Case Study to trial different management treatments to mitigate tunnel erosion

South Gippsland 2017

Australian Government

National Landcare Program

Demonstrating Sustainable Farm Practices

Mornington Peninsula

South Gippsland Landcare Network

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1.1 Background

The 80-hectare farm used in the demonstration was situated on the slopes between the townships of Poowong and Loch in South Gippsland. It is a mixed beef & lamb farming operation, with some green fodder production (Sorghum).

The property has been owned and managed by Jonathan Koolstra for the last five years, and before that his father for four years. Jonathan has a young family and also manages a second property at Yannathan. Between 2014 and 2016 Jonathan took part in a demonstration trial through the Demonstrating Sustainable Farming Practices Project. A Landholder Partnership Agreement was signed by Jonathan in June 2014 and work on the erosion sites was undertaken until May 2015.

The property is located within the Strzelecki (S) soil mapping unit. The soils on the property are described as high magnesium soils (Chris Alenson pers. com) and the hillsides are generally steep. The surface soils are dark greyish-brown or brown clay loams with moderate organic matter. They have a moderate soil acidity pH of 5.9 and are moderately fertile. The major land use is grazing of either beef or dairy cattle.

The soils are low in Phosphorus, Sulphur, Molybdenum and Copper. Several factors contribute to the inherent soil instability. The steep nature of the Strzelecki region, the high annual rainfall average of 1000+mm, along with the underlying geology of mudstone or siltstone, makes the slopes susceptible to land slippage and other types of erosion on slopes with only shallow rooted perennial grass cover. The movement of subsurface groundwater and the presence of natural springs along with surface runoff from roads, tracks and laneways influence on where mass soil movement occurs. The area also experiences irregular, if minor, seismic activity.

1.2 Rationale for trial of demonstration sites

Jonathan has six tunnel erosion sites on his property at Loch. Five of the six sites can be accessed from Frys Lane approximately 2.5kms west of Poowong, whereas Site 1 is located on the lower section of the property and is accessed from the Loch/Poowong Road (refer to Map 1).

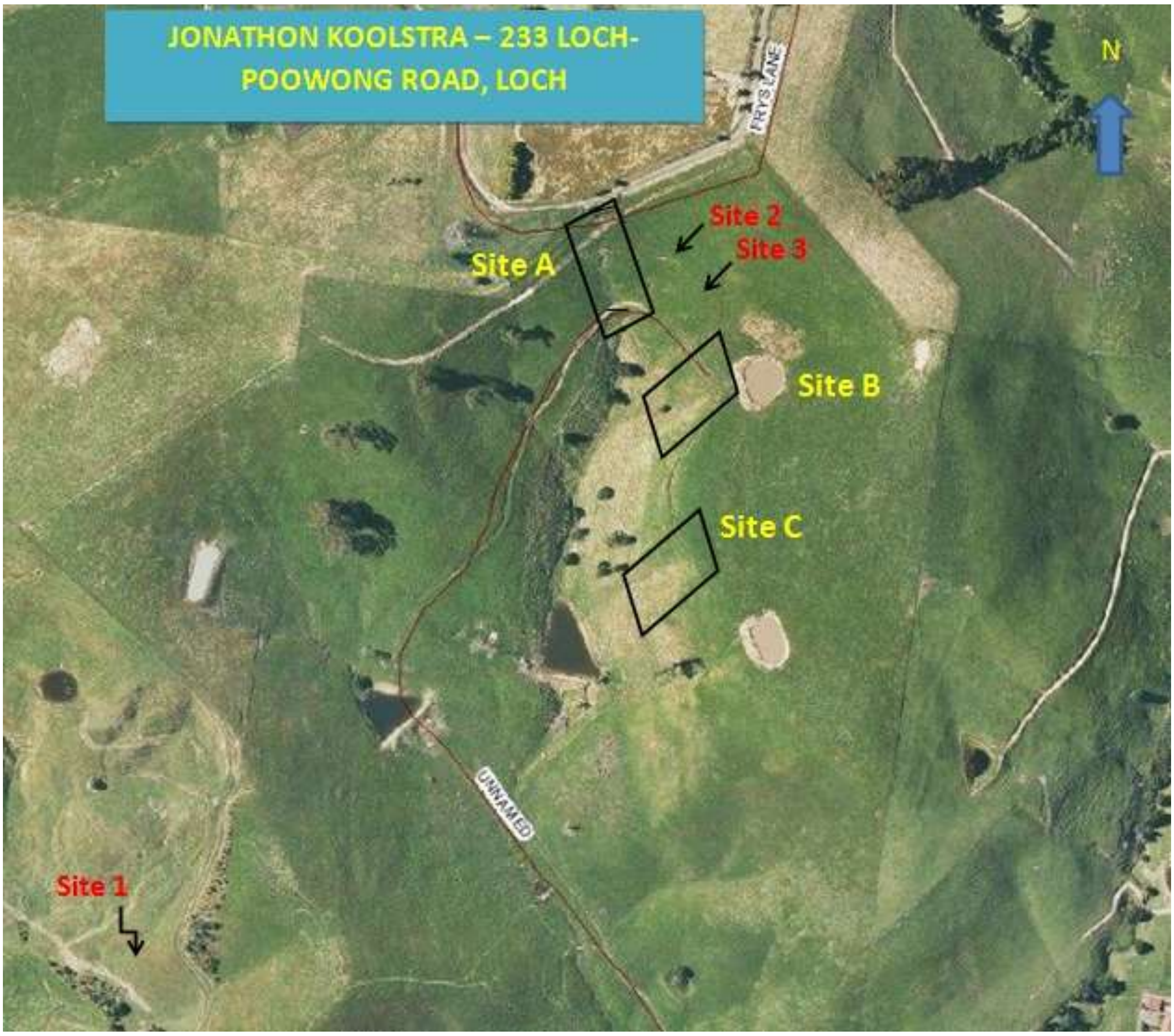
Sites A, B and C

Jonathan proposed a trial of several different remediation methods. The three shorter gullies (A, B and C) were fenced and two of these (Sites A and C) were revegetated with a mixture of trees and shrubs. Site B was fenced but not revegetated and was used as a control site to see if pasture grasses would stabilise the tunnel as effectively as other deep-rooted vegetation. The major gully (Site A) was lined with 2 x 15m rolls of erosion matting (geotextile fabric) and then filled with 65 of cubic metres of bluestone to slow down water flow from the adjacent farm access track and help to stabilise the edges of the gully until plant roots could take hold.

Sites 1, 2 and 3

The three other tunnels (Sites 1, 2 and 3) were managed quite differently (refer to Section 1.5). Site 1 is located on a lower section of the property, whereas sites 2 and 3 are located in the same paddock as the fenced tunnels. All three sites were in areas previously used for grazing. Jonathan was keen to rehabilitate these sites and return them to production if possible.

Map 1: Tunnel Erosion Sites



1.3 Giant Gippsland Earthworm survey

A survey for Giant Gippsland Earthworm (GGE), which is listed under the Flora and Fauna Guarantee Act 1988 and Environmental Protection and Biodiversity Conservation Act 1999, was carried out in July 2014 by INVERT-ECO prior to excavation and fencing work. GGE have previously been recorded in other parts of this property and within 200m south of Site 1 (Van Praagh pers.obs. 2009). The property is within the distribution range for this species and the south-facing slopes, along with suitable clay soils, represent potential habitat.

Evidence of GGEs were recorded below the track at the foot of the south to south-west slope leading to the vegetated gully at Site 3 (worm and burrows). While no evidence of GGEs was located below the track at Site 2, suitable clays were identified. No evidence of GGEs were located above the track or at Sites 2 & 3, and the soils did not appear to be as suitable as those below the track (refer to Map 2). It is likely that this colony extended into the gully that has been revegetated (Van Praagh, 2014). It was recommended that no excavation work was carried out in this area to protect GGE colonies. No evidence of GGE were detected at Site 1, however there was evidence of GGE in a landslip area 20 metres west of the site (refer to Map 3).

Map 2: Giant Gippsland Earthworm Habitat below Site 2 and 3

Map 3: GGE colony location to the west of Site 1

1.4 Demonstration site establishment

The demonstration trial establishment design was as follows;

Site A: Clean out side drain on laneway above to divert water (surface runoff) to a culvert located 80 metres away to redirect surface water. Use stones at the base of the culvert to intercept and disperse water. Line the gully with erosion matting and several round bales on upper slope to trap sediment, then fence and revegetate. This is the major gully on the property which has developed from what was originally a tunnel and has since collapsed.

Site B: This is a minor tunnel/gully located below the internal farm access track that was fenced and left to grass over without any further intervention.

Site C: This is another more minor tunnel/gully also located below the internal farm access track that was fenced revegetated with shrubs and ground covers.

Each of these tunnel erosion sites were monitored on an annual basis (see Section 2.1 for results).

Site 1: Excavate to top of tunnel with machinery to identify entry point for sub-surface water, backfill with existing soil, smooth down and sow with perennial ryegrass & fertilise. This tunnel is located at the lower section of the property and is on a south facing slope.

Site 2: Rip tunnels, backfill with existing soil, treat with lime to correct acidity (pre- and post- soil tests to determine), cultivate and sow with ryegrass.

Site 3: Rip tunnel and backfill, smooth and treat with gypsum, sow down ryegrass to stabilise. Sites 2 and 3 are in the same paddock and can be compared. Erect temporary fences on all three sites until grass has established. Although this was recommended in the experimental design, Jonathan elected not to do this and laid down hay instead.

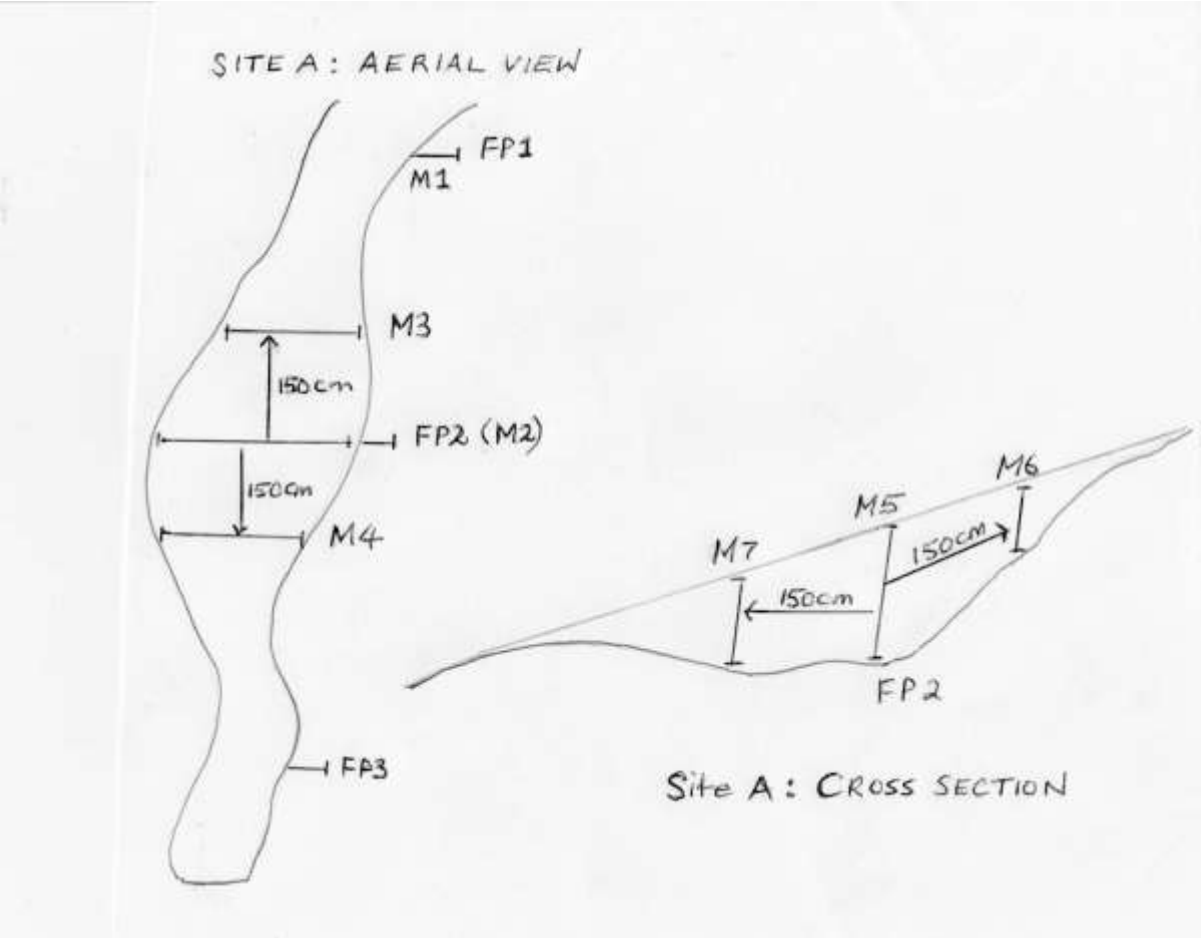
2.1 Tunnel erosion measurements and interpretation

Sites A, B and C were monitored for erosion activity as per the Tunnel Erosion Monitoring Plan developed for the property. Four sets of data were collected on-site during the term of the trial. Unfortunately, the benchmark data from Year One of the project, collected in August 2014, could not be located, and therefore only three datasets (February 2016, December 2016 and January 2018) can be examined. The earliest measurements we can use as a benchmark date are from February 2016, which was a nearly a year after management intervention occurred.

2.2 Description of Measurement Points (Refer to Diagram 1)

- Measurement 1 - Distance and bearing from fixed reference point to the gully edge
- Measurements 2 - Gully width at its widest point
- Measurement 3 - Gully width 150cm above widest point
- Measurement 4 - Gully width 150cm Below widest point
- Measurement 5 - Gully depth at its deepest point
- Measurement 6 - Gully depth 150cm above deepest point
- Measurement 7 - Gully depth 150cm below deepest point

Diagram 1 - Tunnel Erosion Measurement Points



Legend: FP = Fixed point
M = measurement

Site A, Fixed Point 1: This was located towards the top end of the gully. This is the longest of the three gullies and was fenced. The base was lined with rock and revegetated with trees and shrubs. There appears to be a decreasing trend for gully width at this point between February 2016 and January 2017 for the first four measurements. Gully depth at deepest point showed an increase for 100cm to 150cm, however gully depth 1.5m above and below the deepest point showed a decrease between February 2016 and January 2018.

Table 1 – Tunnel Erosion Measurements for Site A – Fixed Point 1

Measurements (cms)	FP1 - 2/2/16	FP1 -1/12/16	FP1 -18/1/18
M1	47	30	25
M2	200	195	220
M3	190	196	180
M3	180	184	180
M5	100	130	150
M6	170	190	80
M7	180	160	nr

Diagram 2 Site A - Fixed Point 1 – Measurements 1-7

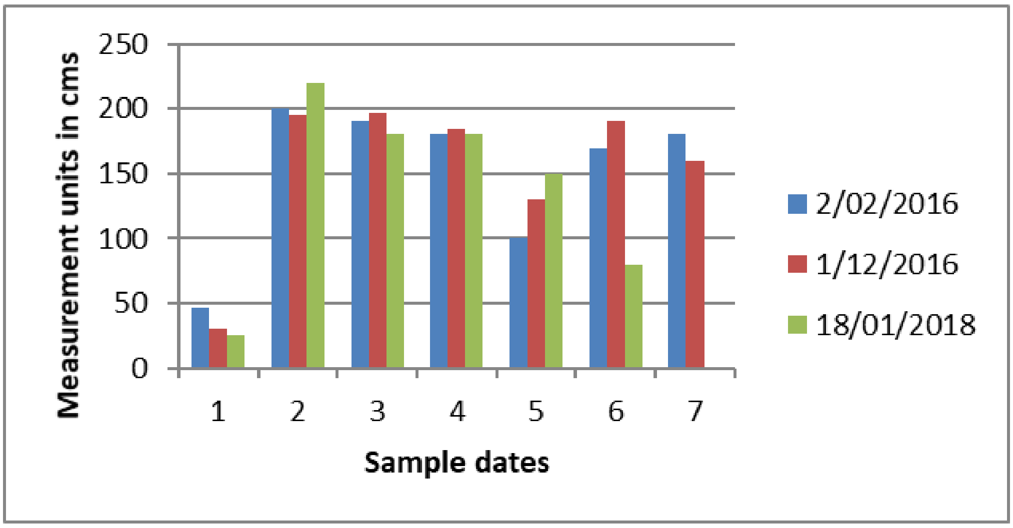


Photo 1 - Site A: August 2015: Top of gully looking upslope (Fixed Point 1)

Site A, Fixed Point 2: This was located approximately half way down the gully. There didn't appear to be much variation for measurements 1 and 2, however there was significant variation for measurements 3 and 4. Overall measurements decreased between February 2016 and January 2018 which would appear to indicate that gully depth and width was decreasing at this point.

Table 2 Tunnel Erosion Measurements for Site A – Fixed Point 2

Measurements (cms)	FP2 -2/2/16	FP2 - 1/12/16	FP2 - 18/1/18
M1	30	35	65
M2	470	380	420
M3	470	110	190
M4	520	100	390
M5	190	78	85
M6	220	93	80
M7	410	74	35

Diagram 4 Site A - Fixed Point 2 – Measurements 1 -7

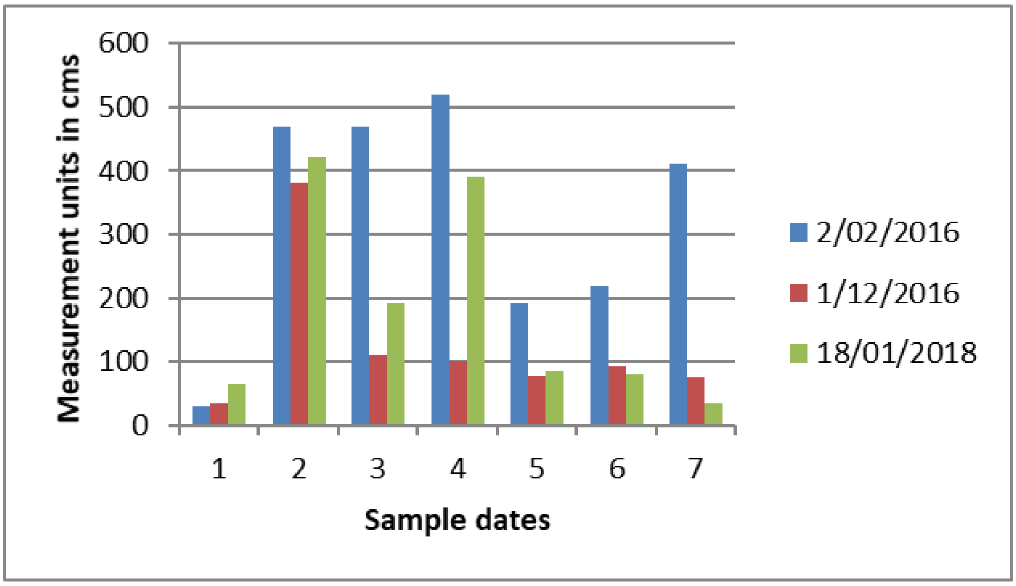


Photo 2- Site A: May 2014 - Top of tunnel looking downslope

Photo 3 - Site A: January 2018: Post fencing, rock stabilisation and revegetation

Site A, Fixed Point 3: This was located towards the end of the gully about three quarters of the way down the slope. The data appears to show some minor increase in both tunnel width and depth at this point with the exception of measurement 5 which was measured initially at 700cm in Feb 2016 but decreased markedly for the next two measurement dates.

Table 3 Tunnel Erosion Measurements for Site A – Fixed Point 3

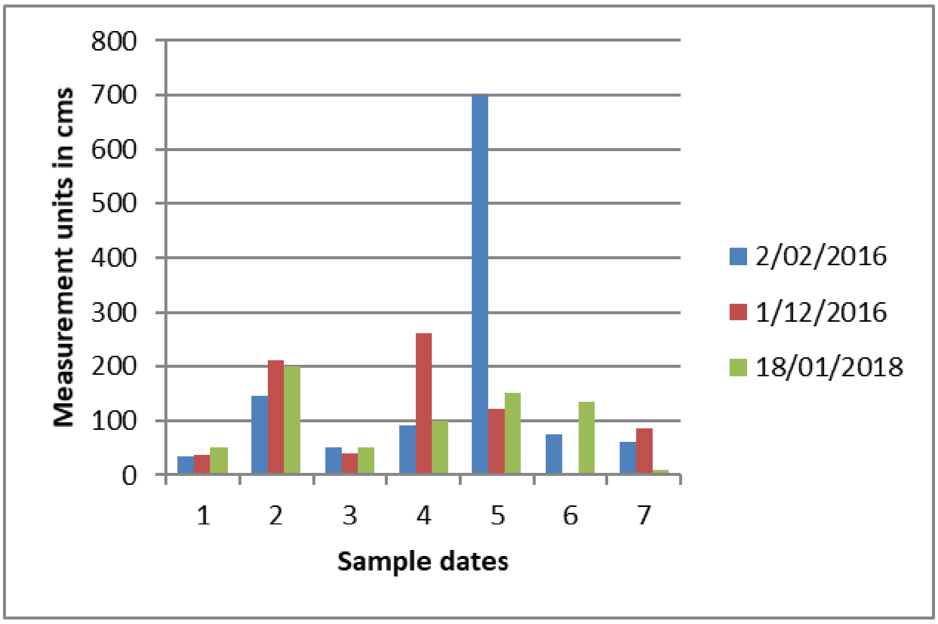


Diagram 5 Site A - Fixed Point 3 – Measurements 1-7

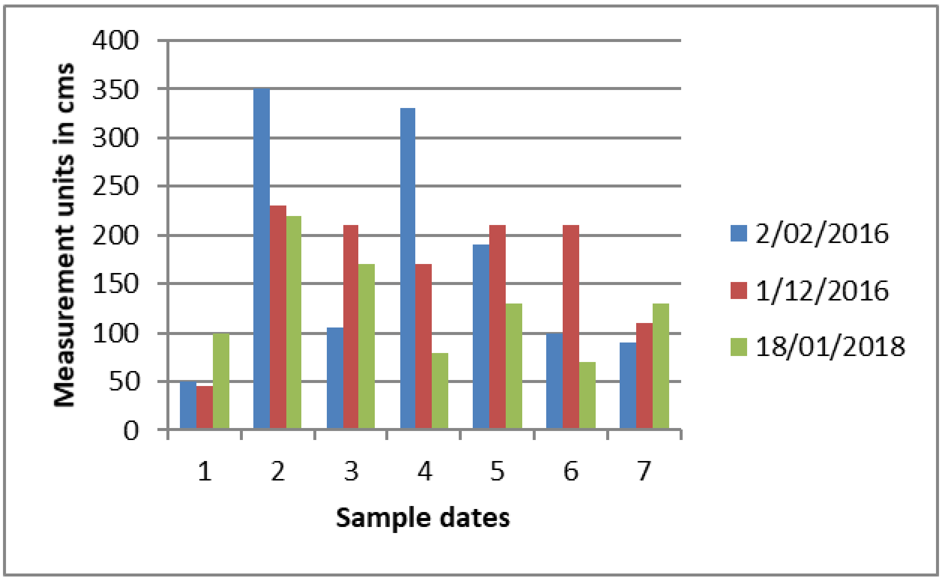
Measurements (cms)	FP3 - 2/2/16	FP3 - 2/12/16	FP3 - 18/1/18
M1	33	36	50
M2	145	210	200
M3	50	40	50
M4	90	260	100
M5	700	120	150
M6	75	0	135
M7	60	85	10

Site B: Due to its shorter length only one fixed point was measured for this gully. This gully was fenced but no revegetation was undertaken, instead pasture grass was the dominant ground cover. Due to its shorter length only one fixed point was measured for this gully. The data showed a slight increase for measurement 1 between February 2016 and January 2018. There was an overall decrease in gully width at its widest point. Measurement 3 was inconclusive but measurement 4 showed a decrease of 150cm between February 2018 and January 2018. Measurement 5 showed an overall decrease from 190cm to 130cm. The gully depth above the deepest point also showed a decrease, but gully depth below the deepest point showed a 40cm increase in depth.

Table 2 - Tunnel Erosion Measurements for Site B – one fixed point only

Measurements (cms)	FP1 - 2/2/16	FP1 - 1/12/16	FP1 - 18/1/18
M1	50	45	100
M2	350	230	220
M3	105	210	170
M4	330	170	80
M5	190	210	130
M6	100	210	70
M7	90	110	130

Diagram 5 Site B – Fixed Point 1 - Measurements 1-7



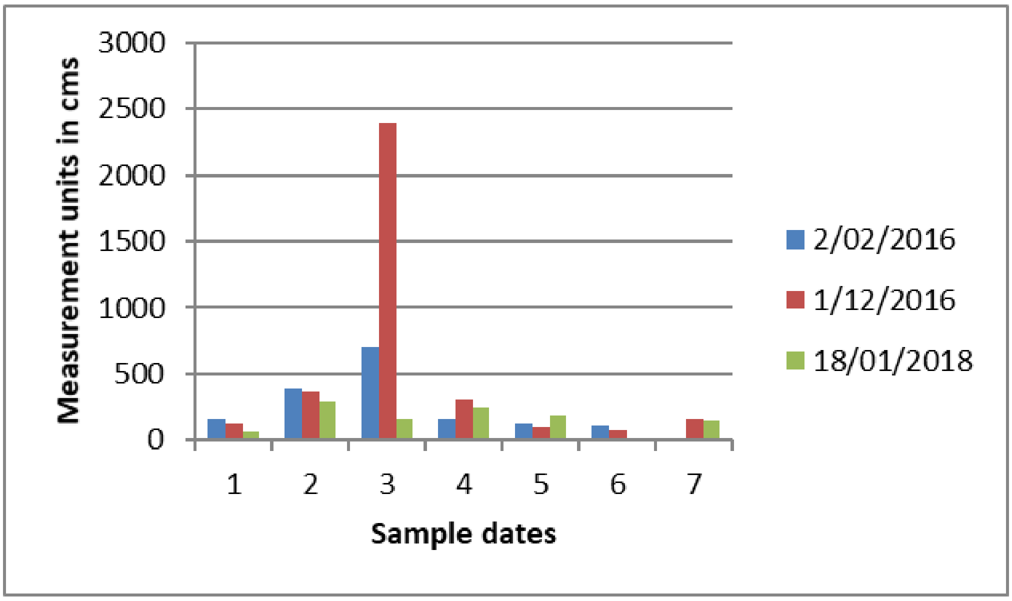
Photos 4 and 5 - Site B: Before fencing grass control site (May 2014) and post fencing (January 2018)

Site C: Due to its shorter length only one fixed point was measured for this gully. This gully was fenced and revegetated with mainly shrubs. There was a decrease in the first two measurements between February 2016 and January 2018, however measurement 3 collected in December 2016 seems widely inconsistent. This is possibly due to human error. Measurements 4 and 5 showed an increase in gully width both below the widest point and gully depth at the deepest point. Measurement 6 had decreased to the point where no measurement could be taken. Measurement 7 however showed a decrease in gully depth of 5cm between December 2016 and January 2018.

Table 3 - Tunnel Erosion Measurements for Site C – one fixed point only

Measurements (cms)	FP1 - 2/2/16	FP1 - 1/12/16	FP1 - 18/1/18
M1	157	125	60
M2	390	367	290
M3	700	2400	160
M4	160	300	240
M5	130	100	180
M6	110	80	0
M7	nr	155	150

Diagram 10 Site B – Fixed Point 1 - Measurements 1-7



Photos 6 and 7 - Site C: May 2014: Before fencing and revegetation

Photo 8 - Site C: January 2018 – Post fencing and revegetation

2.3 Discussion of tunnel erosion measurements

The three sets of data used to measure the tunnel erosion are from February 2016, December 2016 and January 2018. In the absence of the original data collected in August 2015, it is most useful to compare the December 2016 data and January 2018 data.

So, what does the data that we do have tell us? Have the existing tunnels stabilised or was there further movement post management intervention?

For Site A there is evidence to suggest that fencing the gully from livestock and slowing down the flow of water has largely arrested further widening of this gully at the three fixed monitoring points measured. Most recent observations at fixed point 2 (January 2018) showed evidence that rabbits or other digging animals had accessed the site and may account from some slumping on gully edges above and below the widest point. There was an increase in total erosion length for fixed points 1 and 2 but this had decreased for fixed point 3. This would appear to indicate that there was further development in length of the gully but not width. There was an overall decrease in tunnel depth at the first two fixed points which could be due to a deposition of material, but an increase in depth towards the bottom of the gully at fixed point 3.

For Site B the measurement showed a decrease in overall gully width but an increase in depth at the deepest point. Fencing and vegetation establishment would appear to have arrested further widening of the existing gully, however there appears to be continued movement of sub-surface water through the gully from upslope which continues to deepen and lengthen erosion effects along the gully.

For Site C the measurements showed a decrease in gully width at its widest point, but further widening above and below the widest point. Gully depth below the deepest point showed an increase of 0cm to 150cm perhaps indicating that further tunnel collapse had occurred at this point between February 2016 and December 2016. Results appear to show a similar pattern as that of Site B, where overall gully width has decreased but there has been further erosion in terms of depth and length of area showing evidence of erosion. It would appear to be a good thing that these areas now exclude livestock as they present a clear hazard to livestock and machinery.

3.0 Soil sample collection and analysis pre and post treatment

Soil samples were collected at Sites 1, 2 and 3 before and after treatment to identify whether there had been a change in soil chemistry with the addition of lime. GPS coordinates were taken for each of these collection points. Soil samples were initially collected in December 2014 with a final soil test taken from the same locations in February 2018. (See Table 4 for results).

Table 4: Soil analysis results 2014 and 2018						
Nutrient	**Kool 1 2014**	**Kool 1 2018**	**Kool 2 2014**	**Kool 2 2018**	**Kool 3 2014**	**Kool 3 2018**
pH (1:5) water	5.09	5.53	5.53	5.35	5.49	5.5
Available Calcium mg/kg	795	737	750	721	703	766
Available magnesium mg/kg	314	191	272	264	248	262
Available Potassium mg/kg	101	89	83	110	70	127
Olsen P mg/kg	19	21	20	28	25	29
Colwell P mg/kg	48	67	43	87	76	84
Nitrate N	68.8	9.3	14.1	52.8	9.3	45.4
Ammonium N	8.8	32.0	10.2	45.6	8.1	35.3
Sulphur	13.4	10.3	10.8	11.4	12.3	15.1
Total Nitrogen %	0.4	0.4	0.4	0.4	0.3	0.3
Organic matter %	7.8	7.1	8.0	7.3	6.5	6.3
Total Carbon %	4.4	4.1	4.6	4.2	3.7	3.6
Effective Cation Exchange Capacity (ECEC) cmol+/kg	15.2	11.1	13.1	12.5	12.3	12.3
Calcium/Magnesium ratio	1.9	2.8	2.1	2.0	2.1	2.0
Calcium CEC %	56	65	60	58	59	59
Magnesium CEC %	30	23	28	30	28	29
Potassium CEC %	4	5	4	5	4	6
Sodium – ESP %	2	2	3	2	3	3
Aluminium CEC %	6	4	4	4	4	2
Carbon/Nitrogen ratio	11.2	10.6	11.8	11.4	12.0	11.8

3.1 Interpretation of soil analysis results

Site 1: No soil additives

The Magnesium content was high for this site which may have a negative effect on soil structure. Aluminium was also quite high, however, this can be rectified with the addition of lime. The pH is low at 5.09, which is regarded as strongly acidic.

The 2018 sample shows that pH has increased slightly from 5.09 to 5.53. The Calcium content has remained fairly consistent with a slight increase between sample dates. However Aluminium and Magnesium has decreased. This could be due to the mixing action due to excavation activity. The percentage of organic matter has also decreased slightly.

Photos 9 and 10 - Site 1 at southern end of property: pre-excavation (May 2014) and post excavation (January 2018)

Site 2: No soil additives

The 2014 soil sample is relatively consistent with the initial benchmark (refer to Table 4).

In the trial methodology the landholder intended to add lime to this site to help correct the acidity. However, in a conversation with the landholder on 16/1/18, he indicated that he did not end up applying lime to this site which would explain why there was no response. In the 2018 sample the pH has declined slightly from 5.53 to 5.35. The levels of Phosphorus have almost doubled. It is useful to note the variation in measurement which occurred at these two sites. For example, the initial measures of pH were similar, but the final measure showed one increasing and one decreasing. This highlights the variability in soil measurement. Similar variability is noted with the level of Ammonium, with levels much higher in 2018 sample.

Photos 11 and 12 - Site 2: Looking upslope (May 2014) pre-excavation and post excavation (January 2018)

Site 3: Addition of Lime (Calcium carbonate)

In the trial methodology it was proposed to add the mineral Gypsum to this site to assist the compacted clay soil to become more porous so that roots can develop better and make elements such as Calcium and Sulphur available to aid plant growth. However this was not done and the landholder advised that he added lime to this site at a rate of a tonne/per acre to Site 3 only and to a 15 metre wide strip along tunnel that was ripped.

The landholder was advised that it would have no effect on these soils as they are magnesium clays. Gypsum is only effective on soils that are sodium clay. Gypsum also has no effect on pH.

Table 4 shows that despite the addition of lime, no change in pH was measured but the available Calcium has increased. However, the cation exchange rate (CEC%) has remained the same between the 2014 and 2018 sample. There was a significant increase in the amount of Nitrate between the 2014 and 2018 samples which can be attributed to the addition of urea at this site.

Photo 13 - Site 3: May 2014: Showing tunnel development

Photo 14 - Site 3: January 2018: Looking downslope: Sorghum crop

3.3 Discussion of soil analysis results

The addition of lime at Site 3 resulted in no measurable change in pH but the available Calcium has increased. It could be that the application of lime was too small to have a more significant effect or that it hasn't made it down into the plant root zone. The landholder may have to consider increasing the amount of lime added to the soil to bring the pH closer to 6 or 6.5.

The soil analysis has shown these soils to be high in Magnesium, which means that the addition of lime would be of benefit.

3.4 Discussion of pre and post treatment photos

The photos taken between May 2014 prior to the trial and January 2018, post-trial activities, show a clear improvement in the condition of the fenced sites (Sites A, B and C). The revegetation at Sites A and C is now well established. Site B has grassed over, as expected, in the absence of grazing. On balance the use of fencing to exclude livestock has been an effective management option. Monitoring of the tunnels indicates that vegetation has stabilised the edges of the tunnels/gullies i.e. there has been no further significant widening, however it has not prevented continued erosion in terms of overall length and depth of tunnels/gullies. The continued movement of sub-surface water through the tunnels may be causing them to remain active.

In the areas not fenced and remediated with soil excavation, there has been mixed results. Site 2 and 3 would appear to have stabilised. These were more minor tunnels in the first instance and the sowing of a green fodder crop over the top of these two sites has made it difficult to determine if further tunnel development has been arrested. The addition of lime at Site 3 resulted in no increase in pH, however there was an increase in the amount of available Calcium which will aid plant growth.

4 Key learnings from trial

Fenced Site A: The diversion of surface runoff, fencing from livestock and revegetation with deep rooted species e.g. trees and shrubs would appear to have arrested further widening of this gully at the three fixed monitoring points measured. Most recent observations at fixed point 2 (January 2018) showed evidence that rabbits or other digging animals had accessed the site and may account from some slumping on gully edges.

Fenced Site B: The measurement showed a decrease in overall gully width but an increase in depth at the deepest point. Fencing and allowing shallow rooted grasses to establish would appear to have arrested further widening of the existing gully. However, there appears to be continued movement of sub-surface water through the gully from upslope which continues to deepen and lengthen erosion effects along the gully.

Fenced Site C: This site has benefited from exclusion fencing and revegetation with shrubs and ground covers. The results appear to show a similar pattern as that of Site B, where overall gully width has decreased but there has been further erosion in terms of depth and length of area showing evidence of erosion. It would appear to a good management decision to exclude these areas as they present a clear hazard to livestock and machinery.

Excavation Site 1: Based on observations made in January 2018 the tunnel at Site 1 has since partially reformed and remains a hazard for livestock. The excavation and backfill of this site appears to have been unsuccessful in the short term. Fencing may be the only feasible long term management option for this site.

Excavation Site 2: Based on observations made in January 2018, the tunnels do not appear to have reformed at Site 2 that were remediated in early autumn 2015. In this respect the management intervention appears to have arrested further development. However, the paddocks that were previously used for grazing have now been sown down to a green fodder crop (possibly Sorghum) making it difficult to see if tunnel erosion is evident.

Excavation Site 3: Based on observations made in January 2018 the tunnels do not appear to have reformed at Site 3, which were remediated at the same time as Site 2.

There is a large bare area that has not been cropped in the middle of the sites 2 and 3 (see Photo 12). This was a steep area that the seed sowing contractor wasn't comfortable crossing with a tractor and other machinery. This would indicate an area where structural instability remains and in the longer term these tunnels at Sites 2 and 3 may reform

5 References

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Websites

https://en.climate-data.org/location/16357/

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