Monitoring Mallee Seeps

Project 1569C for the

South Australian Murray-Darling Basin Natural Resources Management Board

Progress Report July-Dec 2017

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1 Project Summary

At all sites there was a dramatic increase in the areas of seeps with large areas of cropped land becoming saturated and often dominated by ryegrass. While this was mainly due to the very high burden of excess water moving through the catchments as a result of the well above average 2016 rainfall, there were numerous 2017 rainfall events that were found to contribute to the perched water tables beneath.

On non-wetting sandhills with very poor water holding capacity it has been found that any rainfall event over 10 mm can quickly lead to significant rises in water table levels in the mid-slopes below. Midslope sands with slightly higher water holding capacity were found to require more significant rainfall events, closer to 20 mm, to contribute water to recharge. These are far less frequent in the Mallee.

There are 4 main management strategies that have been employed within this monitoring project including:

1. **Changing to a higher water use farming system**. Growing lucerne for hay has been clearly show to utilize soil moisture levels to depth all year around, allowing them to absorb high rainfall events rather than contributing to recharge. The lucerne was the only one to reduce the water table levels in 2016, despite the very high rainfall. However, committing large land areas of productive cropping land to lucerne is not a suitable option for many farmers.
2. **Ameliorating sandy soils to retain and utilize more water.** The spading of chicken manure has clearly broken compaction, while increasing fertility and water holding capacity and productivity over a number of years. However, it does have high upfront costs, which makes it difficult to apply aver large areas of land. Accessibility to machinery and manures may also be an issue.
3. **Intercepting the lateral flow of moisture before it reaches the discharge areas.** The strategic tree planting can be applied where suitable within the landscape to intercept water movement through the catchment. It is however, very important to target the right areas, and a surface visual assessment of subsoil water movements are not always accurate. Understanding the salinity levels of the subsoil water is also important to make sure that suitable tree species are used. Along with tree lines, strategic strips of lucerne have also been established and plan to be analyzed in coming years.
4. **Utilizing the excess water within the discharge areas.** Saltbush has been established within seep areas at numerous sites, along with Messina pasture, to both utilize moisture and provide soil cover to minimize evaporation and surface salt accumulation. Messina (and to a lesser extent Saltbush) has proved to be difficult to establish on the most scalded or waterlogged areas. A new strategy of sowing summer crops into the specific saturated crop areas to soak up excess water and prevent further land degradation, is showing some promise at this early stage.

All of these sites and management techniques should continue to be monitored and analyzed in the next few years to increase our understanding of seep formation and the best ways to overcome them.

2 Introduction

The growing seep issues in the Karoonda district has led to the establishment of four sites over the last 3 years, involving the monitoring of soil moisture probes, piezometers and various higher water use catchment management strategies. The body of information gathered, in conjunction with associated catchment assessment reports commissioned by the NR SAMDB, is contributing greatly to our understanding of how these seep issues are developing and what strategies may be employed to best manage and rehabilitate the problems.

This is the fifth report associated with monitoring 4 seep sites between Mannum and Karoonda that were originally established under the "On-Farm Trials and Demonstrations to Address Seeps in the Murray Mallee" project funded through the NR SAMDB.

Background to each site, EM38 mapping, soil tests and initial monitoring are contained in an earlier report entitled "On-Farm Trials and Demonstrations to Address Seeps in the Murray Mallee", by Chris McDonough, Rural Solutions SA in July 2015. The three following Monitoring Mallee Seeps Progress Reports, dated July-Dec 2015, Jan-June 2016 and July-Dec 2016 are a continuation of monitoring of soil moisture readings, water table levels and the progress of various treatments at these 4 established sites. These NR SAMDB reports also provide some recommendations for future seep management.

After 3 years of monitoring at these four sites over a range of seasons, rainfall events, and with various high water use strategies, valuable information for seep management across the Mallee are being understood and developed. Results and recommendations are regularly referred to at various farmer meetings, field days and site visits about these seeps, their causes and management strategies that may be employed that fit in with different farming systems and needs.

This report presents the monitoring findings in the context of what we have learnt from each site, and what is recommended to best overcome these issues for these farmers.

Table 1. Karoonda Rainfall

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	18.1	19.9	17.7	24.7	35.5	34.8	35.2	38.3	35.4	31.7	24	25	343
2016	35.2	6.8	53	8.8	54.2	31.2	57	70.4	119.3	34	28.2	83.8	581.9
2017	29.2	35	18.2	40.4	38.3	9.4	31.2	37.2	13	14.6	32.6	17.4	316.5

Table 2. Mannum/Murray Bridge Rainfall

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	15.9	17.2	18.4	25	29.9	31.9	28.6	30.6	29.9	26.7	21.1	21.6	294.5
2016	21.4	12.4	48.4	9.4	31	28.8	49.1	24.2	79.1	28	31.8	73.8	437.4
2017	42.4	24.4	6.6	30.3	18.8	11.4	37.2	68.7	15	10.6	54.6	42.2	362.2

3 Martins Sites Monitoring (formerly Pope site)

The Martin property, south west of Karoonda, has 2 main areas of monitoring (see Figure 1). There is the southern paddock in the upper catchment area, directly feeding into 2 soaks, as well as the lower catchment area surrounding a major salt scald and seep area. A network of strategically placed piezometers and moisture probes have been placed throughout to monitoring moisture levels, ground water flows within the landscape as well as the impacts of seasonal factors, farming systems influences and spading treatments.

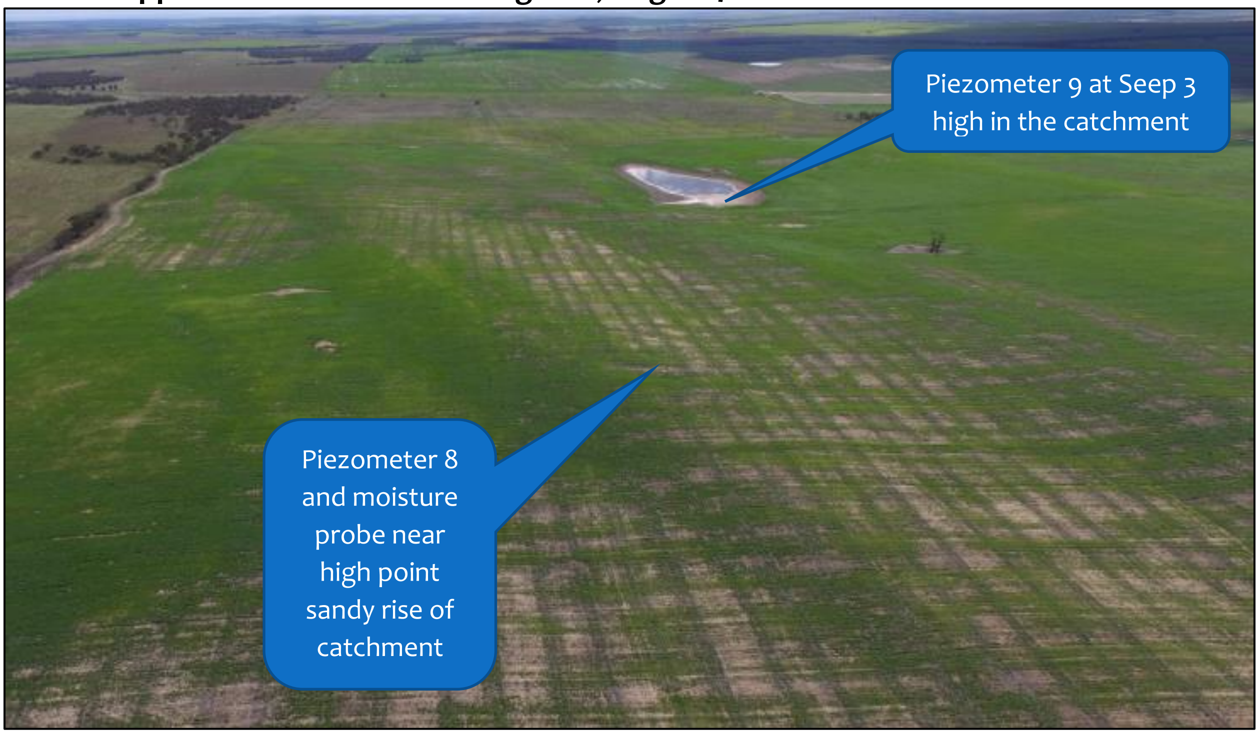
Figure 1. Martin soak site with monitoring equipment approx. locations

There are also areas of developing seeps to the west of the main seep area, where the farmer has begun some seep management activities, including a strategic strip of lucerne to intercept lateral moisture flow, as well as the establishment of the new salt and water tolerant Messina pasture around scalded seep areas (see Figure 2). These areas will also be observed to assess the growth or reduction of these seep areas and the effects of the management strategies applied.

3.1 Findings from upper catchment monitoring

The upper catchment area consists of sand dunes and sand covered slopes running down to lower lying depressions including seep areas. There is one moisture probe and two Piezometer locations as shown in Photo 6. It is unclear at this stage if and how these areas may contribute directly to the lower catchment areas.

Photo 1. Upper catchment area looking east, Aug 2017



Figures 2 & 3 show that at the non-wetting sand rise at the top of the catchment appears to cause soil moisture levels to spike and most likely allow water to pass below the crop root zones for most rainfall events of 18 mm or greater. Despite this, Figure 4 shows that the water table, which is about 7 m below the surface, steadily declined through 2017, and was not greatly impacted by the 55mm Dec 2016 rainfall or the 48mm Apr 2017 rainfall.

However, between this point and the Seep 3 area 340 m to the east, it would appear that these larger events have reached the water table and led to a lateral movement of water, as is clearly evidenced by the Piezometer 9 readings in Figure 5. This seep (evident by lake in Photo 1) remained full of water until declining after the dry spring of 2017.

Figure 2. Top of rise, deep moisture sensor readings to assess possible recharge events

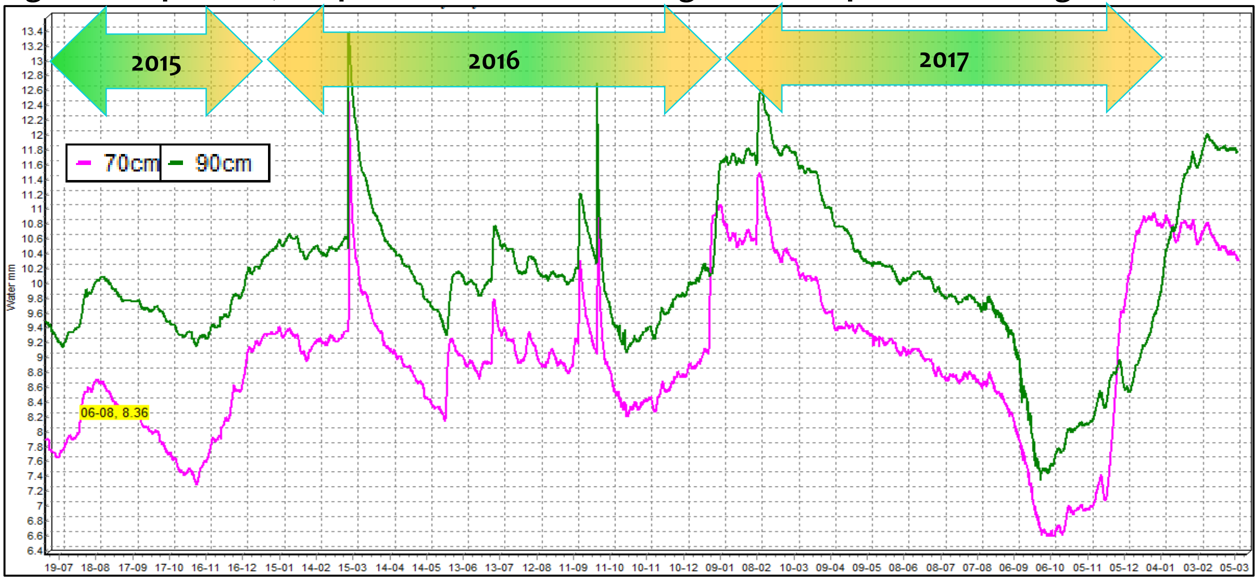


Figure 3. Corresponding rainfall readings to graph above, July 2015 - March 2018

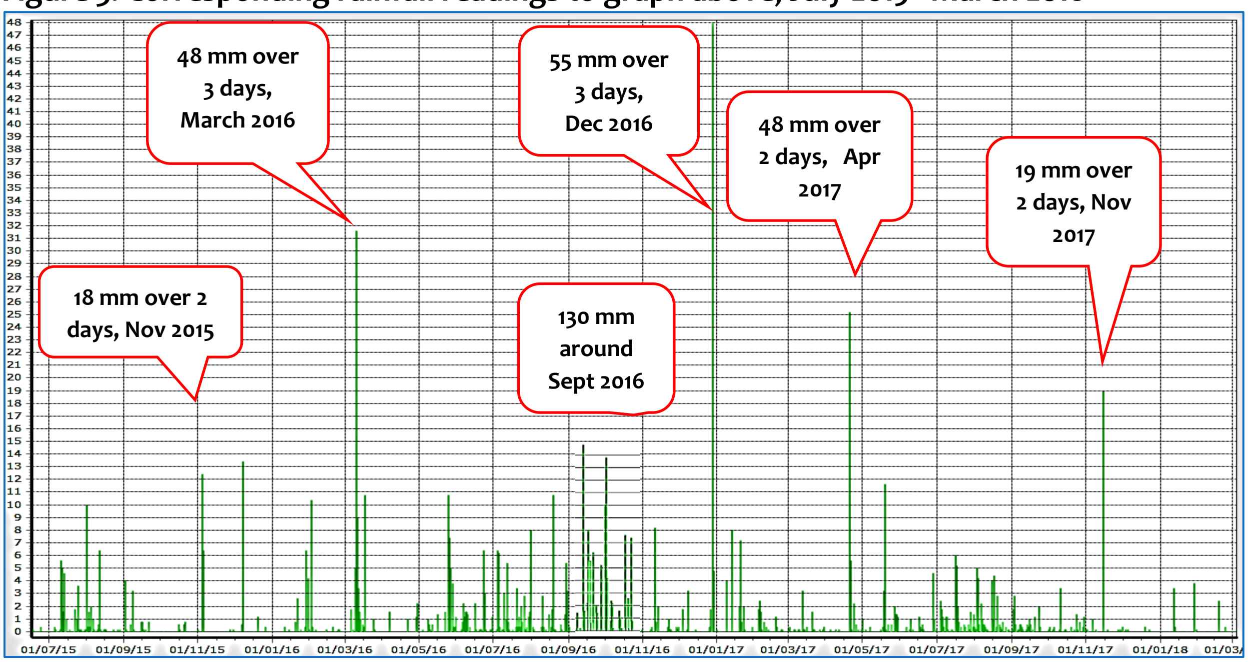


Photo 2. Crop surrounding moisture probe and Piezometer 8 near top of catchment

Figure 4. Piezometer 8, groundwater level for top of southern sand hill, Nov - Dec 2016

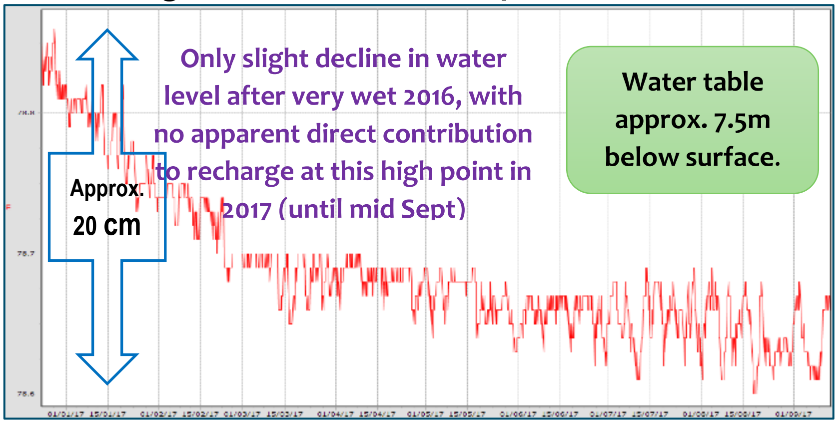


Figure 5. Groundwater level for Piezometer 9, high southern Seep 5, Nov 2016 - Dec 2017

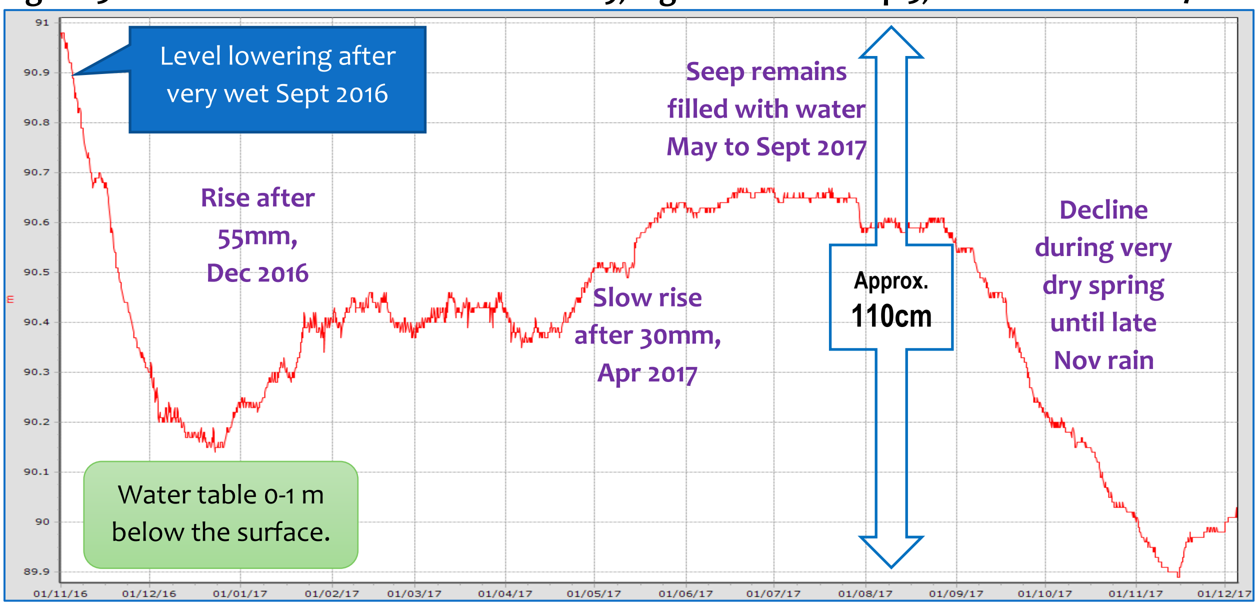


Photo 3. declining surface water in Seep 5 (Dec 2017).

3.2 Findings from lower main seep monitoring

Over the last 3-4 seasons of work at this site the main seep area has rapidly increased in size from 2ha to 6ha (see Fig 6) after being relatively stable for many years prior. It appears much of this expanded area is mainly waterlogged and yet to be degraded by surface salinity (Photo 4). This means that if the problem of excess water flowing into these areas can be halted, it is hoped that they could be restored back to full crop production.

Figure 6. Rapidly growing seep area following high Em38 reading areas

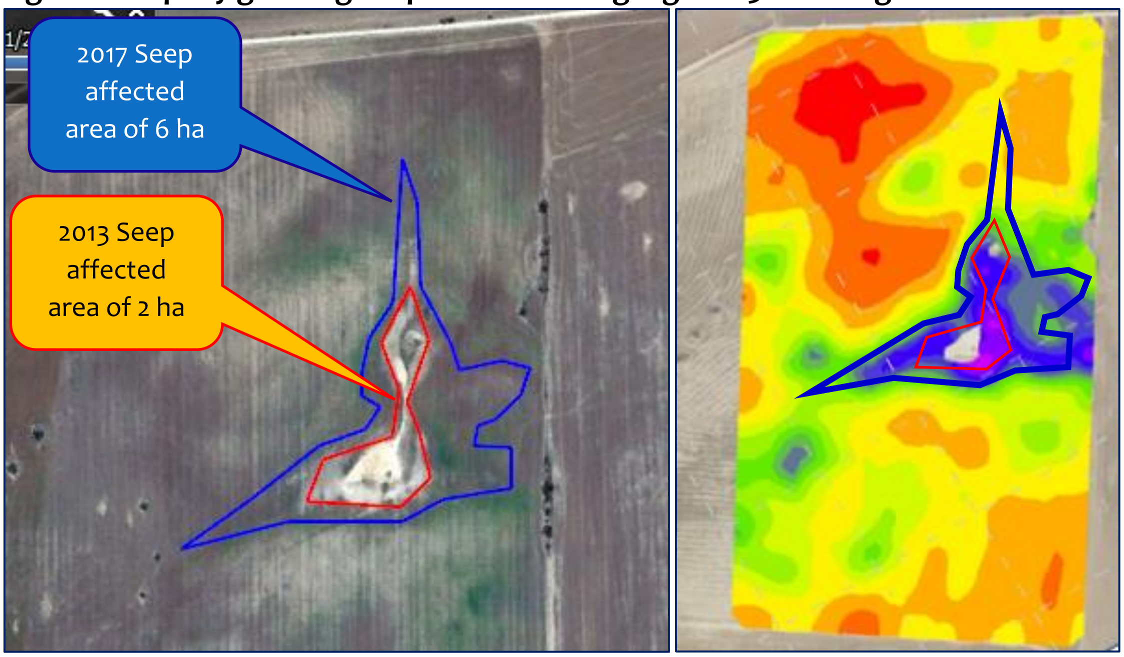


Photo 4. Saturated topsoil at developing New Seep 6 area after seeding

To apply the most effective and efficient strategies to utilize this excess water it is important to understand the rainfall events that are contributing to this build-up of saturated soils, and which directions this lateral flow of water is likely to be coming from. This can be gained by analyzing data from the 3 soil moisture probes and 5 water table piezometers placed throughout this catchment area (see Fig 1), as well as the landscape and soil type reports (Hall, 2016).

Figure 7. Midslope moisture probe deep sensor data revealing possible recharge events

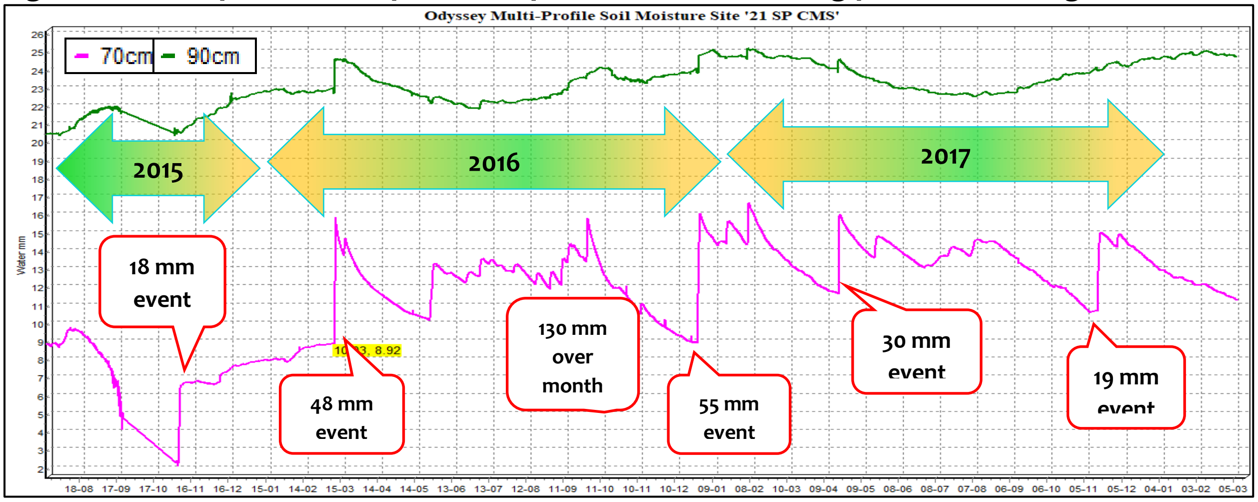


Figure 8. Hydrological cross-section of the long slope (adapted from Hall 2016).

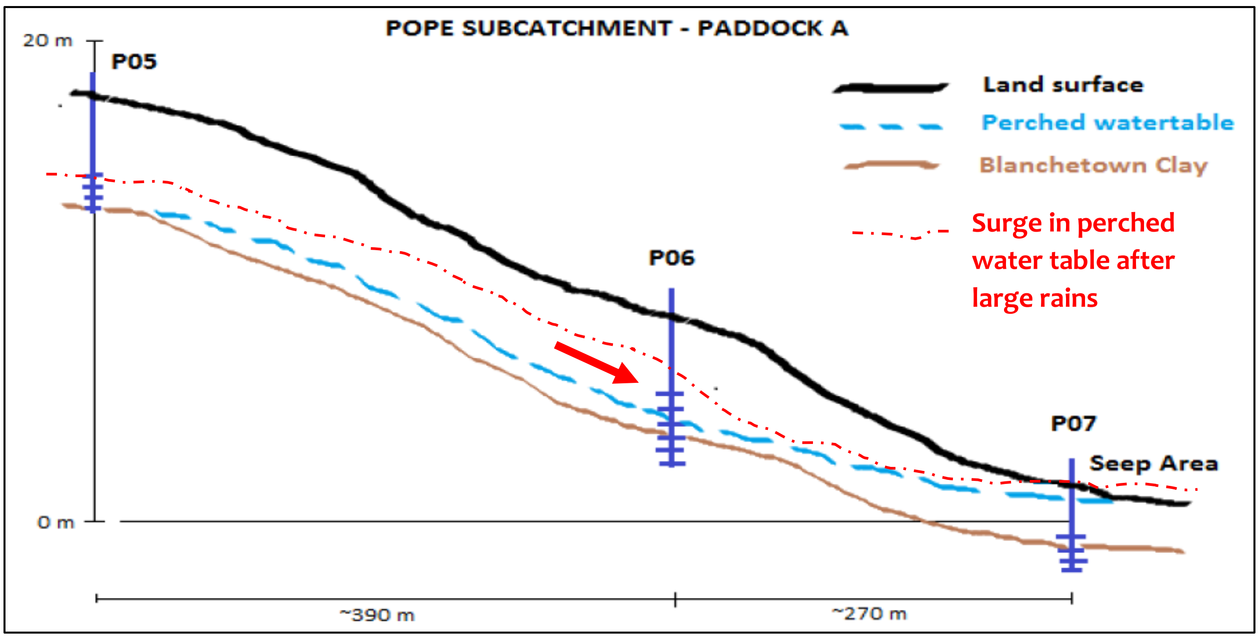


Photo 5 . Piezometer locations, main seep area, Aug 2017

Figure 9. Piezometer 5 (Upper Midslope) showing water table rises, Nov 2016-Dec 2017

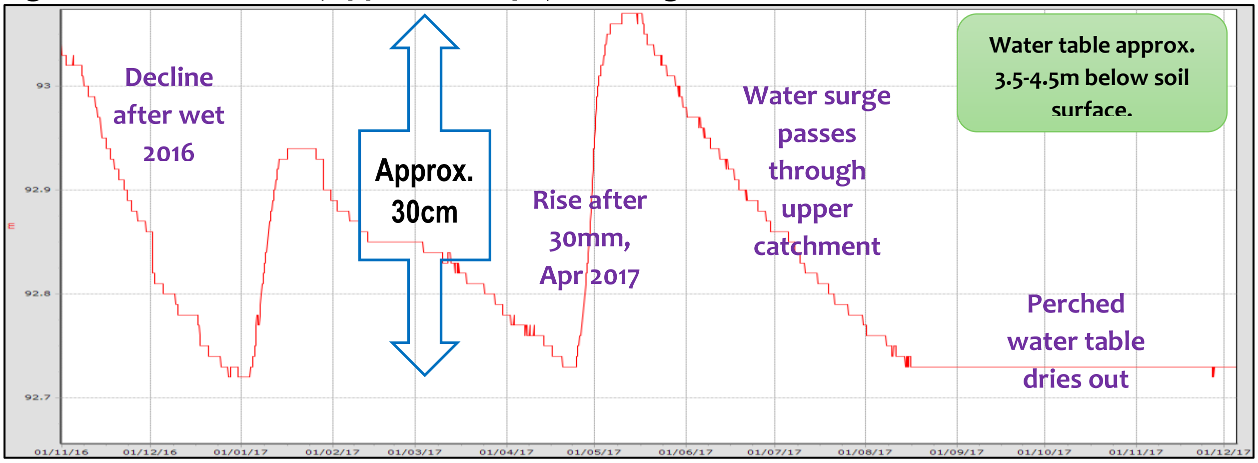


Figure 10. Piezometer 6, (Midslope) watertable levels, eastern fence line, Nov 2016-Dec 2017

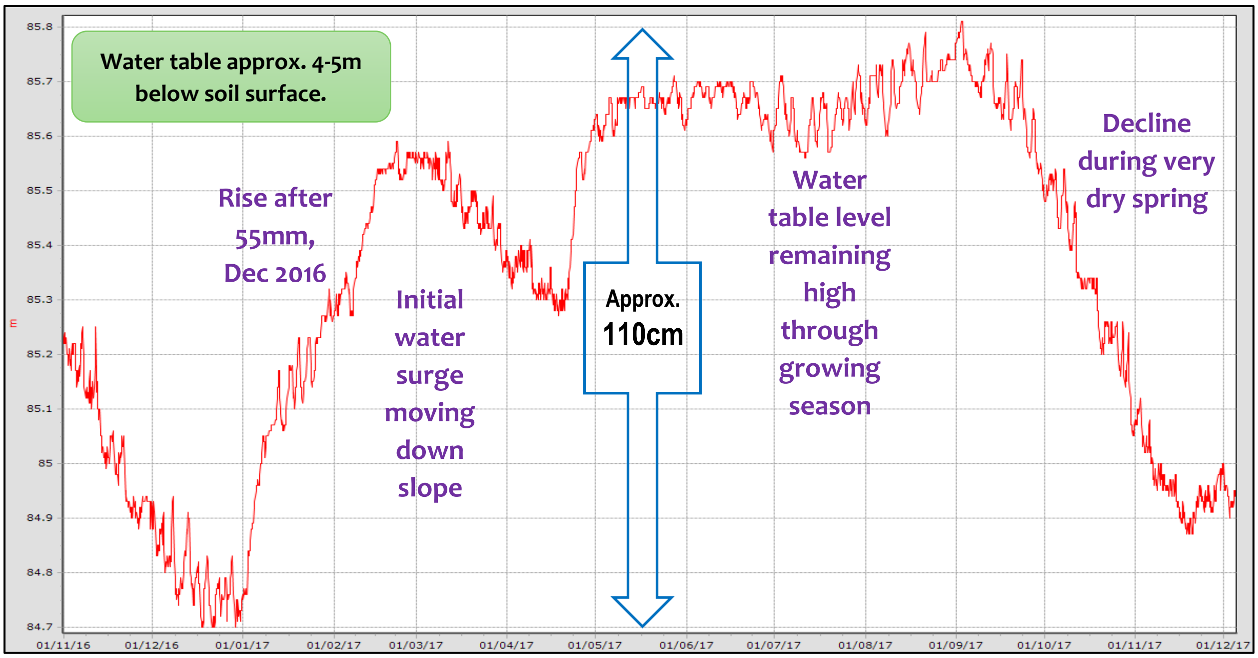


Figure 11. 2017 rainfall at site, corresponding to water table rises in Figures below.

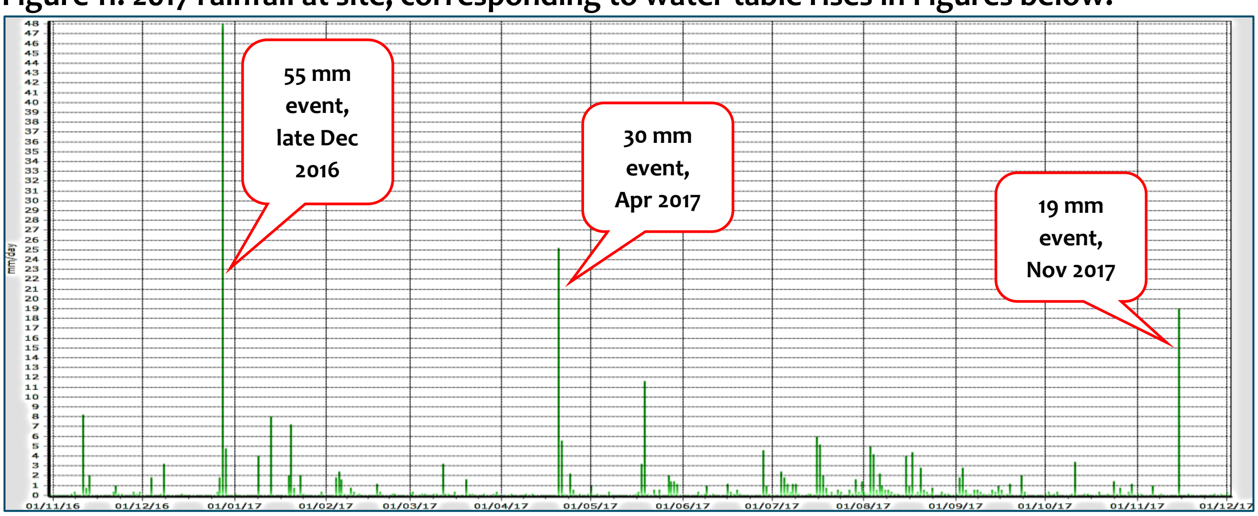


Figure 12. Piezometer 7, (Main seep) water table levels, Nov 2016-Dec 2017

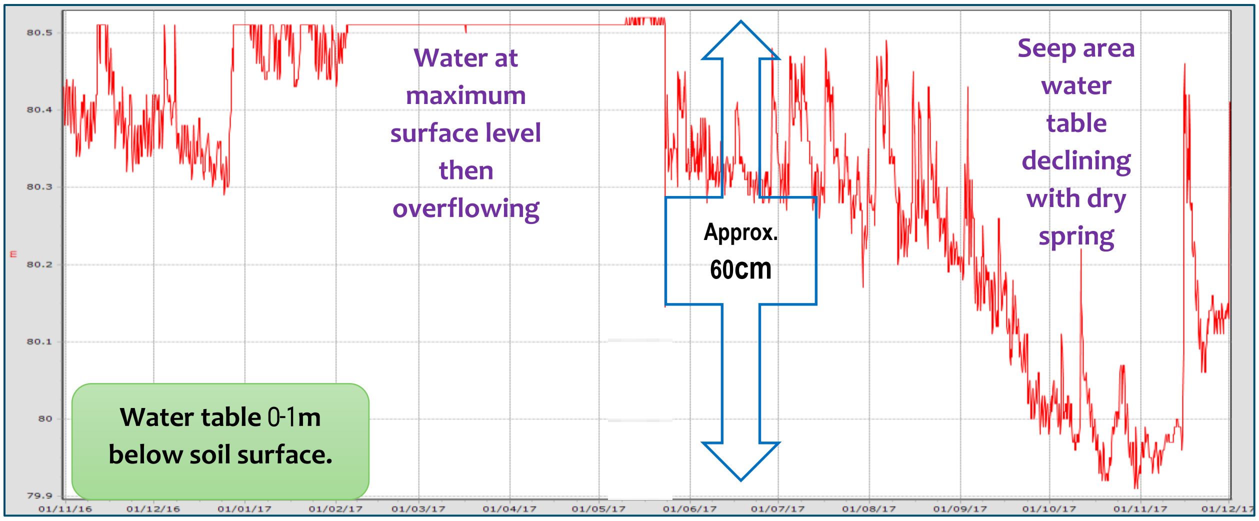


Figure 7 shows the deep sensor (70 cm and 90 cm depth) soil moisture probe results for 2017 to make assessment of potential recharge rainfall events for the midslope soils just above the main seep area. The soil is a deep sand over clay, with the 90cm sensor just penetrating the clay layer and may be at a moisture level approaching field capacity. Sharp rises in the 70cm sensor therefore gives a clear indication of rainfall events that passing through the sand layer to possible recharge. Similar to the upper catchment soils this would suggest that any rainfall event above 18 mm could well be contributing to recharging water tables below.

Figure 8 give representation of the 3 piezometers located at different points of the lower catchment, showing how the perched water table sits above the impermeable Blanchetown clay layer, and causes seeps in areas where this clay comes closer the surface. The red line shows what appears to happen after large rainfall events, which causes some recharge across the sandy areas, and then builds up to a water table surge as it moves laterally to the lower catchment areas.

Figures 9-12 show a very graphic representation as to the dynamics of this catchment through the recordings form each of the 3 piezometers. Photo 5 reveals their actual piezometer locations within the landscape. Piezometer 5 is located within the sand covered slope in land 18 m vertically higher and 480m from the main seep Piezometer 7. While not in direct alignment, Piezometer 6 is in in the lower slopes in between these points.

While it was originally thought that the increases in water table levels in 2017 may have been mainly due to the carry over effects of the well above average 2016 season, these 3 piezometer readings suggest that water levels had subsided appreciably prior to the Dec 28-29 rainfall at the very end of 2016. This 55 mm event led to a 20cm water table rise in the upper midslope at Piezometer 5 (see Fig 9) as water filtered through the top 4 m of soil over a 15 day period before the water table began to subside, almost to its original level by mid-April. It is expected that this rise contributed to a surge of water moving laterally down the catchment slope, along the top of the impervious Blanchetown clay layer.

This can be observed at Piezometer 6, which is approximately 260m further down the catchment. Figure 10 shows it had an initial 30cm water table rise, similar to Piezometer 5, but then rises further at a slower but steady rate, due to the lateral surge of water building from higher in the catchment. This water table rise continued for 50 days before beginning to subside. However, the level was not able to return to its initial level due to the 30mm rainfall event in April.

At the main seep area, this large summer rainfall (Dec 2016) caused water to constantly flow out of the ground at the seep area, with Figure 12 showing the water table to be at its maximum height and overflowing until late May 2017. The seep area rapidly grew by 2-3 ha to the east and the west during this period, causing soil saturation and little crop establishment during this period (see Photos 6 - 10).

Photo 6. New seep 5 area, with expanding saturated zone sown to crop, west of main seep

Photo 7. New Seep 6 area, with rapidly expanding saturated sown crop east of main seep

Photo 8. Large expanded seep area that grew excellent crop in 2016, west of main seep

Photo 9. Large expanded seep area that grew excellent crop in 2016, east of main seep

Photo 10. Saturated clay in developing seep areas at 70cm, in Dec 2017

Figure 14 shows an earlier catchment image with the yellow arrows indicating the likely directions of sub surface moisture flows toward the various surface discharge sites. It is unclear how or if water flows from the upper catchment areas towards the lower main scalded area. The full yellow arrow indicates where large rises in the Piezometer 6 water table indicates a large lateral water movement.

Figure 13. Martin Catchment monitoring area Google Earth image Oct 2012

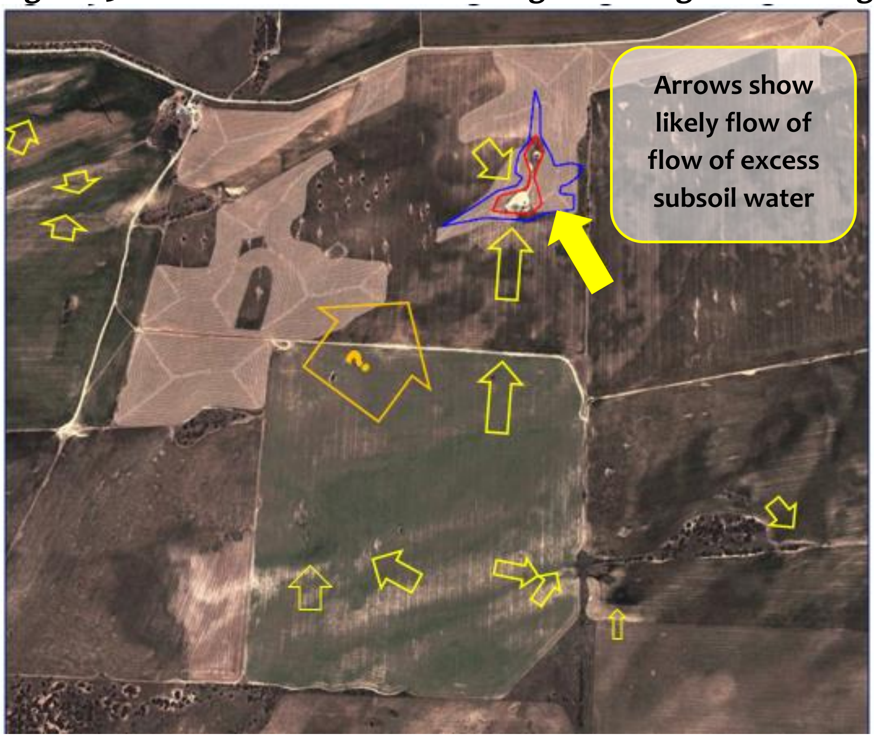


Photo 11. Newer seep forming area in upper catchment

Photo 12. Receding surface water at Seep 3 in Dec 2017

Photo 13. Developing seep areas in midslope below sandy rise

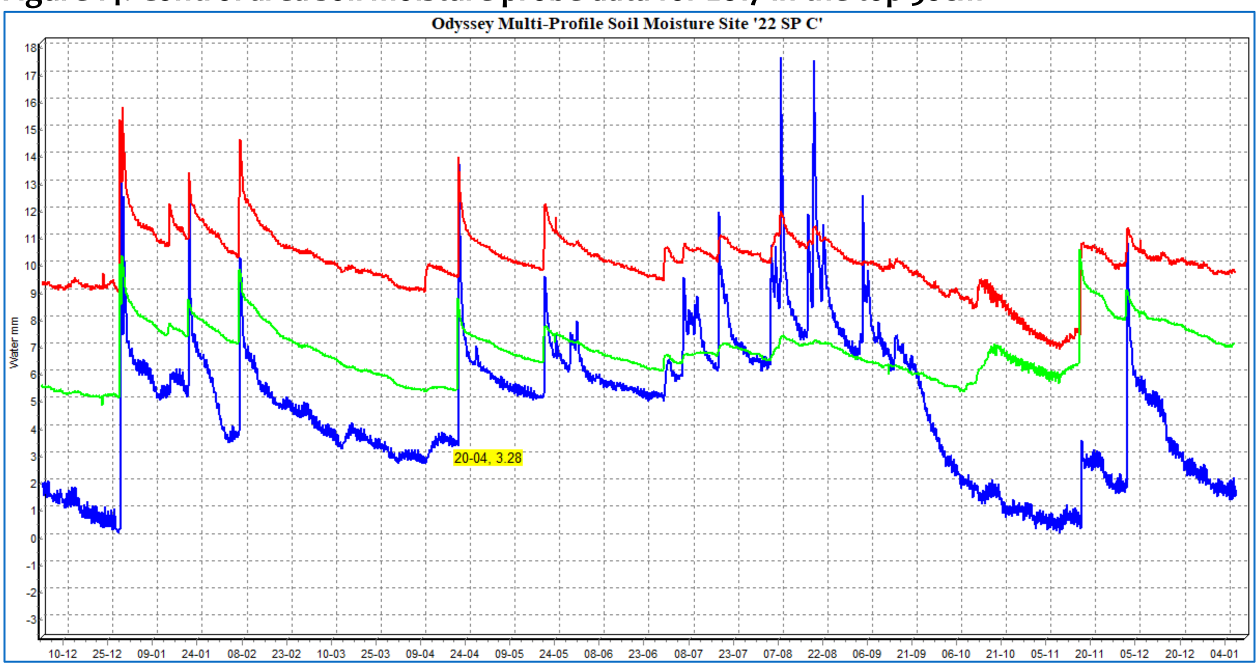
3.3 Management activities to address the ground water issues?

The spading of chicken manure to improve the crop production and water use of the sand above the seep area was unable to measure useful yield data in the 2017 season, as it was sown to lupins which suffered considerable mouse damage and patch crop growth across the various treatments. In previous years this treatment has clearly lead to high yields and gross margins, as well as increased root zone water retention and moisture use, when compared against the control treatment. It is a recommended management technique, but presently under-utilised due to high upfront costs, the poor accessibility of spading machines, as well as the extra effort required by busy farmers to successfully implement this relatively new technology. This may change in the future. Ameliorating the deep non-wetting sands to retain more water and increase productivity is a very attractive option, as farmers don't have to take out valuable cropping land or change management programs to work around trees or lucerne patches. There are still some practical issues that need to be overcome to see a greater uptake of this technique.

The moisture probe data was inconclusive as the crop sown around these probes also suffered mouse damage, and could not accurately display the effects of treatments on crop water use in 2017. This area will be sown to wheat in 2018 and it is expected that yield and quality data will be obtain for analysis for the 4th crop since the treatment was applied. This long term data will be vital in determine its long term value.

Photo 14. Patchy lupin growth at original spading trial area due to mouse damage, Dec 2017

Figure 14. Control area soil moisture probe data for 2017 in the top 50cm



The western paddocks shown in Photo 9 has experienced rapid and severe land degradation since 2010. In 2017 the farmer sowed a 40m wide strip of lucerne at the base of the sandhill intercept the lateral flow of water towards the discharge zones and beyond. The lucerne will be grazed or cut for hay. If this proves to be successful in drying up the ponded areas that are leading to bare scald areas in the drier periods, then this will provide technique is likely to be utilized elsewhere across the farm to help restore seep areas before they become permanently degraded. The lucerne has established well, but is too early to assess its impact on reducing the perched water table at this site (see Photos

Photo 15. Paddock west of main soak, showing new lucerne and Messina planting area

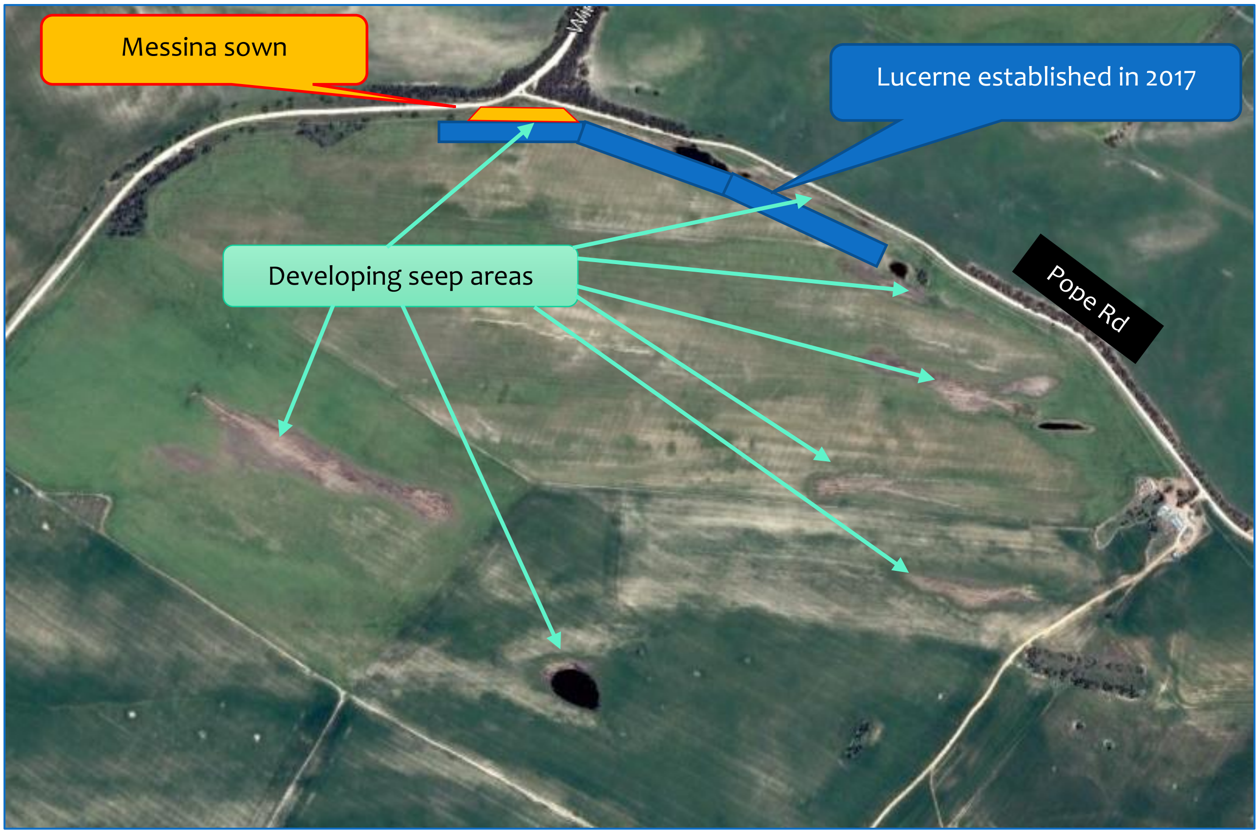


Photo 16. Bare scald and lake areas forming in western paddocks

Photo 17. Lucerne established around seeps may protect Pope Road from degradation.

Photo 18. Established lucerne strip above seeps, Dec 2017

Photo 19. Lucerne established to intercept water flowing from sand hill to seep areas

Photo 20. Lucerne strip surviving through summer

Messina was sown with the farmers air seeder across the scalded and often waterlogged areas beneath the lucerne zone, to test whether this new pasture would provide cover and reduce the ongoing degradation of these areas. As shown in Photos 20 and 21, it established well in the ground just above the scalded bare areas, but was unsuccessful in areas already bare. It would appear that this may be due to the high surface salinity of these areas, rather than water logging. Small raised areas with some organic matter within the scald areas often saw some germination and growth. Consideration should be given to ridging or roughing up these areas to assist in this pasture establishment.

The main scald area that was hand sown using rakes through the main seep area were completely unsuccessful, even with the areas that appeared only waterlogged and not yet clearly saline.

Photo 21. Messina establishing well just above the scalded seep areas (Sept 2017)

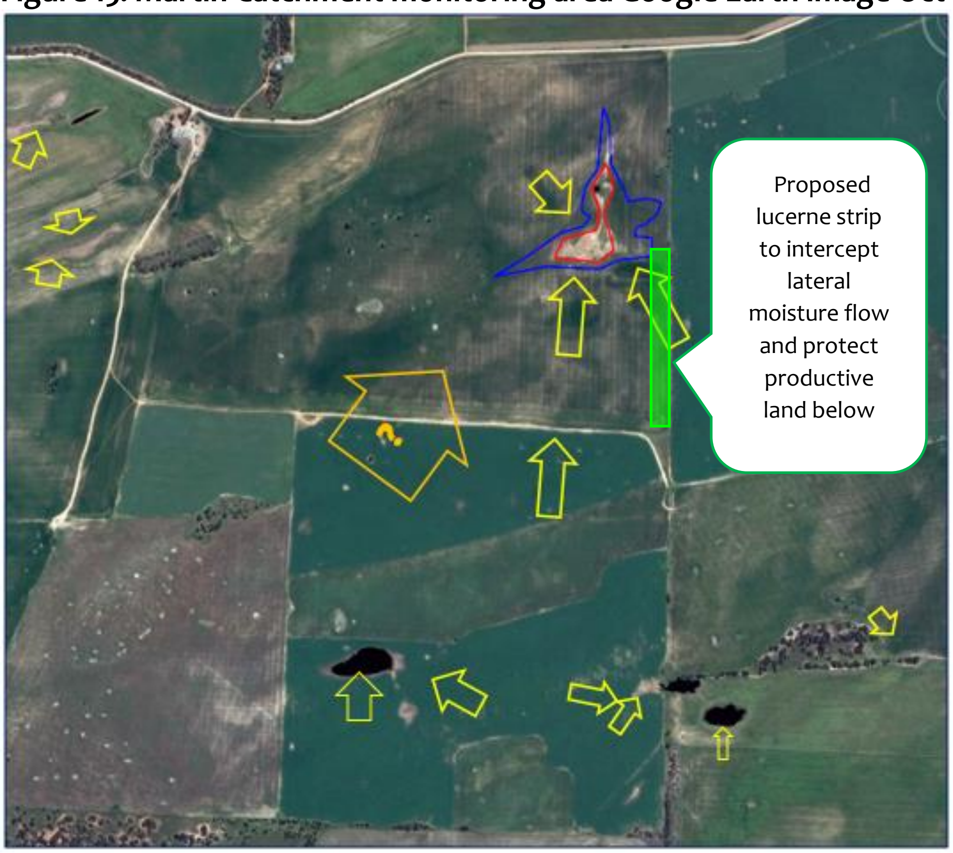
Photo 22. Bare scalds where Messina was unsuccessfully sown, with some near edges

3.4 Summary of Martins site

At this large catchment site, made up of deep non-wetting sands, sand over clay midslopes and rapidly growing seep areas within midslope and lower landscape areas, it would appear that each rainfall event greater than 20 mm is likely to contribute to recharge. This begins with some seepage straight through to the subsoil impermeable Blanchetown clay layer, which builds up and then moves laterally down the slopes, gaining in volume and depth along the way. These surges in perched groundwater tables eventually lead to surface soil saturation in areas where the Blanchetown clays are naturally closer to the topsoil. Once becoming saturated, these areas become more dominated by ryegrass, and soon begin to bare out, due to the anaerobic soil conditions limiting germination and root growth. Once wet and bare, these areas exhibit high evaporation, particularly over summer months, which leaves accumulating salt levels at the surface, leaving these scalded areas degraded and unproductive, or full of water after high rainfall periods.

The Martins must act swiftly to utilize excess water draining through non-wetting sandhills and forming seeps, which is rapidly degrading their farm land. One clear recommendation from this project is to plant a strip of lucerne along the fence line south east of the main seep area. Piezometer readings show that this is where large amounts of perched water passes at about 3m below the surface towards the new 2-3ha area area of recently productive cropping land. It is expected that this lucerne will be established in 2018.

Figure 15. Martin Catchment monitoring area Google Earth image Oct 2016



4 Rose / Thomas Site, Wynarka

This monitoring site consists of a main seep area that is either filled with water or a bare scald below non-wetting sandhills to the north and south. The area has been expanding rapidly since its formation after 2010, most recently with scalded overflow areas and saturated cropping areas that are being overcome by ryegrass competition. The immediate site has 3 piezometers, a soil moisture probe and a rain gauge which continues to build our understanding of the soil/water/crop dynamics and their interactions in seeps formation. This area is rapidly expanding and needs to have remedial action taken immediately to halt further degradation.

Photo 23. Main seep area, piezometers at top sand, midslope and at the edge of the seep

4.1 What have we learnt

It would appear from this site that the non-wetting sand sandy rises are contributing large amounts of recharge water from large rainfall events. These hills have been continuously cropped generally with full summer seed control for the last 10-15 years, meaning that there has been very little deep rooting summer growth (such as skeleton weed) to utilize any of the summer rainfall or other large rainfall events that allow water to pass beneath the cropping root zone of approximately 1m.

In November 2017 the sites moisture probe was shifted from the lower mid-slope to a site on the top of the sandhill right next to the top Piezometer (Photo 26). Figure 16 clearly shows how a 25mm rainfall event (over 2 days) quickly passed from the surface layers to reach

50cm, 70cm and then 90cm after approximately 15-30 days. This was following a 25 mm rainfall 2 weeks prior. It is expected that moisture continued to flow deeper into the soil profile to the perched water table beneath. There was, however, no rise in the perched water table directly beneath as this is between 7-8 m below the surface, and it takes longer and repeated rain events to penetrate to this depth. This is evidenced in Figure 17, which shows a steady rise of 60cm in the above average rainfall year of 2016, which has lowered by 40cm over the below average 2017 season. This initial rise was not likely caused by any lateral water flow, as it is recorded at the very peak of the sandhill. It is water that leached through after the 50 mm rainfall event in March 2016, and then throughout the above average growing season.

Figure 16. Top of sandhill moisture probe, 23 Nov 17 - 21 Feb 18

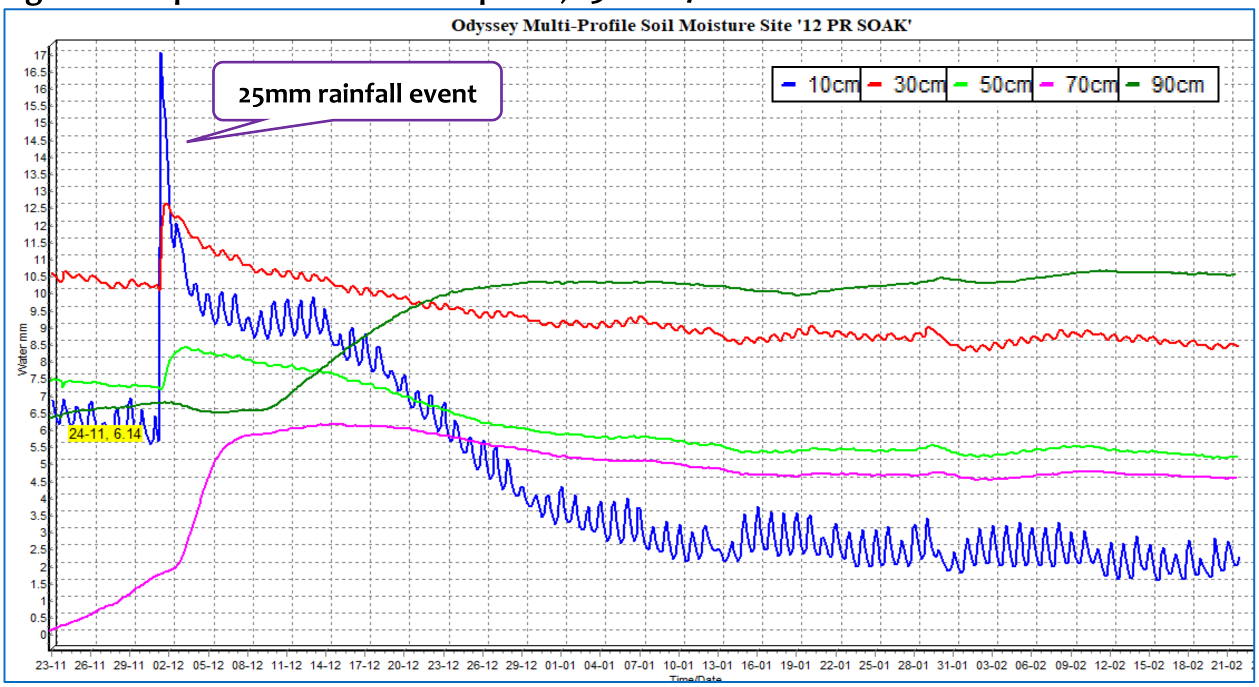


Figure 17. Rise in water table under top of sandhill during above average rainfall in 2016.

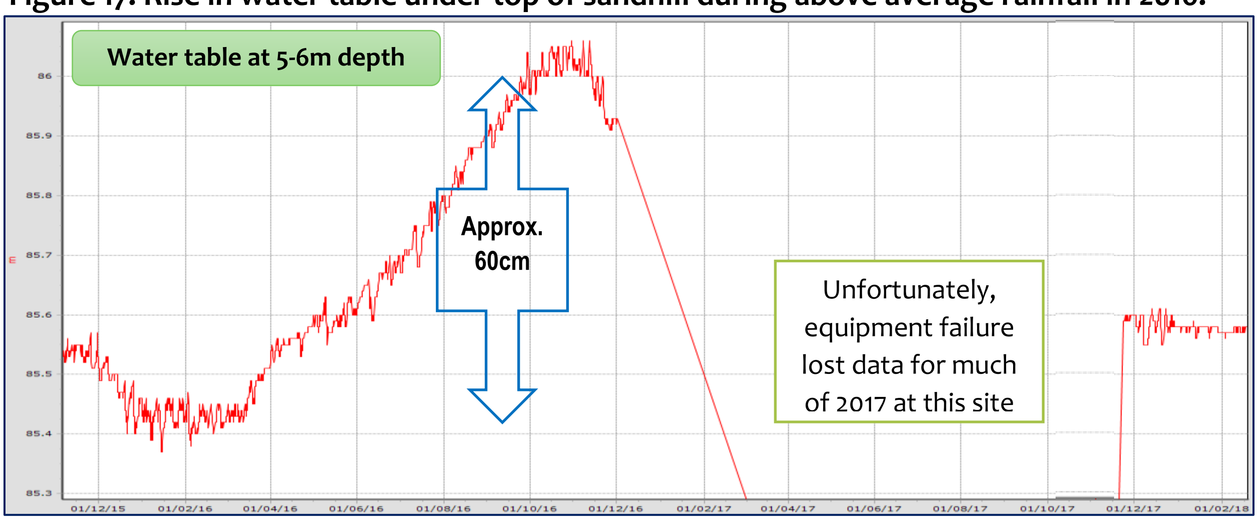


Figure 18 shows the water table under the midslope will rise with every rainfall event above 10 mm, and is often at the rate of approximately a 10 cm rise for every 10 mm of rainfall. This is collecting and accumulating in a distance of approximately 40 m to the top of this sandhill.

The fact that even only a 7mm rainfall event in Jan 2017 could contribute an immediate 10cm rise in the midslope water table (1-3 m below the surface) suggests that this non-wetting sand has a very limited ability to retain moisture. If there is compaction involved which can often be too severe for crop roots between 20-40cm, then it is possible that much of the sand below may have still been close to field capacity going into summer. This means that even a drop of water entering this compacted moist soil layer can quickly push a drop of water out deeper into the perched water table deeper in the profile. As many of these drops leach through over the 40m distance to the top of the sandhill, these accumulate as they move laterally down the slope (on top of the impermeable Blanchetown Clay layer) and then raise the water table levels in the midslope by the 10-20cm shown. It is therefore not surprising that rainfalls of 20-30mm can quickly lead to a dramatic water rise in the seep areas of this catchment.

Figure 19 shows how these rises quickly flow into the seep area, and then overflow to lower in the catchment. According to Figure 21, this sandy rise (orange coloured area B) is not as large as other sandy rises within this catchment (such as orange area A) that appear to be contributing recharge water to the perched water tables beneath. It should therefore be no surprise that there are growing seep areas within this catchment, as identified as areas 1-4 in Figures 21 & 22 and Photos 24-27. There appears to be a direct relationship between the existing and new developing seep areas with the high EM38 reading areas in grey, blue and purple. High EM38 readings are generally associated with heavier soil textures with higher moisture and salt levels within the top 1 meter.

These higher reading EM38 patches are not always associated with seep areas, however, at this site is known that at this site the excess moisture flowing through the sands into the clay beneath eventually hit an impervious clay layer and move laterally to the swale areas where these clays are very shallow, resulting in this water saturating the surface layers and ponding (Hall 2016). It is therefore a combination of the deep sands in relation to the impervious clays that determine where seeps may appear in the landscape.

Other high EM38 reading areas (marked with blue arrows in Figure 21) are not threatening to develop into seeps, as they are generally stony and not directly connected to deep sands.

Figure 22 shows large productive areas within this catchment that are currently threatened with seep degradation if no remedial action is taken. It is currently recommended that trees should be planted strategically along fence lines to intercept some of the lateral flow to lower areas. It is also advised that strips of lucerne be sown for hay production along the mid-slopes above the developing seep areas to assist in deep water use and stop the spread of seep areas. Scalded bare areas would also benefit by reducing evaporation and surface salt accumulation by establishing salt and waterlogging tolerant pastures such as puccinellia, tall wheat grass and Messina.

Figure 18. Mid-slope Piezometer water table levels showing rainfall events causing rises

Figure 19. Bottom seep piezometer levels

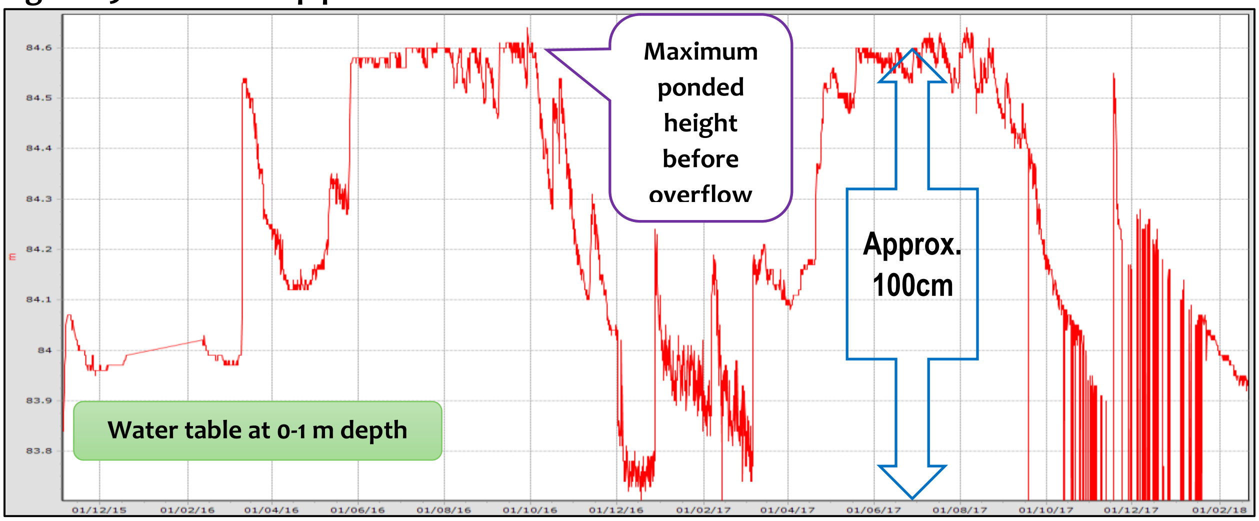


Figure 20. Site rainfall (mm) matching piezometer water table changes above

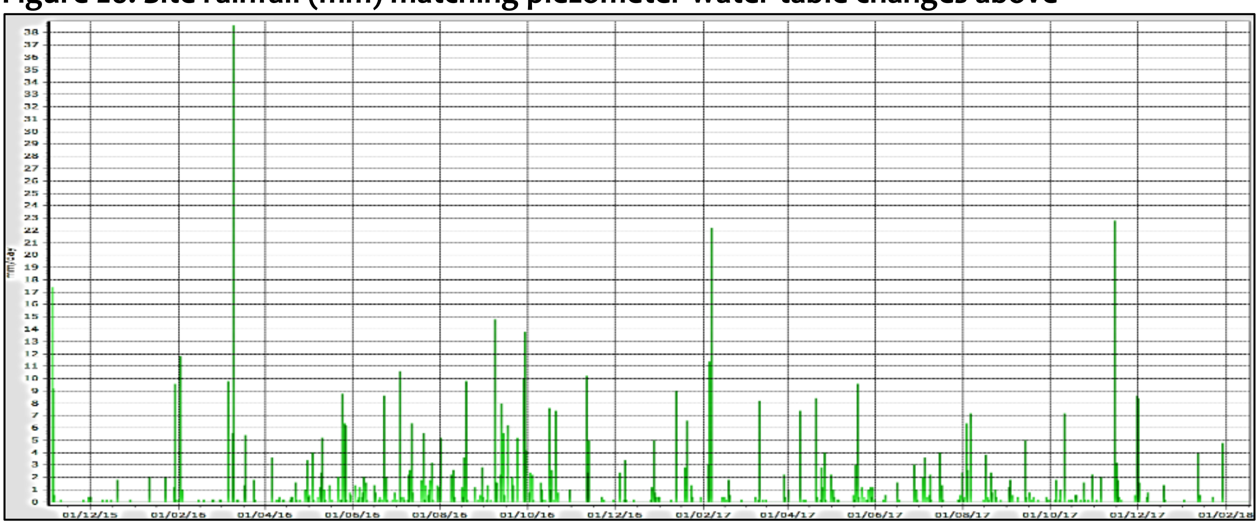


Figure 21. EM38 Map of Rose/Thomas Seep area showing deep sands and seep areas

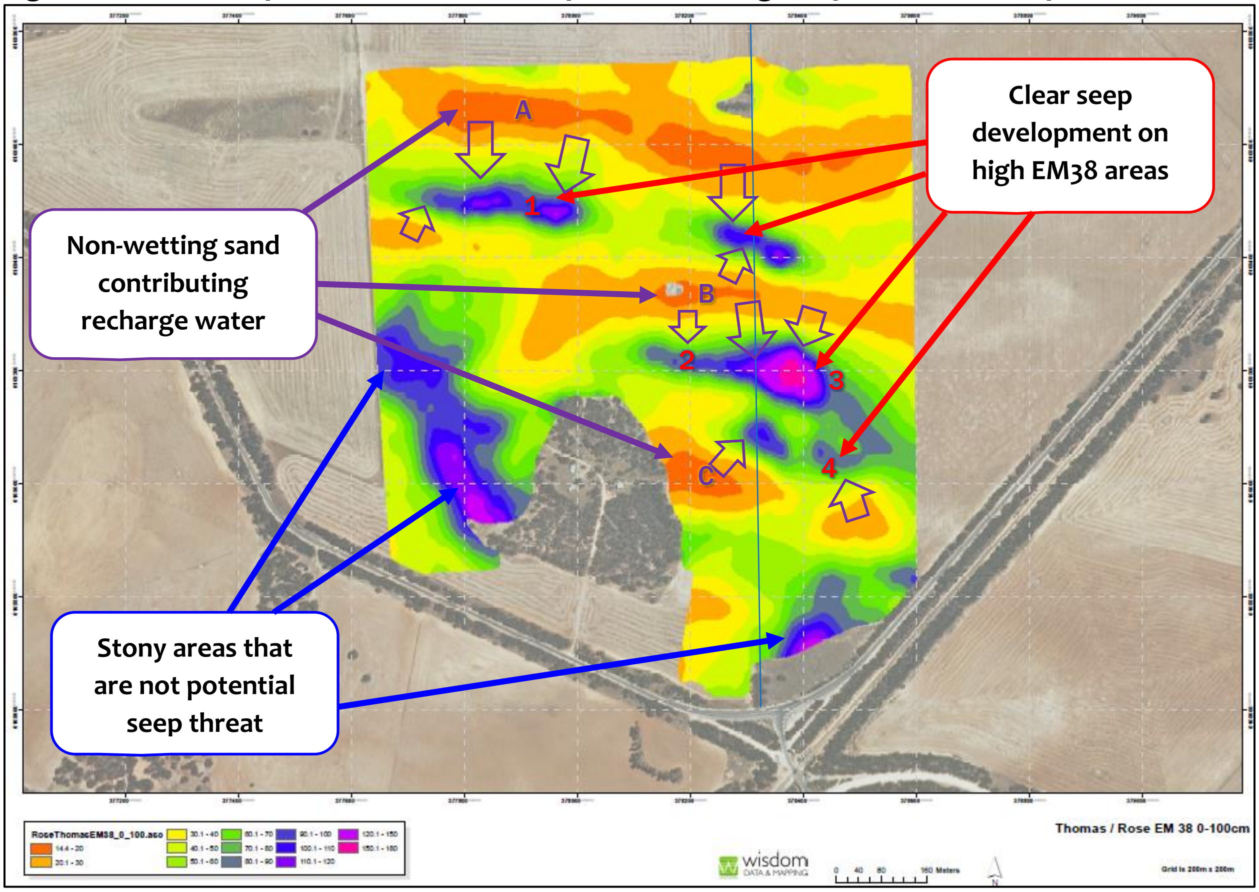


Figure 22. Rose/Thomas wider catchment seep development

Photo 24. View from top of sandhill showing expanding areas around main seep

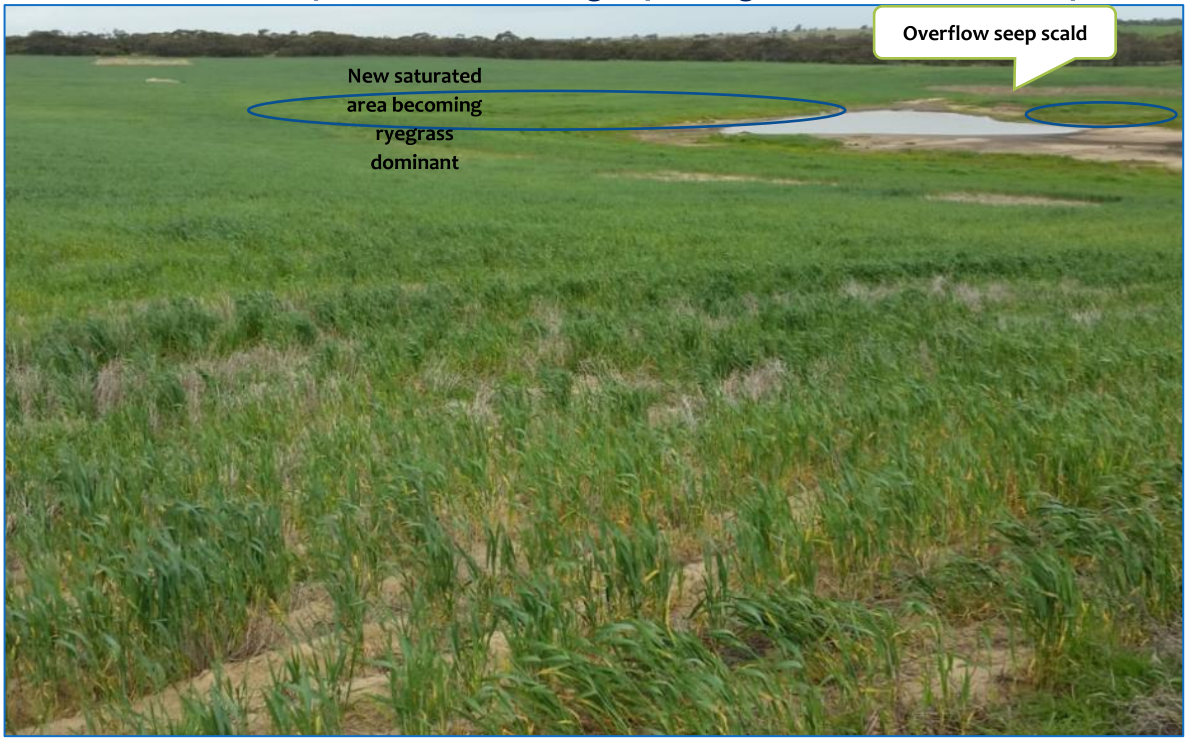
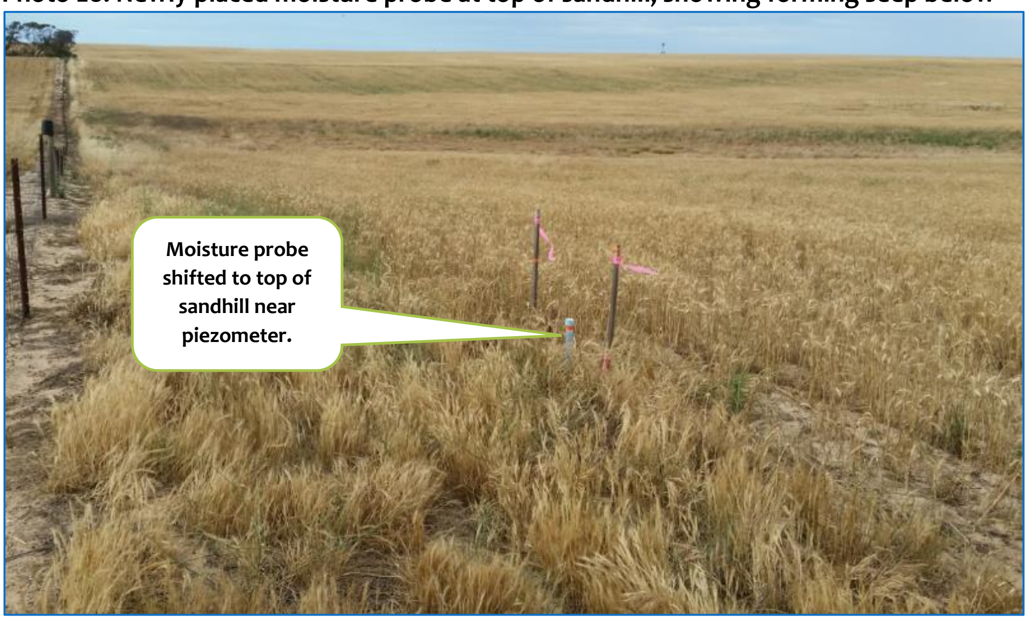


Photo 25. New main seep expansion to the east with ryegrass dominating, area 3

Photo 26. Main seep area remaining full of water for most of 2017 – Bottom piezometer

Photo 27. View of eastern seep area showing area under seeps threat

Photo 28. Newly placed moisture probe at top of sandhill, showing forming seep below



5 Arbon Site, Wynarka

The Arbon site north of Wynarka has four main seep areas that are rapidly growing in size (Figures 23-24). The project activities at this site revolve around the utilization of excess surface water where it is surfacing with productive fodder perennials (such as saltbush) as well as salt/waterlogging tolerant pastures, as well as the interception of the lateral moisture flow above seep areas using native tree planting.

Three of these seep areas experience water ponding for long periods after heavy rainfall periods, and have bare scalded areas with some accumulated surface salinity when dried out. The fourth area is mainly suffering from waterlogging in the midslope where the heavy clay soils appear close to the surface. It is hoped that much of this affected land could be brought back into production through both intercepting the lateral water flow with trees, and by utilizing the water where it is surfacing, using saltbush and tolerant pastures. All areas have increased in size and severity, with an estimated 3 ha of land adjacent to seep areas having become dominated by ryegrass due to surface saturation for much of the 2017 season. This is thought to have been due to the impact of the well above average 2016 year eventually making its way through to the discharge areas (see Photos 29-31).

Figure 23. EM38 map showing seep areas and likely water flow directions

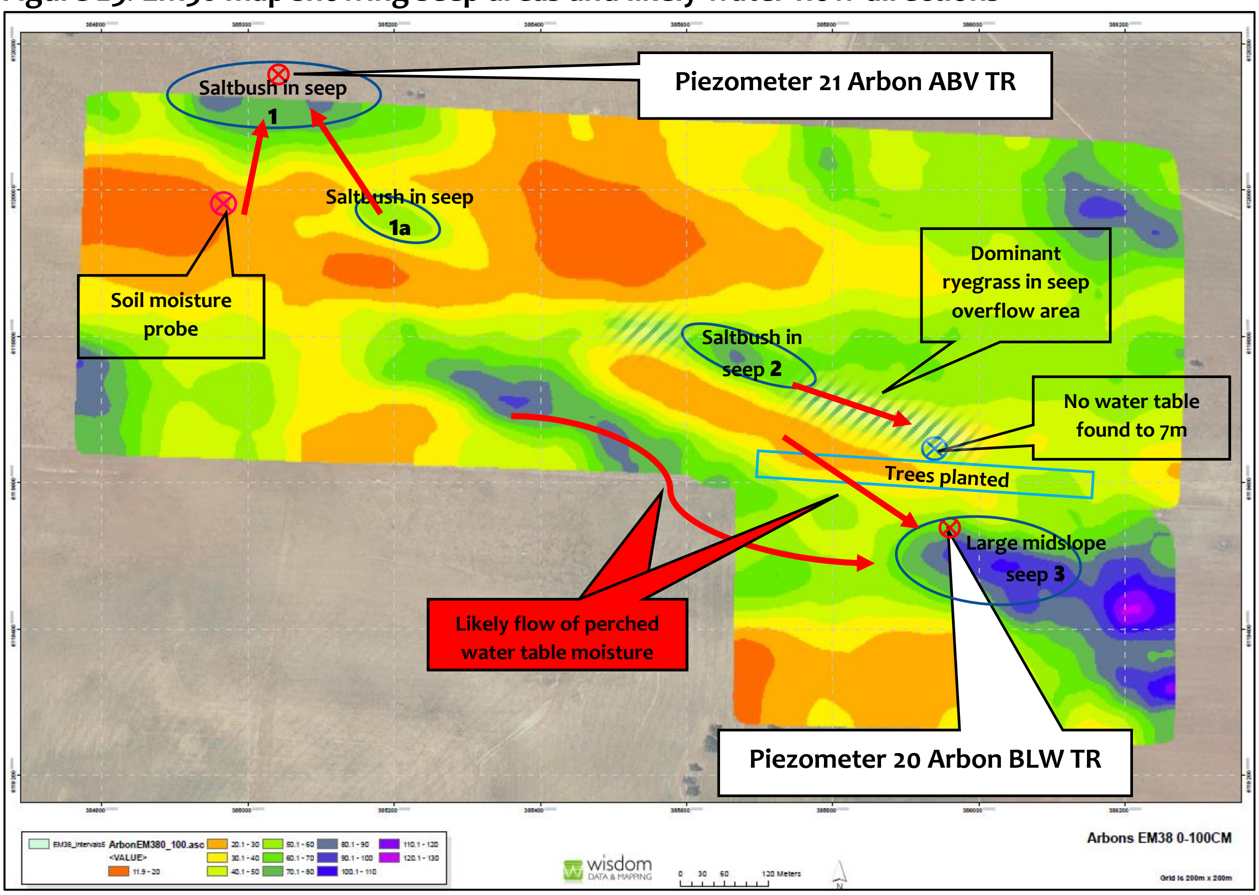


Figure 24. Google Earth image of site showing sand, seeps and activities

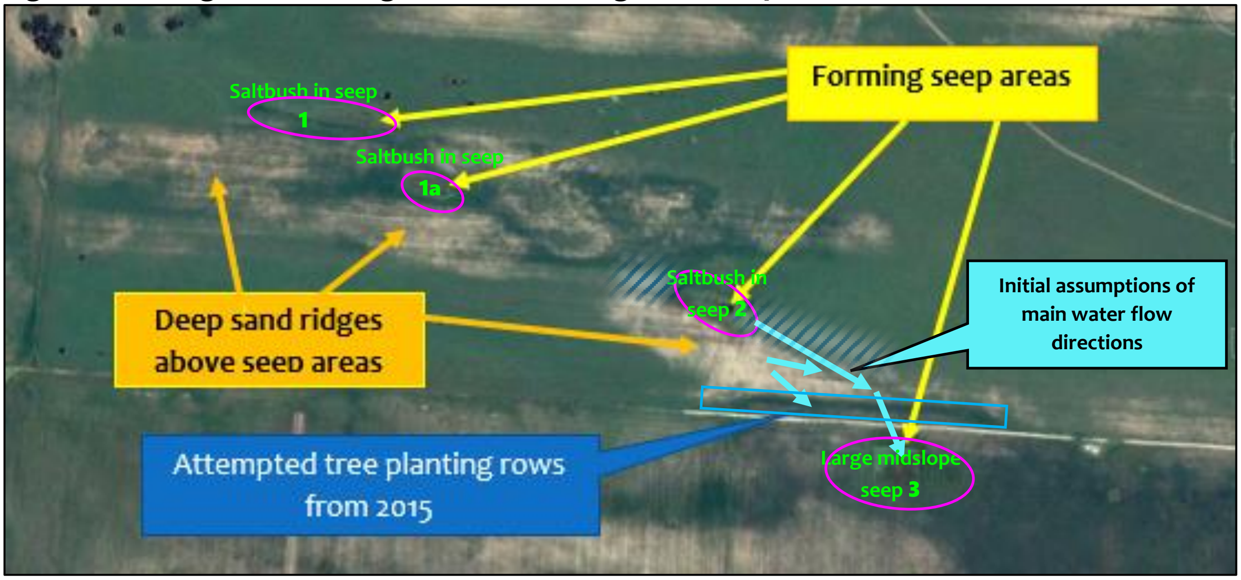


Photo 29. Thick ryegrass establishing in extended saturated soil west of Seep 2

Photo 30. Thick ryegrass establishing in extended saturated soil southeast of Seep 2

Photo 31. Saturated sand below ryegrass areas near Seep 2

Photo 32. Extended thistle and ryegrass growth around Seep 3 area (Nov 2017)

Photo 33. Ponding at the base of Seep 1a, Nov 2017

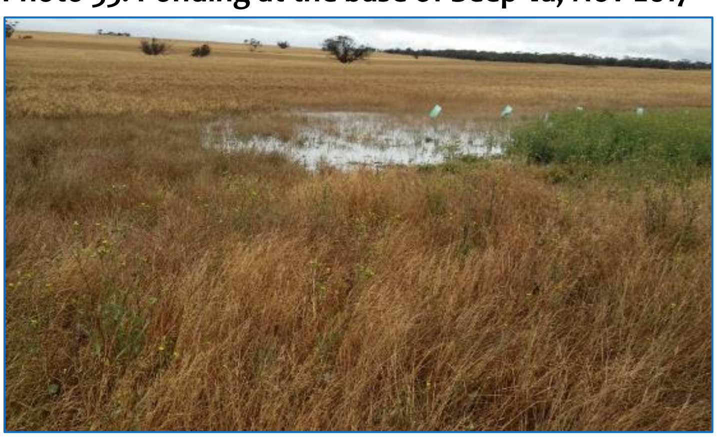


Photo 34. Excellent wheat yield near Seep 1a, utilizing excess moisture in dry season

Photo 35. Wheat dominated by ryegrass competition in area below Seep 2.

Photo 36. Ponding subsiding in Seep 1a saltbush area, Nov 2017

Photo 37. Ponding still evident in Nov 2017 in Seep 2 saltbush area fresh

Photos 34 and 35 illustrate the progression of productive ground into land degradation. Initially the extra fresh subsoil water can provide a huge advantage to the growth of a wheat crop, particularly in a dryer season. However, as the soil becomes saturated for longer, the soil becomes too wet for wheat, and the ryegrass dominates. However, this is still at a stage when the productive potential of the soil could be maintained and restored, provided steps are taken to use up the excess moisture flow into these areas.

In 2015, three seep areas were planted with fodder shrubs saltbush or tagasaste which could be used for grazing, but there were many plant losses to hares and kangaroos. A 5 row block of native trees was also planted along sandy fence line area above a developing soak to intercept the lateral flow of water, which also suffered heavy plant losses (Figure 23). In June, 2017 these areas were successfully replanted with trees and saltbush using tree guards that have greatly improved survival rates Photos 38-42.

The lower seep area was also sown to the new salt/waterlogging tolerant legume pasture variety of Messina, using very simple establishment technique of disc chaining the area (which was thick with ryegrass), then using a mouse bait layer to spread the seed. This proved to be reasonably successful in most areas, however the Messina struggled to establish in any of the bare scalded areas. As the season progressed it was evident that many seeds did eventually germinate once the conditions become more suitable for the plant, but this was fairly patchy (Photos 43-44).

Messina had also been sown between saltbush rows at the other sites using a grader blade to scrape weeds away and prepare some seed bed, followed by the baitlayer seeding. This also proved successful in most edge areas, but was less effective where the soil was more water logged or scalded. Again there was some later seedling emergence evident. While the Messina grew very well, providing excellent winter grazing potential, it was found to dry back to a few sticks over summer, meaning it provided very little soil cover to protect this ground from evaporation which leads to salt accumulation in the surface layers (Photos 45-50).

Photo 38. Tree planting rows above Seep area 3, taken from sandy rise end

Photo 39. Tree planting lines above seep area and Piezometer 20

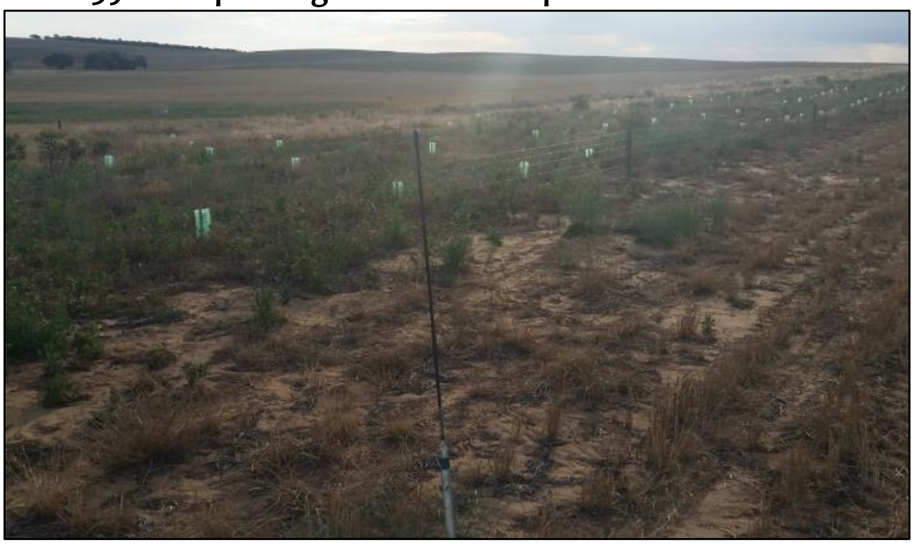


Photo 40. Native seedlings progressing well in guards, Nov 2017

Photo 41. Surviving saltbush growing through tree guard, Nov 2017

Photo 42. Some original tagasaste plants amongst saltbush in Seep 1 area

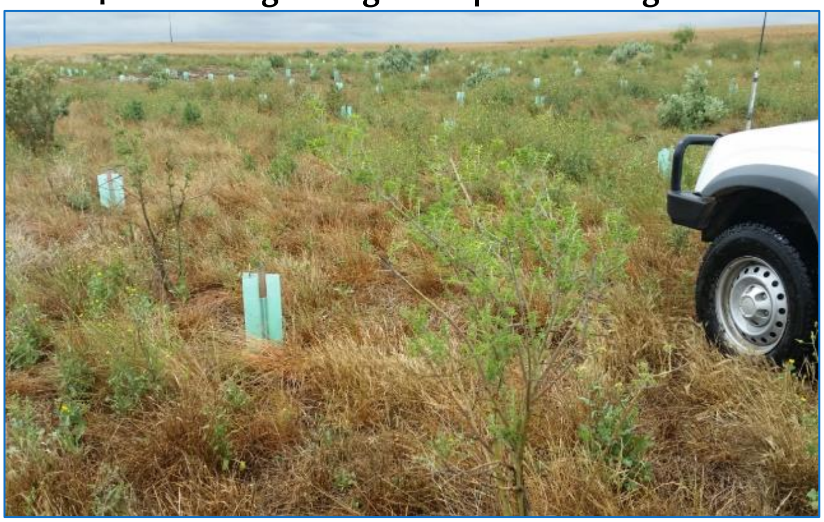


Photo 43. Messina growth amongst ryegrass at Seep 3 area, Sept 2017

Photo 44. Messina growth amongst ryegrass at Seep 3 area, Sept 2017

Photo 45. Messina establishing amongst saltbush Seep 1, Sept 2017

Photo 46. Late germinating Messina, Sept 2017

Photo 47. Late Messina germination, some with fast seed produciton (Nov 2017)

Photo 48. Late ryegrass and Messina growth on the edge of Seep 1a, Nov 2017

Photo 49. Dried Messina showing excellent seed production

Photo 50. Drying Messina resulting in limited soil cover

5.1 New site monitoring established

A key development at this site was the establishment of two piezometers, one soil moisture probe and a rain gauge at this site (locations shown in Figure 23) which will allow for accurate monitoring and analysis as to the effectiveness of the trees and the saltbush of lowering the perched water tables.

Piezometer 20 is placed below the tree line near the top edge of the seep area (see Photo 54). Photo 51 shows the soil profile of the drill hole which was found to a very sloppy clay at approximately 60cm depth, indicating the top of the water table, as evident in Photos 51-52.

Originally it was planned that the one piezometer would be placed directly above the tree line near an area that was clearly experiencing waterlogging and dominant ryegrass competition, seemingly emanating from the seep area above. From the surface it looked most likely that the excess water had been moving from the northwest seep, then down to the midslope seep area 3 on the lower side of the new tree line (as suggested in Figure 24). However, no water table was found when drilling down to over 7m depth (Photo 55), which is well below the water table depth found at the lower seep area 3 piezometer site. On closer inspection of the EM38 make of the site it would appear that the ground water table flow into the seep area may more likely come from the southern side of the sandhill (light orange) and travel south east along the clay towards the discharge seep zone (see Figure 23). So while the majority of the trees planted are still expected to intercept the excess water coming from the sandy rise above, it does reveal that sometimes surface observations can be misleading, and deep (0-100cm) EM38 mapping can play an important role in assessing potential subsoil water table flows.

It was therefore decided to relocate Piezometer 21 on the north side of Seep 1 which will allow for assessment of the effectiveness of the saltbush plantings to lower water table (see Photos 56-57). The water table at this time was recorded within the top meter. The soil moisture probe was placed in the sand hill directly above this site, which will give a clearer indication as to what rainfall events are contributing directly to recharge in this soil.

Photo 51. Drilling Piezometer between tree line and seep area, showing soil profile

Photo 52. Sloppy clay indicating water table at 60cm depth

Photo 53. Perforated piezometer pipe

Photo 54. Piezometer 20 on northern side of Seep area 3, below the tree line

Photo 55. Site of unsuccessful piezometer drill where no water table found to 7m.

Photo 56. Drilling of Piezometer 21 at the edge of the saltbush, Seep 1

Photo 57. Soil profile at Piezometer 21 site

Photo 58. Piezometer 21 on the north side of seep area 1 planted with saltbush

Photo 59. Soil moisture probe placed on sandy rise above Seep 1.

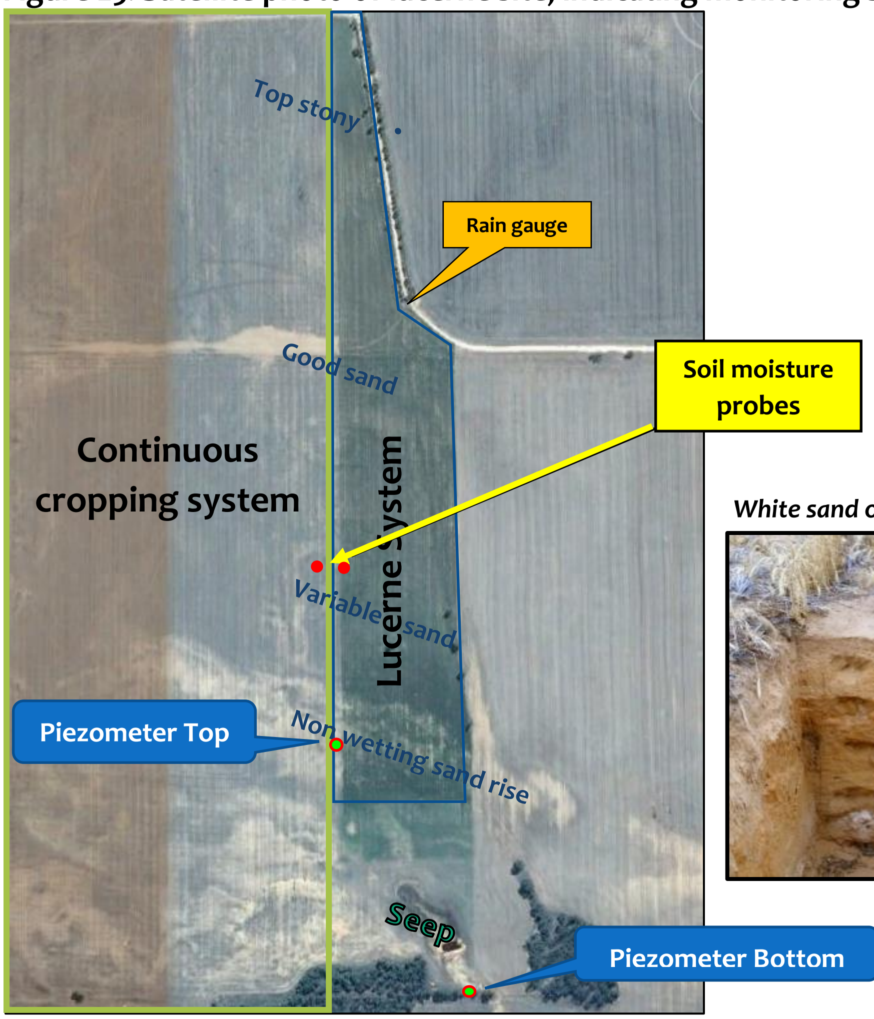
6 Bond Site, Mannum

There are numerous seep areas developing throughout the Bonds property south east of Mannum. In 2015 a 19ha strip of lucerne was established over a long sandy rise above a main seep area. This is surrounded by Notill continuous cropping of cereals, pulses and canola.

The main monitoring at the Bond site has revolved around three main aspects:

1. the measurable differences in soil water dynamics using moisture probes between the 2 different farming systems at the site (lucerne for hay with deep rooted perennial growing all year verses continuous annual cropping system active only in growing season, with clean summer and autumn weed control),
2. the water table levels at the seep and on the sandy rise, using piezometers,
3. the recent use of the summer crop millet to soak up excess moisture at the specific discharge areas before they become scalded and saline, while maintaining normal winter cropping activities through these areas.

Figure 25. Satellite photo of lucerne site, indicating monitoring sites



White sand over clay profile typical of this site

The major development in 2017 was the large areas of saturated soils appearing and affecting crop growth, resulting from the well above average rainfall in 2016, as clearly evidenced in Photos 60-64. The new areas under immediate threat are as high as 10-20ha.

Photo 60. Kevin Bond surveying damage to cropping land resulting from wet 2016 season

Photo 61. Waterlogged seep areas forming at base of sandy rises

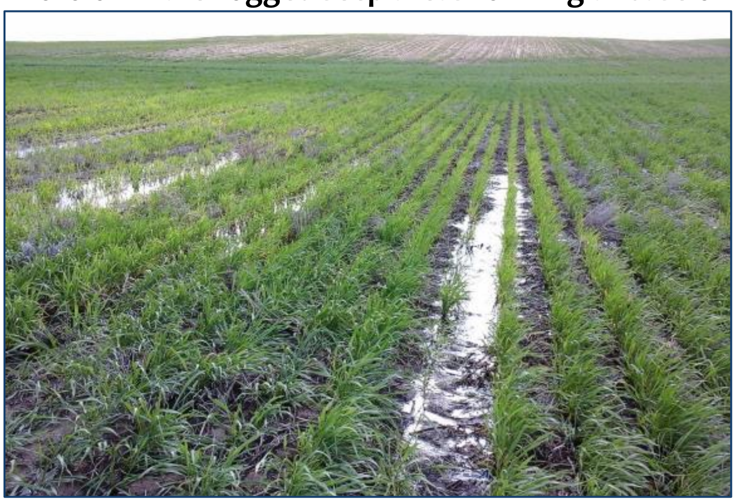


Photo 62. Seep areas (yellow) forming at base of sandy rises

6.1 The impact of changing farming systems on water use and water tables

The benefits of the perennial deep rooted lucerne in reducing the perched water table are clearly demonstrated at this site, with Piezometer BO2 (Photo 65) being the only site that recorded a reduction in ground water levels during the very wet season of 2016 (Figures 27-31). Figure 26 shows that in 2017 the lucerne side consistently had 50-80mm less moisture in the top meter of soil, and this is likely to be a greater difference in the meters below this. While each major rainfall causes a spike in soil moisture levels, it can easily be absorbed in the soil without causing recharge, but rather is used by the plants and moisture levels quickly return to similar levels. The longer term measurements shown in Figure 27 reveal how the moisture levels were drawn down as the lucerne established and have been maintained at this low level, as opposed to the cereal side in which the soil moisture levels continued to rise, particularly though 2016. While lucerne growth was poor throughout 2016 due to early aphid and possible herbicide damage, production levels were very good in 2017.

Photo 63. Excellent lucerne growth in upper catchment and stony soil, Nov 2017

Photo 64. Upper catchment lucerne and cropping zone moisture probe sites

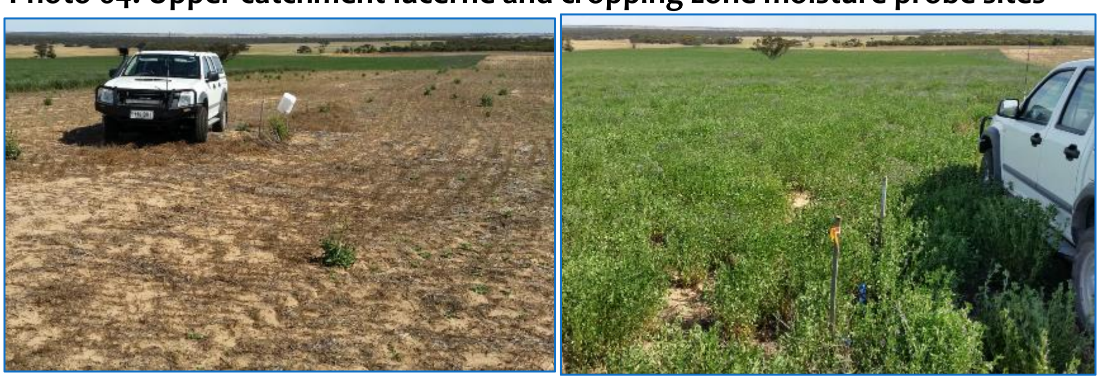


Photo 65. Excellent lucerne growth on non-wetting sand compared to bare cropping zone

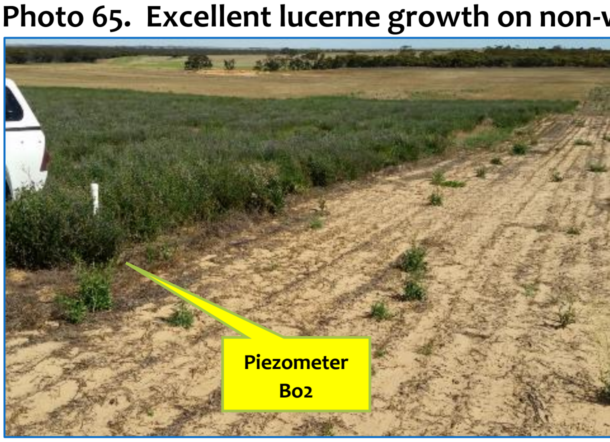


Figure 26. 2017 Soil moisture sensor comparisons between farming systems with rainfall

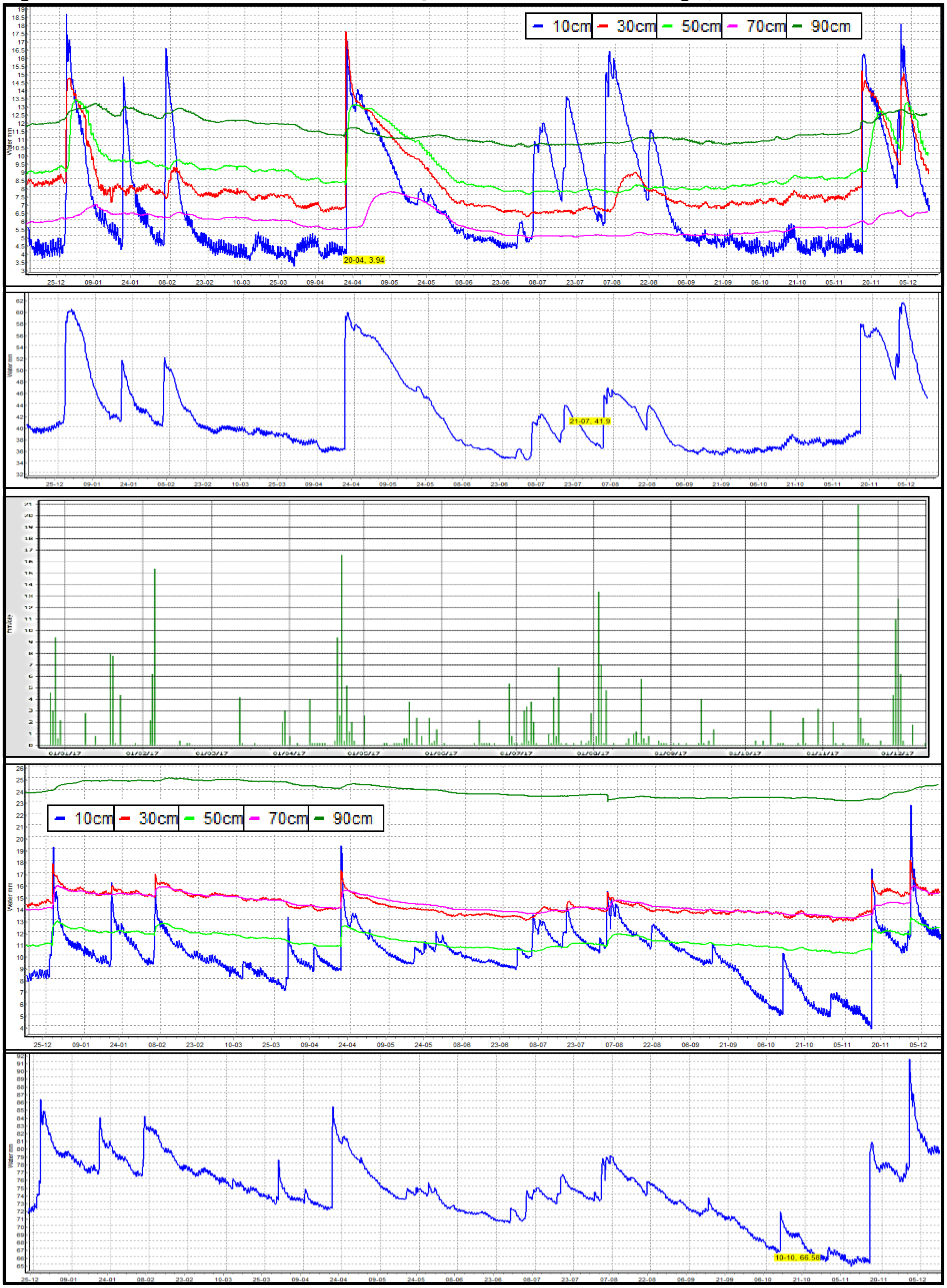


Figure 27. Long term summed moisture comparison of farming systems. July 2015-Dec 2017

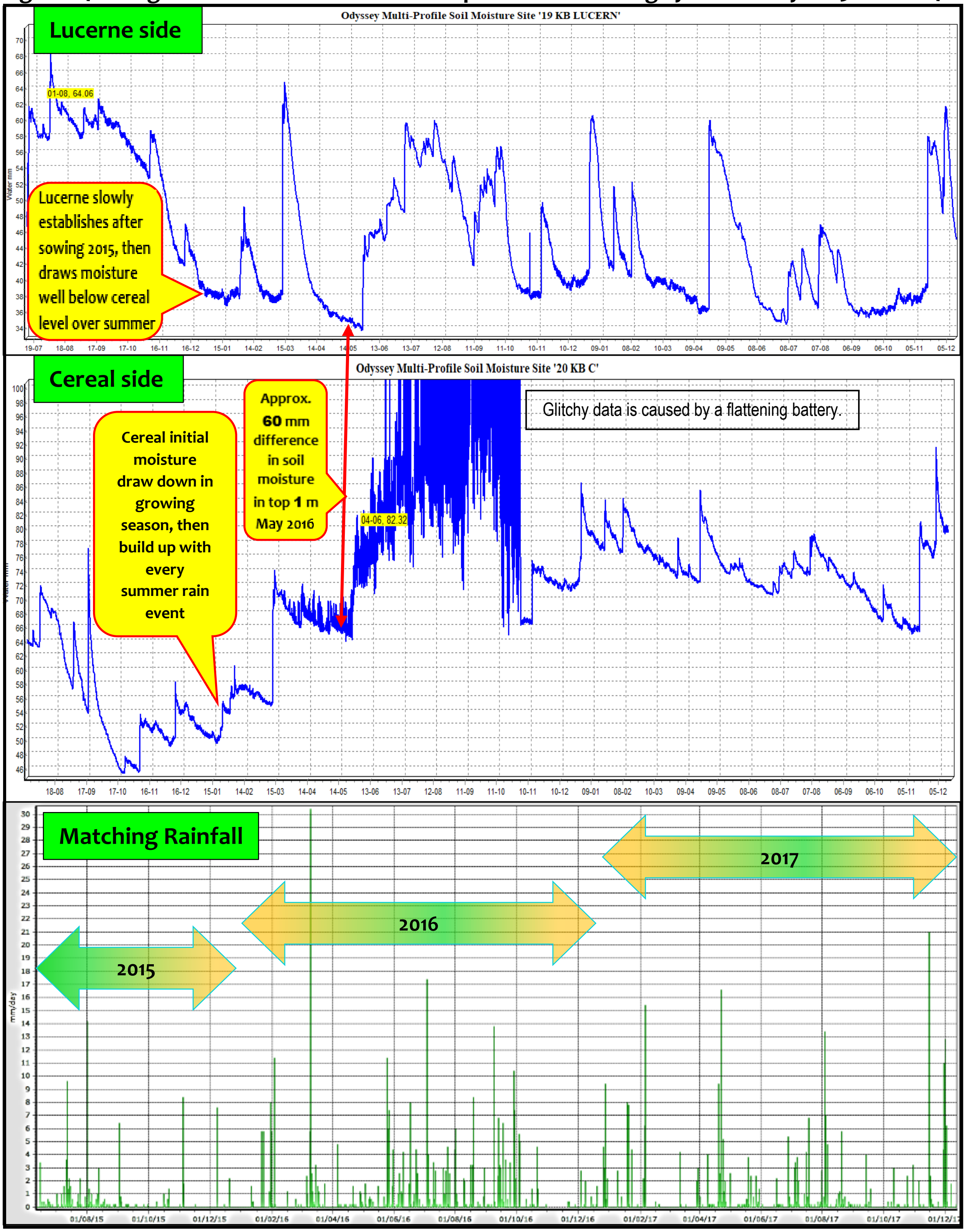


Figure 28. System comparison of 70cm & 90cm soil moisture sensors, July 2015-Dec 2017

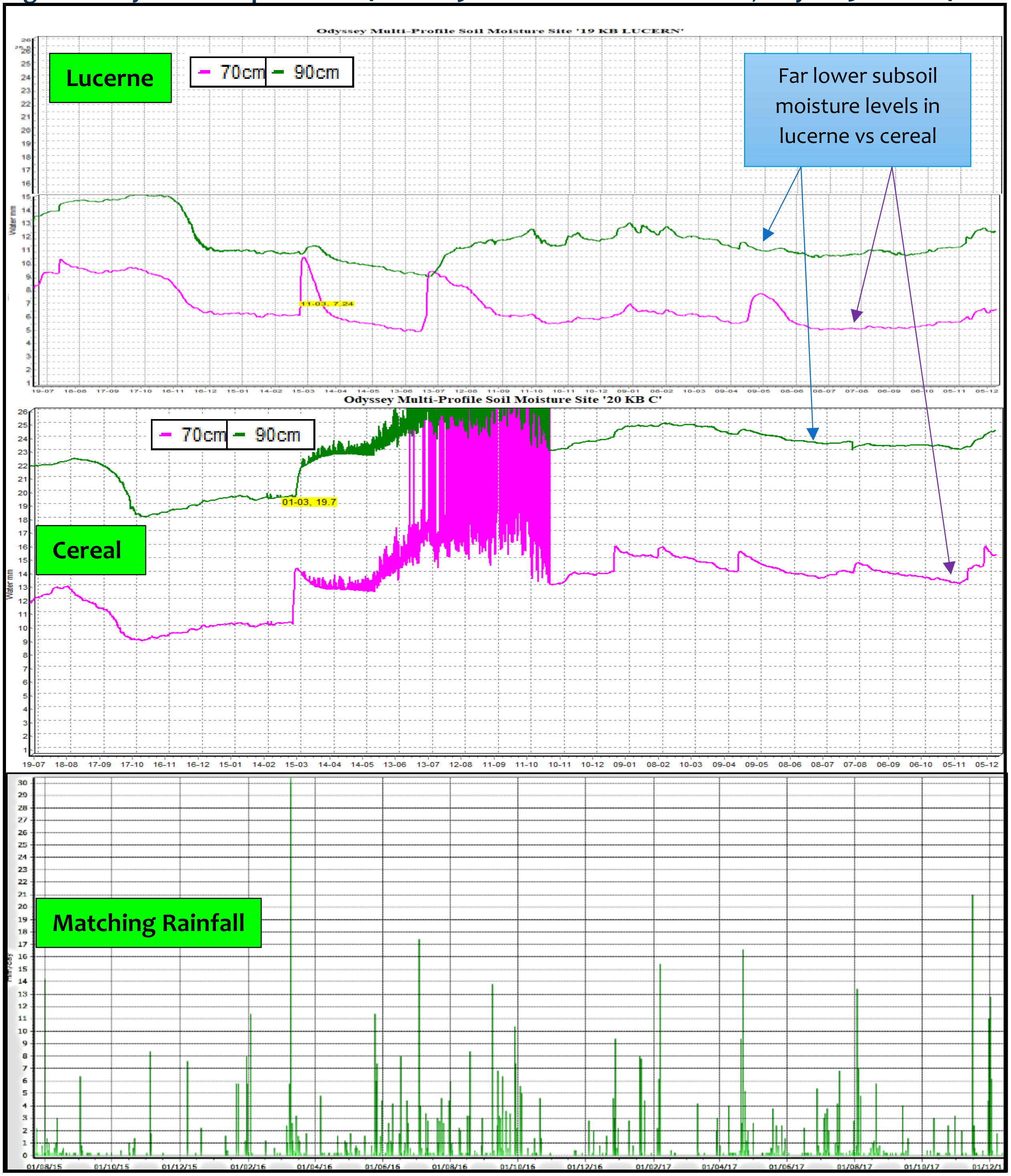


Figure 29. Piezometer B01 readings for Bottom soak area, Dec 2015 - Dec 2017

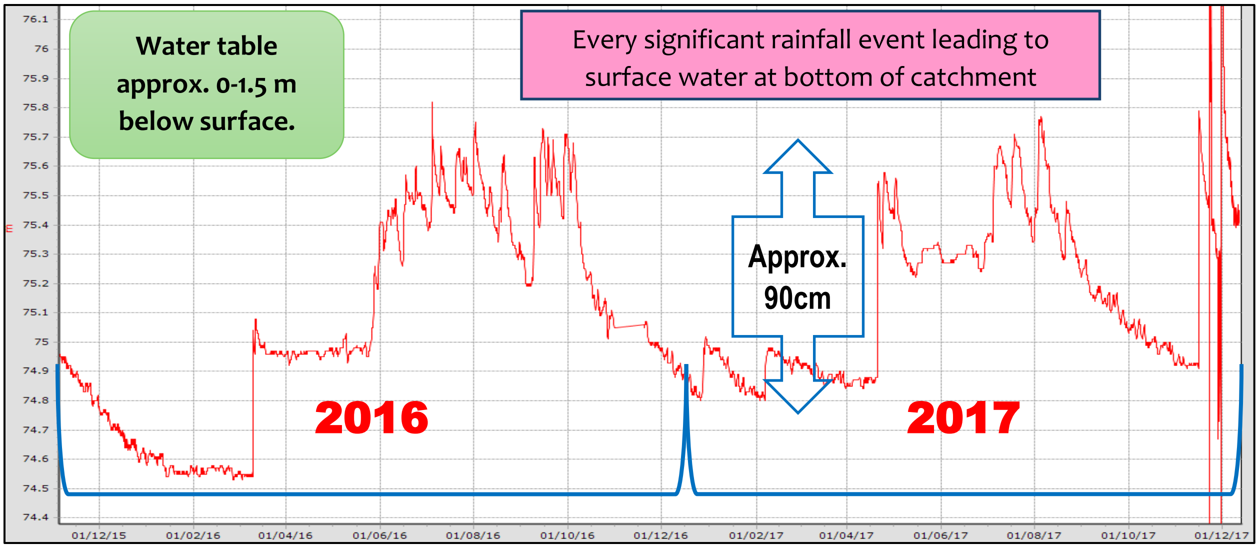


Figure 30. Rain gauge readings from site, Jan 2016 – Dec 2017

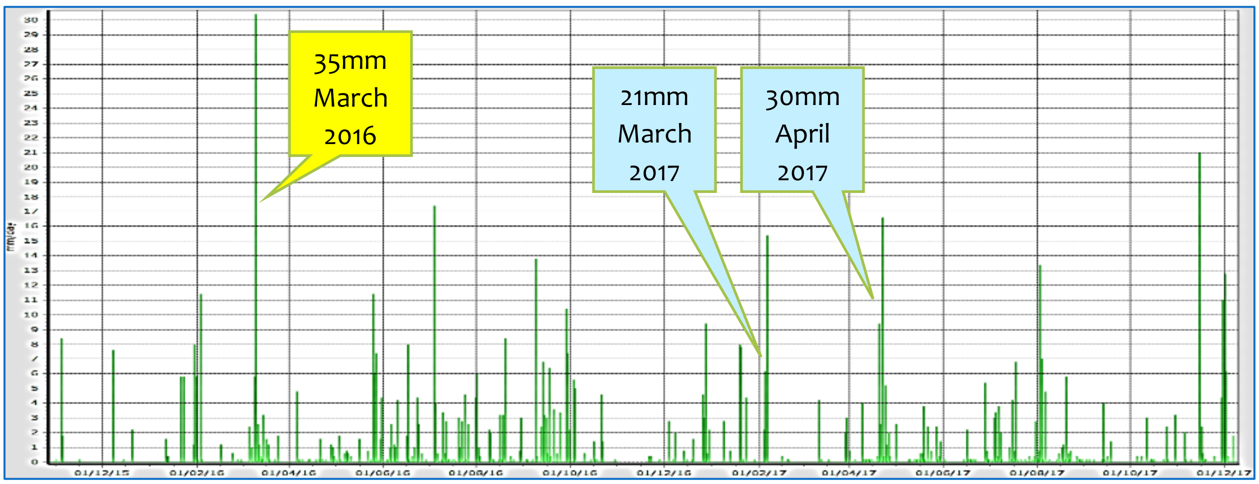
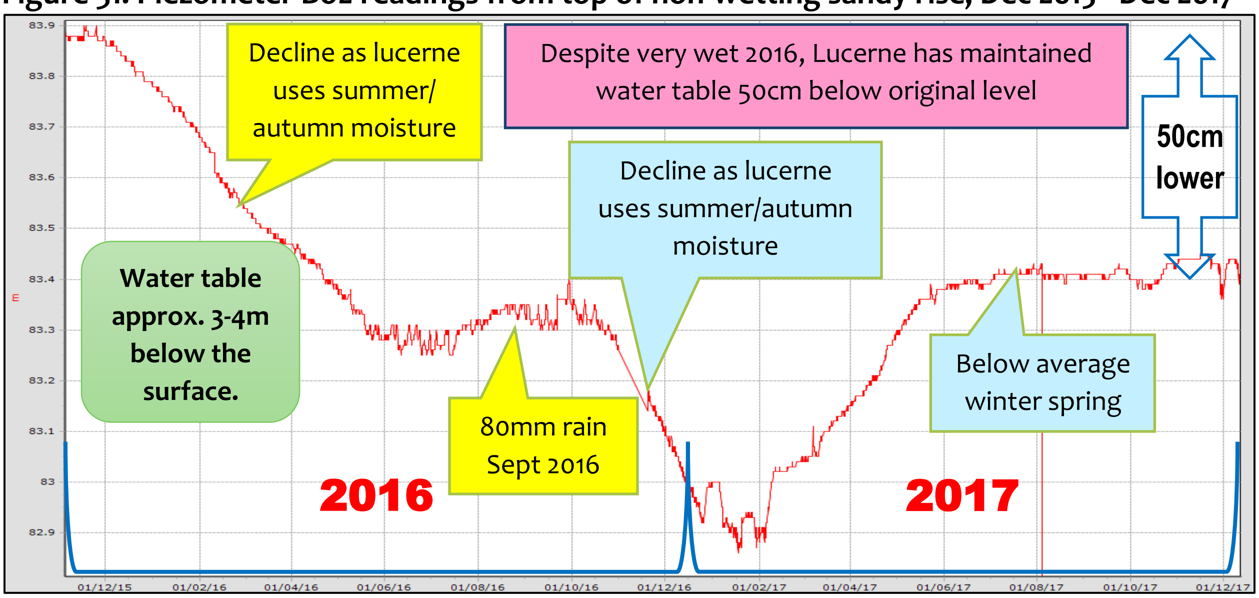


Figure 31. Piezometer B02 readings from top of non-wetting sandy rise, Dec 2015 - Dec 2017



Figures 29 & 31 shows the water table levels at both the lower end of the catchment B01, as well as the top of the non-wetting sandhill above, that is on the edge of the lucurne plantation. Figure 30 shows the paddock rainfall events in line with changes to ground water table levels.

The B01 piezometer is influences by the larger catchment, and so the extra water use of the lucerne growing area will only have a partial impact on this site. With the water table so close to the surface, it is shown to quickly rise with every rainfall event of about 10 mm, and even less when the soil profile is already wet. It reached its lowest point prior to the 35 mm rainfall event in March 2016, and since then has been maintained at least 40 cm above this over the last 21 months. It would appear the the well above average 2016 rainfall has lead to a slow but continual flow of catchment moisture toward this point. There is a large developing seep area just below the B01 piezometer (Photo 66), and areas like this (Photo 67) are expected to continue to grow unless more higher water use management strategies are applied at the site or in the upper catchment areas.

Photo 66. Main seep area showing developing seep below

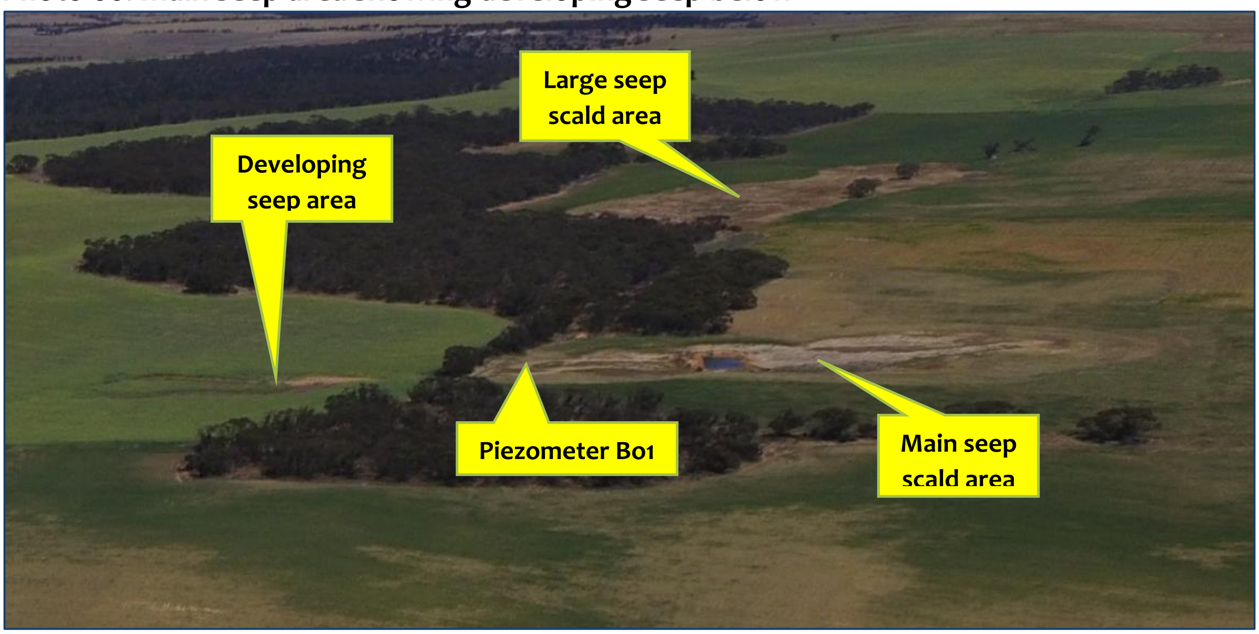


Photo 67. Growing seep area west of main seep

Photo 68. Piezometer B01 at the base of a the main scald and soak area, July 2017

Photo 69. Main seep area near Piezometer B01.

Photo 70. Main seep scald area

6.2 Using summer crops to soak up excess moisture

To help combat the issue of saturated scald areas rapidly developing at the base of sandhills, the Bonds took the opportunistic step of sowing millet into the specific cropping areas that were affected by waterlogging during the 2017 season, straight after the 25mm Nov 2017 rainfall event as shown in Photos 71-73. If successful this strategy will allow them to control the impact of these seep areas after wet years by utilizing the water where it appears, without any major impact on their normal farming system operations. They reported that they were still spray over the millet with glyphosate (for paddock summer weed control) and cause very little damage. While it is not treating the source of the problem it may prove to be a reasonable management solution, if it prevents land degradation without having disrupt paddock operations by planting trees or lucerne. It also serves the key purpose of maintaining soil cover over summer and minimizing salt accumulation at the surface.

The farmers are not sure whether they will try and reap the millet, cut it for hay or just let it mulch back into the soil and reseed for next season (Photos 74-75). It is understood that these summer crops may use up stored summer moisture that may impact on the 2018 crop in, it is possible that these seep areas may still receive extra seep moisture to counteract this. It will be interesting to monitor this in 2018. The Bonds are considering other potential summer crops for next season for these areas.

Photo 71. Area saturated during cropping season sown to millet after harvest

Photo 72. Saturated area in swale sown to millet

Photo 73. Soil moist where millet sown after late Nov rainfall

Photo 74. Millet in March 2018 after low rainfall summer

Photo 75. Millet in March 2018 after low rainfall summer

6.3 Site recommendations

The key message for this farm and those in similar situations is that unless startegic action is taken, the seep areas will continue to grow, become scalded, saline and unproductive.

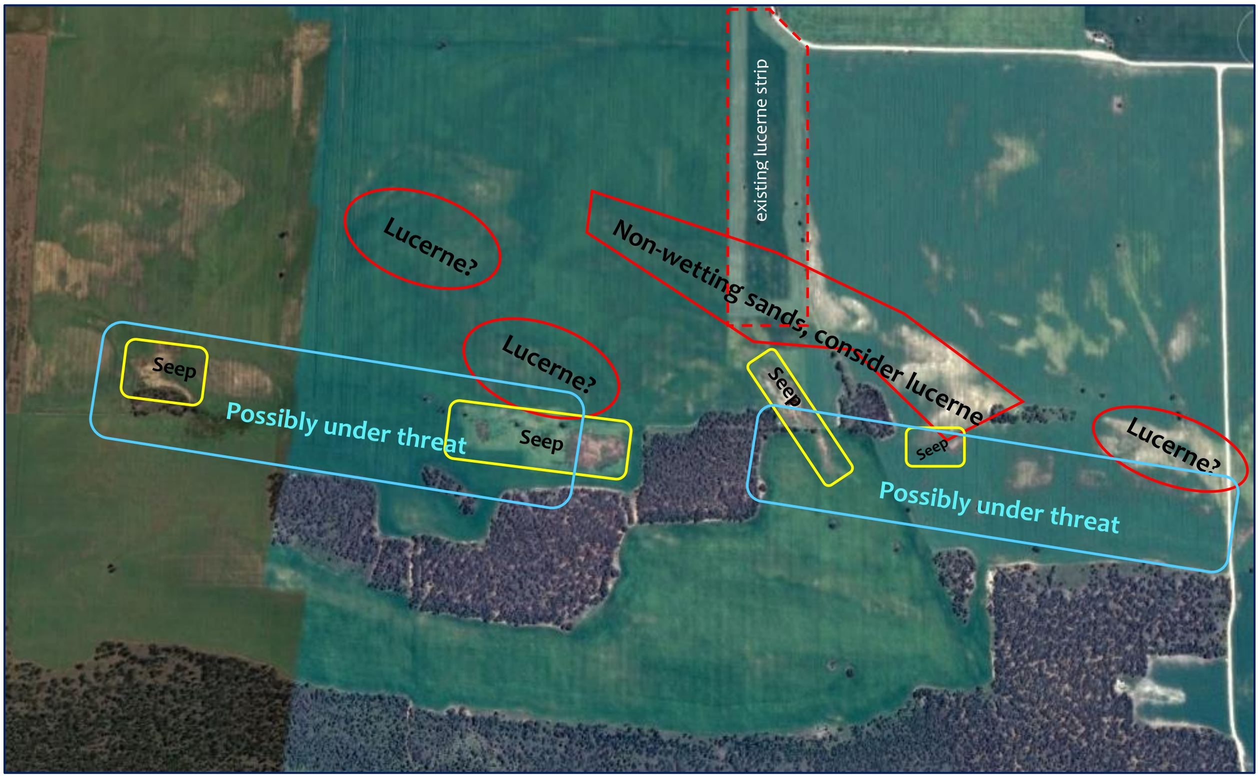
The SA Mallee will continue to experience very high rainfall periods such as 2016 and 2010/11, which contribute farm more moisture to than winter crops and pastures can reaqdily utilise, particularly when there is high rainfall in summer and early autumn. The accumulation of persistent high moisture in developing seep areas may be immediate, but can also many seasons to present. There are many hectares of productive farmland at risk, and need to be protected by things like deep rooted, perennial high water use options before it is too late.

This demonstration site has shown clear evidence that sowing lucerne can greatly increase the critical water use non-wetting sands which are consisitently associated with seep formation in this district. The advantages of lucerne is that it can be used to maintain production on these often high risk areas, through hay production or grazing. Once established, winter crops can still be established through them if desired, although they will cause some yield loss through competition. The farmers at this site would therefore sow their lucurne in the same direction as their crop sowing rather than just sow in the direction of the sandhills, to limit any damage to the established lucerne caused by cross sowing.

Figure 32 show a satellite image of the surrounding paddocks, identifying existing seep site and productive areas still under threat. It also shows non-wetting sands that are contributing recharge and could be planted to lucerne to help protect the productive farming land below. The challege is always to employ strategies that will have maximum effect, but cause the least disruption to the farmers intended paddock use. However, it is always inportant to weigh the costs of these potetnial changes against the risks of what could be lost in no action is taken. It is clear that the seep areas are growing, and are greatly increasing their imact on the paddocks involved. Figure 32 only represents one portion of this farm area that is currently under threat.

It is apparent from Figure 31 that lucerne has lowered the water table by 50 cm in an area that has most likley contributed a lateral flow of water towards the main seep area. If this lucerne area could be extended to more of the key recharge areas, then it is likely that it would sgnificantly lower the water table in the main seep area nad prevent the expansion of this seep in the areas below. The Bonds are encouraged to sow summer crops into any specific wet areas as soon as possible after harvest to stop these areas developing by utilising exess moisture and preventing summer evaporation concentrating salintiy at the surface.

Figure 32. Seep site showing possible lucerne strips and areas needing protection



7 References

Hall, J. (2016). Mallee Dune Seeps, Drilling and Well Installation Report, Pope Subcatchment, Juliet Creek Consulting Pty Ltd.