Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-237-AC1, 2018

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Application of pore water stable isotope method to characterise a wetland system" *by* Katarina David et al.

Katarina David et al.

k.david@unsw.edu.au

Received and published: 18 June 2018

Dear Reviewer, Thanks for the very constructive review and comments provided for the manuscript. We have included a detailed response to the questions below in blue. Reviewer's Comment This paper contains a novel method for characterising the hydrology of wetlands and swamps and presents a scientifically robust model of temperate upland swamp hydrology that fits within the context of current research into similar ecosystems. It is a well written paper with high scientific significance.

Response:We thank the reviewer for the positive feedback.

Comment:One issue is that the terminology for describing groundwater within the swamps and regional groundwater aquifers is not differentiated. A major part of the

paper is concerned with connectivity of the swamp aquifers with regional groundwater, yet the term groundwater is used to describe both aquifers. One way of differentiation may be to call swamp groundwaters 'swamp water' or 'swamp water table' and regional groundwater 'groundwater' or 'sandstone aquifer' or similar and use these terms consistently throughout.

Response:Thanks, the terminology has now been improved by differentiating between swamp groundwater and regional groundwater by introducing the new terminology as suggested. The swamp groundwater is now used to discuss swamp groundwater and regional groundwater to describe regional groundwater.

Comment:Another issue is that while the paper presents the application of the stable isotope direct vapour equilibration method to quantify water sources, it does not discuss this method in great detail. A paragraph (or two) to describe the data accuracy of the vapour method against the more conventional sampling method would be useful as would a more detailed discussion of the circumstances in which it could be used.

Response:The method has been described in detailed in referenced Wassenaar et al, 2008; Wassenaar and Hendry, 2008 and Hendry et al, 2015. Several additional sentences were added to both Sections 3.1 and 3.2 of the manuscript to add to the method description. Data accuracy of the vapour method is provided in Line 25, Pg7 and a comparison to the conventional sampling method and advantages of the method are provided as an additional paragraph in Line 30 Pg 7.

Comment:Characterising flow paths within individual sedimentary units is one area where this method would be hugely advantageous.

Response:We agree that characterising the flow paths in the individual sedimentary units in these particular swamps would be advantageous, however very limited data is available in the public domain. However, additional local geology and hydrogeology data is presented in the Section: Site Description to provide the background to understanding the context. It is expected that more groundwater data will be available in the

future to characterise the flow paths in the individual units for the researched swamps.

Comment:More detail is also required in describing methods and a description of the regional hydrogeology in the site description would be of use.

Response:More details are now also provided in Section 3.2 on describing different methods used in this research. Description of the regional hydrogeology is now provided in Section 2: Site description, based on the limited publicly available data for these swamps.

Specific review's comments

Introduction: Comment:Page 3 Line 27: Change the term "hydrological balance". Swamp flora and fauna are dependent on the high water tables that are characteristic in THPSS. The term hydrological balance does not adequately describe this.

Response:As suggested by the reviewer, the term ''hydrological balance" has been replaced with "high water table".

Comment:Page 3 Line 30: The term groundwater in this instance is confusing. Do you mean swamp groundwater or groundwater from the surrounding sandstone aquifer?

Response:Groundwater was taken from both swamps and sandstone aquifer, but to avoid confusion the term groundwater in this sentence relates to sandstone regional groundwater which is now termed regional groundwater. Another term has been introduced for groundwater in swamp and this is swamp groundwater. As a result, the Line30/Pg3 has added term swamp groundwater to include both.

Comment:Page 4 Line 1: Again groundwater terminology is confusing. Would suggest 'swamp water levels' or 'swamp groundwater' when referring to the swamp water table and 'regional groundwater' or 'sandstone aquifer' when referring to the bedrock aquifer.

Response:The term swamp groundwater has been adopted based on the reviewer's suggestion for swamp water while regional groundwater term describes the bedrock

aquifer. This has been corrected at Page4 line 1 and throughout the document.

Site Description: Comment:Need a description of regional hydrogeology to give a better picture of likely groundwater interactions.

Response:Description of the regional geology and hydrogeology is provided on Pg5/Line 12 to 24.

Comment:Page 6 Line 4: Does this mean the longwalls are located directly below the swamps?

Response:The longwalls are not directly underneath the swamps, but below ground to the southwest of the swamps, with the closest swamp to the longwall being GGSW. This has been reworded in the text to clarify.

Methods, Fieldwork and Sampling: Comment:More details of piezometers are required. Depth, installation method, construction materials etc Details of groundwater bore required including installation method, construction materials and depth

Response:Piezometers were installed by the mining company prior to our research study. To minimise disturbance to the swamp, all piezometers were installed by manual augering the 80-mm diameter hole to refusal and pushing the slotted 50 mm diameter PVC tube in the hole. A full PVC casing is attached to the top of the pipe. All piezometers in the swamp were installed to the base of the swamp, where auger refusal did not allow further progress. The typical installation depth is around 1m to 1.3 m. The bore installed in sandstone is 8. 5 m deep as shown on Figure 7, it is installed with 50 mm diameter PVC screen 3-meter length at the bottom, and extended with casing to the top. The top was sealed by grout, and a steel monument constructed to protect the bore. This information has been added to the manuscript Line10-17/Pg7.

Comment:Include a section on statistics and software used Response:For simple statistical analysis, an XLStat software package was used for analysis of moisture content, precipitation and organic matter content. Barnes and Allison (1988) model was setup

in R, an integrated set of software facilities for data manipulation, linear and non-linear modelling and graphical display. This information is added to the manuscript Lines1-3/Pg9. Comment:Page 7 Line 5: Was a Russian D corer used to recover samples? If not how were samples recovered intact from a conventional auger? Response:Yes, Russian D corer was used to recover samples. This information has been added to the manuscript Line15/Pg6.

Comment:Page 7 Line 12: Swamp groundwater or regional groundwater? How were sandstone aquifer samples collected? Was the existing piezometer drilled within the bedrock? ..to enable comparison with the swamp groundwater.

Response:This has been clarified in the manuscript. One sandstone aquifer sample was collected by emptying three well volume and then sampling, as described in the original manuscript Pg7/Line21.

Results:

Comment:Page 10 Line 14-15: wouldn't this just be collected rainwater?

Response: Yes, very likely the quick swamp groundwater levels rise is due to direct rainfall.

Comment:Page 10 Line20: This sentence would be better placed within the methods

Response:Thanks, this sentence was moved to Methods 3.2 Section.

Comment:Page 11 Line 7: It also may be the result of lateral throughflow along the longitudinal gradient, particularly within the sandy units

Response: Thanks, this was added to the manuscript Pg 11/Line9.

Comment:Page 15 Line 8: Or that the surface water sample points are located in the discharge zone for groundwater flow

Response:Thanks, the mixing of surface water with lateral regional groundwater is

likely occurring in the groundwater discharge zone where surface samples were collected. This was added to the manuscript Pg. 15/Line 9.

Comment:Page 15 Lines 10-14: Figure caption is confusing. Change groundwater terminology.

Response:Changed terminology to swamp and regional groundwater as per response to general comments. Changes were made to Figure 7 legend to avoid confusion.

Comment:Page 16 Line 28: Probably should be explained in the methods

Response:The Barnes and Allison (1988) model parameters were moved to Methods section Pg 9/Line 6-9

Comment:Page 17 Line 5: In that case it would be informative to relate enrichment to relative humidity to assess whether that has more influence on evaporation than temperature

Response:Barnes and Allison model does not specifically include humidity in the evaporation calculation. However, indirectly the effective diffusivities of isotopes are dependent on water content, and isotopes can diffuse in the vapour phase even without humidity gradient. The isotopic composition changes with depth by taking into consideration changes in water content. Where evaporation is proceeding, the production of heavy isotopes is affected by diffusion of water vapour and the kinetic effect includes the humidity factor. As described in Barnes and Allison: The kinetic effect is due to slightly different rates of diffusion of the different isotopic species through the 'atmospheric boundary layer'. In our case this is the unsaturated space in the pores. In the atmosphere it is affected by relative humidity and thus the degree of kinetic fractionation is affected by turbulence. The turbulence was one of the parameters used in the evaporation estimate.

Discussion:

Comment:Page 18 Line 10: This sentence should be combined with line 11 below to

strengthen this argument. As it is, the sentence hangs without supportive evidence

Response:Thanks, the sentence has been linked to the sentence on Line 11 to strengthen the argument.

Comment:Line 14: I'm not sure this statement holds up. Long water residence times within the swamp water table may be occurring to sustain this vegetation community

Response:We agree, the vegetation community is sustained by swamp groundwater, however swamp groundwater is maintained by regional groundwater (in addition to rainfall) in particular during dry periods and, as the reviewer suggests, in case where residence times are long. The sentence on line 14 indicates that consistency of vegetation during different weather periods, stable water levels and Holocene swamp sediment age all confirm that swamp system interacts with regional groundwater.

Comment:Line 14-measurement of groundwater. Measurement of groundwater levels is not evidence of aquifer connectivity. Consistency of swamp water tables and lack of significant drawdowns in dry periods may however be linked to aquifer connectivity. See Cowley et al 2018 "The hydrological function of upland swamps in eastern Australia: The role of geomorphic condition in regulating water storage and discharge"

Response:True, the wording has been changed to reflect the importance of consistency of water table and not the water level measurement. The sentence was corrected Pg20, Line 13.

Comment:Line 18: Again this statement does not represent evidence of groundwater interactions per se. It is speculation. Reword

Response:The sentence has been reworded, Pg20 Line 17-19

Comment:Line 20: Measurement of GW levels above & below sandstone is not an indication of connection. GW level comparison of both aquifers may be, as might be comparison of isotopic signatures. Reword.

Response:Thanks, the sentence has been reworded to indicate that comparison of groundwater levels indicates possible connection.

Comment:Line 22: Rapid infiltration and discharge of what? Swamp or sandstone aquifer?

Response:Rapid infiltration and discharge of swamp groundwater, - This sentence has been corrected.

Comment:Line 22: Where are measurements of groundwater salinity?

Response:The measurements of major ion composition and salinity are published separately in David et al, 2018. This has been updated in the manuscript.

Comment:Line 23: "resulting from limited leaching of salts from the swamp".Not sure you have the evidence for this statement

Response:This part of sentence-"resulting from limited leaching of salts from the swamp"- was deleted

Comment:Line 23: "recharge of the groundwater table". Swamp or sandstone aquifer?

Response:This is clarified to read: recharge of swamp groundwater system.

Comment:Line 29: reference required for EC & pH results

Response:Reference has been added in the sentence - David et al, 2018

Comment:Page 22: Line 4: groundwater from sandstone aquifer? swamp groundwater?

Response:Thanks, this part of sentence has been reworded as follows: -consistent with regional groundwater value

Comment:Line 9: 'Isotopic signature' of precipitation?

Response:Clarification has been made to this part of sentence as follows: too small to

result in any difference in pore water isotopic signature

Comment:Line 14: A cross section of underlying hydrogeology would add to this conceptual model of swamp hydrology

Response:We agree that the underlying hydrogeology would add to the conceptual model, however at this stage the detailed hydrogeology and evidence of interlayering of sandstone with thin siltstone in the Burralow Formation in these swamps is not available. Regional hydrogeology is described in Section 2. From shallow coring we do know that sandstone directly underlies the swamp, it is expected that more information will become available in time.

Technical Corrections Abstract:

Comment:Line 6: Add 'Endangered' before the word ecological and 'Under state and federal legislation' after communities

Response:Thanks, we have added the suggested wording.

Comment:Page 5 Figure 1: An Aerial photo or satellite base map would be better to define swamp boundaries than a topographic map.

Response:This is a good suggestion, and we have also prepared Figure 1 using the satellite map. However, the satellite map does not allow reader to appreciate the elevation changes in the swamp both in the downgradient direction and across the swamp. As a result, we have adopted the topographic map.

Comment:Page 7 line 13: Space needed between 'were' and 'described'

Response:Thanks, space was added.

Comment:Page 10 Figure 4: Where are the profiles and sediment logs for GGSWG swamp?

Response:Profile and sediment logs for GGSW swamp have been drawn and a new

figure was added to the manuscript, Figure 5.

Comment:Page 11 Figure 5: These charts may be better shown by putting the sampling periods together on one graph rather than separating the swamps. That would make it easier to flip between then and the rainfall charts. Putting sediment logs down the left-hand side may make comparisons between sediment, moisture content and organic matter easier

Response:Original Figure 5 (now Figure 6) has been updated based on review's suggestion. The sampling periods were separated, such that each is given on one graph for all three swamps. Sediment logs were already provided in Figures 3 to 5, so it would be a repetition to add them below new Figure 6.

Comment:Page 15 Figure 7: Why are the surface water sample points low down in the depth profile in c and d but at the surface in a and b? Put them all at the surface

Response:Thanks , this has been corrected and surface water samples are now all plotting at the top where they should be.

Comment:Page 18 Line 21: THPSS Page 19 Figure 9: Change the colour of the Medium to fine grained sand/clayey sand unit. It appears at first glance to be indicating a water table

Response:Thanks, to improve the clarity we have added the "water table "to the legend, as we considered that changing the colour of sand/clayey sand unit did not achieve this clarity.

Comment:Page 19 Line 14: Explain ETc

Response:The ETc is crop evapotranspiration which incorporates incorporates the ground cover, canopy properties and aerodynamic resistance of the particular crop into the calculation This definition been added to the manuscript.

Comment:Page 20 Line 7: space between day and is

Response:Thanks, space added.

Comment:Page 21 Figure 10: This graphic does not effectively display the data in table 2. A simple column graph may be more effective. I don't understand why you used 2018 dates. Would it not be better to use sampling period dates? You need to explain why these dates were chosen

Response:Thanks, we understand that the graphic maybe confusing compared to Table 2. The error in dates was corrected. We have looked at the option of using the column graph, but can not use this graph type as the values do not represent a range but one data point. Therefore, we have updated the Table 2 to clarify the values so that it is easier to see. We have also updated the graph such that legend clearly shows what ET is presented in the graph.

Comment:Page 23 Line 9: Missing word after 'relatively'

Response:Thanks, this has been reworded.

Comment:Line 15: Gorissen reference should go after the word 'ecosystem'. Insert 'this' before 'ecological'

Response:Reworded and changed as per reviewer's comments.

Comment:Page 32-33 Table 3: should be Table 1. It's difficult to determine which numbers pertain to which parameter. Either move the parameters or put borders around columns and rows. Move column 3 down do that the first 'peat' is in lone with the first bulk density number

Response:Thanks, Table 1 has been amended to make it easier to determine which numbers belong to which property.

Comment:Page 33: Table 4 should be table 2

Response:Thanks, this is amended now.

References:

Comment:References cited in text that are not in reference list: Huneau et al, 2003, Hendry et al 2013, Hendry, 2008, Hunt et al, 1996, Mandl et al, 2017, Bickford and Gell, 2005, Middleton and Kleinebecker, 2012, Johnson, 2006, Valentin et al, 2005, Gatt, 1996, Dansgaard, 1964, Linacre et al, 1967, Mathieu and Bariac, 1996, dePaolo et al 2012.

Response:All references missing from the list, or where incorrect year was attributed, have now been added to the list of references and checked in the manuscript. References in reference list not cited in text: Andersen, M., Barron, O., Bond, N., Burrows, R., Eberhard, S., Emelyanova, I., Fensham, R., Froend, R., Kennard, M., Marsh, N., Pettit, N., Rossini, R., Rutlidge, R., Valdez, D. and Ward, D.: Research to inform the assessment of ecohydrological 10 responses to coal seam gas extraction and coal mining. Department of the Environment and Energy, Commonwealth of Australia, 2016. Bukata, B.J., Osborne, T.Z. and Szafraniec, M.I.: Soil nutrient assessment and characterisation in a degraded Cnetral Florida 30 Swamp. Water Air Soil Pollut, 226: 307, 2015. Centennial Coal.: Springvale Mine Extension project, Environmental Impact Statement, Available online http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=5594 Accessed on 20 April 2017, 2014. Cloern, J. E., Canuel, E. A. and Harris, D.: Stable carbon and nitrogen isotope composition of aquatic and terrestrial plants of the San Francisco Bay estuarine system. Limnology and Oceanography, 47(3): 713-729, 2002. Denk, T. R. A., Mohn, J., Decock, C., Lewicka-Szczebak, D., Harris, E., Butterbach- Bahl, K., Kiese, R. and Wolf, B. D.: The nitrogen cycle: A review of isotope effects and isotope modeling approaches. Soil Biology and Biochemistry 105: 121-137, 2017. Deegan, L. A. and Garritt, R.H.: Evidence for spatial variability in estuarine food webs. Marine Ecology Progress Series 147: 31-47, 1997. Fry, B.: Stable isotope ecology, Springer, LA, pp 317, 2006. Gardner, W.H.: Water content. In: (ed. A. Klute) Methods of Soil Analysis, Part 1. Bibliography 165 Physical and

Mineralogical Methods. Agronomy Monograph No.9 (2nd edn). pp493- 544, 1986. Gorissen, S., Mallinson, J.Greenlees, M. and Shine,R.: The impact of fire regimes on populations of an endangered lizard in montane south-esastern Australia. Austral. Ecol. 40, 170-177, 2015. Heaton, T.H.E.: Isotopic studies of nitrogen pollution in the hydrosphere and atmosphere: a review. Chem. Geol. 59, 87-102, 20 1986. Huneau, F, Blavoux, B, Aeschbach–Hertig, W. and Kipfer, R.: Paleogroundwater of the Valreas Miocene aquifer (Southeastern France) as archives of the lgm/Holocene transition in the western Mediterranean region, IAEA report, IAEA-CN-80/24, 2013. Johnson, D.: Sacred waters: the story of the Blue Mountains gully traditional owners. Broadway, N.S.W.: Halstead Press, 237 pp, 2007. Liu, Y., Sheng, L. and Liu, J.P.: Impact of wetland change on local climate in semi-arid zone of Northeast China. Chinese Geographical Science. 25,309-320, 2015. Mandl, M. B., Shuman, B. N., Marsicek, J., Grigg, L.: Estimating the regional climate signal in a late Pleistocene and early Holocene lake-sediment _18O record from Vermont, USA. Quaternary Research (United States) 86(1): 67-78, 2016. Potter, N.J., Chiew, F.H.S., Frost, A.J., Srikanthan, R., McMahon, T.A., Peel, M.C. and Austin, J.M.: Characterisation of 20 recent rainfall and runoff in the Murray-Darling Basin. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project. CSIRO, Australia. 40pp, 2008. Rau G.H.: Carbon-13/carbon-12 variation in subalpine lake aquatic insects: Food source implications. Can. J. Fish. Aquat. Sci 37: 742-746, 1980. Reddy, K.R. and DeLaune, R.L.: Biogeochemistry of wetlands science and applications. Boca Raton, FL: CRC Press, pp774, 30 2008. Zhang, X., Sigman, D.M., Morel,F.M.M>, Kraepiel, A.M.L.: Nitrogen isotope fractionation by alternative nitrogases and past ocean anoxia. Proceedings of the National Academy of Sciences of the United States of America 111, 4782-4787, 2014.

Response:References which were not mentioned in the text were excluded from the reference list.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2018-

237, 2018.

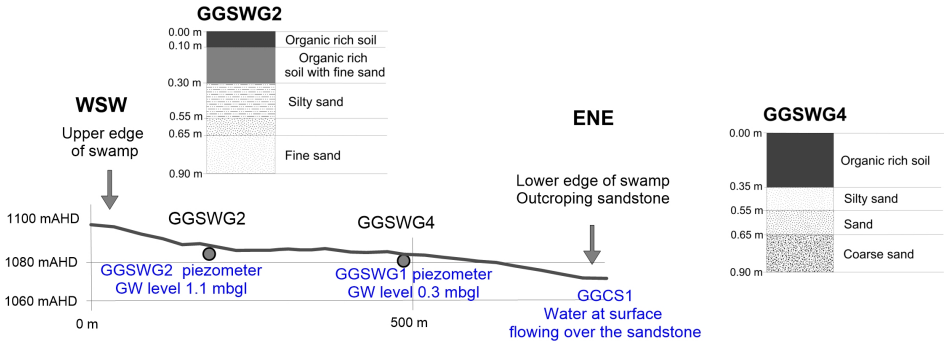
GGSWG2
0.00 m
0.10 m
0.30 m
0.55 m
0.65 m
0.90 m
Organic rich soil
Organic rich soil with fine sand
Silty sand
Fine sand
WSW
Upper edge of swamp
ENE
Lower edge of swamp
Outcroping sandstone
GGSWG4
0.00 m
0.35 m
0.55 m
0.65 m
0.90 m
Organic rich soil
Silty sand
Sand
Coarse sand
1100 mAHD
1080 mAHD
1060 mAHD
0 m
GGSWG2
GGSWG4
500 m
GGSWG2 piezometer
GW level 1.1 mbgl
GGSWG1 piezometer
GW level 0.3 mbgl
GGCS1
Water at surface
flowing over the sandstone

Fig. 1.

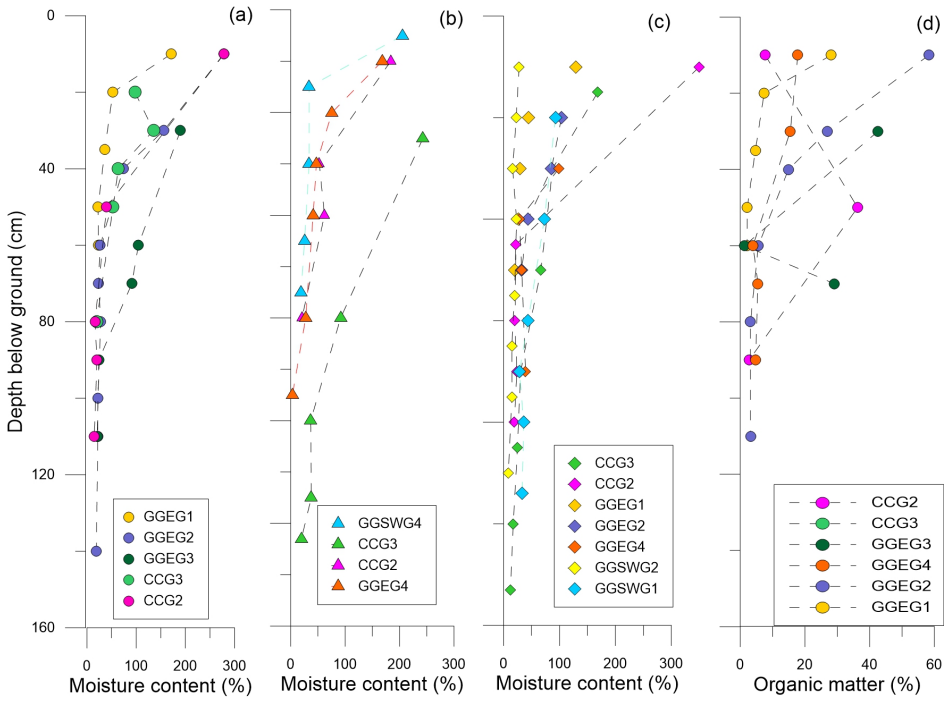
(a)
(b)
(c)
(d)
Depth below ground (cm)
0
40
80
120
160
GGEG1
GGEG2
GGEG3
CCG3
CCG2
GGSWG4
CCG3
CCG2
GGEG4
CCG3
CCG2
GGEG1
GGEG2
GGEG4
GGSWG2
GGSWG1
CCG2
CCG3
GGEG3
GGEG4
GGEG2
GGEG1
0
100
200
300
Moisture content (%)
0
20
40
60
Organic matter (%)

Fig. 2.

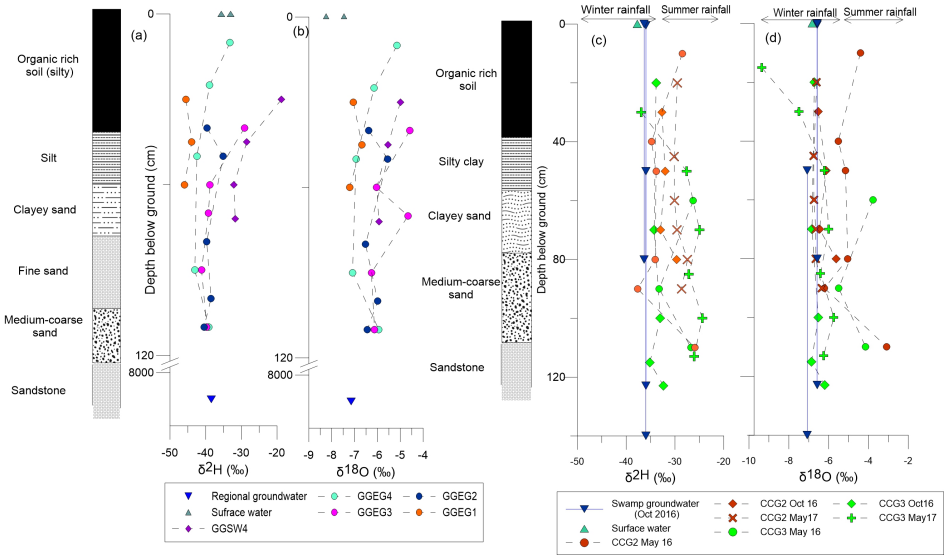
Organic rich soil (silty)
Silt
Clayey sand
Fine sand
Medium-coarse sand
Sandstone
(a)
(b)
Depth below ground (cm)
δ2H (‰)
δ18O (‰)
Regional groundwater
Surface water
GGSW4
GGEG4
GGEG3
GGEG2
GGEG1
Organic rich soil
Silty clay
Clayey sand
Medium-coarse sand
Sandstone
Winter rainfall
Summer rainfall
(c)
(d)
Swamp groundwater (Oct 2016)
Surface water
CCG2 May 16
CCG2 Oct 16
CCG2 May17
CCG3 May 16
CCG3 Oct16
CCG3 May17

Fig. 3.

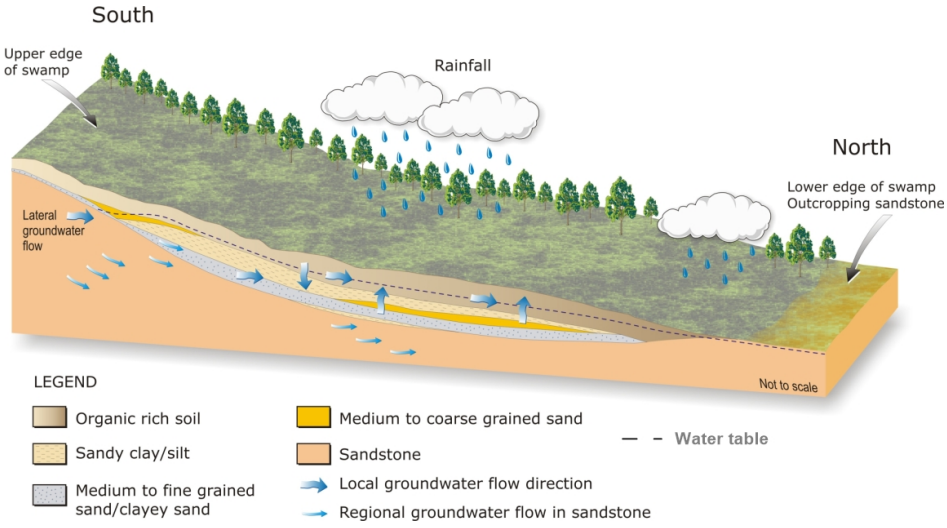
South
Upper edge of swamp
Rainfall
North
Lower edge of swamp
Outcropping sandstone
Lateral groundwater flow
Not to scale
LEGEND
Organic rich soil
Sandy clay/silt
Medium to fine grained sand/clayey sand
Medium to coarse grained sand
Sandstone
Local groundwater flow direction
Regional groundwater flow in sandstone
Water table

Fig. 4.

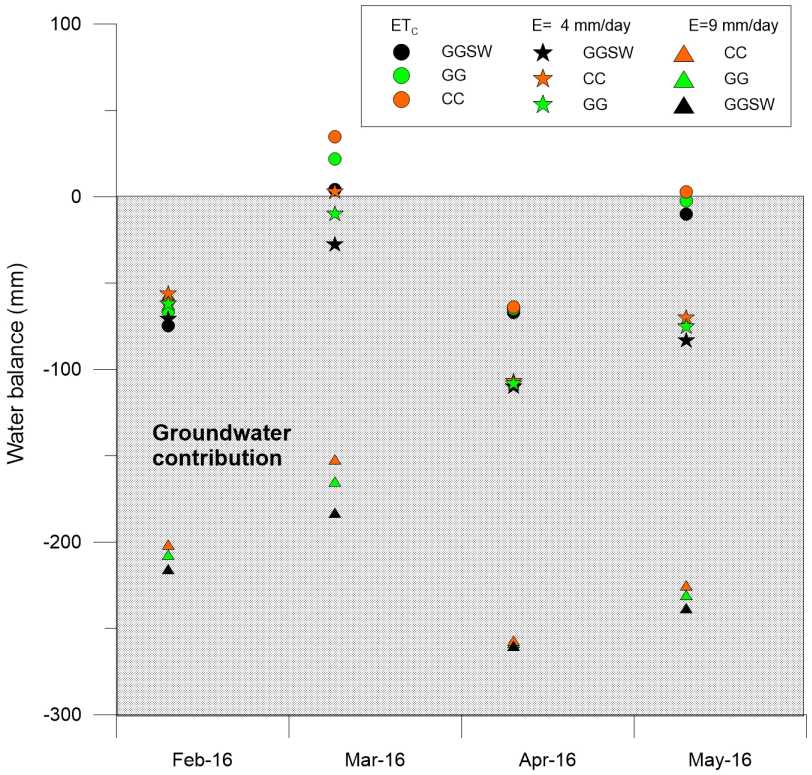
ETc
GGSW
GG
CC
E= 4 mm/day
GGSW
CC
GG
E=9 mm/day
CC
GG
GGSW
100
0
-100
-200
-300
Water balance (mm)
Groundwater contribution
Feb-16
Mar-16
Apr-16
May-16

Fig. 5.