Conservation without borders

Towards Sustainable Landscapes: Phosphorus management to protect wetlands

Greening Australia

Project Summary – Aim and Activities

Catchments and estuaries around the world are under pressure from encroaching human land uses. A problem of international and local importance is the increase in nutrients in waterways and estuaries. In the Peel Harvey catchment, south of Perth in Western Australia, inputs into waterways of phosphorus (P) come primarily from agricultural land. Of particular concern are the impacts of these nutrient flows into the Ramsar listed Peel Yalgorup estuary system. These inputs of P are detrimental as they may trigger algal blooms and cause water quality decline. Practical approaches for farmers and landowners to address this problem are urgently required.

The Peel Harvey catchment is characterised by a highly seasonal environment with prolonged hot dry summers and cool, wet winters. The coastal plain receives rainfall during winter and early spring which far exceeds evapotranspiration and soil storage, leading to surface flooding. Historically, drain networks were installed across farmland on the coastal plain to alleviate this surface flooding; these networks direct water into the Peel-Harvey Estuary. Soils on the coastal plain vary greatly, often over short distances, from light sands to heavy clays.

This project was designed to investigate the pathways of P movement off farm into waterways and whether cycling of P can be modified using plants with novel P nutrition. Sampling of P and other nutrients in soil, plants, shallow groundwater and drains commenced in 2011 and was focused on three sites near Waroona.

Site 1: A relatively low-input beef property with low soil P levels;
Site 2: A pasture site under revegetation with low soil P levels close to the foothills; and
Site 3: A high input dairy with high soil P levels.

Site 1 was the focus of most research activities as it represented a land use that is widespread within the catchment and included a range of common soil types.

Site 1. Beef property. Photo taken from high area of landscape ("upland"), across the "midslope" and "riparian" zones. The trees are growing along the edge of a major drainage channel.

Initial Project Hypotheses

1) A pulse of P release would occur following opening autumn rains (see item 1 in APPENDIX).
2) A significant pathway of P movement would be below the soil surface through shallow groundwater.
3) Movement of P could be reduced through use of plants with an ability to rapidly take up P.

Anticipated Results

1) After the first significant rain in autumn, shallow groundwater tables would connect across the landscape from upper to lower (riparian) landscape zones and provide a means for P movement. Knowledge of this subsurface P movement could then be used to investigate places, times and methods to intercept P before it reached waterways (see item 2 in APPENDIX))
2) P losses could be reduced through use of perennial native plants with an ability to accumulate P. For instance, *Ptilotus polystachyus* can store P without toxicity until it constitutes 4% of shoot dry weight (most plants regulate concentrations to well below 1%).

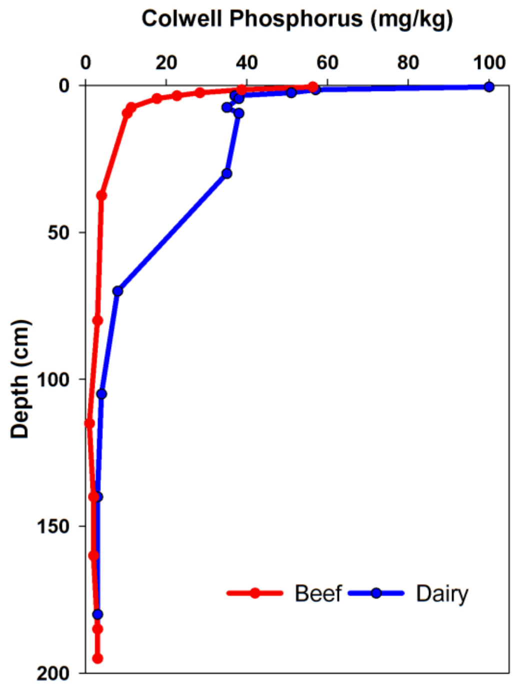
Research Results

1) Shallow groundwater tables rise rapidly after opening rains across the landscape from upslope areas to riparian areas (see item 3 in APPENDIX)
2) Groundwater P concentrations are seasonally variable and peak when connectivity is established. At Site 1, P accumulated at the midslope.
3) In response to an excess of water moving from the upland to midslope as the groundwater connects, P likely moves from midslope groundwater to drains via flow over the soil surface.
4) There was limited water movement from the groundwater through the drain banks into the drain. Riparian zones surrounding drains could therefore be a useful place to intercept water and P.

UWA Honours student Miss Hani Mohamad conducted flow velocity measurements in the drain at Site 1 to measure the exchange of water between the groundwater table and the drain.

5) At the beef farm (site 1), pasture growth is primarily limited by nitrogen and, often, sulphur. Such limitations may be widespread in the Peel Harvey region and result in inefficient use of applied P fertiliser.

6) Soil P is highly concentrated in surface layer (0-5 cm), particularly in the top 1-2 cm. As a consequence, P is readily available to move off farm via movement of water over the soil surface. Strategic (infrequent) cultivation or other management options that reduce the risk of this P moving off-farm should be explored.



Colwell P (represents labile or plant available P) down the soil profile (sand over clay) to close to 2 m depth under pasture on a beef farm (Site 1) and dairy farm (Site 3). Note the much concentration of P close to the soil surface and the higher P on the dairy farm

7) Plants other than the traditional pasture species of the region, including P accumulating natives, may be difficult to establish due to waterlogging and the presence of root diseases. Identification of suitable alternative species is therefore very challenging.

Small plots of alternative and traditional pasture species being trialed at Site 2 in 2013.

What this means for landowners who want to reduce P movement off their farms into drains or waterways

1) Ensure pastures are not limited by nitrogen or sulphur when P fertiliser is applied
2) Consider reducing water and P supply from sandy ridges by revegetating higher areas with native perennial vegetation
3) Manage riparian areas around drains in winter to reduce movement of water and P into drain
4) Divert and/or treat water moving over the soil surface towards drains to remove P. For example, consider use of small weirs and native wetlands to remove P.

Conclusion

Research on this project is on-going. Field sampling and experimental work in 2014 should allow us to strengthen these preliminary conclusions.

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Project structure and partners

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http://www.alcoa.com/global/en/community/foundation/info_page/home.asp
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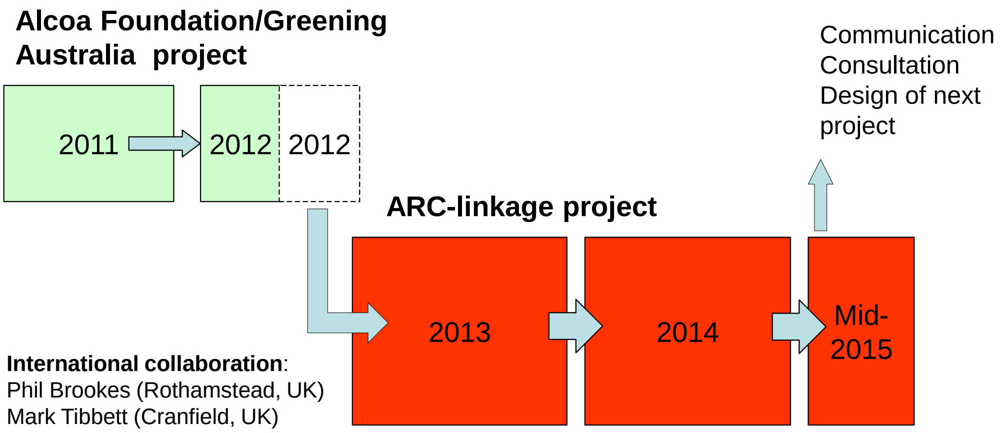


Schematic of project funding

Acknowledgements

The UWA project team warmly thanks all the collaborators, especially Jane Townsend who prompted the initial discussions about the project. We also very gratefully acknowledge the farmers who have generously hosted the research on their farms over the years, particularly Neil Bruce and the late Kevin Dilley.

APPENDIX

1. Time-lapse video of the impact of a storm event on the Mayfield drain:
https://www.youtube.com/watch?v=FJqA-LEdvgQ&feature=youtu.be

This time lapse corresponds to a storm event recorded between the 3rd and 5th of September 2012 and it was characterized by wild weather with strong winds, hail, and heavy rain (total of 51.6 mm).

Water level in the Mayfield drain (at Whettam Road, Waroona) jumped by 1 m over a period of 12 hrs reaching its maximum water level (peak at 1.25 m in the staff gauge) on Sept 4th at 2.30 am. The instantaneous water discharge rate during the peak was estimated at 2500 L/sec.

High Total phosphorus (TP) concentration values were observed for over a period of four days with an average value of 0.25 mg/L for TP and with no attenuation (dilution effect) by the rain water. A large proportion of phosphorus (58%) leaving the catchment during the event was in reactive form and readily available for plants but also for harmful algae growth in the Peel-Harvey estuary.

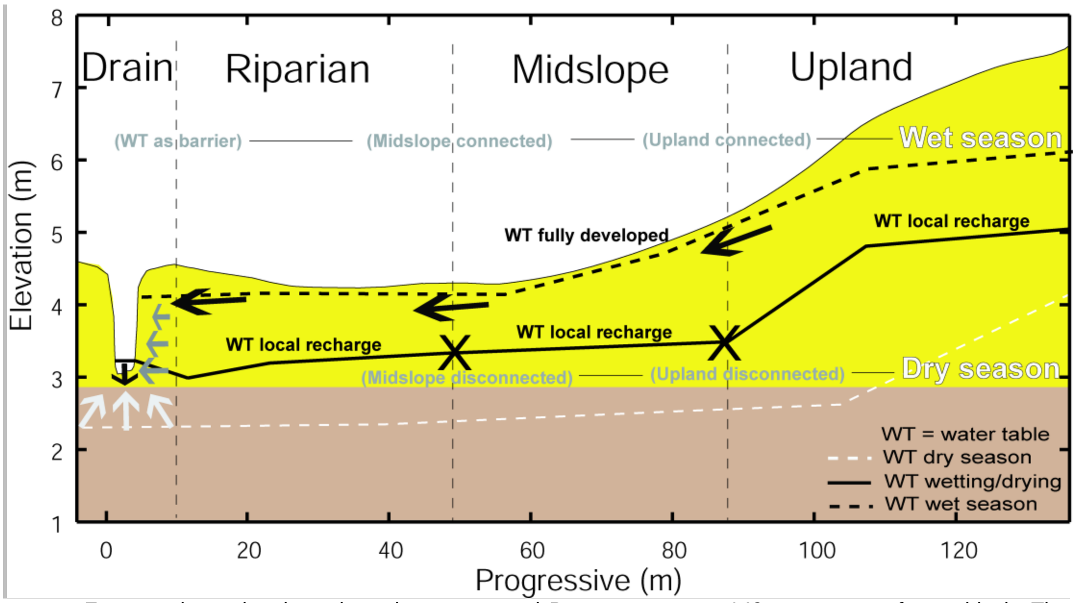
Such event can deliver between 60-80% of the total annual load of phosphorus from the catchment area and it is able to activate the entire catchment in delivering water and phosphorus via surface and subsurface pathways using the drain network.

Time-lapse video of impact of large rain event on the Mayfield drain:
https://www.youtube.com/watch?v=dYifxb2P8Kw&feature=youtu.be

This time lapse corresponds to the largest event recorded for the Mayfield drain from August 4th to August 10th 2013. The peak of the stormflow event (at 1.53 m in the staff gauge) occurred on August 7th close to midnight (see movie camera almost underwater) as a result of 46.4 mm of intense rain between 12 am and 8.40 pm. The stormflow in the Mayfield drain overtopped its bank and temporarily flooded surrounding paddock areas.

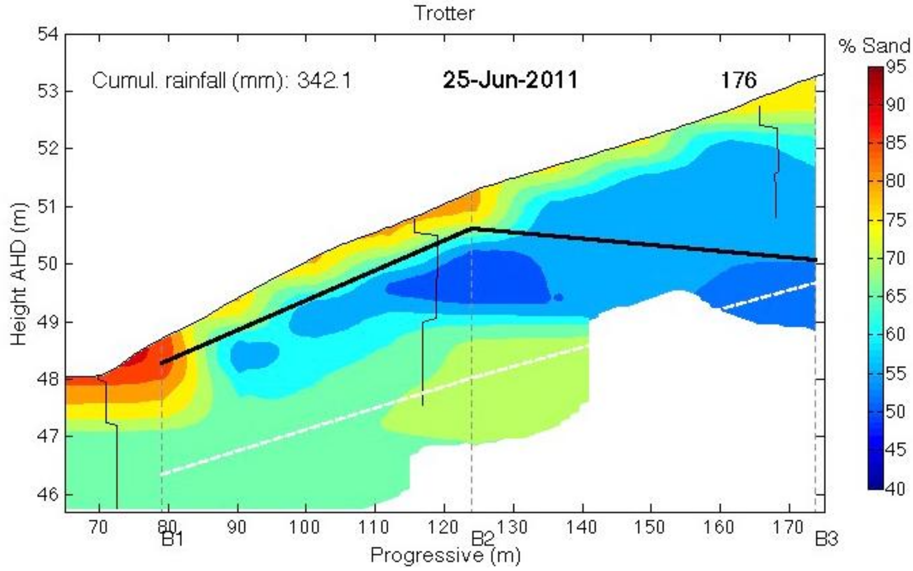
High total phosphorus concentration values were observed in the drain (of the order of 0.41 mg/L of TP) with approximately 65% of total phosphorus in reactive form readily available for plant and algae. Unlike the previous event, high TP concentration values measured over the following days resulted mainly from runoff originated from flooded paddock returning now to the Mayfield drain.

2. The first research component of the study has tackled how water and P move below the soil surface through a shallow groundwater table that is present only at some times of year.



Framework used to investigate how water and P move across a 140 m transect of a paddock. The paddock cross-section and shallow water table (WT) position correspond to real data from Site 1 and show that in the summer dry season the water table does not connect across the landscape, but that in the winter wet season the water table rises to become very close indeed to the soil surface and connects across the landscape. Note the relatively small change in elevation between the riparian zone and the upland zone which indicates the paddock had only quite a gentle slope (see Site 1 photo).

3. Shallow groundwater dynamics following opening rains strongly depended on soil type and topographic slope. For example in 2011 at Site 2 (foothills soils, classified as Soil of the Ridge Hills), groundwater storage became full first at the riparian zone, then the midslope and then the upland. Hydrological connectivity and potential transport of P from upland to near stream riparian zones began in late July.



Landscape cross-section of a sloping hillside at Site 2 on 25 July 2011 after 342 mm of rainfall in the year. The shallow water table is fully connected from midslope (B2) to riparian zones (B1). Upland water storage is still building up. The black line represents the shallow water table position at observation points B1, B2, and B3, while the white dotted line represents the water table position in the dry summer season.

Water table dynamics were much more complex in July 2011 at Site 1 where deep sandy soils interact with clay lenses (also known as duplex soils) on a relatively flat landscape (Pinjarra Soil type unit). Early rainfall in autumn rapidly infiltrated resulting in water accumulation and the formation of a shallow water table in riparian, midslope, and upland zones. However, the volume of water stored was not sufficient to fully connect the landscape via subsurface flow. Full hydrological connectivity was instead achieved by early August/ September. Under full hydrological connectivity of the water table, P transport processes from upland to midslope locations were initiated and continued during spring.