the fixed head in the lakes, what about the others? What are the two black lines – roads? Some grids have shades from brown to blue, what is that – topography?

The information in Figure 5 are external boundary conditions (constant head the lake), grid (Δx and Δx). Black line is road (see legend) and other is grid lines. Grids have shades from brown to blue are beach of lake.

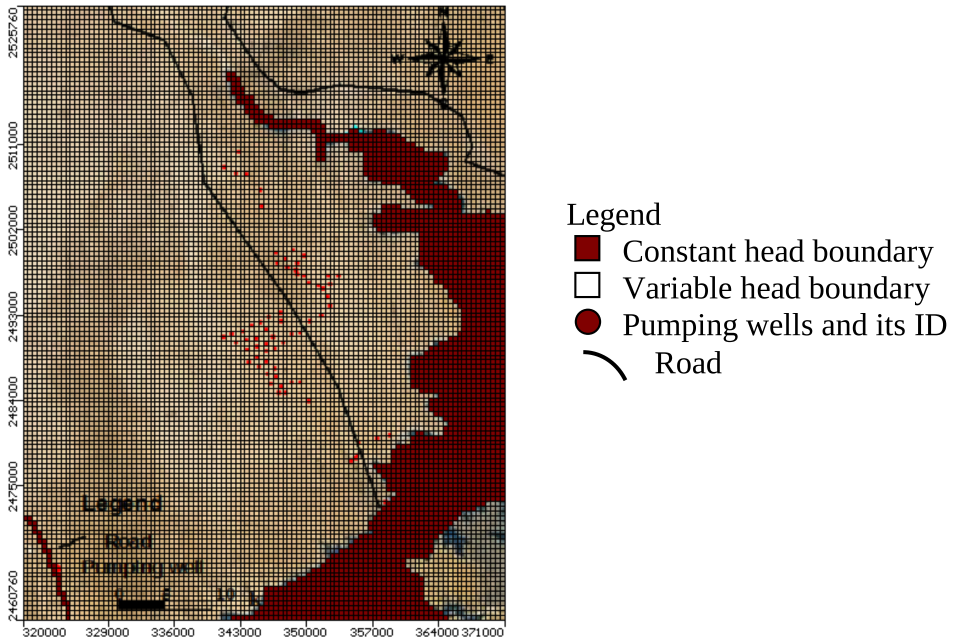

Fig. 5: Flow model domain grid and the boundary conditions of the NSATA model

Figure 6, I do not understand this figure, what does is illustrate?

Figure 6 illustrated the constraint of location of wells; the locations of wells constraint is to be decided by the model itself within a user defined region of the model grid until the optimal location is reached..

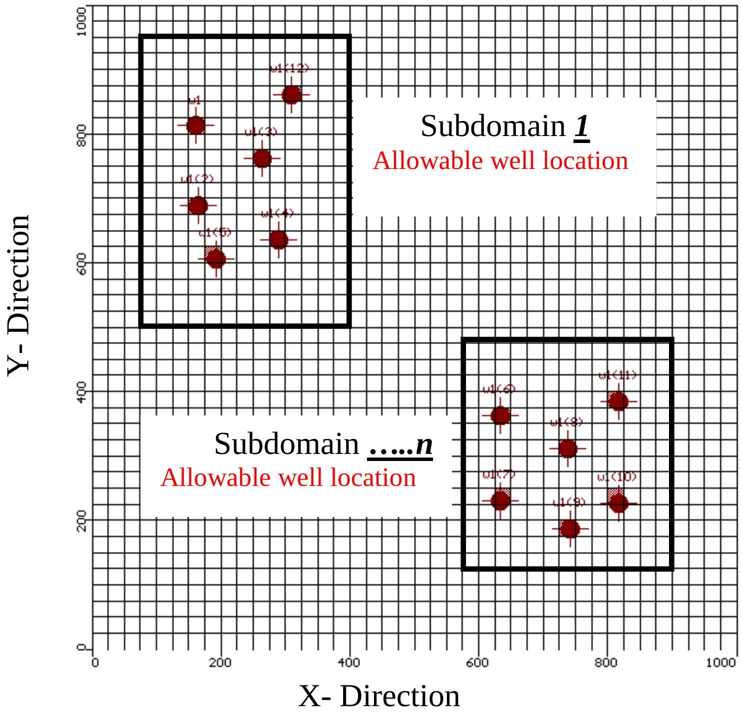

Figure 7. Very relevant figure, but I do not quite understand it. Left side illustrates a MOFLOW simulation without wells? How does this simulation generate initial population? On the right figure is the second box MODFLOW MODEL (Simulation model) With wells a simulation with one possible well distribution i.e. one member of the population?

MOFLOW simulation without wells is making to generate the initial head, but initial population generate from genetic algorithm via random number for each well according to constraints and number of chromosome.

Figure 8a and 8b can be left out and replaced by a table with the final results from the calibration

Ok, you are right, can be replaced by a table with the final results from the calibration, but to illustrate the calibration behavior.

Figure 9, why is there no background for this figure displaying the results of scenario, while the results from the two other scenarios (Figure 11 and 13) have a background

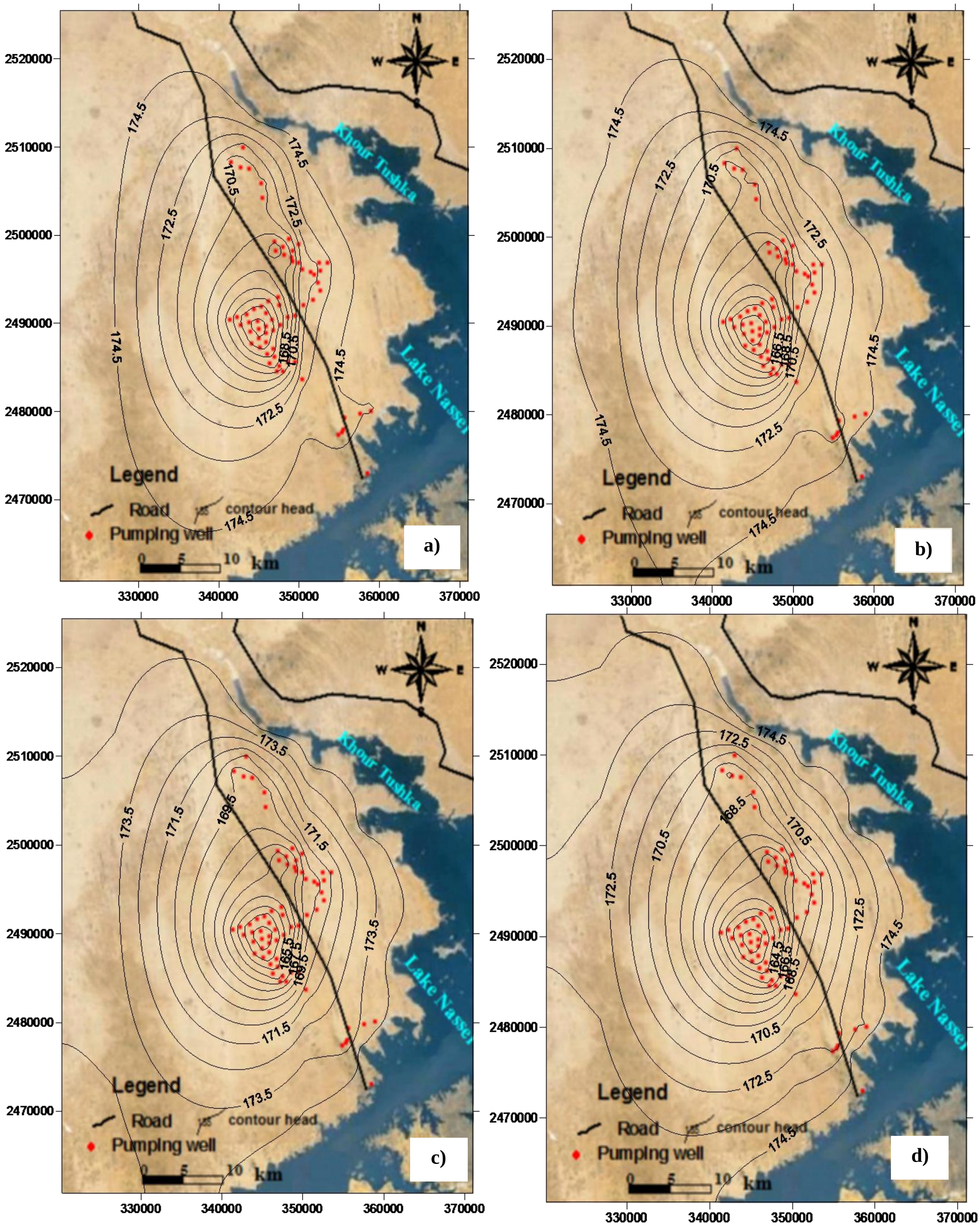

Fig. 9: Predicted head distribution map of the NSATA for optimal pumping rates applying 1st scenario a) at 2015, b) at 2025, c) at 2035, and d) at 2060

Figure 10, provides little information, either skip this figure or include the present location of the wells with another colour.

Ok, the below figure illustrate required

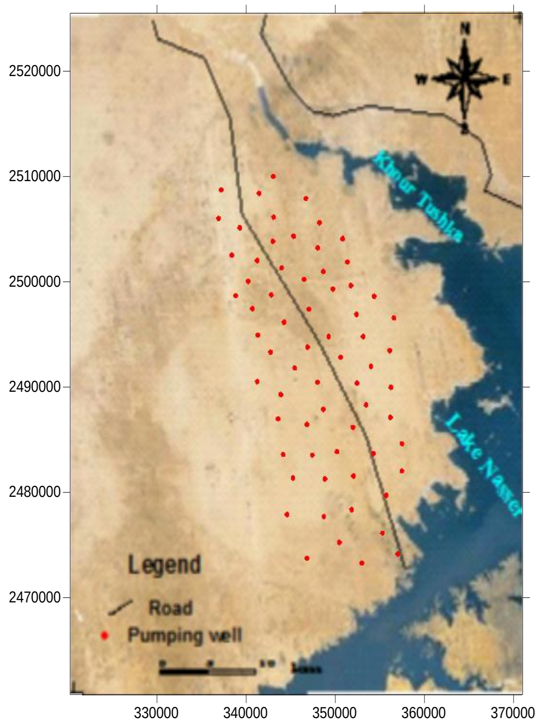

Fig.10: Optimal location of wells (2nd scenario)

While some figures can be left out, it would be nice to have the following figures:

One displaying the conceptual model with a cross section and the thickness of NSATA

Ok.

One displaying the location of the observation wells used in the calibration of the groundwater model

Ok, the location of the observation wells used in the calibration of the groundwater model was added in Fig. (1).

Comment (15): Number of wells:

Different number of wells in the area is mentioned. In the site description it is stated “About 155 wells were already for this purpose (Fig. 1) besides 210 wells will be drilled by the end of the year 2017”. In figure 1 there is not 155 wells, the figure caption mentions 48 flowing wells (abstractions wells?) and in the optimisation scenarios the existing number of production wells is 68?

Ok, sorry the different number of wells in the area is mentioned because 48 this number write wrong the right number is 68 in the figure caption "the figure caption mentions 48 flowing wells".

Number of well in study are

1st scenario = 68 production wells (optimal pumping rate)

2nd scenario = 68 production wells (optimal location of wells)

3rd scenario = 68 + increase 20% *68 (optimal location of 20% wells)

Comment (16): Units:

Different units are used throughout the text, e.g. acres and square meters, please use SI units

Ok.

With kind regards,

Authors