*Dear Giorgos,*

*My comments this time are in italic green.* ***Again here we are only discussing the saturated condition.***

My comments and corrections are in red. This is only for the case of **saturated** connection. Please do not introduce River Package interpretation for the unsaturated connection into the equations I have written with only the case of saturated connection in mind.

In some parts of your report you use FORTRAN expressions rather than mathematical equations. Please modify your notations to be more precise and then I shall review your document again. X = Ax has meaning as a FORTRAN expression but mathematically it is only possible if A = 1. In most equations where you use the Fortran symbolism, A is definitely not 1. Forgive me for such emphasis on being precise because if we have errors in these relatively simple procedures it will be very difficult to detect them when integrated into a complex numerical scheme.

**Inputs:**

: Groundwater head

: Stream head

: The elevation (of what? The groundwater head in the aquifer?) where the river becomes disconnected. I interpret it to mean the elevation of the bottom of the riverbed **, not** the elevation of the bottom of the river. That would fit the River Package (RP) definition for incipient desaturation. Unfortunately in the literature people use the word disconnection for incipient desaturation. Actual disconnection of flow is not incipient desaturation.

My understanding is that your interpretation is correct. It is the bottom of the riverbed. I had totally neglected the riverbed thickness. However, the IWFM input files refers to this value as “*Stream bottom elevation relative to a common datum [L]*”. This is also a question for Can and Tariq. *Yes it is. Check with them. The point is that desaturation will occur when the capillary pressure at the interface between the aquifer and the riverbed drops below the entry pressure of the aquifer material. With RP it is implicitly assumed that this entry pressure is zero; so desaturation will come when the groundwater head drops below the bottom of the riverbed, when pressure at the interface is below atmosphere.*

The difference of these two elevations is the thickness of the riverbed (clogging layer), . In IWFM that value is assumed to be, I think, 1 foot but it could be 1 meter.

Riverbed thickness is a user input parameter, and it is defined for each stream node it’s not necessarily 1.

I do not favour that terminology “disconnected”. There is no disconnection of flow. The flow in the aquifer below the riverbed is either saturated or unsaturated. It is not disconnected. Disconnection would happen if the water content in the unsaturated zone dropped below the residual water content. That will not happen during a receding water table below a riverbed. It will happen when evaporation has dried the top part of a soil such as for example an agricultural field. It could happen if the riverbed itself had fully dried up and the river itself was completely dry.

I use the term  to mean elevation of Bottom of RiverBed relative to the bottom of the aquifer used as the datum. Then 

**I proceed with the assumption that you mean *elevation of the bottom of the riverbed*,**

is the elevation of the bottom of the first geologic layer defined by the user.

**Calculate head for left and right. These equations are incorrect. (**I have updated the equations)

Correct

Correct

Missing in the denominator of the fractions in the two equations is the effective porosity of the aquifer also known as specific yield. I use the symbol: .

**Calculate stream stage.** Assuming again that ELEVdisc is elevation of the **bottom of the riverbed** this equation is incorrect. From Hstream you would have to subtract in addition the thickness of the riverbed, .



I agree. Just to be safe we have to clarify the definition of ELEVdisc with Can and Tariq. Yes do.

**Calculate aquifer depth, normalized depth and wetted perimeter.**

Daq is meant to be the saturated thickness of the aquifer. The saturated thickness of the aquifer is the sum of the elevation of the phreatic surface (with datum at the bottom of the aquifer) plus the thickness of the capillary fringe, with symbol . So that value has to be added.



I have to discuss the implementation with Can. The difference is not going to be very large because  is never larger than 30 to 50 cm for the aquifer material

If then I understand that this check has to be done due to numerical procedures. No comment.

and

Otherwise Below is correct. No changes up to page 5

**Calculate and**

**Calculate coefficients based on the tableTable

Description automatically generated**

**Calculate**

**Calculate the equivalent stream width and**

**For the Asymmetric case only:**

Note that this average value is the same as Hgw

Both hL and hR are heads. Thus in the below equations it should not be the river stage, Hstg, but the river head, Hstream.

**Note my note of February 18, 2021**

The formula for the left and right sides of the ***flat*** conductance for a given wetted perimeter is analytically derived to be:

 (11a) with  (12)

 (11b)

is the stream head.

Below is incorrect; it should not be Hstg but Hstream

Below is fine

**For the Isotropic case:**

**For the Symmetric case (Isotropic):** Gsafe is not defined

is calculated once prior to the simulation as

unnecessary equation



Where is the area of the node (I presume that you mean the area of influence of the node) and L ( or  ) is the half distance to upstream node + half distance to downstream node.

**For the Asymmetric case (isotropic): See corrections below**



 

OK

OK

**For the Anisotropic case:**

OK

OK

OK

OK

**For the Symmetric case (Anisotropic):**

OK

OK

OK

OK

**For the Asymmetric case (Anisotropic):**

 *Adjust*

 *Adjust*

*Change  to *

*Change  to *

**Correction for clogging layer**

**For Symmetric case(isotropic):**

*OK*

**For Symmetric case(anisotropic):** *OK*

**For the Asymmetric and Isotropic case:**

*OK*

*OK*

**For the Asymmetric and Anisotropic case:** *I cannot read the last part of the equation but I think it is correct with the thickness of the riverbed in the numerator and adding the stream stage to the half width in the denominator.*

**Calculate stream-gw interaction:**

In the following expression is the output of the clogging correction. Depending on the case it is one of the following ,. Similarly, and can be ,, or , respectively.

**For Symmetric case:**

No this is using a River Package interpretation on how to deal with the unsaturated case. Under saturated connection what is subtracted is Hgw.

Is the following the correct SAFE approach? *Yes.*

Under an unsaturated connection first of all the criterion for incipient desaturation is not hbrb and second the discharge is not calculated by the above equation. This is RP approach. It is not SAFE approach.

**For the Asymmetric case:** *The same answer as above. The term is ELEVdisc is never used in these equations. Only the actual groundwater heads on left and right.*

*Naturally it is possible that one of the sides desaturates if it head falls below the incipient value. And the incipient value will not be the same for each side.*

*As a reminder I add the formula for incipient desaturation for the case of symmetry:*

*According to SAFE incipient desaturation starts when*

* (2)*

*is the head in the river, is half the river bottom width,  is the river stage, is the horizontal saturated conductivity of the aquifer,  is the one-sided SAFE dimensionless conductance, is the riverbed (clogging layer) saturated conductivity, is the thickness of the riverbed and is the entry pressure of the material of the aquifer below the riverbed expressed as a water height. Note the relation between stream head and stream stage:  (3)*

*In Eq.(2)  is evaluated for a saturated aquifer thickness , a degree of penetration  (4) and a normalized wetted perimeter  (5)*

*Now why do you add the left and right discharges?*

*Can was particularly interested in assessing the discharge on both sides are they are different….Of course you may have need for the total in the overall mass balance.*