Response to Referee # 2

We would like to thank the reviewer for their comments. The suggestions made have substantially improved the quality of the manuscript and they have been addressed as outlined below (in red).

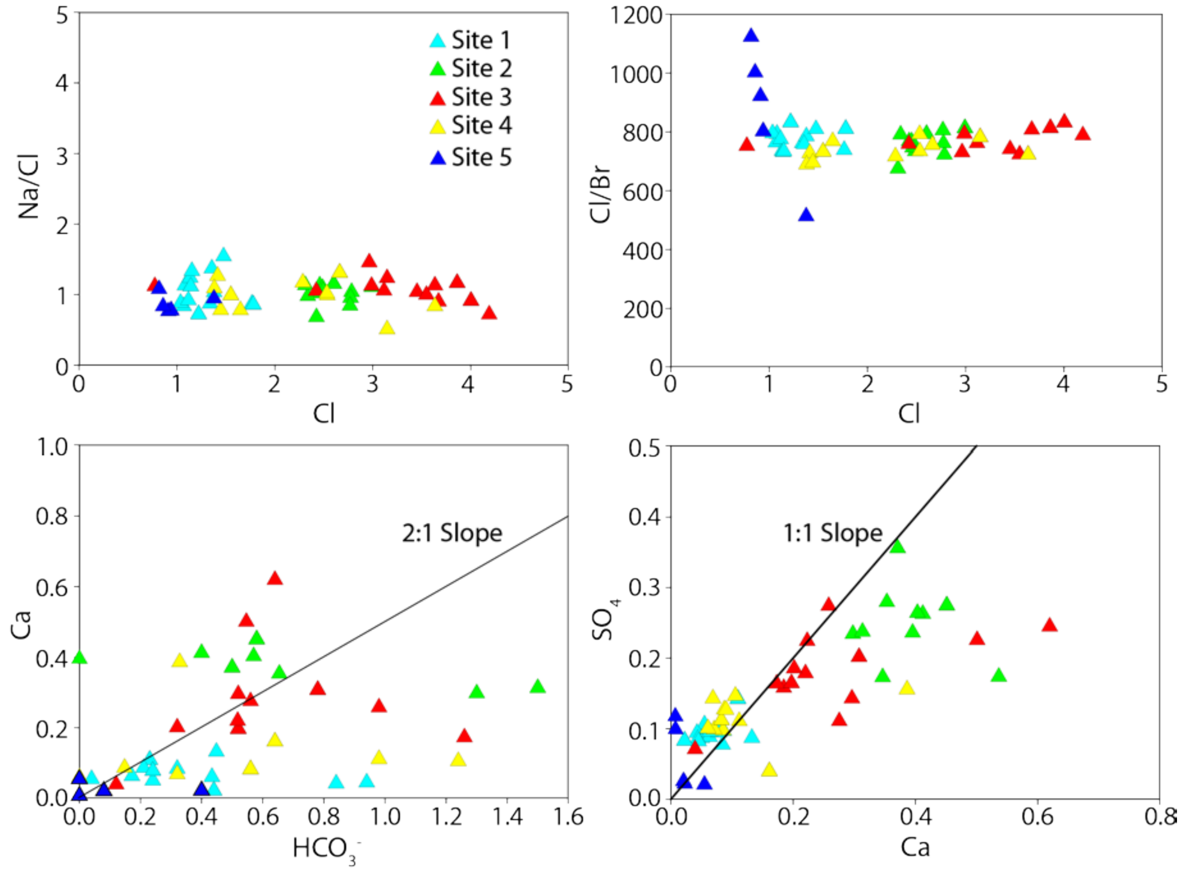
General comments:

This paper describes the hydrogeological study of the "aquifer window" (indeed, the discharge zone) of the Eastern View formation, a confined aquifer located in southeast Australia, with a major focus on groundwater/surface water interactions. The tools used are long-term river water levels and water table levels, major ion geochemistry, stable isotopes of water and carbon, and radiogenic 14C and 3H.

The paper is well written and the figures are clear, despite some modifications pro-posed thereafter. Still, in my opinion, the discussion could be notably enhanced, as the potential of the geochemical tools is not really exploited. Indeed, most considerations on the hydrogeological flow pattern that compose the conclusion could have been attained mainly based on the available water level data, i.e. without requiring costly 3H and 14C analysis. Nonetheless, I believe there is a very interesting potential for reaching an upper level of knowledge of the hydrogeological context by optimizing the available material. Therefore, if the paper pretends using environmental tracers to understand groundwater flow and recharge in the study area, the manuscript should go deeper into geochemical and isotopic interpretation and try to provide quantitative results on the water balance in the valley. I therefore recommend "major" revisions.

According to the authors, "major ion chemistry of groundwater is similar across the catchment, and the groundwater is Na-Cl type". Then, a written description of the proportion of several species is provided as well as some indicators (Figure 3). Nonetheless, the contribution of these considerations, conducted at a general scale, is not clear regarding the aim of the paper. Why are all dots graphically undifferentiated? Is there really no geochemical distribution of water types, no different mineralization processes? I believe improved graphical representations of geochemistry could help the authors to go deeper into the interpretation, and provide more efficient and convincing elements to the reader. Rather than simply describing mineralization processes, the interest of such approach would be to define specific geochemical features of groups of samples and to attend to identify and quantify mixing processes between water masses.

Response: To take this into account we have grouped groundwater bores across the catchment into different sites based on location. The bores have been separated into 5 different sites, four of which are groundwater bores located < 15 m of the river and 1 site composed of bores located further back on the valley floodplain. By doing this it is easier to assess whether there is a difference in chemistry between those bores which sample regional groundwater (Sites 1-4 – old ^{14}C ages and tritium free) and those which sample local groundwater which has been recharged within the valley (Site 5 –groundwater with high ^{3}H and ^{14}C activities).

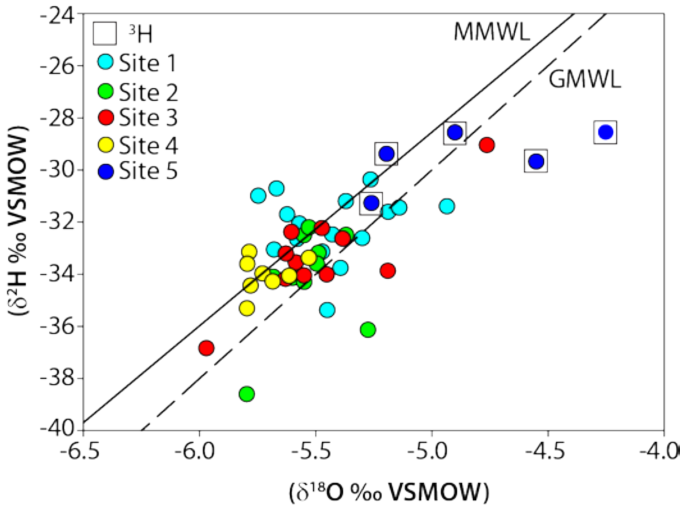


The only real difference between the geochemistry of the local and regional groundwater is that the Site 5 samples from the edge of the valley have lower salinity than those from the other sites. Since evapotranspiration is the major process in determining the salinity of the groundwater, it implies that the samples recharged at the edge of the valley have undergone less evapotranspiration than samples derived from the regional recharge area on the Barongarook High. This is not unexpected as the regional groundwater was recharged prior to land-clearing (~200 years ago) when the landscape was dominated by eucalypt forest with high transpiration rates while current recharge through the Gellibrand valley is through cleared grasslands that have lower transpiration rates. However, on the ion vs. ion plots there is little distinction between the various waters; hence the major ion ratios are not a good discriminator of the water origins.

We will introduce the differentiation between different sites in the revised manuscript and note that the major ions do not discriminate between the groundwater from the various regions.

Similarly, stable isotopes of water might provide additional information. But, why was such scale chosen in Fig. 4? What is it supposed to show? To my mind, it impeaches visualizing any process that could take place, any potential differentiation between groups of samples based on fractionation processes. Ideally, a dual "Barongarook High" and "Gellibrand River Valley" signature might be found inside the Eastern View formation, with the corresponding altitudinal gradient of precipitation. As well, a slight differentiation might be found between groundwater recharged from infiltration of Gellibrand river and from local precipitation in the valley, as boreholes k and l, located where the Eastern View formation outcrops in the valley, do feature evaporated signature (when plotted on a more representative scale).

Response: The replotted δ^2H and $\delta\ ^{18}$O data are shown below (using the distinction between the sites discussed above). The difference in height between the Barongarook High and the Gellibrand Valley is ~150m, which assuming typical fractionation gradients of -0.15‰ to -0.5‰ per 100 m for δ^{18}O (Clark & Fritz, 1997) should result in δ^{18}O values being -0.25‰ to -0.75‰ lower in waters derived from the Barongarook High vs. those that are locally recharged in the valley. Revisiting the stable isotope data, groundwater in the regional system (Sites 1 to 4) does have lower δ^{18}O values than the groundwater recharged in the aquifer window (Site 5). The trend of the waters away from the Meteoric Water Line to higher δ^{18}O values most likely represents evaporation that is commonly recorded in stable isotope signatures in SE Australian groundwater; however, the observation that all the waters from the aquifer window have higher δ^{18}O values most likely reflects the altitude effect. Further to this, combining stable isotope data with ^{3}H data further shows the separation between 'young' water recharged within the valley (site 5) and 'old' regional groundwater recharged on the Barongarook High. There is one sample from site 3 that appears not to fit this pattern (high δ^{18}O, ^{3}H-free and a ^{14}C age of 980 years). This sample may be more evaporated than the other regional groundwater samples; however overall these data are consistent and help in the interpretation of the flow system. We will incorporate this material in the revised manuscript



The interpretation of geochemistry seems to consider that the river is the only possible source of recharge to the aquifer in the valley. What about groundwater recharged from rainfall infiltration on the unconfined surface of the Eastern View formation inside the valley? Its role is cited when describing potentiometric data, but seems to have been forgotten for geochemical interpretation. Indeed, potentiometric data does indicate that such recharge happens at important levels, as shown in Fig. 2 for piezometer “j”, located in the Southern part of the valley. By the way, why isn’t water table data for piezometers k and l, also located southwards, displayed here? If available, it could provide a confirmation of such process.

Response: The aim of the paper was to look at the impact of recharge from within the valley from rainfall, recharge within the valley from the river and regional recharge on the Barongarook High on the groundwater within the Gellibrand Valley. As suggested we have split the bores into different sites and this clarifies that there is recharge at the southern edge of the valley via rainfall (site 5). Recharge from local rainfall is evident mainly from ^{3}H activities (groundwater from bores at the southern edge of the valley all contain substantial ^{3}H) and also from the stable isotope signatures.

The water table data for other piezometers is taken from data loggers that were installed at the beginning of the study whereas piezometers K and l were not part of the initial investigation. We have added the water level data that is available at the Victorian Water Resources Data Warehouse for bores k and l, which show yearly recharge cycles and provide confirmation of recharge via rainfall in the valley.

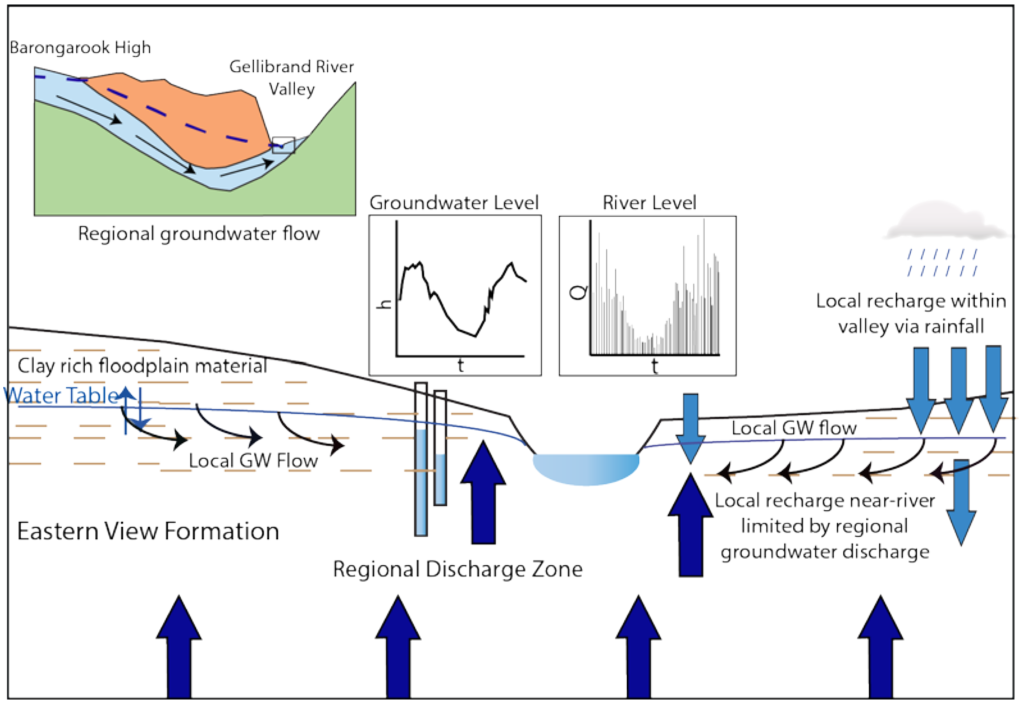
Overall while there is recharge in the valley as evidenced by the fluctuating groundwater heads, there remains a separation between the deeper and shallow groundwater. Notably, side from the southern edge of the valley, groundwater from only a few metres below the water table has relatively old ^{14}C ages, is ^{3}H free, and has stable isotope values consistent with it being derived from the Barongarook High. Similarly recharge from the river does not penetrate more than a few metres into the aquifers. This leads to the conceptualisation of the flow system shown on Fig. 8 whereby we have a very local and a regional groundwater system interacting in the valley.

We will discuss the role of local recharge in the geochemical interpretation, and make clear throughout the paper that local groundwater flow processes and recharge within the valley are being considered. The role of the local GW component is also more clear in the revised conceptual model (Fig. 8).

The role of recharge from rainfall infiltration on the unconfined surface of the Eastern View formation inside the valley is also absent of the conceptual flow model from the Gellibrand River Valley (Fig. 8), although its impact on groundwater recharge is probably the main driver of water table variations measured in the aquifer, later transmitted to the river by groundwater discharge as supposed by the regional configuration of the aquifer and confirmed by the upward vertical head gradient in the valley (Fig. 2a). The contribution of infiltrated river water to the recharge of the Eastern View formation, if it exists, will be limited to periods where the upward vertical gradient is downward. As aforementioned, these conceptual considerations do not necessarily require geochemical or isotopic analysis of groundwater.

Response: We have improved the conceptual model to make clear the distinction between the regional and local systems which exist in the valley and how local recharge is impeded in the near-river zone. Although conceptually this may be deduced from water level data alone, in reality there are not sufficient bores (nor monitoring data from the existing bores) to do this. Additionally, the hydrometric data does not help understand the timescales of groundwater flow nor the residence times of groundwater, which are important for the understanding and management of this groundwater system.

This is an important point that we will incorporate into the Discussion section of the revised manuscript.



Regarding the interpretation of 14C and 3H, I would propose some clues to reach a more integrated interpretation. As described in several textbooks (e.g. Cook and Böhlke, 2000), the spatial distribution of groundwater ages differs according to the aquifer geometry and to the flow configuration. In addition, depending on the length of the screen inside the aquifer, groundwater pumped from a well or tubewell might result from a distribution of ages, as it is representative of several flow lines. To take into account these features in the interpretation of the tracers, some tools exist, like the physical modeling of groundwater flow or Lumped Parameter Models (LPM, e.g. Zuber and Maloszewski 2001; Jurgens et al. 2012; Suckow 2012). I would suggest trying to reproduce the conceptual model of groundwater flow pattern through one of those tools in order to deduce the respective contribution of groundwater recharged inside the valley and originated from the

Barongarook High. To my understanding, this would be one of the most interesting way to fit to the title of the paper by "using 14C and 3H to understand groundwater flow and recharge in an aquifer window".

Response: Using LPM's to interpret ^{14}C and ^{3}H was considered. The most common LPMs that are considered are the exponential-piston flow model (EPF) and the dispersion model (DM). The EPF accounts for groundwater flow paths of different length within the aquifer with an exponential distribution. In this study the Eastern View aquifer is confined along most of its length so that flow closely approximates piston flow. Additionally in this study the bores have screens of 1-2 m. Such screen lengths are many times smaller than the thickness of the Eastern View Formation and likely integrate a small range of flow paths, again approximating piston flow. The DM models dispersion within a single flow path and the key parameter is essentially the Peclet number (v.x)/D (where D is the dispersivity, v is velocity, and x is distance). The dispersivity is given by a.v where a is the dispersion coefficient. For a groundwater system with typical hydraulic gradients of 10^{-4} to 10^{-3} and hydraulic conductivities appropriate for sands of 10^{-8} to 10^{-6} m/s, the Darcy flux is 10^{-12} to 10^{-9} m^3/m^2/sec. Assuming a porosity of 0.3, yields velocities of $3.3x10^{-12}$ to $3.3x10^{-9}$ m/s. Dispersion coefficients for regional systems are likely ~100 m (Domenico and Schwartz, 1997: Physical Hyrdogeology, Wiley), implying D = $3x10^{-10}$ to $3x10^{-7}$ m^2/day. For a flowpath that is 10,000 m long all Peclet numbers calculated using the above values are >1 implying (as is commonly the case for regional flow systems) advection dominates dispersion and under such circumstances the DM approximates a piston flow model. The above discussion implies that the flow system approximates piston flow and although it was not explained in those terms, the way that the calculations were done for the regional groundwater was by assuming a piston flow model.

We will make more comments as to the choice of flow model in the revised manuscript.

For the bores at the southern margins of the valley that are recharged locally we will determine ages from the ^{3}H data using lumped parameter modelling and incorporate ages into the revised manuscript. In this cases (short flow path and an unconfined aquifer) an EPF model would be appropriate.

Some specific observations

- Figure 8 indicates groundwater levels lower than river levels, i.e. supposing losing conditions. Are water levels in this figure really to scale? - Regional potentiometric data: it would be interesting to know where were measured the potentiometric heads used for this map. - Number/name of the groundwater bores: why not use the same names everywhere? I would recommend generalizing the use of letters a, b, c as Table 1 provides the "official" name.

Response: This has been amended to indicate gaining conditions. Water levels in this figure are not to scale, and are used to emphasise upward head-gradients in the near-river environment. The potentiometric data used are from nested piezometers, with the data available at the Victorian Water Resources Data Warehouse. We have used the generalized letters throughout the manuscript (with the official names listed in Table 1). We have redrawn Fig. 8 to try and make water levels more representative.