Analysis of three-dimensional groundwater flow toward a radial collector well in a finite-extent unconfined aquifer

The authors present a solution for transient flow toward a radial collector well. The title suggests that the solution covers transient flow in an unconfined aquifer, but the boundary conditions along the phreatic surface are simplified to such an extent that I doubt that the approximation is sufficiently close to the stated problem to be of much use. The phreatic surface is not only assumed to be a horizontal straight line, which in itself is a severe approximation, it is also assumed to remain in its original position at all times. The boundary along the moving phreatic surface, equation (7) in the paper, is simplified to equation (8), which implies that the vertical component of flow is equal to minus the specific yield multiplied by the rate of decrease in elevation of the phreatic surface, maintained at the original position ($z = 0$). Compressibility of the aquifer is included, but not in the sense of poro-elasticity, but using the Terzaghi approximation. I agree that this approximation is usually acceptable dealing with groundwater flow, but the authors should state their approximations carefully, including this one.

The boundary conditions along the two streams are applied over the height of the aquifer (full penetration); this is not mentioned (referee 1 also mentions this point).

The authors integrate a point sink along the legs of the radial collector well, but fail to mention what boundary condition applies along the legs. The head should be maintained constant along the legs, whereas the condition applied by the authors is constant influx, as far as I have been able to gather from the description.

The mathematical model resulting from the highly simplified boundary conditions and the application of the various transforms is not presented in sufficient detail for me to be able to verify the steps without re-deriving much of the work, which should not be necessary.

The flow problem shown in Figure 2 is not clearly defined. The authors comment about existing models assuming 2-D flow with neglecting the vertical flow component; based on this comment, I assume that this figure applies to 3D flow, but this is not stated clearly. The sections shown in the figure do not mention whether these are horizontal or vertical; neither do they mention where the sections apply. If the flow considered is three-dimensional, then there does not exist a stream function, but the authors define one in equation (65). If the flow is transient ($\bar{t} = 10^7$), then the transient storage is yet another reason for the stream function not to exist; the divergence of the specific discharge vector is not zero. Perhaps the authors made the assumption that the time considered is so large that change in storage can be neglected, but this approximation must be stated. Furthermore, equation (65) is not obvious and, besides stating the approximation, the derivation should be presented.

Summary

The authors present a very complex solution based on highly simplified boundary conditions and with insufficient detail. The authors do not present any comparison with

existing solutions for simplified boundary conditions as a validation, both of their equations, and of their simplifying assumptions.

The derivations are very difficult to follow and lack sufficient detail. The authors refer to equations further in the text, a procedure that violates standard approach in scientific work, and forces the reader to look ahead for equations that have not been digested yet.

I believe that the authors in their use of the stream function, violate basic principles; however, they may have made assumptions that are not stated clearly but if so, this needs to be rectified.

I suggest that the paper be shortened substantially and rewritten as follows:

- Remove the claim that the work applies to unconfined flow; it does not.
- Focus on one particular case, e.g., a radial collector well in a confined aquifer.
- State all boundary conditions clearly, including the ones along the legs of the radial collector well and the ones along the streams.
- Make a comparison with an existing solution for at least one case.
- Present the details of the analysis, taking into account that the reader should be able to follow the steps without the need to redo the analysis.
- If use is made of a stream function, make it clear that the flow is two-dimensional and steady. Otherwise, there does not exist a stream function at all.