# SA Drought Hub Technical Report

## Rangeland Mineral Testing

**PROJECT LEAD: University of Adelaide**

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# Contents

# PROJECT SUMMARY

Meeting the macro and micro mineral requirements for cattle is essential for growth, health and reproduction. However, Australian soils are commonly deficient in several of these minerals with cattle often requiring nutritional supplementation. Research in other states has demonstrated the health and productivity benefits of correcting mineral deficiencies, particularly Phosphorous, although this work is yet to be adequately validated across the South Australian rangelands.

This project tested cattle (blood and faeces), soil and water from seven stations across northern South Australia in spring of 2023. A range of minerals and water/soil quality traits were measured.

Overall, results enhanced our understanding of the current soil, water and animal status of macro and micro minerals in pastoral South Australia. At the time of sampling the mineral status of the majority of cattle tested was appropriate and there was little indication that supplementation was required. However, the project tested mineral status at a singular timepoint and may not give a complete picture of the mineral status. It is recommended that additional testing be conducted over contrasting seasons, on different land types and when feed quality is at its peak, to get a true indication of the mineral status across these regions.

# EXECUTIVE SUMMARY

Meeting the macro and micro mineral requirements for cattle is essential for growth, health and reproduction. However, Australian soils are commonly deficient in several of these critical minerals with cattle often requiring nutritional supplementation to ensure they meet minimum requirements. Research in other states has demonstrated the health and productivity benefits of correcting mineral deficiencies, particularly Phosphorous, although this work is yet to be adequately validated across the South Australian rangelands.

Based on the work from other states we believe that identifying mineral deficiencies and applying appropriate and targeted nutritional supplementation of these minerals could improve growth rates, increase pregnancy rates and increase weaning rates and weaner liveweights. However, there is limited information available surrounding the incidence of macro and micro mineral deficiencies of South Australian rangeland cattle. As such, this pilot project had three main aims:

1. Determine the essential minerals status of rangeland cattle across 3 pastoral regions: North Flinders, Marree-Innamincka, and Marla-Oodnadatta.
2. Utilise blood, soil and faecal testing and predict what the, if any, mineral supplementation needs are for cattle in these regions.
3. Identify opportunities for further work to be undertaken in mineral supplementation of South Australian rangeland cattle.

In total, 7 properties were sampled as part of the project. Blood samples and pregnancy status were collected from 25 breeding heifers, a pooled faecal sample was collected from the heifer mob, soil samples were collected from 4 locations per paddock and a water sample was collected from the water source in the paddock. All samples were analysed for important macro and micro minerals.

This project enhanced producer knowledge in regards to identifying clinical signs of mineral deficiencies and what the current soil, water and animal status was for macro and micro minerals. Overall, results indicated that:

- At the time of sampling mineral status of cattle was appropriate.
- Based on the samples at one time point there was no indication for supplementation, in the majority of cases.
- In many cases calcium was high, resulting in a high Ca:P ratio meaning additional Ca is not required as a base in any supplements.
- Faecal NIR which hasn't been calibrated on Southern Rangelands feed was considered an unreliable indicator of feed quality in these regions.

This project tested mineral status at a singular timepoint only and only tested heifers from one paddock. As such, it may not give a true representation of the mineral status in these areas. It is recommended that additional testing be conducted over contrasting seasons and/or on different land types across the same properties and regions to give a complete picture of the mineral status across the South Australian rangeland area.

## PROJECT BACKGROUND AND OBJECTIVES

Meeting the macro and micro mineral requirements for cattle is essential for growth, health and reproduction. However, Australian soils are commonly deficient in several of these critical minerals with cattle often requiring nutritional supplementation to ensure they meet their requirements. Some of the most common mineral deficiencies and toxicities for cattle, along with their related clinical signs, are listed in Appendix 1. However, three are commonly recognised for their impact on productivity and health: phosphorous (P), the calcium phosphorous ratio (Ca:P) and selenium.

Phosphorus is one of the major nutrients in the soil, and without it, plant growth is retarded and resultant feed quality is poor. For animals, phosphate (phosphorous) plays a critical role in energy metabolism, muscle contraction, skeletal integrity and delivery of oxygen to tissues. In cattle it is also required by the rumen micro-organisms for digestion and the creation of microbial protein. Because of the importance of phosphorous in many physiological processes, there are several conditions in cattle that are commonly associated with phosphorus deficiency. These include, reduced milk yield, weight loss and infertility in lactating cows; osteomalacia, ill-thrift and depraved appetite (pica – eating dirt, licking rocks or bones) in mature cattle and rickets in young growing animals. In Australia, approximately 70 percent of soils are phosphorus deficient and phosphorus deficiency is probably the most common nutritional deficiency with cattle grazing tropical and subtropical pastures.

Similar to phosphorus, calcium is involved in a wide variety of physiological processes. Nearly 99% of the calcium in the body of an animal is found in the skeleton, while the remaining calcium is extracellular and plays a role in nerve conduction, muscle contraction, blood clotting and immune system activation. Calcium and phosphorus are closely linked and work in conjunction because of their mutual roles in bone formation and metabolism. Because calcium and phosphorus are closely linked, high levels of calcium can inhibit the uptake of phosphorus. High levels of calcium in the diet also interfere with the mobilisation of phosphorus from the bones of cattle on low phosphorus diets. The recommended calcium to phosphorus ratios in beef cattle diets is 1.5Ca:1P to 2Ca:1P. If the ratio is inverted and phosphorus exceeds calcium, absorption of calcium in the digestive tract is reduced, and the animal will metabolize calcium and phosphorus from bone. This can result in less bone growth, brittle bones, and "water belly" or kidney stones. In general, the symptoms of calcium deficiency are similar to the symptoms of phosphorus deficiency.

Another common nutritional disease in cattle is Selenium deficiency. Selenium is required for normal growth and fertility of cattle, is found in a number of enzymes and proteins and protects against damage to cells. It also plays an important role in keeping the immune system healthy. Although Selenium is recognised as an essential element for ruminants, it is not for plants. The selenium concentration in plants is often insufficient to meet the requirements of grazing ruminants and as such supplementation can be required. Selenium deficiency symptoms in cattle include the onset of nutritional muscular dystrophy, also known as white muscle disease, with cattle often displaying difficulty breathing as a result of damage to the muscles supporting the heart, problems standing and general stiffness. Other selenium deficiency symptoms in cattle include poor milk production and fertility, mastitis, and the premature birth of calves. Young cattle in the growth stage are especially susceptible to selenium deficiency. High or low concentrations of dietary Calcium reduce the digestibility of Selenium. While supplementation with selenium can be common in some areas of

Australia, care needs to be taken not to supplement too high, as selenium toxicity is the most toxic of the trace minerals and can lead to death.

Research in other states have reported on the health and productivity benefits of ensuring appropriate nutritional mineral levels in cattle, particularly Phosphorous (MLA 2023), although similar work is limited within the South Australian rangelands. In 2013, a report for the Outback Lakes group looked at the nutritive status of 11 stations around Lakes Eyre and Frome. The report examined soil mineral status and the nutritive value of numerous preferred grazing species from 2006-2012. From this report, soil mineral tests revealed strongly alkaline soils with typically low N, P (very low), Mn, Cu, Zn, & Mg. The report also revealed high K & Na largely typical of the strongly alkaline soil pH. The preferred grazing species across this region (as identified by the participant pastoralists) were found to be low in P, Cu, Zn and occasionally Se, Mn, Na & Mg. While the report suggested that high alkaline soils can be predictive of potential mineral deficiencies it did also highlight that mineral deficiencies were not conclusive and are dependent on seasonal and grazing conditions. Additionally, this work focussed on deficiencies in the soils and grazing species in these areas with limited work undertaken into how cattle were utilising these minerals and if they were in turn classed as deficient.

Based on the work from other states and the previous work undertaken by San Jolly, we believe that identifying mineral deficiencies and applying appropriate and targeted nutritional supplementation of these minerals could improve growth rates, increase pregnancy rates and increase weaning rates and weaner liveweights of South Australian rangeland cattle. With limited information available surrounding the incidence of macro and micro mineral deficiencies of South Australian rangeland cattle, this pilot project had three main aims:

1. Determine the essential minerals status of rangeland cattle across 3 pastoral regions: North Flinders, Marree-Innamincka, and Marla-Oodnadatta.
2. Utilise blood, soil and faecal testing and predict what the, if any, mineral supplementation needs are for cattle in these regions.
3. Identify opportunities for further work to be undertaken in mineral supplementation of South Australian rangeland cattle.

The study was able to utilise blood, faecal, soil and water sampling to determine the mineral status of both cattle and their environment at the time of sampling. Producer sites from all three regions were included, however only one site from the Marree-Innamincka region was involved in the project. It has been discussed that future work in this area should include additional properties further North in the state; should sample at multiple timepoints throughout the year and potentially over two consecutive years, and feed samples should be collected instead of faecal samples in order to get a true representation of mineral status in both cattle and their environment.

# METHODOLOGY

## *Sampling sites*

An expression of interest (EOI) was circulated to producers across the three major pastoral regions of South Australia: North Flinders; Marla – Oodnadatta and; Marree – Innamincka. The EOI was circulated through the following methods:

- Social media posts by AgCommunicators
- Interview with *A Country Hour*, ABC
- Targeted email to producers and producer groups

A total of nine producers completed the EOI with seven sites enrolled in the study: 3 in North Flinders, 3 in Marla-Oodnadatta and 1 in Maree-Innamincka. Timing of mustering was a key factor in determining appropriate sampling sites.

Each sampling site was visited by a veterinarian (either Dr Kate Litchfield or Dr Jack Coffey) and a Drought Hub Node Coordinator for animal sample collection and then, later, by Geoff Kew (Soil Officer with Landscape SA) to collect soil samples. Sampling visits occurred in late September to October, with soil sampling undertaken in November 2023 and water sampling occurring in June and July 2024. The study was approved by University of Adelaide Animal ethics Committee (S-2023-079)

## *Blood sampling and pregnancy testing*

Twenty-five breeding heifers were pregnancy tested and aged where possible. Each of these 25 heifers had a 9ml blood sample taken from the tail vein in a plain blood tube. Blood samples were centrifuged as soon as possible (within 24 hours) and the plasma poured off and stored. Plasma samples were submitted to Regional Laboratory Services (Benalla, VIC) for a blood trace mineral profile, including zinc, calcium, magnesium and phosphorous.

## *Faecal sampling*

A small (half tennis ball sized) sample was taken from 10-15 animals/fresh faecal pats on the ground. These samples were well mixed in a container before a 200gm sample was taken and placed in a plastic bag. The bulk sample was then spread out to approximately 1cm thickness on a sheet of aluminium foil or baking tray and left in a hot and sunny spot. After approximately half a day drying, the sample was turned over to allow the other side to dry. Once dry, the sample was allowed to cool before being sent to Gcology F.NIRS service (Osborne Park, WA) for faecal near-infra red spectroscopy (F.NIR) and phosphorous analysis. The results from Gcology F.NIRS service were then sent to Désirée Jackson Livestock Management for further interpretation.

## *Soil sampling*

In November 2023, approximately a month after blood and faecal sampling, Geoff Kew (Senior Soil Officer with Landscape SA) visited each of the 7 properties and collected 4 soil samples (5 from one property). Samples were collected from different soil types across the paddock the heifers were grazing prior to the time of blood sampling. Soil samples were taken from a depth of 0-10cm, stored in individual zip lock bags and sent to Eurofins APAL (Hindmarsh, SA) for testing.

### *Water sampling*

In May of 2024, water sampling instructions and collection containers were posted to producers. Water samples were taken from the same water source (bore, tank, trough) as where the heifers were located in October 2023. Samples were posted to Eurofins APAL for testing. Only 4 of the seven properties received the full water sample testing (including fluoride), while 2 received the testing minus fluoride. One sample was not returned in time for testing to be included in this report.

### *Dissemination of results*

Preliminary results were delivered by Drought Hub Node Coordinator Fiona Tomney at the Drought Hub Stakeholder Advisory Group meeting, Port Augusta on June 28th, 2024. Final individual, producer reports have been developed and are to be distributed to producers late July 2024. Individual discussions with the project's nutrition consultant, Deb Scammell, are scheduled for August 2024.

# RESULTS

## ***Blood minerals***

Blood analysis looked at the concentration of multiple macro and micro minerals including B12, Calcium, Phosphorous, Magnesium, Selenium, Zinc and Copper. Results indicated that, at the time of sampling, there are no significant concerns in regard to mineral deficiencies or toxicities in the cattle tested.

For visual interpretation of the results each mineral was averaged across the herd (25 animals/property) and the minimum and maximum values recorded were identified. A calcium phosphorous ratio (Ca:P) was calculated from the results of calcium and phosphorous per animal and then averaged across the herd. The below figures report on the mean blood concentration for each mineral per property, with error bars identifying the minimum and maximum concentration recorded per property. The blue horizontal bars indicate the “normal range” for each mineral concentration in the blood for cattle. Properties are reported separately but have been deidentified.

Overall, the vast majority of animals on each property fell within “normal limits” for each of the blood minerals analysed (Figure 1 – Figure 8) except for blood selenium which was, on average, high for most properties (Figure 7). Six of the seven properties recorded ≥40% of animals with elevated levels of blood selenium, with three of these with >75% of animals recorded with elevated selenium. There were also a number of animals across the board that recorded elevated blood zinc with three properties recording ≥25% of animals with elevated blood zinc levels. Only one farm had animals (n=20%) that were considered low in blood phosphorous and one farm had 12% of animals recorded as low in blood copper.

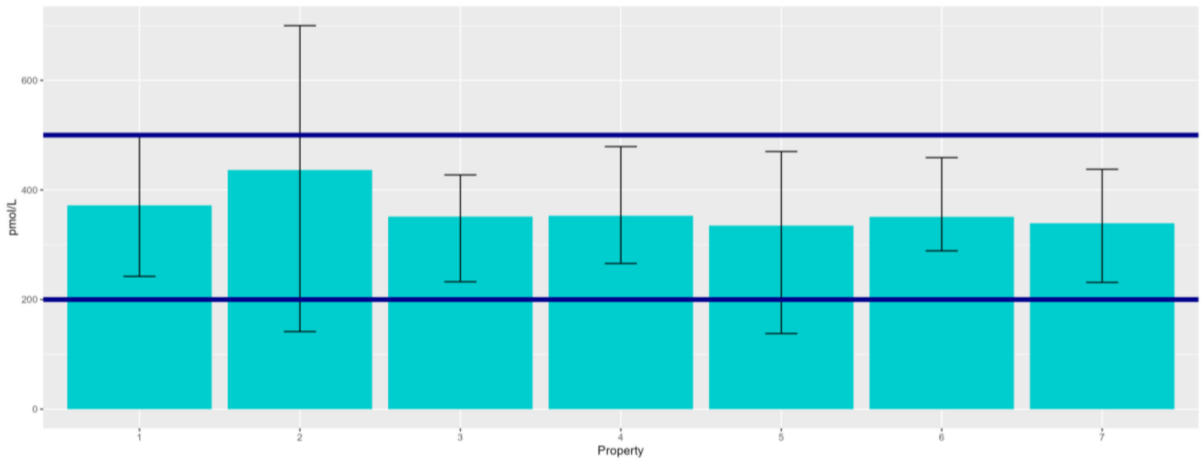


**Figure 1:** Blood B12 concentrations for 7 rangeland cattle stations across northern South Australia.

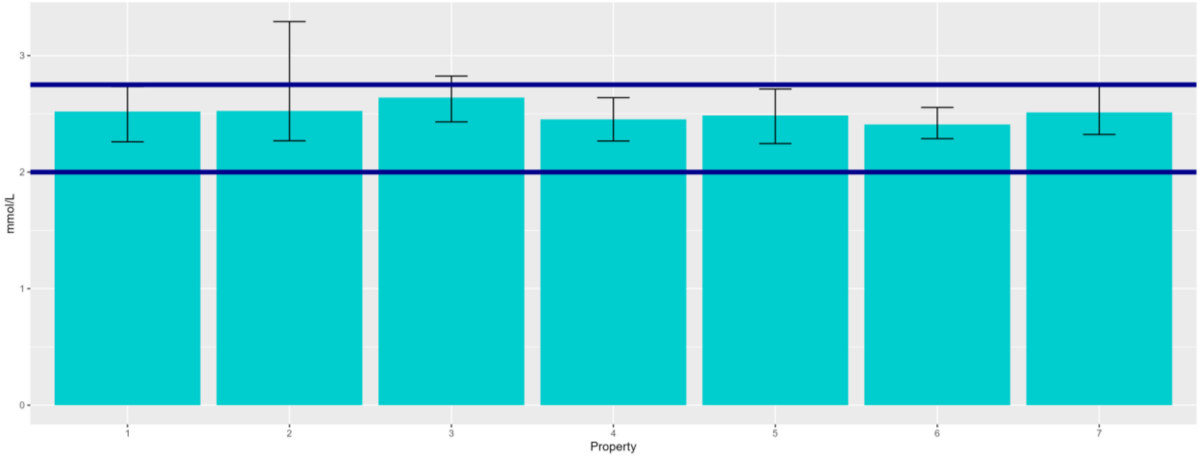


**Figure 2:** Blood calcium concentrations for 7 rangeland cattle stations across northern South Australia.

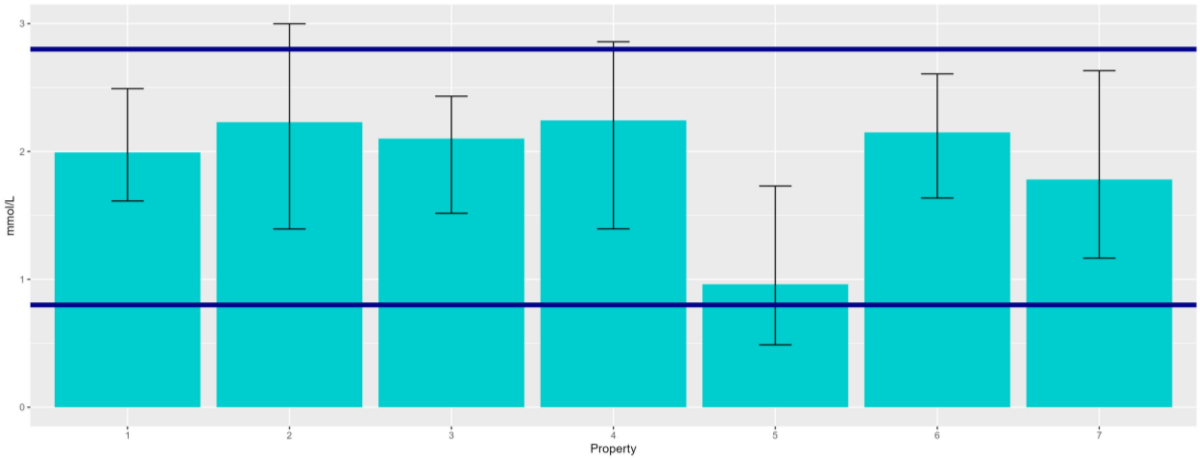


**Figure 3:** Blood phosphorus concentrations for 7 rangeland cattle stations across northern South Australia.

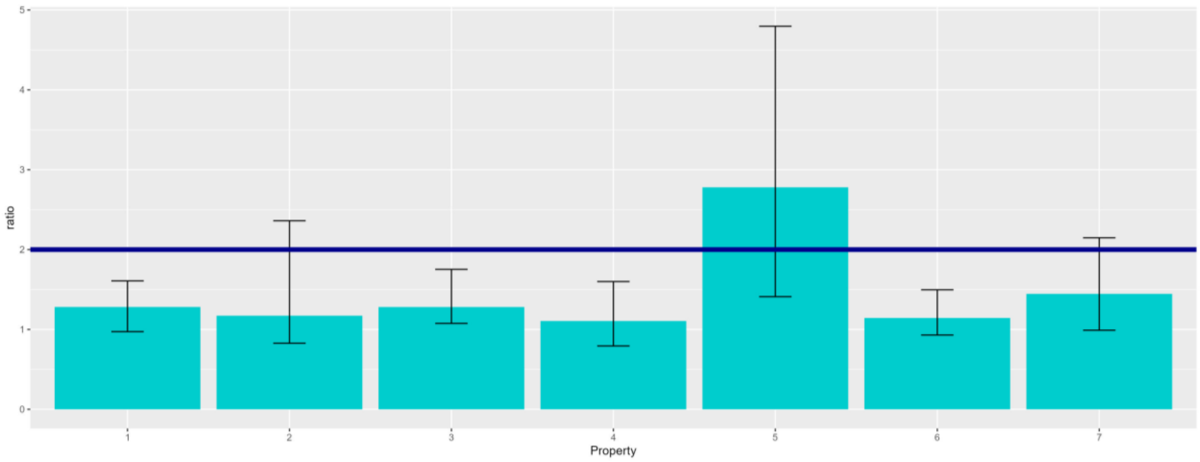

**Figure 4:** Blood Ca:P ratios for 7 rangeland cattle stations across northern South Australia.

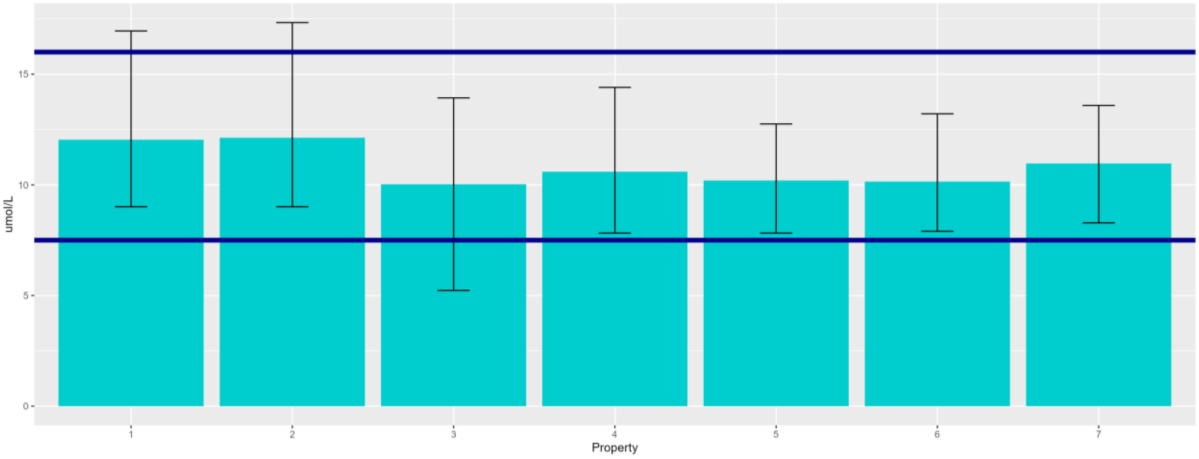


**Figure 5:** Blood Copper concentrations for 7 rangeland cattle stations across northern South Australia.

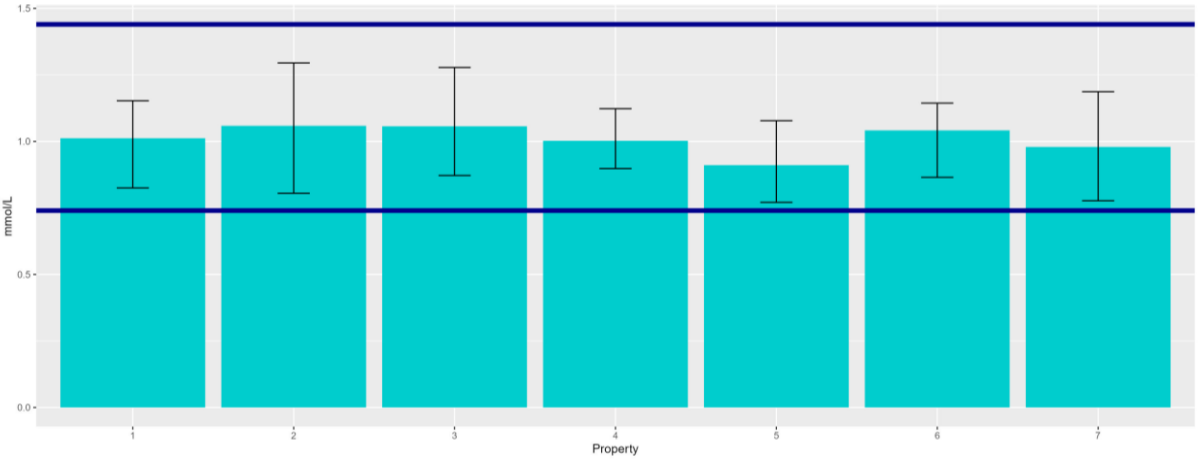


**Figure 6:** Blood Magnesium concentrations for 7 rangeland cattle stations across northern South Australia.

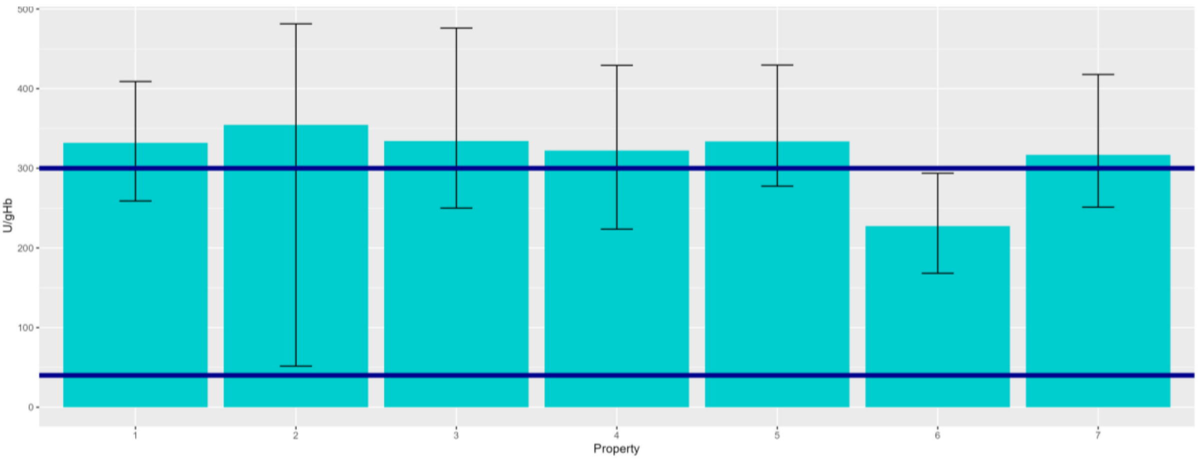

**Figure 7:** Blood Selenium concentrations for 7 rangeland cattle stations across northern South Australia.

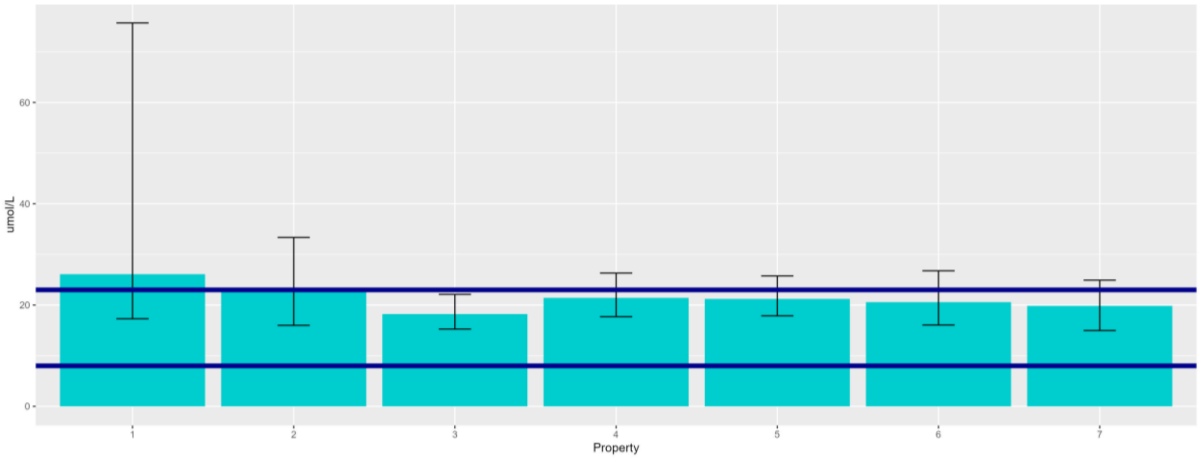


**Figure 8:** Blood Zinc concentrations for 7 rangeland cattle stations across northern South Australia.

### *Soil minerals*

Soil analysis looked at the concentration of multiple macro and micro minerals including Calcium, Phosphorous, Magnesium, Potassium, Sodium and Nitrate. For visual interpretation of the results each mineral was averaged across the paddock the heifers were in in the lead up to sampling (4 samples/property) and the minimum and maximum values recorded were identified. A calcium phosphorous ratio (Ca:P) was calculated from the results of calcium and phosphorous per sampling site and then averaged across the herd. The below figures report on the mean soil concentration for each mineral per property, with error bars identifying the minimum and maximum concentration recorded per property. The blue horizontal bars indicate the “normal range” for each soil mineral concentration. The blue “normal level” lines shown show pastoral country P levels required. The other soil mineral levels are compared to ‘Agricultural adequate levels’ required in soils as unfortunately there is no adequate range of other minerals determined for pastoral country. Properties are reported separately but have been deidentified.

Soil analysis identified that soil composition across the northern SA rangelands was varied (Figure 9 – Figure 17). All but one property indicated that soil phosphorous was adequate or above adequate, as determined by MLA’s report *“Phosphorous management of beef cattle in northern Australia, second edition.”* One property indicated extremely high levels of soil sodium (Figure 14), while soil zinc was below adequate in all but one property (Figure 15). Lastly soil Nitrate (Figure 16) was generally below desired ranges.

Soil mineral levels, except for phosphorous, were referenced against agricultural soil levels as there is currently no benchmark for pastoral soil levels.

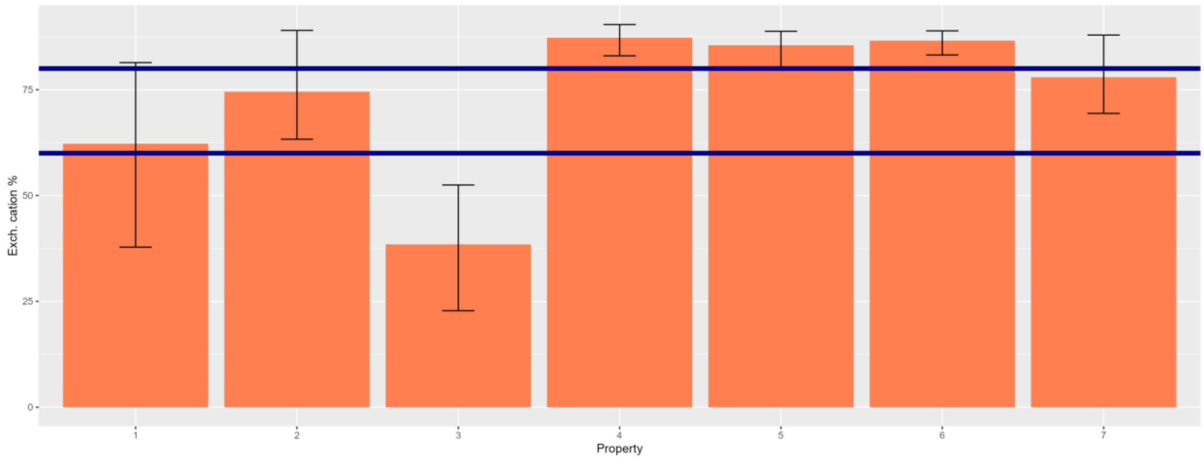


**Figure 9:** Soil Calcium levels for 7 rangeland cattle stations across northern South Australia.

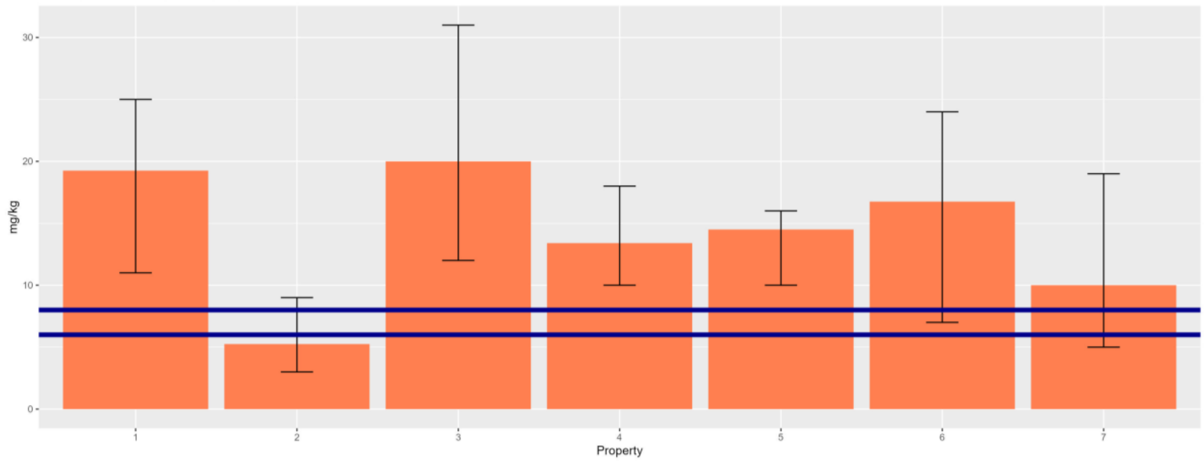


**Figure 10:** Soil phosphorous levels for 7 rangeland cattle stations across northern South Australia.

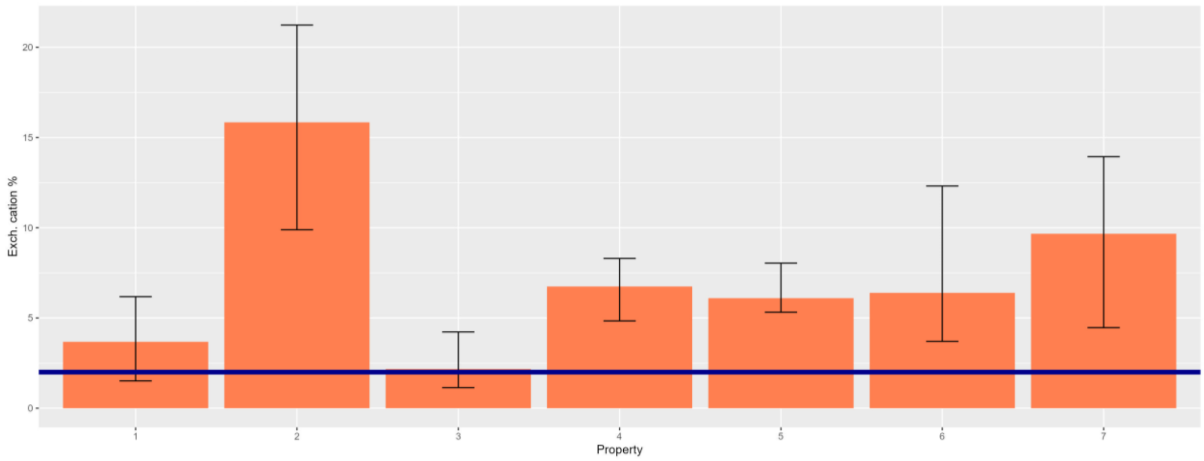


**Figure 11:** Soil Ca:P ratios for 7 rangeland cattle stations across northern South Australia.

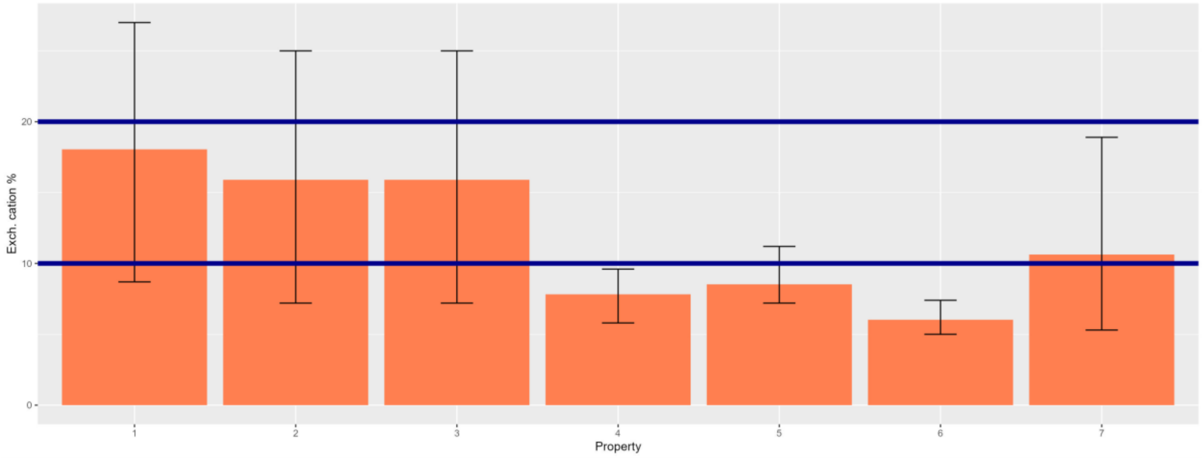


**Figure 12:** Soil magnesium levels for 7 rangeland cattle stations across northern South Australia.

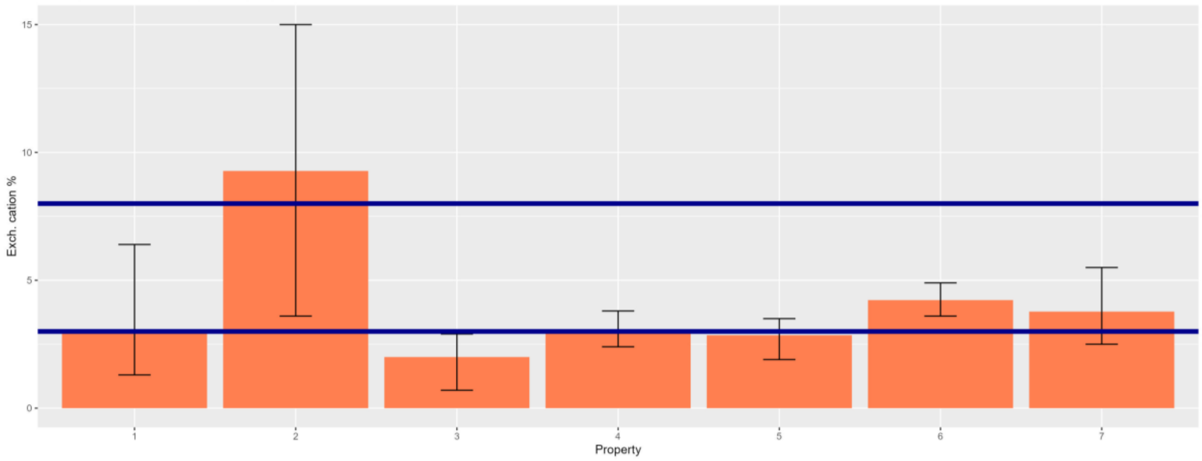


**Figure 13:** Soil potassium levels for 7 rangeland cattle stations across northern South Australia.

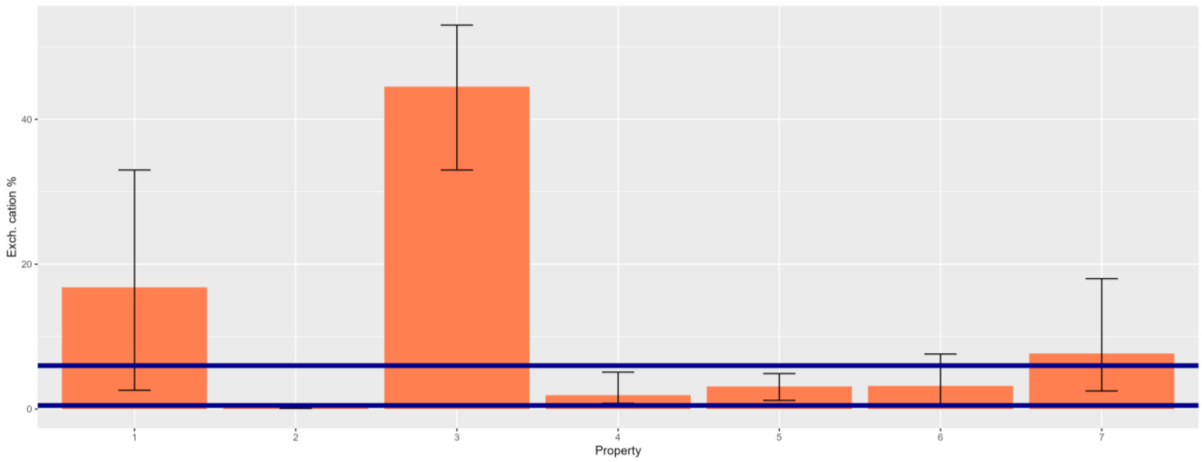


**Figure 14:** Soil sodium levels for 7 rangeland cattle stations across northern South Australia.

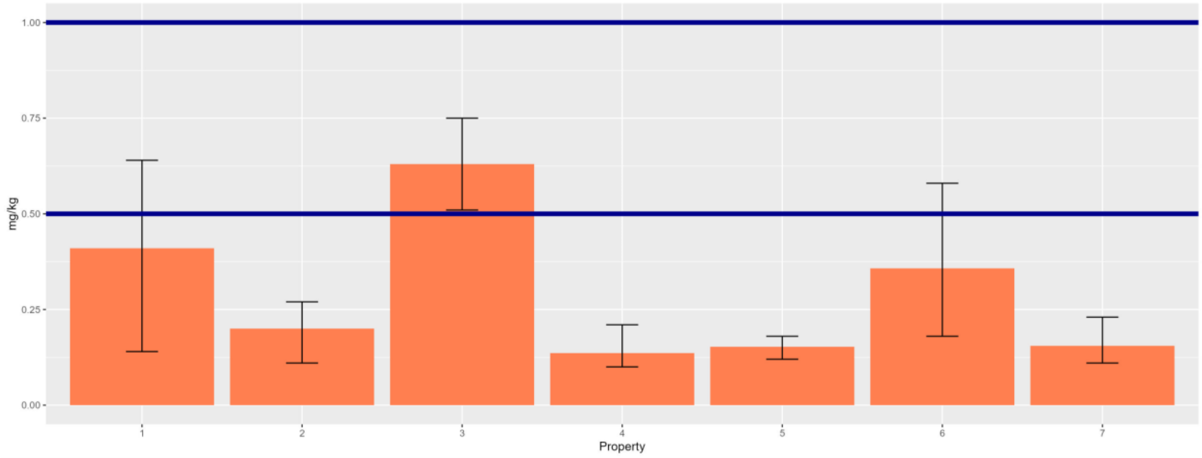


**Figure 15:** Soil zinc levels for 7 rangeland cattle stations across northern South Australia.

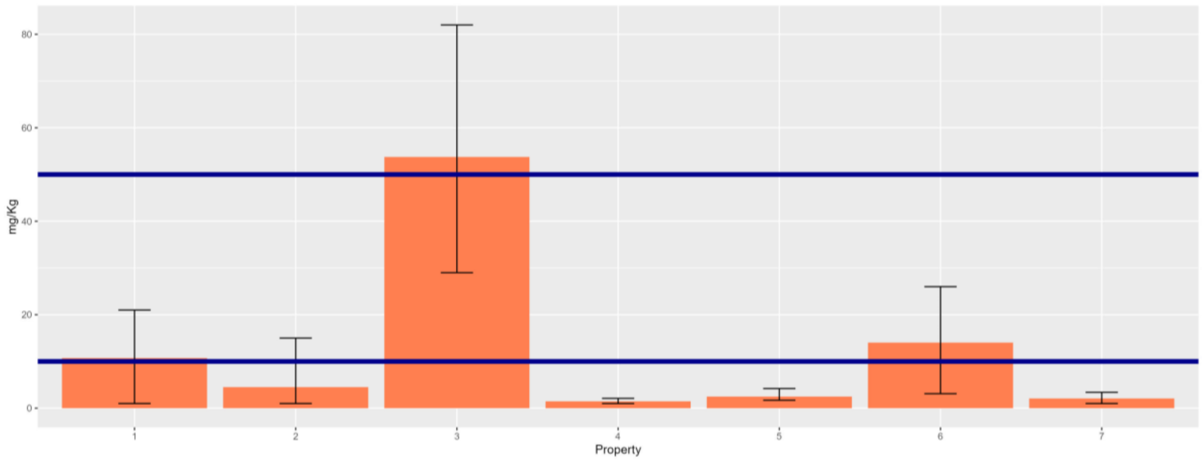


**Figure 16:** Soil nitrate levels for 7 rangeland cattle stations across northern South Australia

### *Soil types*

Soil types across the paddocks sampled were varied (Figure 17). When compared by region Maree-Innamincka had a higher proportion of loam soils, Marla-Oodnadatta had a mix of clay loam and loamy sand and the one property in the North Flinders region was predominantly sandy loam.

Finally, soil pH identified that most samples were not acidic or alkaline (Figure 18). However, three properties, all from North Flinders, had soils tending towards acidic. The importance of understanding soil pH is that soil pH affects the availability of nutrients in the soil, and how they react to one another. At a low pH, minerals such as phosphorous, magnesium and calcium become less available to plants. In contrast, at a soil pH greater than 7.5, calcium can tie up phosphorous making it less available to plants, while zinc and cobalt deficiencies are also common.

Plants perform best at a soil pH between 5.2 and 8.0, although some can tolerate a wider pH range, while others are extremely sensitive to small variations in acidity and alkalinity (Figure 19).

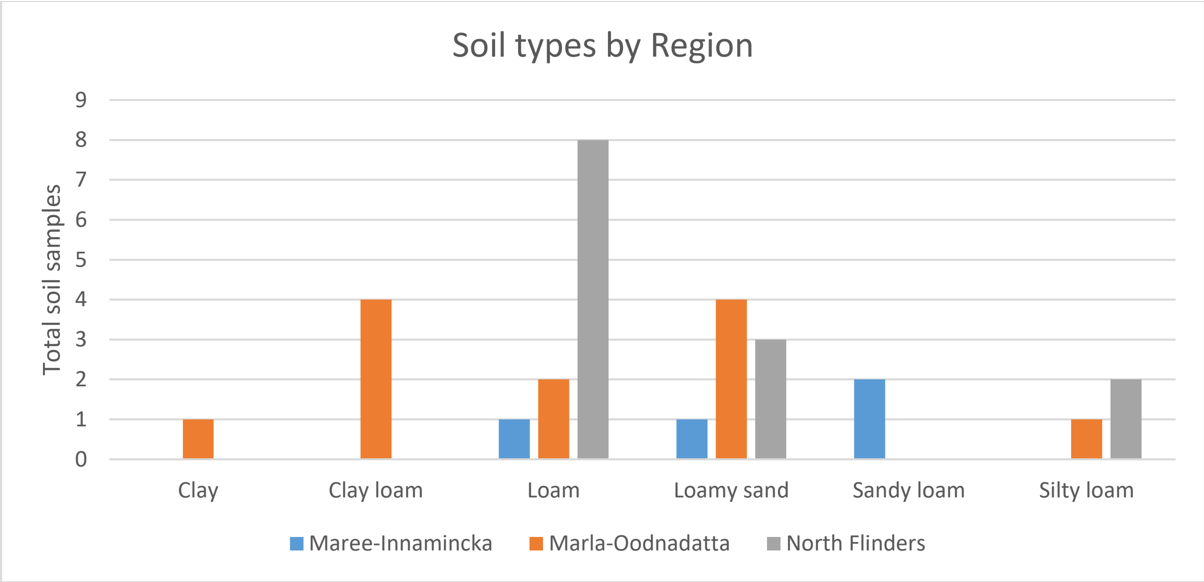


**Figure 17:** Soil types by region for 7 rangeland cattle stations across northern South Australia

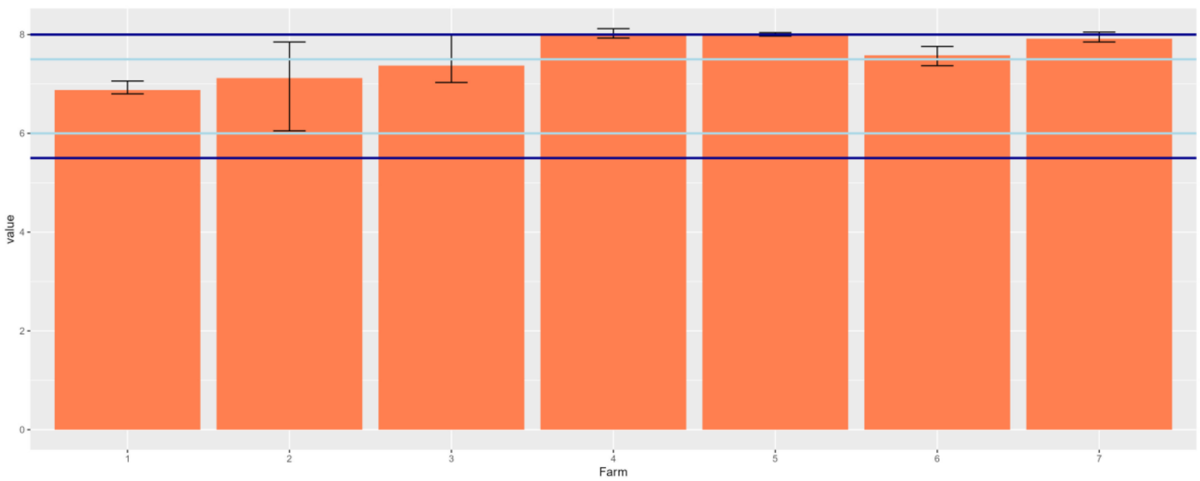


**Figure 18:** Soil pH for 7 rangeland cattle stations across northern South Australia

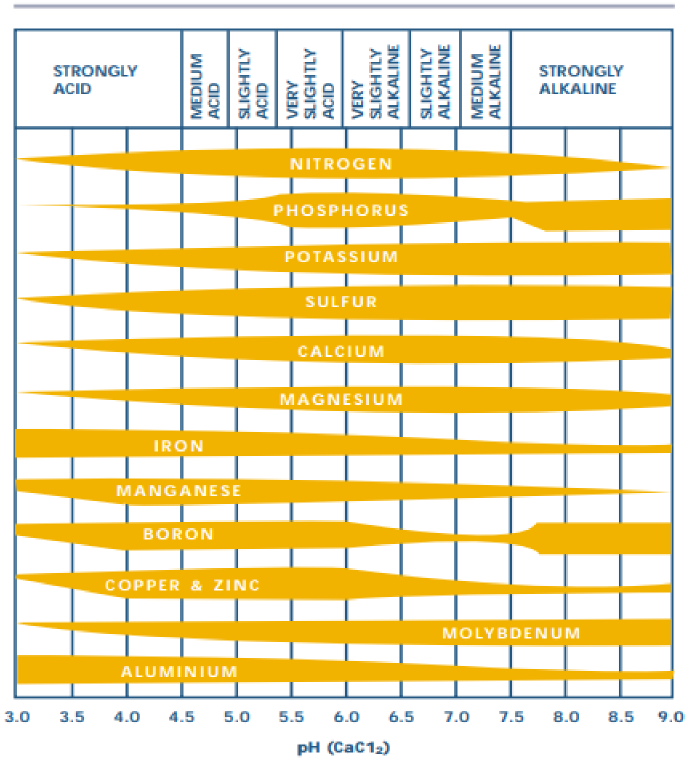


**Figure 19:** Effect of pH (CaCl2) on the availability of soil nutrients. Taken from "Understanding Soil pH" (NSW Agriculture, 2000)

### *Water minerals*

The water sampling results for 5 of the 7 properties are listed in Table 1. Five of the 6 properties which undertook water testing ran off bore water, with a pH of approximately 7.7, which is just above neutral but not yet alkaline. Majority of properties, had high mineral content, as indicated by the 'hardness' of the water. In particular, sodium, chloride and magnesium were elevated.

Fluoride was high or extremely high in three of four properties tested. Understanding the level of fluoride in stock water is important as high levels of fluoride (>2 mg/L) can lead to dental and skeletal disease, resulting in pain and lameness, a reduction in general health, fitness, body condition and reproductive parameters due to alterations in metabolism, gait and feed intake (DCCEEW, 2023).

**Table 1:** Water testing results for 7 rangeland cattle stations across northern South Australia. Red = very high; orange = high; green = low; blue = very low; grey = below limit of quantitation.

| | Desired level | Property 2 | Property 3 | Property 4 | Property 5 | Property 6 | Property 7 |
|---|---|---|---|---|---|---|---|
| Water type | - | Bore water | Bore water | Bore water | Mains water | Bore water | Bore water |
| pH | **6.5 - 8.5** | 7.80 | 7.90 | 7.60 | 8.00 | 7.70 | 7.80 |
| Alkalinity ($CaCO_3$ mg/L) | **<150** | 232.00 | 231.00 | 234.00 | 206.00 | 279.00 | 819.00 |
| Bicarbonate ($HCO_3$ mg/L) | **<400** | 284.00 | 282.00 | 286.00 | 251.00 | 340.00 | 1000.00 |
| Carbonate ($CO_3$ mg/L) | **-** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Calcium (mg/L) | **<500** | 72.00 | 69.00 | 95.00 | 61.00 | 183.00 | 17.00 |
| Magnesium (mg/L) | **<125** | 87.00 | 15.00 | 79.00 | 41.00 | 78.00 | 5.00 |
| Hardness (mg/L) | **<150** | 538 | 234 | 561 | 321 | 775 | 60 |
| Saturation Index | **-0.5 - 0.5** | 0.3 | 0.4 | 0.3 | 0.4 | 0.7 | 0.2 |
| Sodium (mg/L) | **<180** | 339 | 759 | 520 | 182 | 435 | 815 |
| Chloride (mg/L) | **<250** | 573 | 980 | 750 | 287 | 811 | 803 |
| Nitrate mg $NO_3$/L | **<50** | 179 | <0.5 | 3 | 5.4 | 1.1 | <0.5 |
| Phosphorous (mg/L) | **<1** | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Sulphate (mg $SO_4$/L) | **<250** | 149 | 372 | 381 | 107 | 292 | <0.5 |
| Potassium (mg/L) | **<20** | 27.7 | 18 | 2.9 | 3.1 | 5.1 | 5.5 |
| Aluminium (mg/L) | **<5** | <0.05 | 0.06 | <0.05 | <0.05 | <0.05 | <0.05 |
| Iron (mg/L) | **<0.3** | 0.08 | 0.16 | <0.05 | <0.05 | <0.05 | <0.05 |
| Cobalt (mg/L) | **<0.01** | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Copper (mg/L) | **<0.1** | <0.01 | <0.01 | <0.01 | 0.07 | <0.01 | <0.01 |
| Manganese (mg/L) | **<0.1** | <0.005 | 0.05 | <0.005 | <0.005 | <0.005 | 0.01 |
| Zinc (mg/L) | **2** | 0.1 | 0.06 | <0.02 | 0.03 | <0.02 | <0.02 |
| Boron (mg/L) | **0.5** | 0.9 | 0.65 | 1.1 | 0.28 | 0.44 | 1.57 |
| Flouride (mg/L) | **NA** | 1.5 | NA | NA | 0.7 | 1.3 | 3.7 |

### *Faecal interpretation*

The faecal analysis and interpretation of results has been developed to assess the diet quality for cattle from Northern Australia and is less accurate for the plant species and grazing types found in Northern South Australia. As such it was determined that the results for faecal analysis were not truly accurate for the regions we were testing and were excluded in the producer reports. This is useful information as producers had questioned whether this was a technology we should be using in the southern rangelands, however, we've concluded it needs further calibrations before being useful. Only one site had faecal analysis results that were reasonably correlated with the feed available and this site was located in the far north of SA and had some C4 grasses present.

As an overview, the F.NIR interpretation of feed quality on the seven properties, at the time of sampling, are below.

> **Property 1** – Suggests diet quality was low however dietary P is adequate for dry/empty cattle but low for pregnant and wet cows. Suggest supplementing with both P and N but ensuring no additional Ca (DCP or limestone) is included as due to high Ca levels this would further exacerbate P levels. Suggested that additional sampling was needed when diet quality reaches its peak.
>
> **Property 2** – Diet quality was quite high at sampling. P, N and Ca:P were all adequate for all classes of breeders, including pregnant maiden heifers and first-calf cows.

**Property 3** – Suggest that dietary P is low but that due to the relationship between P and N, also need to supplement with N. In contrast, Ca was high, and to not further exacerbate the P deficiency in feed, supplements with added/high levels of Ca (e.g. DCP or limestone) should be avoided. Supplementation with P (and N) would stimulate an increase in pasture intake and hence, protein and energy intake.

**Property 4** – Suggests dietary P and N was adequate for all classes of breeders. Ca:P ratio was high and as such supplements with added Ca should be avoided.

**Property 5** – Suggests that dietary quality was low and P was marginally adequate for dry, empty cattle but deficient for heavily pregnant heifers. The Ca:P ratio was very high and no calcium sources should be added to supplements fed to cattle. Suggested that additional sampling was needed when diet quality reaches its peak.

**Property 6** – Suggests that the dietary P was marginal for heavily pregnant heifers. The Ca:P ratio was high and no calcium sources (e.g. DCP or limestone) should be added to supplements fed to cattle.

**Property 7** – Suggests that diet quality wasn't particularly high and P was deficient for all classes of cattle, particularly heavily pregnant heifers. Suggest supplementing with P and N, while avoiding Ca additions (DCP or limestone) as the Ca:P ratio was quite high. Suggested that additional sampling was needed when diet quality reaches its peak.

Overall, the F.NIR interpretation suggests that dietary P and N is adequate, with some regions of deficiency for heavily pregnant stock. Results also suggest that when supplementing cattle, care needs to be taken to choose supplements without additional Ca added as, in most regions, the Ca:P ratio is very high. This is typically ok when dietary P is adequate, but when P is deficient, the excess Ca can bind to the P, causing some of to be excreted and can prevent breeders from mobilizing P from their bones (e.g. for lactation), further exacerbating a P deficiency. For three of the seven sites, it was also suggested that additional testing is required when diet quality is at its peak to get a true indication of the feed quality status of each region.

### *Comparison of soil, water and animal minerals*

In general, if Phosphorous, Nitrate or Zinc were low in water, they were also typically low in soil (Table 2). Likewise, if soil pH was high, so too was water pH. Farm 5 was the only site with low blood phosphorus in its animals, it also had high Ca:P ratios for soil and bloods. It's important to note that the low soil phosphorous on Farm 2 may eventually lead to a phosphorous deficiency in cattle, but at the time of sampling, cattle were within normal ranges for maintenance. However, a small number of cattle off two sampling sites could be considered low when looking at mineral requirements for pregnancy.

While the phosphorous status of cattle across the study was adequate, when looking at the laboratory cutoffs for target P levels for maintenance, it is important to understand that the availability of phosphorous changes with feed quality. Table 3 highlights how phosphorous status changes in cattle at different levels of feed quality in tropical pastures. When using these cutoffs cattle could have been marginally deficient in phosphorous at the time of testing. It is recommended that re-testing cattle when feed quality is high (greater than 60% digestibility) is undertaken to get a broader understanding of what the phosphorous status of the cattle truly is and if there is a need for supplementation. As soil P results show more than adequate levels, it's likely that with higher feed quality blood phosphorus results may be adequate but blood testing at this time could confirm this.

**Table 2: Comparison of high and low mineral status for water, mean soil and mean blood results, for 7 rangeland cattle stations across northern South Australia. Blank cells = within normal ranges; n/a = data not applicable.**

| | Farm 1 | | | Farm 2 | | | Farm 3 | | | Farm 4 | | | Farm 5 | | | Farm 6 | | | Farm 7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Soil* | *Water* | *Animal* | *Soil* | *Water* | *Animal* | *Soil* | *Water* | *Animal* | *Soil* | *Water* | *Animal* | *Soil* | *Water* | *Animal* | *Soil* | *Water* | *Animal* | *Soil* | *Water* | *Animal* |
| **pH** | | n/a | n/a | | High | n/a | | n/a | n/a | High | High | n/a | High | High | n/a | | High | | High | High | n/a |
| **Calcium** | | n/a | | | | | Low | n/a | | High | | | High | | | High | | | | V.low | |
| **Phosphorous** | | n/a | | Low | V.low | | | n/a | | | V.low | | | V.low | Low | | V.low | | | V.low | |
| **Ca:P** | High | n/a | | V.high | n/a | | | n/a | | High | n/a | | High | n/a | High | High | n/a | | High | n/a | |
| **Magnesium** | | n/a | | | High | | | n/a | | Low | High | | Low | | | Low | High | | | V.low | |
| **Sodium** | High | n/a | | | V.high | | V.High | n/a | | | V.high | | | High | | | V.high | | High | V.high | |
| **Nitrate** | | n/a | | Low | V.high | | High | n/a | | Low | V.low | | Low | V.low | | | V.low | | Low | V.low | |
| **Potassium** | | n/a | | High | V.high | | Low | n/a | | | V.low | | | V.low | | | V.low | | | V.low | |
| **Zinc** | Low | n/a | High | Low | V.low | | | n/a | | Low | V.low | | Low | V.low | | Low | V.low | | Low | V.low | |

**Table 3: Phosphorous status in cattle for a range of plasma inorganic P levels and diet DM digestibility in tropical pastures (MLA, 2023)**

| Category | Dry matter digestibility (DMD) | | |
|---|---|---|---|
| PIP (mmol/L) | >60% (Good pastures) | 55–60% (Moderate pastures) | <54% (Poor quality pasture providing maintenance requirements or less) |
| Growing cattle and breeders not-lactating and up to the last two months of pregnancy | | | |
| <1.0 | Acutely deficient | Acutely deficient | Deficient |
| 1.0–1.5 | Acutely deficient | Deficient | Marginal |
| 1.5–2.0 | Deficient | Marginal | Adequate |
| Breeders in the last two months of pregnancy and early to mid-lactation | | | |
| <1.0 | Acutely deficient | Acutely deficient | Deficient |
| 1.0–1.3 | Acutely deficient | Deficient | Deficient |
| 1.3–1.5 | Deficient | Marginal | Marginal |

## CONCLUSION

This project has developed a greater understanding of current mineral status and land types of South Australian rangeland properties and their association with plant and animal mineral status. While none of the properties, at the time of sampling, had cattle that were heavily deficient in one or more critical minerals, there were properties that would warrant further testing and may benefit from supplementation at certain times.

While the methods for faecal analysis are not currently calibrated for South Australian pastoral systems, their inclusion in this project has highlighted that care may be necessary when supplementing to avoid additional calcium. High Ca:P ratios were common in faecal analysis and soil and could mean phosphorous is being tied up and unable to be used by grazing cattle. We do recommend that further calibration of the F.NIR methods be undertaken using southern rangelands browse, bush and C3 grasses so that this technology can be used for Southern rangelands feed types.

It is also recommended that future work in this area undertake testing over multiple seasons and different land types to more accurately define the mineral status and supplementation requirements for these areas. This is important as results will allow for more effective and targeted supplementation, rather than blanket supplementing cattle.

## REFERENCES


Australian Government Department of Climate Change, Energy, Environment and Water (DCCEEW), 2023, Livestock drinking water guidelines

NSW Agriculture, 2000, Understanding Soil pH, Understanding soil pH (nsw.gov.au)

MLA, 2023, Phosphorous management of beef cattle in northern Australia, 2nd Edition, mla---phosphorus-management-of-beef-cattle-in-northern-australia---2nd-edition_v19.pdf

Outback Lakes Group, 2013, Grazing management using nutritional content of native pasture, understanding soil nutrients and their effect on plant nutritional value, Final Report

## APPENDIX 1: MINERAL DEFICINCIES AND TOXICITIES

**Table 2: Mineral and trace element deficiencies and toxicities in cattle.** Table adapted from Outback Lakes Group 2013 Final Report.

| Mineral | Function in body | Deficiency symptoms | Toxicity Symptoms | Comments |
|---|---|---|---|---|
| ***Calcium*** | Essential mineral component of skeleton.<br><br>Also assists in muscular contraction, blood coagulation and hormone secretion. | Milk fever<br>o Muscle tremors<br>o Staggers<br>o Unable to stand<br>Water belly<br>o Straining to urinate<br>o Swollen abdomen<br>o Hunched up appearance<br>Poor skeletal growth<br>Bone abnormalities<br>Reduced milk production | Toxicity rarely occurs<br><br>High levels of calcium in late pregnancy may predispose animals to milk fever | Calcium deficiency can be induced by comparatively high phosphorus levels, a Ca:P greater than 2:1 is desirable |
| ***Phosphorous*** | Required for muscle contraction, bone strength, oxygen delivery and metabolism | Poor skeletal growth<br>Loss of appetite<br>Pica<br>oCraving/consumption of abnormal materials (eg. Bark or dirt)<br>Infertility | Sudden death, some animals found with head swelling<br><br>May predispose animals to water belly (see above – Calcium) | High levels of P can induce a calcium deficiency, therefore a Ca:P greater than 2:1 is desirable |
| ***Potassium*** | Important for skeletal, muscular and cardiac function | Reduced appetite<br>Poor growth<br>Muscular weakness<br>Hind leg stiffness<br>Lethargy | Induced hypomagnesaemia (see below – Magnesium) | Hypomagnesaemia induced if<br>Ca + Mg : K (%)<br>> 1 : 2.2 |
| ***Magnesium*** | Key component of the nervous and muscular systems | Hypomagnesaemia (tetany)<br>o Irritability<br>o Staggers<br>o Muscle twitching<br>o Frothing at mouth<br>o Convulsions<br><br>Loss of appetite | Loss of appetite<br>Reduced growth rates<br>Severe diarrhoea<br>Drowsiness | |
| ***Copper*** | Key component of the immune system; basic role in red blood cell development | Poor growth (calves)<br>Faded coat colour<br>Thin, wavy, harsh coat<br>Anaemia<br>Osteoporosis<br>Abnormal gait<br>Swayback<br>Diarrhoea<br>Infertility<br>Reduced immune response<br>Sudden death | Accelerated breathing<br>Weakness<br>Excessive thirst<br>Dark brown urine<br>Arched back<br>Jaundice<br>Diarrhoea<br>Death | Copper deficiency can be induced by comparatively high molybdenum levels, a Cu:Mo greater than 5:1 is desirable |

| | | | | |
|---|---|---|---|---|
| ***Selenium*** | Required for normal growth and fertility | White muscle disease<br>o Sudden death of young calves<br>o Poor growth (calves)<br>o Stiff-legged gait (calves)<br>o Weak and unable to stand<br>Diarrhoea<br>Low milk yield<br>Poor fertility<br>Retained fetal membranes<br>Mastitis<br>Premature calves/abortion | Most toxic of the trace minerals<br><br>Respiratory distress<br>Anorexia/Emaciation<br>Diarrhoea<br>Hair loss<br>Lameness<br>Shedding of hooves<br>Death | Strong link with Vitamin E deficiency.<br><br>Selenium deficiency may exacerbate an Iodine deficiency. |
| ***Zinc*** | Required for metabolism of carbohydrates and proteins | Loss of appetite/anorexia<br>Thickening, hardening, fissuring of skin (eczema)<br>Rough hair coat and shedding<br>Excessive salivation<br>Bowing of hind limbs<br>Stiffness of joints<br>Swelling of hocks<br>Reduced fertility<br>Wool eating<br>Anaemia | Reduced growth rate<br>Reduced feed intake<br>Decreased feed efficiency<br>Diarrhoea<br>Pica (see above - Phosphorous)<br>Chronic constipation<br>Abdominal pain | Zinc deficiency can occur due to excess dietary Copper, Iodine and Calcium |
| ***Sodium*** | Important component to create the movement of water throughout the body | Pica (see above - Phosphorous)<br>Salt craving<br>Dehydration<br>Hypothermia<br>Excessive water intake<br>Loss of appetite<br>Rough coat<br>Weight loss<br>Reduced milk production | Reduced growth rate<br>Anorexia<br>Water retention<br>Vomiting<br>Diarrhoea<br>Excessive water intake<br>Muscular spasms<br>Convulsions | |

# APPENDIX 2: MEL SUMMARY DATA

## LEARNING ACTIVITY SUMMARY

| **Activity name**<br><br>**To add more rows right click & select insert / insert rows below* | **Type of activity**<br>• farm visits<br>• seminars<br>• Training<br>• workshop<br>• field days<br>• crop/pasture walk | **Location of activity (LGA)** | **Primary category of participants**<br>• Farmers/Producers,<br>• Government extension officers,<br>• Private consultant or agribusiness agent,<br>• Businesses,<br>• Local farmer groups / networks | **No. of participants (by category)**<br>• Farmers/Producers,<br>• Government extension officers,<br>• Private consultant or agribusiness agent,<br>• Businesses,<br>• Local farmer groups / networks | **Primary focus area** | **Delivery style**<br>• online<br>• face-to-face<br>• dual delivery | **No. of products developed, adapted or used to support activity**<br>• decision tools<br>• information sheets<br>• fact sheets |
|---|---|---|---|---|---|---|---|
| ***EXAMPLE ROW:***<br>*Water management field day* | *Field day* | *Barossa* | *Farmers/Producers* | *Farmers / Producers x 16*<br>*Gov extension officers x 1*<br>*Private consultant or agribusiness agent x 3*<br>*Local farmer networks x 2* | *Managing risks around water security. Improve the management of water resources on farm.* | *Dual delivery* | *Fact sheets x 2* |
| | | | | | | | |
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## COMMUNICATION ACTIVITY SUMMARY

| **Category**<br><br>**To add more rows right click & select insert / insert rows below* | **Overview** | **No. issues/posts/?**<br>**(i.e. how many generated/ produced)** | **No. of subscribers/ visitors/ followers** | **Feedback (if available)** |
|---|---|---|---|---|
| ***EXAMPLE ROW:***<br>*Newsletter* | *SA Drought Hub Monthly Newsletter* | *6 (Jan to July 2022)* | *592* | *Hub partners like receiving updates on the Hub and FDF opportunities that are promoted through the newsletter.* |
| Newsletter | | | | |

| | | | | |
|---|---|---|---|---|
| Website | | | | |
| Social media | Social media posts on AgCommunicators Facebook, Instagram, LinkedIn and X (about July newsletter) | 4 (04/08/2023) | | |
| Media | Interview with A Country Hour, ABC | 1 (09/09/2023) | | |
| Ad hoc communiques to partners | | | | |
| Podcasts | | | | |
| Email | Targeted email to producers and producer groups regarding EOI for project participation<br>Mailchimp email from AgCommunicators | 1 (03/07/2023)<br>1 (July 2023) | | |
| Producer 1-on-1s | Individual discussion with nutrition consultant to go through the results and have producer queries answered | 7 (August 2024) | | |
| Other | 1 pager and powerpoint on project to SAGS<br>Project update presented to Stakeholder Advisory Group | 1 (03/07/2023)<br>1 (28/06/2024) | | |

## ON FARM TRIAL DEMONSTRATION SUMMARY

| **Project name**<br>**To add more rows right click & select insert / insert rows below* | **Activity (type and description)**<br>• Demonstration Site<br>• Trial Site | **Location of activity (LGA)** | **Number of visitors to trial/demonstration (please breakdown by stakeholder category if possible)**<br>• Farmers/Producers,<br>• Government extension officers,<br>• Private consultant or agribusiness agent,<br>• Businesses,<br>• Local farmer groups / networks | **No. of farms participating in trial/demonstration** |
|---|---|---|---|---|
| ***EXAMPLE ROW:***<br>*Increasing soil water retention in cereal crop farming systems.* | *On-farm demonstrations of agronomic techniques to retaining soil moisture in the profile over Summer and Autumn to benefit early season crop establishment.* | *1 x Karoonda East Murray*<br>*1 x Loxton* | • *Farmer / Producer x 30*<br>• *Government extension officers x 5*<br>• *Private consultant or agribusiness agent x 12*<br>• *Local farmer Groups / networks x 3* | *2 Farms participating, Management strategies differ on each farm* |
| Testing for mineral levels in stock and soil | On-farm testing | 3 x Marla-Oodnadatta<br>3 x Nth Flinders | These were producer visits for sample collection there were no additional attendees. Total = 7 producers | 7 farms |

| | | | | |
|---|---|---|---|---|
| | | 1 x Maree-Innamincka | | |
| | | | | |
| | | | | |

## DROUGHT RESILIENCE TOOLS AND PRODUCTS SUMMARY

| **Type of tool/product**<br><br>**To add more rows right click & select insert / insert rows below* | **Primary focus area** | **Overview and purpose** | **Promotion strategies** | **Extent of uptake (if available)** |
|---|---|---|---|---|
| ***EXAMPLE ROW:***<br>*Feed base calculator* | *To determine the amount of feed available to livestock in a paddock.* | *This tool has been developed using information from a number of existing calculators to compliment local conditions and livestock management systems. The calculator will assist in managing paddock stocking rates to maintain sufficient ground cover and livestock nutrition.* | *Through local producer group networks, at field days, via node coordinators* | *25 producers are currently trialing the calculator on their properties.* |
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## COMMERCIALISATION OPPORTUNITIES

| **Type of opportunities**<br><br>**To add more rows right click & select insert / insert rows below* | **Stage of commercialization**<br>• research and product development<br>• on-farm demonstration/trial<br>• market validation<br>• commercialisation | **Comments** |
|---|---|---|
| | | |

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