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Well Construction Report for Mallee Dune Seeps Project

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PREMIUM FOOD AND WINE FROM OUR CLEAN ENVIRONMENT

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Land Management Program

Natural Resources Management

SA Murray Darling Basin

Murray Bridge

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1 Introduction

Perched watertable induced seepage is a relatively widespread phenomena occurring in dune-swale landscapes where freshwater seepage / soaks discharge at the base of sandy rises. The occurrence of dune seeps is highly unpredictable and can appear in the landscape without any apparent cause.

Local shallow perched flow systems in aeolian sediments are the principal driver of induced seepages in dune-swale landscapes. Water draining from the aeolian soils has collected within and on top of lower permeability (confining) clay layer (such as Blanchetown Clay). A zone of saturation (perched watertable aquifer) then develops in sandy sediments above the clay layer.

Groundwater or watertable discharge results in waterlogged or salinized areas in the landscape. Saline groundwater discharge is referred to as dryland salinity. While perched watertable induced seepage is not termed as dryland salinity, the processes and mechanisms can be similar. The main difference is that dryland salinity is caused by rising groundwater tables due to clearance of native vegetation while perched watertable seepage is more of a waterlogging issue.

Groundwater discharge causing seepage typically occurs in low lying / depression areas which may be landlocked. Discharge can also occur as seeps on hillsides and at break-in-slopes of larger sand dunes. The expansion and contraction of seepage areas is a cyclical phenomenon exacerbated by summer rains, large out of season rainfall events and changing farming practices.

To date, there has been little information available regarding hydrological processes of dune-swale systems, or the soil layers below the 1.5 metres depth used for soil description. Electromagnetic Mapping (EM) is currently being tested to ascertain its effectiveness in identifying clay layers in the soil profile but is limited to the top couple of metres of the soil. Deep drilling of soil profiles to characterise soil and sediments to greater depths is essential in providing a greater understanding of the movement of water in dune-swale systems.

Funding has become available through the SAMDB NRM Board for the installation of watertable monitoring bores at two sites in the mallee region of SA. Study sites were selected based on interest expressed by the landholders and / or famers who are leasing properties where seepage is of concern.

Site investigations are provided from two farm sites in the SA mallee region:

- Rose-Thomas sub-catchment, Wynarka (Kulde)
- Bond site, Mannum

Drilling was carried out on the two properties between the 10th and 18th June, 2015. The drilling rig is owned by PIRSA and the operator was Simon Knowles. The rig is a truck mounted rotary auger rig.

Drilling logs and well construction details are provided for each site of drilling. The relative elevation of the sites was obtained from surveying.

Observation / monitoring wells were installed at three sites in the Rose-Thomas sub-catchment and two monitoring wells were installed at the Bond site. Casing was not installed in boreholes that did not make water at the time of drilling.

Water level and water quality data is provided from each of the monitoring wells with on-going monitoring being envisioned.

2 Site Investigations

2.1 Rose-Thomas Sub-catchment

The property on which this seepage occurs is located at Kulde which is 7km south west of the township of Wynarka (Figure 1). It is currently being leased by Peter Rose. Seepages also occur on an adjoining property leased by Andrew Thomas.

The seepage problem first appeared around 2005. Up until about 2008 this area grew good crops although tending to be boggy. By 2011 the area was too wet to drive on and gradually became bare and apparently saline. Currently the ground is bare and scalded with visible mineral salt crystals during summer and inundated with seepage water in winter.

The land was cleared between 1905 and 1920 so typical evidence of groundwater-driven salinity would be expected to have become apparent in the 1950s. However, this seep only become evident after 2005 which suggests that the seep is not caused by a rising saline groundwater table. Large out of season rainfall events and changing farming practices suggests that the seeps have occurred as a result of unused rainfall draining through the soil profile and accumulating on top of an impermeable soil layer.

Drilling was carried out and monitoring wells installed at three sites on 10th - 11th June 2015. Site drilling logs and well construction details are provided in this section.

Figure 1. Location of Rose-Thomas dune seep case study site

SITE DETAILS:

Field Site No: RO1 **Landholder**: Peter Rose

Site Location: Kulde

Site Description: Top of sandhill

Date Drilled: 10/06/15 **Logged By**: CJH

Driller: Simon Knowles **Drilling Method**: solid flight augers (125mm hole diam.)

PROFILE DESCRIPTION:

Depth (m)	Profile Name	Description
0.0 – 0.5	TOPSOIL	Pale grey-brown loamy sand
0.5 – 1.0	SAND	Pale grey loamy sand
1.0 – 1.5	SAND	Bleached white sand
1.5 – 5.0	CLAYEY SAND	Moist orange clayey sand
5.0 - 6.0	SANDY CLAY	Moist orange mottled light sandy clay
6.0 – 7.0	SANDY CLAY	Wet dark orange sandy clay with carbonate grit & pebbles
7.0 - 10.5	CLAY	Tight plastic clay with green (anoxic) & red (oxic) layers

COMPLETION DETAILS:

Casing: 50mm class PN18 PVC-U

Screen: Vertically slotted for 4.00m and covered with a geofabric filter sock

Gravel Pack: washed rubble / gravel to cover the screen (2.0m – 10.5m)

Bentonite Seal: Bentonite pellets poured down to form a watertight seal above the gravel pack to within 0.5m of the ground surface (0.5m – 2.0m).

Figure 2. View of piezometer tube at site RO1 with seepage zone in background

SITE DETAILS:

Field Site No: RO2 **Landholder**: Peter Rose

Site Location: Kulde

Site Description: Break-of-slope at base of sandhill

Date Drilled: 11/06/15 **Logged By**: CJH

Driller: Simon Knowles **Drilling Method**: solid flight augers (125mm hole diam.)

PROFILE DESCRIPTION:

Depth (m)	Profile Name	Description
0.0 – 0.5	TOPSOIL	Pale grey-brown loamy sand
0.5 – 1.0	SAND	Pale grey loamy sand
1.0 – 2.0	CLAYEY SAND	Moist orange clayey sand to sandy clay
2.0 – 3.0	SANDY CLAY	Damp orange sandy clay
3.0 – 3.5	CALCRETE	Carbonate grit & pebbles
3.5 – 4.5	SANDY CLAY	Wet orange-brown gravelly sandy clay
4.5 – 6.0	CLAY	Tight plastic clay with grey & red-brown layers

COMPLETION DETAILS:

Casing: 50mm class PN18 PVC-U

Screen: Vertically slotted for 2.00m and covered with a geofabric filter sock

Gravel Pack: washed rubble / gravel to cover the screen (3.0m – 6.0m)

Bentonite Seal: Bentonite pellets poured down to form a watertight seal above the gravel pack (2.0m – 3.0m). Backfill with drilling spoil to the ground surface.

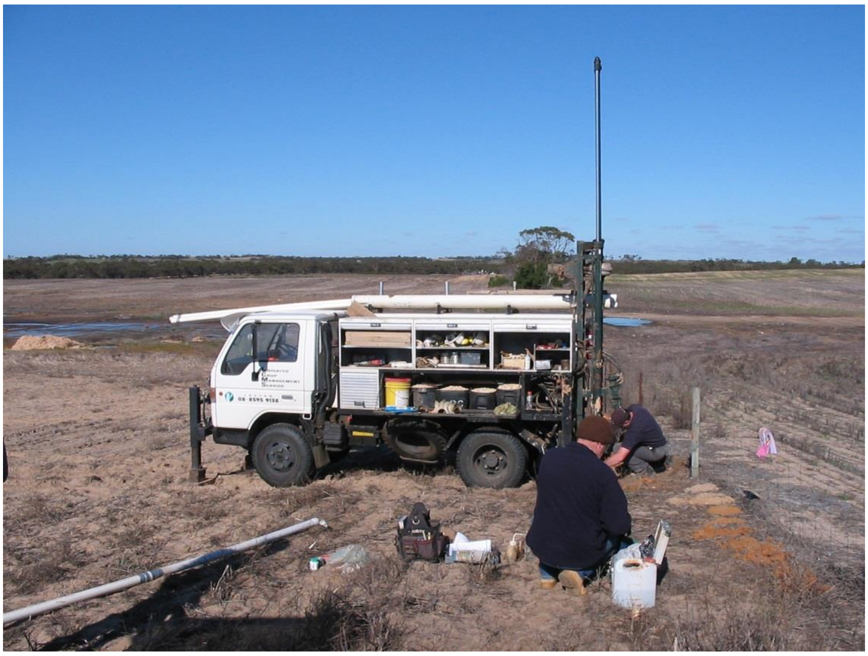

Figure 3. Describing samples at drill-site RO2 - base of sandhill

SITE DETAILS:

Field Site No: RO3 **Landholder**: Peter Rose

Site Location: Kulde

Site Description: Edge of soak

Date Drilled: 11/06/15 **Logged By**: CJH

Driller: Simon Knowles **Drilling Method**: solid flight augers (125mm hole diam.)

PROFILE DESCRIPTION:

Depth (m)	Profile Name	Description
0.0 – 0.5	TOPSOIL	Dark grey wet sandy loam with calcrete stones
0.5 – 1.5	CALCRETE	Calcrete stones, grit and marl
1.5 – 2.5	SANDY CLAY	Wet brown mottled gritty sandy clay
2.5 – 3.0	CLAY	Tight plastic clay with mottled greenish & blue-grey layers

COMPLETION DETAILS:

Casing: 50mm class PN18 PVC-U

Screen: Vertically slotted for 2.00m and covered with a geofabric filter sock

Gravel Pack: washed rubble / gravel to cover the screen (1.0m – 3.0m)

Bentonite Seal: Bentonite pellets poured down to form a watertight seal above the gravel pack to within 0.5m of the ground surface (0.5m – 1.0m).

Figure 4. Drilling on edge of soak at site RO3

SITE DETAILS:

Field Site No: RO4 **Landholder**: Peter Rose

Site Location: Kulde

Site Description: Top of sandhill on southern side of seepage zone

Date Drilled: 11/06/15 **Logged By**: CJH

Driller: Simon Knowles **Drilling Method**: solid flight augers (125mm hole diam.)

PROFILE DESCRIPTION:

Depth (m)	Profile Name	Description
0.0 – 0.5	TOPSOIL	Yellow loamy sand
0.5 – 1.0	SAND	Yellow sandy loam
1.0 – 1.5	SAND	Bleached white sand
1.5 – 2.5	CLAYEY SAND	Pale yellow clayey sand
2.5 - 3.0	CALCRETE	Rounded carbonate pebbles
3.0 – 4.0	CLAYEY SAND	Moist orange-brown clayey sand
4.0 – 5.0	SANDY CLAY	Moist red-brown sandy clay
5.0 – 6.0	CLAY	Tight plastic clay with blue-grey (anoxic) & red (oxic) layers

COMPLETION DETAILS:

The borehole did not make any water at the time of drilling, so no casing was installed. Figure 5 shows the open borehole which is covered with a large stone.

Figure 5. Site RO4 on southern sandhill

2.2 Bond Site

This property is located to the east of Mannum and is bounded by Cross Road and Burdett Road (Figure 6). The seepage areas first appeared around 2005 and by 2010-11, the main seep area was unable to be sown with crops due to the wet and boggy soil. The bare soil shows signs of crusting and white efflorescence (mineral salt accumulation). There is currently around 4 hectares of land affected.

From a geomorphic point of view, this site is somewhat atypical of the mallee as the landscape is transitional from the Mount Lofty Ranges to the Murray Basin. Some of the largest hills may represent basement highs. The prominent valley in which the seeps occur may be part of a remnant palaeochannel.

A deeper groundwater system occurs in this area as indicated by old abandoned wells dug to 55m but having groundwater that is too saline for use. The deeper underlying saline groundwater system is therefore unlikely to be connected to the shallow perched watertable which is solely responsible for causing the dune seepage.

Drilling was carried out and monitoring wells installed at three sites on 17th - 18th June 2015. Site drilling logs and well construction details are provided in this section.

Figure 6. Location of Bonds dune seep case study site

SITE DETAILS:

Field Site No: BO1 **Landholder**: Geoff and Kevin Bond

Site Location: Mannum

Site Description: Below seepage area and excavated pond on old fenceline

Date Drilled: 17/06/15 **Logged By**: CJH

Driller: Simon Knowles **Drilling Method**: solid flight augers (125mm hole diam.)

PROFILE DESCRIPTION:

Depth (m)	Profile Name	Description
0.0 – 0.5	TOPSOIL	Yellow-brown loamy sand
0.5 – 1.0	SANDY LOAM	Orange moist sandy loam
1.0 – 1.5	CLAYEY SAND	Orange-brown damp clayey sand
1.5 – 2.5	CLAY	Damp mottled orange soft silty clay
2.5 - 3.0	CLAY	Wet orange silty clay
3.0 – 3.5	CLAY	Tight plastic mottled greenish-grey clay
3.5 – 6.0	SANDY CLAY	Red-brown sandy clay with carbonate pebbles
6.0 – 7.0	SANDY CLAY	Orange-brown moist sandy clay
7.0 – 11.0	CLAYEY SAND	Orange to yellow-brown moist clayey sand

The deep borehole was left un-cased and another borehole was drilled to 3m depth a few metres to the south and cased:

Casing: 50mm class PN18 PVC-U

Screen: Vertically slotted for 2.00m and covered with a geofabric filter sock

Gravel Pack: Blue metal gravel to cover the screen (0.45m – 3.0m)

Bentonite Seal: Bentonite granules poured down to form a watertight seal above the gravel pack to within 0.20m of the ground surface (0.2m – 0.45m).

Figure 7. Site BO1 at Bonds with seepage inundating soil pit (August 2015)

SITE DETAILS:

Field Site No: BO2 **Landholder**: Geoff and Kevin Bond

Site Location: Mannum

Site Description: Crest of first sandhill above seepage area

Date Drilled: 18/06/15 **Logged By**: CJH

Driller: Simon Knowles **Drilling Method**: solid flight augers (125mm hole diam.)

PROFILE DESCRIPTION:

Depth (m)	Profile Name	Description
0.0 – 0.5	TOPSOIL	Yellow-brown loamy sand
0.5 – 2.0	SANDY LOAM	Yellow moist sandy loam
2.0 – 2.5	CALCRETE	Carbonate layer
2.5 – 3.5	CLAYEY SAND	Moist yellow-brown clayey sand
3.5 - 4.5	CLAYEY SAND	Damp orange clayey sand
4.5 – 5.0	CALCRETE	Hard carbonate layer
5.0 – 6.0	CLAYEY SAND	Wet gritty limey clayey sand
6.0 – 7.0	CLAY	Tight plastic mottled greenish-grey sandy clay

COMPLETION DETAILS:

Casing: 50mm class PN18 PVC-U

Screen: Vertically slotted for 2.00m and covered with a geofabric filter sock

Gravel Pack: Blue metal gravel to cover the screen (1.5m – 7.0m)

Bentonite Seal: Bentonite granules poured down to form a watertight seal above the gravel pack to within 0.50m of the ground surface (0.50m – 1.50m).

Figure 8. Drilling and taking samples on first sandhill above the seepage at Bonds

SITE DETAILS:

Field Site No: BO3 **Landholder**: Geoff and Kevin Bond

Site Location: Mannum

Site Description: Haby-Hutt Road adjacent to soil moisture probe

Date Drilled: 18/06/15 **Logged By**: CJH

Driller: Simon Knowles **Drilling Method**: solid flight augers (125mm hole diam.)

PROFILE DESCRIPTION:

Depth (m)	Profile Name	Description
0.0 – 0.5	TOPSOIL	Yellow-brown loamy sand
0.5 – 1.0	SANDY LOAM	Yellow-brown sandy loam
1.0 – 2.0	SANDY LOAM	Yellow-brown fine sandy loam
2.0 – 4.0	SANDY LOAM	Brown sandy clay loam with carbonate pebbles
4.0 - 5.0	CALCRETE	Carbonate layer
5.0 – 6.0	CLAYEY SAND	Carbonate layers and moist clayey sand
6.0 – 8.0	SANDY CLAY	Orange-brown moist silty sandy clay
8.0 – 10.0	CLAY	Orange-brown moist stiff silty clay

COMPLETION DETAILS:

The borehole did not make any water, so no casing was installed.

Figure 9. Site BO3 on highest sandhill above the seepage at Bonds

3 Monitoring Well Installation Details

Data is tabulated for each site for GPS coordinates and well construction details

Table 1. GPS Coordinates

Site	Easting	Northing	Elevation (m AHD)
RO1	0378311	6109333	93.83
RO2	0378322	6109300	89.47
RO3	0378417	6109152	85.47
RO4	0378323	6109036	89.95
BO1	0354640	6130635	76.00
BO2	0354423	6131014	87.40
BO3			

***Easting and Northing are in the GDA94 coordinate system; zone = 54H**

NOTE: Elevations are not tied into a specific AHD datum but are relative to one another with an estimated AHD taken from Google Earth.

Table 2. Well Specifications

Site	Total Depth (m TOC)	Riser (m agl)	Depth (m bgl)	Screen Interval (m)
RO1	11.57	0.72	10.85	6.85 – 10.85
RO2	6.97	0.90	6.07	4.07 – 6.07
RO3	3.63	0.75	2.88	0.88 – 2.88
RO4	No well			
BO1	3.28	0.75	2.53	0.53 – 2.53
BO2	7.52	0.80	6.72	4.72 – 6.72
BO3	No well			

bgl= Depth of tube below ground level
agl = Height of tube above ground level
TOC= Top of casing

4 WATER LEVELS AND QUALITY

Table 3. Groundwater Levels for date 13/08/2015

Site	DTW (m toc)	SWL (m bgl)
RO1	6.92	6.20
RO2	3.03	2.13
RO3	0.71	-0.04
BO1	1.00	0.25
BO2	4.45	3.65

DTW = Depth to water from reference point (TOC = Top of PVC casing)
SWL = Standing water level below ground level (GL = ground level)

Table 4. Field Parameters, Water Quality for date 13/08/2015

Site	Temp (°C)	pH	Redox Potential (mV)	EC (µS/cm)	TDS (mg/L)
RO1		8.06	115	9250	
RO2		8.17	107	3910	
RO3		7.89	118	10440	
BO1		7.97	110	5150	
BO2		8.33	95	3110	

EC=Electrical conductivity in microSiemens per cm (µS/cm)
TDS=Total Dissolved Solids (calculated using a factor)

5 SUMMARY OF INVESTIGATIONS

These preliminary investigations of dune seepage in the mallee confirm that local shallow perched flow systems in aeolian sediments are the principal driver of induced seepages in dune-swale landscapes.

The occurrence of Blanchetown Clay or its equivalent in the landscape appears to be a pre-requisite for the formation of perched watertable discharge and this was confirmed from the drilling carried out at the two sites in the mallee. Tight stiff clays with a high plasticity were encountered at various depths beneath sand dunes and sufficiently impermeable to allow a perched watertable to form.

The deeper very tight clay layer has been determined to be Blanchetown Clay (subject to confirmation – James Hall pers. comm.). Drilling on sandy slopes at the two sites revealed a saturated layer in sandy materials at around 4 - 6m depth just above the impermeable Blanchetown Clay.

On the lower slopes and depressions the Blanchetown Clay comes much closer to the ground surface and seepages and waterlogged areas are induced as the clay comes to within 2.5 - 3m of the soil surface.

Rose-Thomas Sub-catchment

The results of drilling at four sites indicated that a perched watertable had developed above the Blanchetown Clay layer at three of the sites drilled. At the crest of the northern sand dune, the watertable is 6m below the surface with the impermeable clay layer at 7m depth. This gives a saturated thickness of around 1m.

At the base of the sandhill, the watertable is a little over 2m from the surface with the tight clay layer at 4.5m depth giving a saturated thickness of 2.5m. The watertable is at the surface in the seep with the tight clay occurring at 2.5m depth.

No watertable was encountered below the southern dune (site RO4), although moist sandy sediments were encountered at depths of 3 – 5m. In August 2015, some water was found to be occurring in the open borehole (covered with a rock) and the EC tested at 2040 µS/cm suggesting a temporary perched watertable may develop a this site at the end of winter. Further drilling is recommended in this sub-catchment to gain a better understanding of the geometry (spatial extent) of the perched system.

Figure 10 provides a hydrogeological cross-section of dune-swale system in the Rose-Thomas sub-catchment.

The salinity (electrical conductivity) of the watertable ranged from 3900 µS/cm (base of sandhill) to 10,400 µS/cm (within the seep area). Site 1 at the crest of the sandhill had an unusually high EC of 9200 µS/cm and may be caused by dissolution of extensive carbonate layers that were found to occur in this profile.

Water ponding in the seepage area at the Rose site had an EC of 16,100 µS/cm in June 2015. In August 2015, the seepage area was much more active following late winter rainfall and was filling up a series of depressions along the swale (Figure 2). Seepage in an upslope depression had an EC of 11,600 µS/cm while seepage in a downslope depression had an EC of 6500 µS/cm. Soak water would be expected to concentrate significantly as the weather warms and evaporation increases.

The brackish nature of the watertable indicates that it is picking up stored salts from the soil profile. The nature of the salts has not been determined but may be caused by dissolution of carbonate layers at depth. It is also likely that sodium chloride salts are stored in the Blanchetown Clay.

The pH of the watertable was slightly alkaline (around 8.0) indicating carbonate dissolution. Seepage water sampled in the soak was somewhat more alkaline ranging from 9.1 to 9.6. The oxidation-reduction potential (ORP) of the watertable is just over +100 mV indicating that the watertable is in an oxidising state.

Installation of automatic water level datalogger probes will help to determine the nature and frequency of rainfall events that cause recharge to the perched watertable. This data can be correlated with the soil moisture monitoring that is occurring on-site in the near vicinity of the piezometers.

Bond Site

At the Bond site, it was speculated prior to drilling that there may be multiple flow paths discharging to the main central valley. Over a period of time the cores of sand dunes can become saturated and provide a store of water for continuing discharge to seepage areas. There may be short flow paths (fresh water) from adjacent sand ridges and longer flow paths through the cores of the dunes originating from topographic highs.

Examination of mineral exploration profiles from Iluka Resources indicates a monotonous profile of sands and clays (Loxton-Parilla Sand) down to a depth of 80m where the regional groundwater system is intersected in marine limestones. There is little evidence of perched watertable development in the Loxton-Parilla Sand sequence; hence perched watertables are likely to only develop above the Blanchetown Clay layer.

The results of drilling at three sites showed a perched watertable had developed above the Blanchetown Clay layer at two sites lower in the landscape. At the crest of the first sand dune from the seep, the watertable is 3.6m below the surface with the impermeable clay layer at 6 to 7m depth. This gives a saturated thickness of almost 3m.

Within the seep area, the watertable is close to the surface with a thin band of tight Blanchetown Clay occurring from 3.0 – 3.5m depth.

No watertable was encountered below the highest dune in the landscape (site BO3), although moist sediments were encountered at various depths down to 10m. Further drilling is recommended to gain a better understanding of the geometry (spatial extent) of the perched system.

Figure 11 shows a hydrogeological cross-section of dune-swale system at the Bond site.

The salinity of the watertable ranged from 3110 µS/cm (first sandhill) to 5150 µS/cm (downslope of seep).

Water ponding in the excavated soak at the Bond site had an EC of 8180 µS/cm in June 2015 and an EC of 6980 µS/cm in August 2015. In August the seepage area was much more active following late winter rainfall. The excavated soil pit at site BO1 had filled with water (see Figure 7) with an EC of 6760 µS/cm.

The pH of the watertable was slightly alkaline (around 8.0) indicating carbonate dissolution. Seepage water sampled in the excavated soak was somewhat more alkaline (around 9.0). The oxidation-reduction potential (ORP) of the watertable is around +100 mV indicating that the watertable is in an oxidising state.

Recommendations

We have now gained a much better understanding of the processes occurring in perched watertable induced freshwater seepage in dune-swale landscapes. Further investigations are considered necessary to better target potential management strategies and include:

- Further drilling to gain a better understanding of the geometry (spatial extent) of the perched system within dune-swale ‘sub-catchments’
- Deeper penetrating remote sensing techniques to map the occurrence of the highly impermeable Blanchetown Clay layer
- Geochemical and XRD analysis of water and soils to determine the type of salts present
- Use of scenario modelling packages to carry out waterbalance studies for targeting suitable high water use treatments.

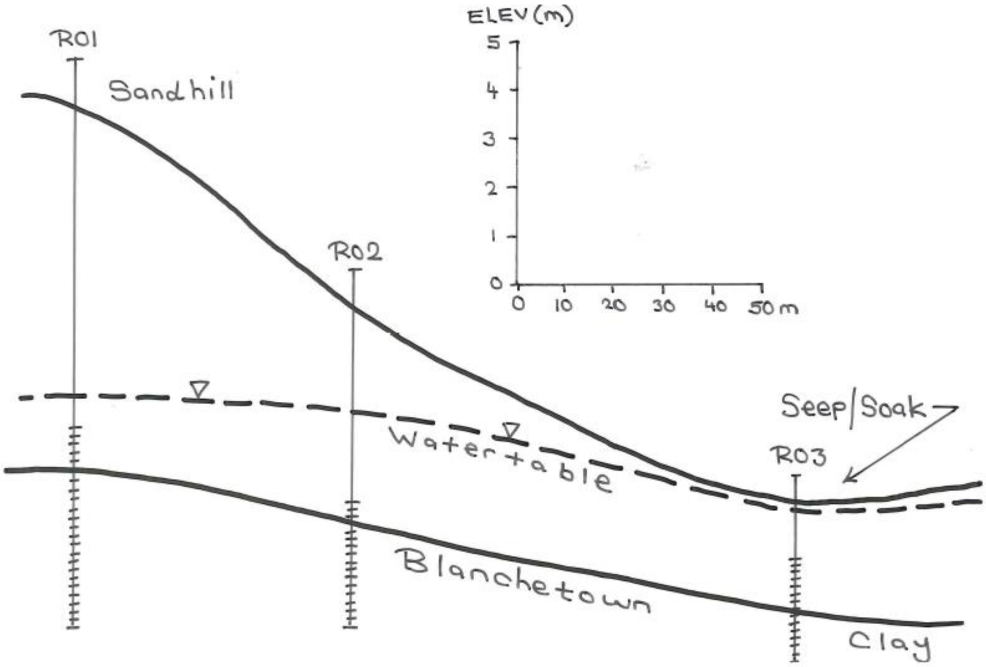

Figure 10. Hydrogeological cross-section of dune-swale system in the Rose-Thomas sub-catchment

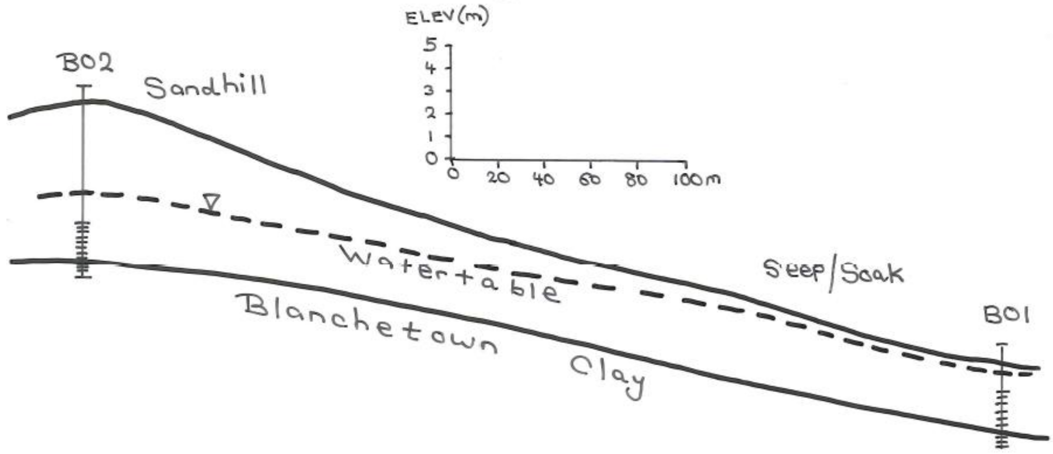

Figure 11. Hydrogeological cross-section of dune-swale system at Bonds seepage site

6 RELATED DOCUMENTS

Hall J (2015a) Dune discharge seepage areas in South Australia- what are they, have they changed over time & can we better manage them for improved productivity? In: 2015 Adelaide GRDC Grains Research Update pp. 93-100.

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