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Ucharonidge Station

GHG Emissions Assessment – A benchmark and Future Scenarios

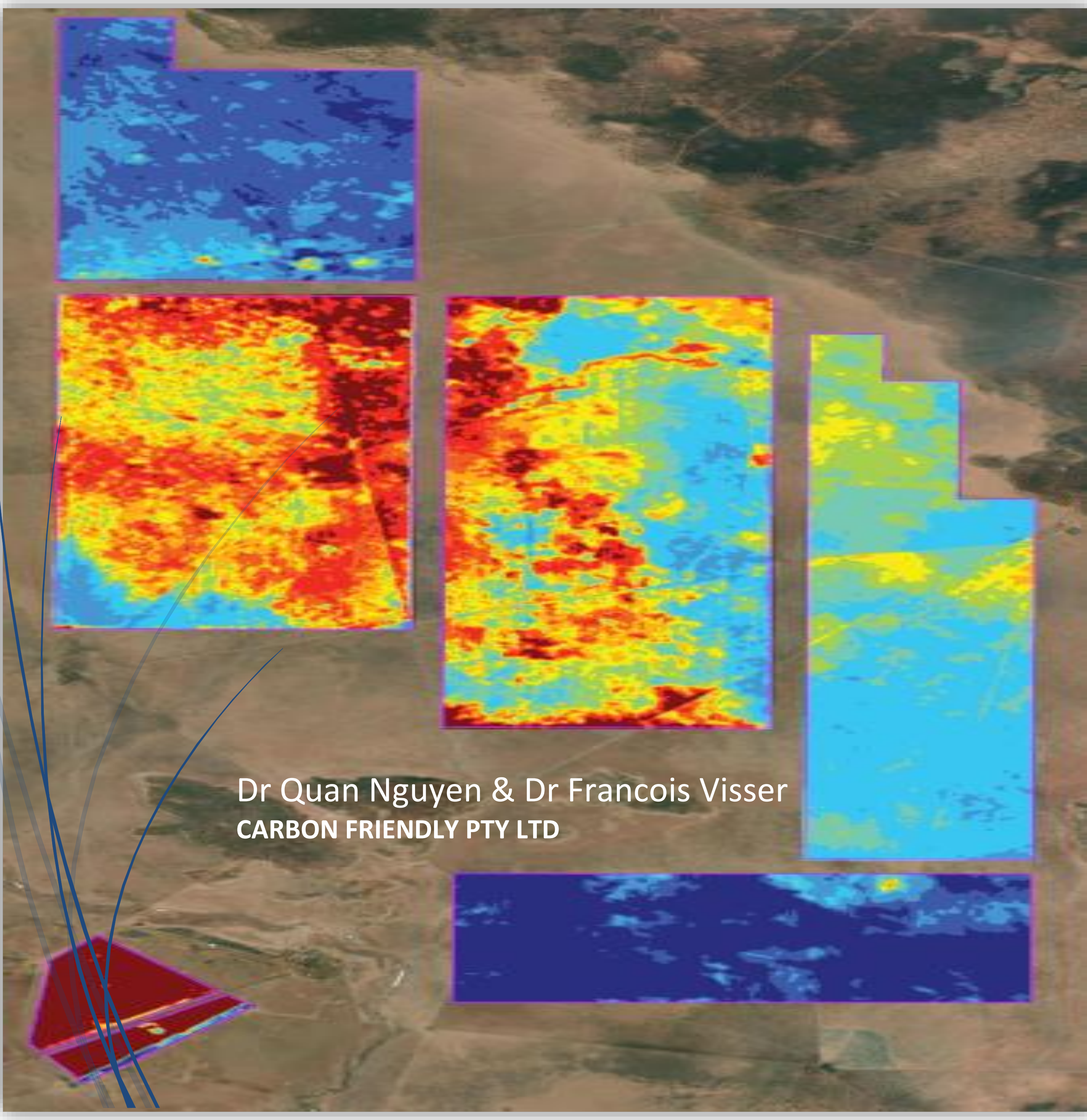

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Table of Contents

List of Tables

List of Figures

Glossary

Term	Explanation
Carbon Friendly^{TM}	Standard developer/owner
CF Certificate/Certification	Carbon friendly Certificate
CF Model	Carbon Friendly Carbon Accounting Model
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
EF	Emissions Factor
GHG emissions	Greenhouse Gas Emissions
GHG reduction	A process that reduces greenhouse gas emissions
GHG removal	A process that capture/ remove carbon oxide from the atmosphere
N_2O	Dinitrogen Dioxide (Nitrous Oxide)
SOC	Soil Organic Carbon
VEG	Native Vegetation zone

Executive Summary

Ucharonidge Station operation is located in the Barkly Tableland of the Northern Territory consists of native pasture areas for grazing and rainfed cropping production system. In recent years, certain areas of native grassland have been converted to dryland cropping and improved pasture for pastoral purposes. These land-use changes resulted in potential greenhouse gas (GHG) emissions directly and indirectly from the loss of native vegetation and the resulting agricultural activities. In this analysis, we modelled the net emissions for ~10,132 ha area at Ucharonidge Station operation in relation to the emissions status before and after the land transformation. GHG emissions were calculated for all the emissions sources using the stipulated Global Warming Potential (GWP100) factors (AR5) and the specific emission factors for Australia from the National Inventory Report (2019). All GHG emission sources and potential carbon sinks were considered, which included:

1) Energy used for farming activities and machinery used for clearing of the native vegetation
2) Emissions from fertiliser used (e.g., in-field emissions and upstream emissions)
3) Use of chemicals (i.e., production of chemicals)
4) Transport of farm inputs
5) Direct emissions from livestock
6) Soil carbon emissions (e.g., soil carbon sequestration and emissions from Urea used)
7) Changes in carbon sequestration/ storage from native vegetation

In addition, the cumulative GHG emissions were modelled for the total approved area of ~10,132 ha (including area of application), up until 2023, by when the full transformation is expected to have occurred. For this purpose, the FullCAM model and LOOC-C (of CSRIO) tool were used to examine changes in the level of soil organic carbon (SOC) and carbon losses associated with land-use changes over time, and these outcomes were then compared to the results from our model.

The results show that the net GHG emissions for Ucharonidge Station operation changed from approximately 3,463 tonnes in 2019 (before any land transformation events) to -35,126 tonnes CO_2e (positive carbon sink) in 2023, assuming 85% of the total approved area was transformed into rainfed cotton, and the cattle herd increased roughly 30% compared to the current size. The three major sources of GHG emissions were 1) enteric methane (CH_4) from livestock, 2) nitrous oxide (N_2O) emissions from crop residues and fertiliser used, and carbon dioxide (CO_2) from fuel used and pre-farm emissions associated with production of chemicals and fertilisers and 3) CO_2 emissions from the loss of native vegetation. The direct emissions from land-use change associated with the loss of native vegetation (land cover) were estimated at 469 t CO_2e for ~320 ha in 2020; 6,525 t for ~ 4,450 ha in 2021, and 12,632 t CO_2e for ~ 8,613 ha in 2023. In addition, the expansion of rainfed cotton from 320 ha to 4,450 and then 8,613 ha respectively for those indicated years, resulted in an increase in GHG emissions of 253 tonnes to 3,489 and then 6,203 tonnes CO_2e, respectively. However, the emissions intensity per 1 bale of seed cotton slightly decreased from 42.67 kg (2020) to 42.36 kg (2021) and 38.91 kg CO_2e in 2023.

Land-use changes also indirectly led to a soil organic carbon (SOC) improvement. Presumably, this was due to an increase in the underground and above-ground biomass from the crops, with all-cotton stalks being incorporated into the soil, and changes in inputs for the cropping system. Particularly, an improvement in SOC in the top layer of 30 cm was found in Dry Paddock (~320 ha of rainfed cotton) at 0.013% per year (equivalent to a reduction of ~2.1 tonne CO_2e per ha) which substantially contributed to offsetting GHG emissions in 2020. Assuming the same rate of SOC improvement for the whole cleared and cropping area from 2020 to 2023, the total GHG emission reduction is likely to increase from -656 to -62,918 t CO_2e, respectively. This significant amount of carbon credits will offset all the emissions from the cropping and livestock production systems and the emissions due to the loss of native vegetation. The results imply that SOC improvement is a crucial factor for Ucharonidge Station operation to reduce its

GHG emissions. A higher SOC improvement rate could be achieved for the cropping area by applying organic amendments such as manure. We assumed a single uniform land type, namely a non-gravelly soil with Mitchell grass as the dominant native vegetation over the large approved area at Ucharonidge Station before clearing. However, one would expect relative differences in the SOC improvement for each area when converted into cropping land depending on the farming practices adopted and the inputs for that area. Therefore, it is recommended that a sufficient number of annual soil samples for SOC testing should be carried out to reduce the uncertainty in evaluating the SOC improvements.

1 INTRODUCTION

Ucharonidge Station is located in the Barkly Tableland of the Northern Territory. The current agricultural operation consists of native grazing pasture and rainfed cropping sytems. In recent years, it was reported that certain area of native vegetation (predominantly Mitchell grassland) has been transformed into cropping land and improved pasture for pastoral. Up to date, land transformation included ~320 ha (Dry paddock) and ~4,920 ha (Mick and Pauls paddock) which has been cleared and converted to cropping such as rainfed cotton since 2019 and 2020, respectively. An additional of ~4,898 ha is expected to be cleared and transformed into cropping land and improved pasture in the near future.

The changes in land use including loss of the native vegetation, expanding cropland and improved pasture are expected to result in increased greenhouse gas (GHG) emissions, while successive application of organic amendments to the agricultural land could improve soil organic carbon (SOC). Increase GHG emissions is likely to occur directly due to the loss of native vegetation and the raising agricultural activities. Particularly, the reduction of the above and below-ground biomass of native vegetation and ground covered area reduce the level of carbon storage in the ecology system.

Estimation of soil carbon loss from forest and agricultural soil systems due to clearing of native vegetation and changes in crop productions using FullCAM has been suggested as a standard approach. However, the feasibility of using FullCAM appears only for the regions which already had crop databases in FullCAM. For the regions where a crop has never been cropped such as cotton in Northern Territory and particularly Ucharonidge Station, there is no such crop database in FullCAM is available for the estimation. Alternatively, a soil test for SOC would provide a measurable indication of changes in soil carbon due to land transformation and cropping practices. Also, GHG emissions associated with the loss of native vegetation can be calculated based on literature (Smith et al., 2013[1], Zhou et al., 2006[2]).

In this study, we analysed the net GHG emissions for the Ucharonidge Station operation (over the total area of 10,132 ha) as the difference between the total emissions from all emissions sources and the total carbon reduction from native vegetation and SOC improvement. The sources of emissions were modelled including the loss of native vegetation, clearing activities and agricultural production systems (e.g., cropping and livestock).

Four scenarios were modelled for pre-clearing (2019), the transformation of ~320 ha (2020), the transformation of ~4,450 ha (2021) and 8,612 ha (approximately 85% of the total approved area, expecting in 2023). For the first three scenarios, we assumed that the livestock herd is remained constant and using the 2021 data as the reference production system. For the 2023 scenario, we expected the full operation of cropping and livestock production to occur, and that livestock herd increased by 30% compared to the current size. Change in crop productivities between 2020 and 2023 included inputs per ha and yield were assumed negligible compared to a reference (base) year of 2020.

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[1] Smith, R. A., & Reid, N. (2013). Carbon storage value of native vegetation on a subhumid -semi-arid floodplain. *Crop and Pasture Science*, *64*(1209–1216). https://doi.org/10.1071/CP13075

[2] Zhou, G., Liu, S., Li, Z., Zhang, D., Tang, X., Zhou, C., Mo, J. (2006). Old-Growth Forests Can Accumulate Carbon in Soils. *Science, 314*(5804), 1417-1417. doi:10.1126/science.1130168

2 INVENTORY DATA ANALYSIS

This section presents the foreground and background inventory data used for the model. Primary data was collected specifically for the rainfed cotton system at Ucharonidge Station for Dry-Paddock and livestock (beef) production system in 2020. These included fertilisers, chemicals, energy use, cropping and native vegetation areas, yield, and herd structure. Soil organic carbon (SOC) was analysed for soil samples taken from pre-clearing, one-crop and two-cropping seasons areas to calculate changes in SOC. Background inventory data and literature value was used if the required data is not available and emissions factors for all farms inputs.

2.1 Farm information and soil organic carbon measurement

The total area in this study was ~10,132 ha (included application area) with approval for land clearing and transformation consists of ~320 ha (Dry Paddock), which has been cropping for two seasons; ~4,916 ha (Paul & Micks) cropping for one season; and 4,898 ha (Rita's Holding, Mick's East and Florence's East) has not cleared or cropped yet (**Figure 1**). In 2019, it was assumed that the total area of 10,132 ha was native grassland as Dry Paddock was not converted into dryland cotton. The native grassland area reduced to approximately 9,812 ha, 5,684 ha and 1,520 ha in 2021, 2022 and 2023, respectively due to land transformation to cropping land and improved pasture. The cropping area for dryland crops was assumed to increase from 320 ha to ~4,450 ha and ~8,613 ha during this period.

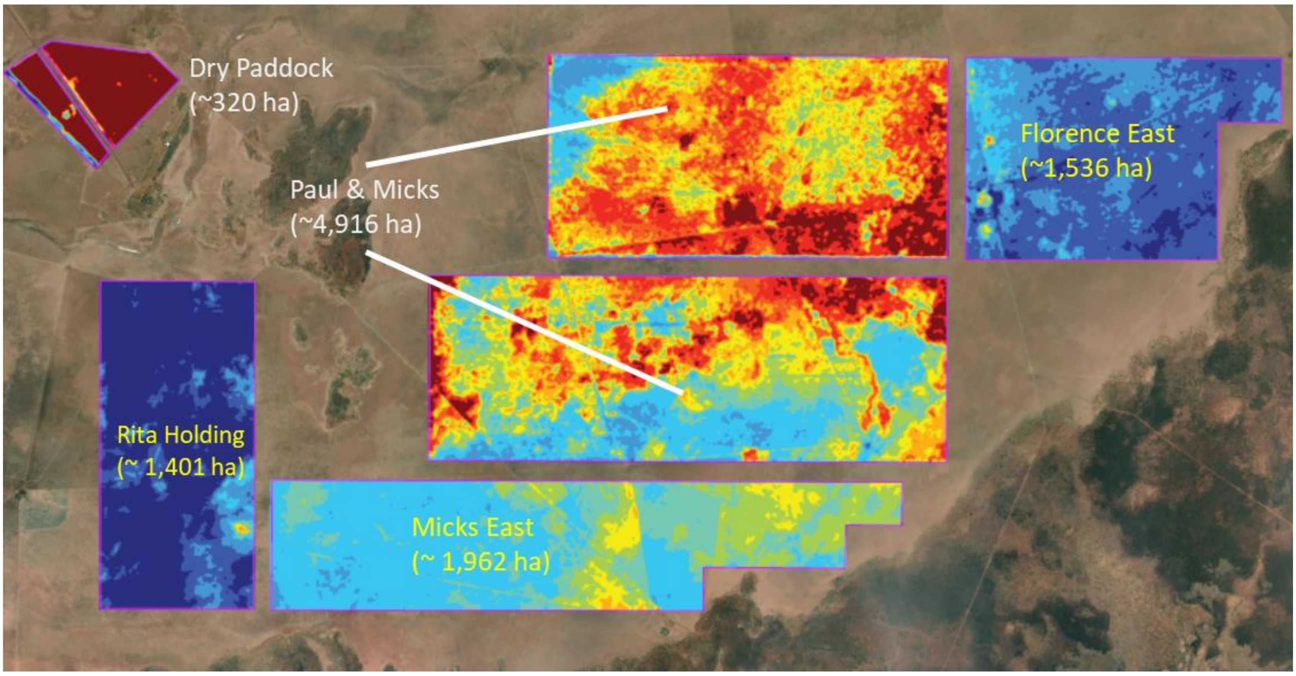

Figure 1. Area of study and average Normalized Difference Vegetation Index (NDVI)

Soil samples were collected for the pre-clearing period, after one season of cropping and after two seasons of cropping. For a pre-clearing period, 2019 soil samples were used, while for the one and two seasons cropping, soil samples were taken in June 2021. The most current soil samples were taken across three farm zones, which was determined by the difference in soil bulk density, elevation and NDVI values in FarmLab[3]. At each farm zone, three soil samples were collected at the depth of 30 cm (**Fig S 1**and **Fig S 2**). Soil samples

[3] FarmLab – GIS Support for Carbon Projects. Retrieved May 2021, from https://www.farmlab.com.au/carbon-projects.

were sent to Environmental Testing and Analysis Laboratory, ALS, Brisbane[4] for analysing total soil organic carbon (SOC) content. The SOC results for each farm zones (**Appendix A**: Soil test results for soil organic carbon in 2019 and 2021) were used to calculate the weighted average of annual SOC for the paddock following the approach described in **Section 5.2**.

The SOC analysis results for the topsoil layer of 30 cm ranged between 0.16 and 0.25% in 2019, and from 0.18 to 0.26% in 2021 for the Dry Paddock (**Appendix A**: Soil test results for soil organic carbon in 2019 and 2021). For this paddock, the weighted average of SOC increased from 0.205 (2019) to 0.230% (2021), which was equivalent to an annual increase of ~2.1 tonnes of CO_2e per ha (with the average soil bulk density of 1.47 for the 30 cm topsoil layer). The initial regression equation presented the increased trend in SOC for the studied area, which was determined from the soil test results, is $Y = 0.0127 \times X - 25.377$. Using this equation, we estimated SOC for 2023 scenarios, and the total soil carbon sequestration was calculated based on the equivalent SOC% rate for different relevant areas (**Table 1**).

Table 1. Summary key inventory for soil carbon sequestration calculation

Year	Relevant area (ha)	Bulk Density (g/cm^3)	Soil depth (m)	SOC (%)	Total soil emission* (tonne CO2e)
2019	10,132	1.47	0.3	0.2050	-
2020	320	1.47	0.3	0.2177	-656
2021	4,449	1.47	0.3	0.2303	-9,772
2023	8,711	1.47	0.3	0.2557	-62,918

**total carbon sequestration was adjusted for specific SOC% of different relevant area. For example, in 2023, SOC% was 0.2557%, 0.2303% and 0.2177% for 320 ha (3 seasons crop), 4,129 ha (2 season crop), and 4,163 ha (1 season crop)*

2.2 Fuel use for clearing activities

The total expected fuel use for clearing the approved native grassland area of 4,898 ha was approximately 40,800 L of diesel. The amount was the combination of diesel required for Offsets area (32,657 L) and Kelly chains area (8,164 L), where an average of 60 L and 30 L of diesel per hour would be required for Offsets at 9 ha per hour and Kelly chains at 18 ha per hour, respectively. The total GHG emissions from fuel used for clearing activities were calculated including CO_2 (major component); and CH_4, NOx, CO, NMVOC and SO_2 (as the minor component) were calculated using the following equation:

$$\mathbf{E = F \times D \times P \times EF \times 10^{-6}} \qquad \text{(Eq. 1)}$$

Where **E** is the total CO_2e emissions of a specific gas (kg), **F** is the amount of diesel used (L), **D** is the energy density of diesel, 38.6 (Gg/kL), **P** is the oxidation factor for CO_2 (99%), EF is the emission factor for the different gas (Gg CO_2/PJ). The specific emissions factors for the different gases are shown in **Table 2**.

Table 2. Emissions factors applied for calculation of diesel used

Gas	**EF** (Gg CO_2/PJ)
CO_2	69.9
CH_4	0.01
N_2O	0.002
NO_x	1.36
CO	0.54
NMVOC	0.19
SO_2	0.116

Source: National Inventory Report 2019

[4] ALS Brisbane laboratory. Environmental Testing and Analysis. https://www.alsglobal.com/en-au/locations/asia-pacific/pacific/australia/queensland/brisbane-food,-environmental

2.3 Farm inputs and productivities for cropping system

Major farm inputs to the rainfed cotton production system are fertiliser, chemical, fuel use for mechanical on-field operations and transports of inputs. The total cropping area, inputs and productions for the rainfed cotton in 2020, 2021 and 2023 was shown in (**Table 3**).

Table 3. Summary key farm inputs inventory for cropping system

Parameter	2019	2020	2021	2023	Unit
1. Crop productivities					
Area sowed (harvested)	-	320.0	4,448.8	8,612.6	ha/farm
Harvested amount	-	1,345	18,693	36,189	tonnes
Average yield	-	4.20	4.20	4.20	t/ha
The studied area	10,132	10,132	10,132	10,132	ha
Co-product amount (cottonseed)	-	635	8,823	17,081	tonnes
Leave stalk on the field	no	yes	yes	yes	
2. Fertiliser use					
Average N-fertiliser applied*	-	62.2	62.2	62.2	kg N/ha
Urea application (incl. in the above)	-	43.3	601.8	1,165.0	Tonne urea
3. Chemical use					
Insecticide *(only Transform was reported)*	-	0.1	0.9	1.7	kg/year
Herbicide *(the only Roundup was reported)*	-	960	13,346	25,838	kg/year
Defoliants	-	256	3,559	6,890	litres/year
Adjuvants and others	-	-	-	-	litres/year
4. Energy use					
Diesel consumption for crops	-	10,499	145,963	282,573	litres/year
5. Native Vegetation (ha)					
Native grasses area	10,132	9,812	5,684	1,520	ha
Cropping area	-	320	4,448	8,612	ha
Total area modelled (ha)	**10,132**	**10,132**	**10,132**	**10,132**	**ha**

**A benchmark value of 40 kg N per ha (~135 kg Urea 46%) for dryland cotton taken from Gross margin dryland cotton (NSW DPI) was used as the farm data was not available.*

2.4 Livestock production inventory data

The inventory data for livestock production for the year 2020 (**Table 4**) was considered as the reference year. It was assumed that the changes in the herd size and structure between 2019 and 2021 are relatively small. However, the total herd would be increased by 30% due to more available cottonseed and hay on the farm when 85% of the approved area is converted into cropping land. The total fuel (e.g., the combination of diesel, petrol, and Avgas) used for livestock production was reported at 281,588 L which was assumed to remain constant during the 2019-2021 period, however, would be expected to increase by 30% in 2023, conservatively. We noted that the reported fuel consumption included the usage for electricity generation and that there was not direct consumption of electricity on farm at the time of this report.

Table 4. Summary livestock structure in 2020

Parameter	Bull (>1 year)	Steers (1-2 yr)	Cows (>2 yrs)	Heifers (1-2 yrs)	Unit
Livestock number	366	24	7,777	6,784	Head
Liveweight	600	170	420	420	Kg/head
Average live weight gain	-	1.10	-	0.99	kg/day

Background inventory data included feed composition, nutrient requirement and emissions factors (EF) for each class of animal were taken from National Inventory Report 2019. Briefly, the average annual crude protein (CP) and dry matter digestibility (DMD) was calculated as 16% and 68%, respectively which often varied depending on different seasons of the year. For example, CP of feed ranges between 7% (in Summer) to 25% (in Spring), or DMD varies between 55% (in Summer) to 80% (in Spring) (NIR 2019).

Table 5. Summary key inventory data for livestock production

Parameter	Seasons	Bull (>1 year)	Steers (1-2 yr)	Cows (>2 yrs)	Heifers (1-2 yrs)	Units
Feed Intake (I)	Spring	8.8	5.0	1.0	8.7	kg DM/head/day
	Summer	8.8	3.9	8.7	7.5	kg DM/head/day
	Autumn	8.8	4.2	6.9	7.7	kg DM/head/day
	Winter	8.8	4.2	6.9	7.3	kg DM/head/day
Gross Energy intak (GEI)	Spring	163	91	19	160	MJ/head/day
	Summer	163	73	160	138	MJ/head/day
	Autumn	163	77	128	141	MJ/head/day
	Winter	163	78	128	134	MJ/head/day
Daily Methane Yield	Spring	0.278	0.142	0.005	0.272	kg CH_4/head/day
	Summer	0.278	0.107	0.273	0.231	kg CH_4/head/day
	Autumn	0.278	0.114	0.211	0.237	kg CH_4/head/day
	Winter	0.278	0.117	0.211	0.224	kg CH_4/head/day
Total rumen CH_4	Spring	9.27E-03	3.12E-04	1.68E-01	3.90E-03	Gg CH_4
	Summer	9.27E-03	2.34E-04	1.05E-03	1.94E-01	Gg CH_4
	Autumn	9.27E-03	2.50E-04	1.08E-03	1.50E-01	Gg CH_4
	Winter	9.27E-03	2.55E-04	1.02E-03	1.50E-01	Gg CH_4
	Total	**3.71E-02**	**1.05E-03**	**1.71E-01**	**4.97E-01**	**Gg CH_4**
Total faecal & urinary-N_2O	Spring	1.84E-02	5.80E-04	3.24E-01	2.52E-02	Gg N_2O
	Summer	5.08E-03	1.19E-04	5.60E-04	9.23E-02	Gg N_2O
	Autumn	7.31E-03	1.80E-04	8.29E-04	1.22E-01	Gg N_2O
	Winter	1.55E-02	4.35E-04	1.73E-03	2.58E-01	Gg N_2O
	Total	**4.63E-02**	**1.31E-03**	**3.27E-01**	**4.97E-01**	**Gg N_2O**

Feed intake and gross energy were calculated for different classes of animals for different seasons of the year based on their live weight (W) and live weight gained (LWG) based on Equations 2 and 3. Total enteric methane (CH4) production and nitrous oxide (N_2O) emissions from animal manure were calculated based on the total feed intake which was presented in **Table 5**.

$$\mathbf{I = (1.185 + 0.00454 \times W - 0.0000026 \times W^2 + 0.315 \times LWG)^2 \times MA} \qquad \text{(Eq. 2)}$$

Where I is the total feed intake (kg), W is the live weight of an animal (kg), LWG is the average daily live weight gain (kg), and MA is the addition feed intake for milk production (only for cow).

$$\mathbf{GEI = (I \times 18.4)} \qquad \text{(Eq. 3)}$$

Where GEI is the gross energy intake (MJ), and I is the total feed intake (kg) derived from Equation 2.

2.5 Carbon sequestration rate for native vegetation

Extensive research studies[5,6], have provided guidelines on the carbon sequestration rates of the different native vegetation (VEG) types. Five types of VEG systems, which sequester additional carbon from the atmosphere on an annual basis, were considered in our model including woody vegetation (woodland), shrub and savanna, native grasses, improved pasture, and riparian. Changes in these vegetation types or annual ground cover on-farm between 2019 (pre-clearing) and 2023 (after clearing) were assumed to be in reverse correlation with the expansion of cropping land. The specific area for each VEG type was determined from Google Earth Pro[7] and FarmLab, online platforms. Carbon sequestration is calculated for the VEG area (zones) suggested by Minister for the Environmental and Energy (2021)[8]. Following the estimation of the VEG area for different vegetation types, we employ conservative sequestration rates (**Table 6**) to calculate the potential carbon sequestration for the VEG system. Carbon sequestration from the VEG system is allocated for the assessing production system based on the area which excludes areas of roads/infrastructure.

Table 6. Carbon sequestration rate applied for different native vegetation

Category	Sequestration rate* (t C/ha)	2019	2020	2021	2023
Native Grasses	0.40	10,132	9,812	5,684	1,520
Cropping Area	-	-	320	4,449	8,613
Total area modelled (ha)		**10,132**	**10,132**	**10,132**	**10,132**

[5] Luyssaert, S., Schulze, E. -., Börner, A., Knohl, A., Hessenmöller, D., Law, B. E., . . . Grace, J. (2008). Old-growth forests as global carbon sinks. *Nature, 455*(7210), 213-215. doi:10.1038/nature07276

[6] Zhou, G., Liu, S., Li, Z., Zhang, D., Tang, X., Zhou, C., Mo, J. (2006). Old-Growth Forests Can Accumulate Carbon in Soils. *Science, 314*(5804), 1417-1417. doi:10.1126/science.1130168

[7] Google Earth Pro. Google (2021). Available at: https://www.google.com/earth/download/gep/agree.html?hl=en-GB

[8] Minister for the Environmental and Energy (2021) *Carbon Credits (Carbon Farming Initiative—Measurement of Soil Carbon Sequestration in Agricultural Systems) Methodology Determination 2018*. Attorney-General's Department. Available at: https://www.legislation.gov.au/Details/F2018L00089 (Accessed: 7 June 2021).

3 RESULTS & DISCUSSION

3.1 Total GHG emissions from machinery used for clearing

The total GHG emissions from diesel used for clearing 4,898 ha was estimated at 112.4 tonne CO_2e. Of which, CO_2 accounted for ~97% of the emissions, NOx accounted for 2% of the emissions and <1% of the total GHG attributed for other gases (**Figure 2**). We expected that this clearing activity would occur between 2021 and 2023 depending on the actual time that the project is approved. Therefore, this total emission was not accounted for in 2023 and is dependent on the net GHG emissions calculated for the 2023 scenario.

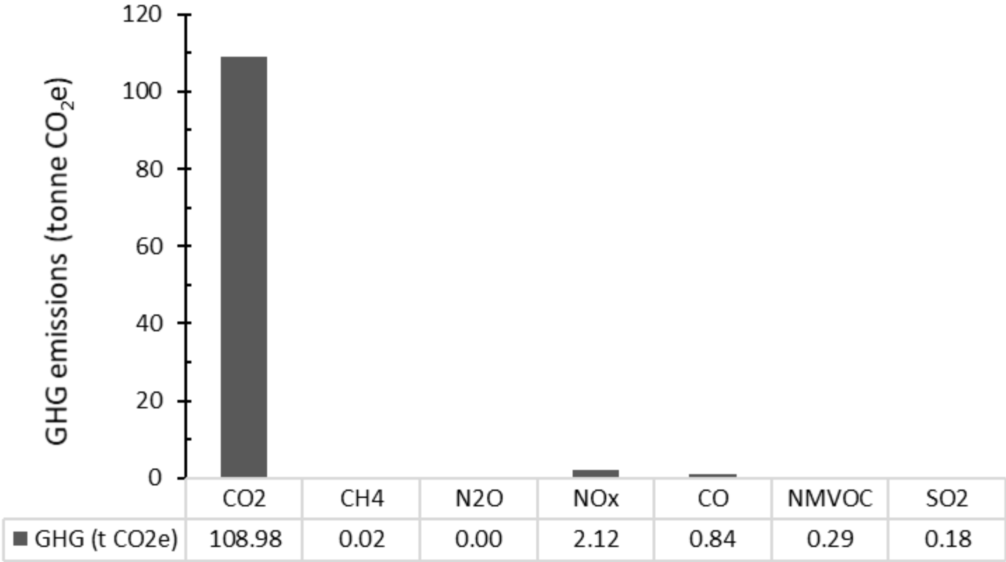

Figure 2. Total GHG emissions associated with diesel used for clearing 4,898 ha of native vegetation areas

3.2 Total GHG emissions from the loss of native vegetation and cumulative impacts

Direct emissions associated with the loss of native vegetation (VEG) area was estimated at 469; 6,525 and 12,632 tonne CO_2e in 2020, 2021 and 2023, respectively which was corresponded to the clearing of approximately 320 ha, ~4,450 ha and ~8,613 ha. It is noted that this emission was due to the loss of carbon storage from the reduced VEG area over time. We assumed that the loss rate of carbon was 0.4 tonne C per ha per year (**Table 7**), equivalent to 1.47 tonne CO_2e per ha per year. The cumulative direct GHG emissions due to the loss of the whole studied area of ~10,132 ha VEG was estimated at 14,861 tonne CO_2e. Of which, GHG emissions associated with the loss of 4,898 ha was 7,184 tonne CO_2e.

Table 7. Estimated GHG emissions associateed with the loss of native grasses between 2019 and 2023

Category	Sequestration rate (t C/ha)	2019	2020	2021	2023
Native Grasses	0.40	14,861	14,392	8,336	2,229
Shrub/savanna	0.47	-	-	-	-
TOTAL GHG emissions (t CO_2e)		14,861	14,392	8,336	2,229

3.3 Total GHG emissions from the crop production system

Total GHG emissions from the major crop production (e.g., rainfed cotton) were estimated at 320; 4,428 and 8,021 tonne CO_2e in 2020, 2021 and 2023 scenario, respectively (**Table 8**). The increase in the total GHG emissions was corresponding to the expansion of rainfed cotton production during this period. The results suggested that GHG emissions from on-farm fuel used for the mechanical operations was the second greatest contributors, accounted for between 30% and 32% of the total emissions in the crop production system in 2020 and 2023, respectively.

Table 8. Total GHG emissions of rainfed cotton production between 2020 and 2023

Sources	2020	2021	2023
Fertiliser use	79	1,097	1,574
Chemicals use	18	257	497
Electricity for crop*	-	-	-
Emissions from crop residues	124	1,730	3,350
On-farm fuel use	29	397	769
Transports	2.4	7.5	12.7
Total GHG emissions (t CO_2e)	**253**	**3,489**	**6,203**

**no electricity from grid was used. Diesel was used to generate electricity for on-farm use.*

The biggest contributor to GHG emissions is crop residue, namely cotton stalk. This residue when left on-field release a considerable amount of nitrogen to the soil environment and is consequently emitted as N_2O emissions either directly or indirectly through leaching and run-off. The total N derived from cotton stalk remained in the field was estimated at ~30, 416 and 805 tonnes in 2020, 2021 and 2023, respectively, with the residue to crop ratio, was 1.9, dry matter content of the stalk was 90% and below-ground biomass ratio was 0.3 (NIR 2019, volume 1). We assumed that direct CO_2 emitted from cotton residue due to the decomposition was part of biogenic carbon, which was captured from the photosynthesis process during cotton growing, therefore these short-term emissions did not contribute to the actual emissions in the system. In contrast, it appears that cotton residue when was left on the field contributed to improving soil organic carbon, which was partly shown in the soil test results of the topsoil layer of 30 cm.

The detailed GHG emissions profile of the rainfed cotton production at Ucharonidge Station between 2020 and 2023 was shown in (**Table 9**). The results showed that N_2O was the dominant contributor to GHG emissions, accounted for between 57% and 63% of the total GHG (between 144 to 3,886 tonnes CO_2e in 2020 and 2023, respectively). Of which, N_2O emissions from crop residues is the largest contributor, accounting for approximately 124 to 3,350 tonnes CO_2e in 2020 and 2023, respectively. The second biggest N2O emissions contributor was direct and indirect (e.g., leaching and run-off) emissions from fertilisers used. The second contributor to GHG emissions was CO_2 from fuel used and pre-farm emissions associated with production of chemicals and fertilisers used (between ~108 to 2,315 tonne CO_2e in 2020 and 2023, respectively). CH_4 and other GHG emissions contributed less than 1% of the total emissions in the crop production system, which is consistent to literature on Australian dryland cotton production system.

Table 9. GHG emissions profile of rainfed cotton production overtime

GHG emissions profile	2020	2021	2023*
CO_2 -Energy	28	396	766
CO_2 -Lime	-	-	-
CO_2 - Urea application	32	441	854
CO_2- production of fertiliser use	27.3	379.7	185.9
CO_2 - production of chemicals used	18.5	256.5	496.6
CO_2 - emissions from transport of farm inputs	2.4	7.5	12.7
N_2O - Fertiliser direct emissions	16.6	230.5	446.3
N_2O - Crop residues (above & below ground)	124	1,730	3,350
N_2O - Atmospheric deposition from fertiliser	1.7	23.1	44.6
N_2O - Leaching and Runoff fertiliser	1.6	22.3	43.2
N_2O - Field Burning	-	-	-
N_2O - Energy	0.08	1.13	2.18
CH_4 - Field Burning	-	-	-
CH_4 - Energy	0.04	0.56	1.09
Emissions from Crops	**253**	**3,489**	**6,203**

**it was expected that 85% of the total approved area (~8,613 ha) was transformed into rainfed cotton production*

3.4 Total GHG emissions from the livestock production system

GHG emissions from livestock production in 2020 and 2021 were estimated at 18,322 tonne CO_2e (**Table 10**), of which 81% was the enteric methane (CH_4) emissions. The second biggest contributor to GHG emissions of the current livestock production system at Ucharonidge was the direct and indirect N_2O emissions from manure and urine which accounted for ~15% of the total emissions. The remaining emissions are associated with CO_2 emissions from fuel used for the production of feed and other activities in this system. We noted that the contribution of feed production to the total GHG emissions in the livestock production system would be reduced when cotton production is expended as more cottonseed would be available as the feed supplementary. However, since the major contributor to GHG emissions in the livestock system is CH_4, it is not likely to reduce a large amount of GHG emissions in 2023 scenarios.

In 2023 scenarios, we expected that the livestock herd would be expended due to the availability of cottonseed which can be used as supplementary feed. The estimated total GHG emissions were estimated at 23,820 tonne CO_2e for 30% expansion of the current herd. The total GHG emissions from CH_4 is likely to be > 19,000 tonnes CO_2e and from N_2O is projected to be ~3,500 tonne CO_2e. The remaining emissions are approximately 1,000 tonne CO_2, primarily derived from fuel use. We noted that the actual expansion and change in the livestock herd at the time when is reported would provide more accurate inventory data to improve the calculation of GHG emissions from the livestock system.

Table 10. Summary GHG emissions from livestock production

GHG emission profile	2020	2021*	2023**
CH_4 - Enteric	14,845	14,845	19,298
CH_4 - Manure	9	9	11
N_2O - Indirect	1,554	1,554	2,020
N_2O - Dung, Urine	1,138	1,138	1,480
CO_2 - Energy	776	776	1,009
Total GHG emissions (kg CO_2e)	**18,322**	**18,322**	**23,818**

**Assuming the change in the herd size was negligible between 2020 and 2021; ** expected 30% larger herd*

3.5 Net GHG emissions

Net GHG emissions of Ucharonidge Station operation, which was the difference between the total emissions and reduction/carbon sink sources, was reduced from 3,463 tonne CO_2e in 2019 to -35,126 tonne CO_2e in 2023 (**Figure 3**). The substantial reduction in the net GHG emissions was expected due to SOC improvement for the cropping area with the current rate at 0.0135% (~2.1 tonne CO_2e per ha per year). The current improvement in SOC was similar to that of carbon sequestration rate at 2.13 t CO_2e per ha per year, which could be achieved by "*Reforestation by environmental or mallee plantings"* under the Vegetation method used in LOOC-C to estimate the carbon credit for the total area[9] of 10,925 ha at Ucharonidge Station (**Appendix B**: Estimated soil organic improvement per year over 25 years from LOOC-C). Using the "*Measurement of soil carbon sequestration*" under the Agricultural method in LOOC-C, the estimated carbon sequestration rate was at 0.66 tonne CO_2e per ha per year, which was one-third of our current rate used in the model. Nonetheless, LOOC-C estimated that the average SOC for the whole area was 0.4% which was much higher than the actual soil test results at Ucharonidge Station both in 2019 (average of 0.21%) and 2021 (average of 0.32%).

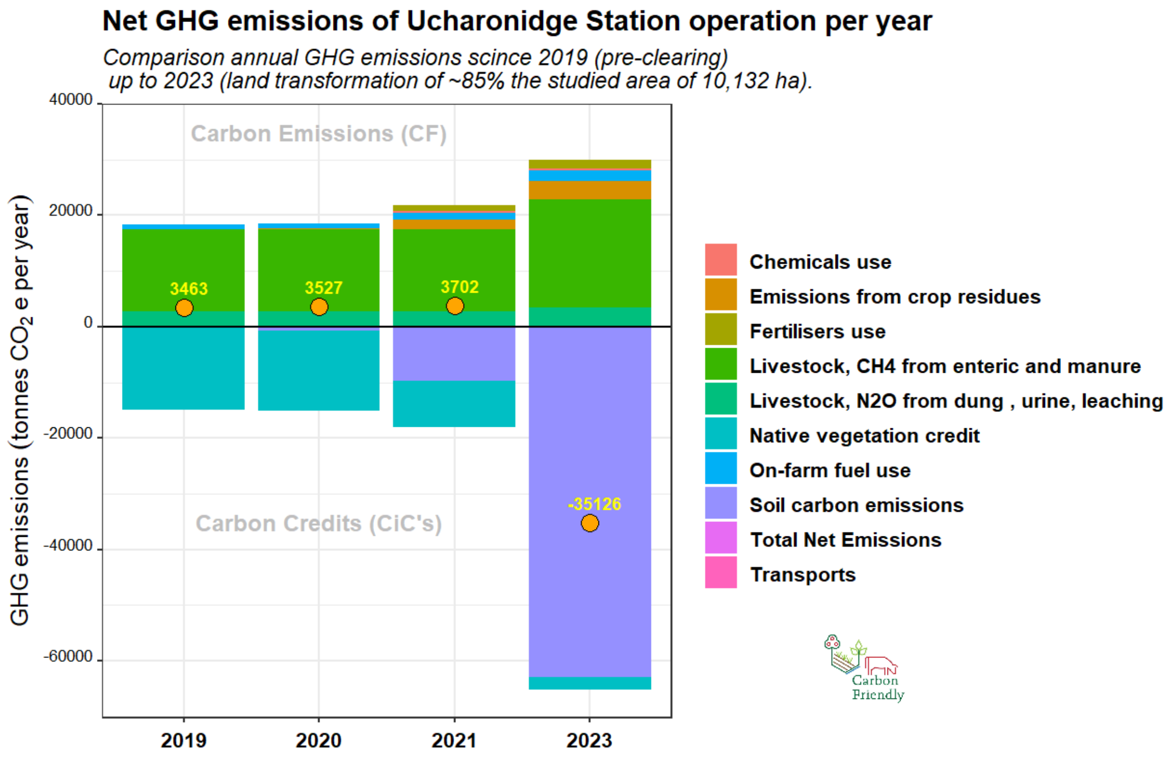

Figure 3. Net GHG emissions of Ucharonidge Station between 2019 (pre-clearing) and 2023 (after land transformation); dot-points presented the net GHG emissions (the difference between the GHG emissions sources and sinks).

Comparing the emissions intensity per 1 ha of land use between 2019 (pre-clearing) and 2023 (after clearing) over the total studied area of ~10,132 ha shows that the net GHG emissions intensity likely reduced from 0.34 tonne CO_2e to -2.59 tonne CO_2e. This suggests that SOC improvement is the determining factor to reduce the net emissions at Ucharonidge Station.

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[9] included the study area, with an assumption of 5% excluded area such as dam, buildings, road etc.

In this analysis, we assumed that the crop yield does not increase between 2020 and 2023, as well as the livestock production efficiency remains relatively constant. We noted that any improvement in the crop yield and/or livestock production could significantly reduce the net emissions. In addition, a change in SOC is highly sensitive to net GHG emissions.

3.6 GHG emission by gas type

The results suggested that CH_4 emissions are the dominant contributor to GHG emissions in the livestock system, while CO_2 emissions are the largest contributor to the cropping system between 2019 and 2023 (**Figure 4**). Of livestock production system, CH_4 accounted for 81% of the total GHG emissions, which primarily derived from enteric and manure (as discussed above). For the cropping system, the majority of CO_2 emissions was found associated with fuel used for machinery operation on-farm, and the production of fertiliser and chemical use, which was pre-farm emissions. For both systems, N_2O emissions accounted for less than 25% of the total GHG emissions between 2019 and 2023.

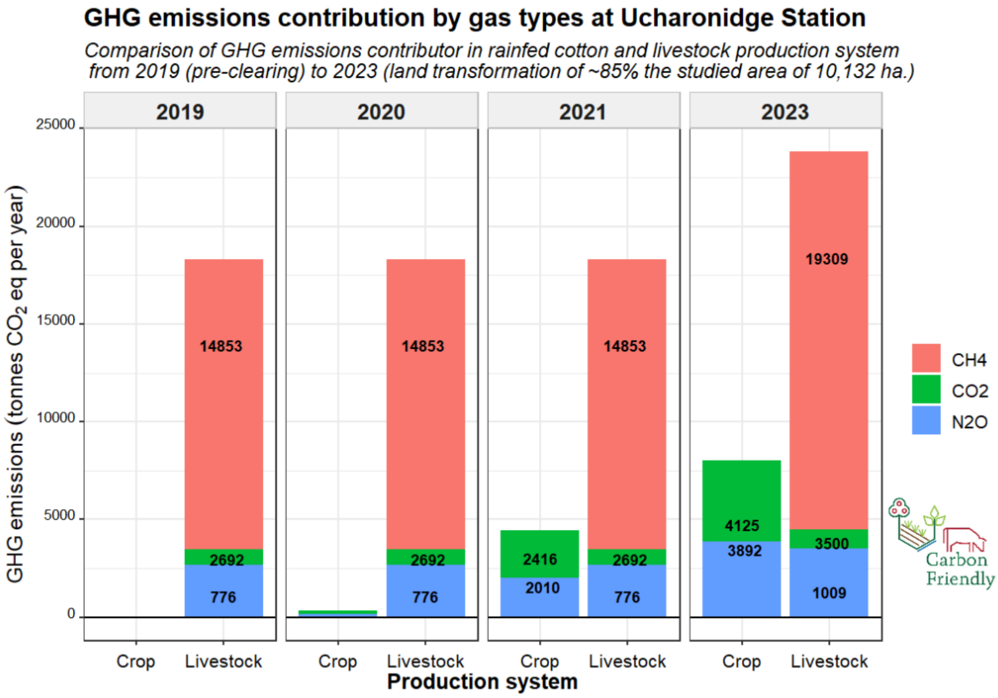

Figure 4. GHG emissions contribution by gas types for the cropping and livestock system at Ucharonidge Station from 2019 (pre-clearing) to 2023 (after land transformation of 85% of the approved area).

4 CONCLUSION

Ucharonidge Station consists of farming areas for grazing and rainfed cropping. In recent years, certain areas of native grassland have been converted to rainfed cropping and improved pasture for grazing purposes. These land-use changes resulted in potential greenhouse gas (GHG) emissions directly and indirectly from the loss of native vegetation and the resulting agricultural activities. In this analysis, we modelled the net emissions for a studied area of 10,132 ha at Ucharonidge Station operation (including cattle emissions) in relation to the emissions status before and after the land transformation.

The results show that net GHG emissions for the studied area at Ucharonidge Station operation changed from approximately 3,463 tonnes in 2019 (before any land transformation events) to -35,126 tonnes CO_2e (positive carbon sink) in 2023, assuming 85% of the total studied area was transformed into dryland cotton, and the cattle herd increased roughly by 30% compared to the current size. The substantial reduction in GHG emission was due to the potential improvement in SOC over the large cropping areas and improved pastures. This is a remarkable outcome whereby resulting land-use change emissions can be offset through eco-friendly cropping practices (e.g., leaving cotton stalk on the field, minimum-till, etc.) and the application of organic amendments on the farm.

We noted that the improvement in SOC, crop productivities and livestock production efficiency is the most sensitive factors to the net GHG emissions outcome. Although soil test results suggested that the current SOC improvement at Ucharonidge Station is relatively small at 0.0135%, it significantly contributed to offset the total GHG emissions in this operation. It is suggested that a larger number of soil samples for SOC testing over the whole studied area of 10,132 ha would strengthen the SOC improvement trend and reduce uncertainty in this regard.

Acknowledgement: We sincerely thank Jenni Seigmeier of Cleveland Agriculture Pty Ltd, for providing inventory data for cropping system and livestock production at Ucharonidge Station; Dallas King of Northern Plains Agriculture Pty Ltd and Nicholas McGrath for soil sampling performance at Ucharonidge Station. We also thank other staff members of Cleveland Agriculture and Ucharonidge Station for all their assistance in providing the data and answering our many queries that enabled us to make a detailed assessment.

Disclaimer

The calculations and analyses in this report are based on published scientific methodologies as far as possible and on input data provided by the company. We have carried out our best endeavours to ensure that the results are accurate and a true reflection of the situation, given that data inputs were not always complete. In cases where we were not provided with data for paddocks, we have made assumptions based on average values for similar paddocks where data was available. Several validations were undertaken on the extraction of input data and the results of the modelling to ensure that results are as reliable as possible. To the maximum extent permitted by law, Carbon Friendly Pty Ltd disclaims all liability for any loss, damage, expense and /cost incurred by any person arising from the use of the information contained in this report.

5 METHODOLOGY

5.1 Carbon Friendly Standard Method and Carbon Footprint model

The scientific basis and methodology of the carbon footprint model is a part of the registered Climate Friendly™ Certification Standard (CF-IP 2110771). This proven method is based on peer-reviewed published scientific research studies by Visser et al.[10,11] in compliance with the international GHG emissions protocol guidelines[12] and adopted the Performance Tracking of the same product over time. Although the Standard does not require third party assurance for these types of comparisons, we are in the process of engaging the services of AUS-QUAL[13], a leading global third-party sustainability verification agency to certify the integrity and also the application of the methodology.

Briefly, relevant GHG emissions were calculated for all inputs used for the assessed crop (i.e., fertilisers, energy and chemical), direct and indirect field emissions, changes in soil organic carbon and native vegetation on-farm and transports of inputs and products. Formulas, algorithms, and emissions factors employed by Carbon Friendly™ for the GHG emissions simulation model are derived from the Intergovernmental Panel on Climate Change (IPCC)[14] and the Australian National Greenhouse Gas Inventory[15].

The accuracy of analysis and results are dependent on primary data collected at farm levels. It is noted that while most of the quantitative data for inputs for the production system are highly robust and straightforward to be used in the model after verification such as fertiliser, chemical and energy use, some factors are relatively sensitive to the results and appears to be challenging. Particularly for soil tests data, a laboratory can determine what the carbon or nitrate levels are in the samples, but it is not possible to put a dome over a farm and measure what the emissions are that are emanating from the soils or the native vegetation, especially with changes in climatic conditions. Therefore, Carbon Friendly has developed an emissions simulation model where we endeavour to calculate these various emissions as accurately as possible. Background data and/or data that is not available on-farm are taken from literature, national Life Cycle Inventory databases for agriculture such as AusLCI[16]. Our aim is also to advance the science and location accuracy in this space, in particular by utilising as many site-specific data sources and emission factors as possible.

5.2 Soil Carbon Calculation

There is growing recognition of the important role of agriculture which is highly potential to reduce the total GHG emissions. The reduction is expected by lowering emissions intensity from the agricultural product supply chain and increasing SOC level via improving sequestration in soil and VEG zones. Improvement in SOC over time suggests an increase in soil carbon stocks due to changes in farming practices which is identified as one of the key factors that could provide significant potential abatement from a cropping system. Therefore, *Carbon Friendly*™ has placed specific emphasis on developing and incorporating the

[10] Visser, F., Dargusch, P., Smith, C., & Grace, P. R. (2014). A Comparative Analysis of Relevant Crop Carbon Footprint Calculators, with Reference to Cotton Production in Australia. *Agroecology and Sustainable Food Systems, 38*(8), 962-992. doi:10.1080/21683565.2014.923799

[11] Visser, F., Dargusch, P., Smith, C., & Grace, P. R. (2015). Application of the Crop Carbon Progress Calculator in a 'farm to ship' cotton production case study in Australia. *Journal of Cleaner Production, 103*, 675-684. doi:10.1016/j.jclepro.2014.09.093

[12] Bhatia, P., Cummis, C., Draucker, L., Rich, D., & Lahd, H. (2011). *Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard* (pp. 1-148, Rep.). Washington, D.C.: Greenhouse Gas Protocol.

[13] AusQual 2021. https://www.ausmeat.com.au/links-tools/aus-qual-certification-application-forms/

[14] The Intergovernmental Panel on Climate Change. (n.d.). Retrieved May, 2021, from https://www.ipcc.ch/

[15] Department of Industry, Science, Energy and Resources. (2020, July 21). National Greenhouse Gas Inventory. Retrieved January, 2021, from https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-quarterly-updates

[16] The Australian National Life Cycle Inventory Data (AusLCI). Retrieved May, 2021, from http://www.auslci.com.au/

methodology of how these potential reductions and removal sources can contribute to reducing the net GHG emissions of a production system in the simulation modelling.

5.2.1 Calculation of soil carbon sequestration

Annual site-specific SOC level and VEG zones are determined by soil carbon test and/or modelling approach for various field zones depending on soil conditions and farm size, following sampling protocol by FarmLab[17] and the Official guidance e.g. Sampling guidance for measurement-based soil carbon methods (The Clean Energy Regulator, 2021)[18]. These data are used to calculate to what extent the soil carbon stocks and corresponding emissions may have changed over the assessment period. Soil carbon stocks are calculated for the total harvested area of the assessed crops, using a site-specific regression equation of historical annual SOC for the topsoil layer of 0.3 m following the national guidelines e.g., Carbon Credits[19] and Managing Soil Organic Matter (GRDC, 2013)[20].

Change in soil carbon stock (ΔC_{soil30}) for the relevant production system in the reporting period is calculated based on the SOC results for the 0.3 m topsoil layer and expressed in tonnes of carbon per year and/or kg CO_2-e per tonne of product, using the following equation[21].

$$\mathbf{\Delta Csoil30} = \sum_{i=1}^{n}(\mathbf{\Delta Csoili - CNSFi}) \qquad \text{(Eq. 4)}$$

Where: ΔC_{soil30} is the change in soil carbon stock at the topsoil layer of 0.3 m (tonne carbon) between the base year and the reporting year; $\Delta C_{soil\ i}$ is the value for the change in soil organic carbon stocks at zone i of the production system over the reporting period; $CNSF_i$ is the total amount of organic carbon in all non-synthetic fertilisers applied (e.g., animal manure, compost and organic amendments) to the production zone over the reporting period. Soil organic carbon at a given year (C_{soil}) is calculated as a weighted average of SOC results from the soil tests (CF) for different production zones or paddock (i), which varies depending on soil bulk density (BD).

$$\mathbf{C_{soil}} = \sum_{i=1}^{n}(\mathbf{CFi} \times \mathbf{BDi} \times \mathbf{Vi})/\ \mathbf{V} \qquad \text{(Eq. 5)}$$

Where: CF_i is the fraction of carbon at paddock/zone i (percentage carbon divided by 100), BD_i is soil bulk density (kg per cm^3) at zone or paddock i, and V is the soil volume of 0.3 m soil layer (m^3).

If there are insufficient soil tests available, estimated SOC is used. For example, organic amendments application may be used to determine potential carbon sequestration rates[22] and compared with the estimated values using regression approach from previous SOC tested results. In this case, we account for a conservative portion of the fraction of the carbon in the organic fertiliser that becomes inert or stabilised in the soil, as a basis for our calculations.

5.2.2 Determination of soil bulk density

Soil bulk density (BD) is an important site-specific parameter for the estimation of the total potential soil organic carbon for the cropping area. To determine this, the FarmLab platform is used to identify variation in soil BD across farm areas and within each paddock. For example, at the Dry Paddock (~282 ha, excluded

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[17] FarmLab – GIS Support for Carbon Projects. Retrieved May 2021, from https://www.farmlab.com.au/carbon-projects.

[18] Department of Industry, Science, Energy and Resources 2021. Sampling guidance for measurement-based soil carbon methods. http://www.cleanenergyregulator.gov.au/DocumentAssets/Pages/Sampling-guidance-for-measurement-based-soil-carbon-methods.aspx

[19] The Clean Energy Regulator (2021) *Measurement of soil carbon sequestration in agricultural systems method*. Online. Available at: http://www.cleanenergyregulator.gov.au/ERF/Pages/Choosing a project type/Opportunities for the land sector/Agricultural methods/The-measurement-of-soil-carbon-sequestration-in-agricultural-systems-method.aspx (Accessed: 20 May 2021).

[20] GRDC (2013) *Managing soil organic matter a practical guide*. Edited by Grains Research & Development Corporation. Online: GRDC. Available at: http://www.grdc.com.au (Accessed: 7 April 2021).

[21] Donovan, Peter. 2013. Measuring Soil Carbon Change. A flexible, practical, local method. https://soilcarboncoalition.org/files/MeasuringSoilCarbonChange.pdf

[22] Biala, J. (2011). *The benefits of using compost for mitigating climate change* (pp. 1-39). Sydney South, NSW: Department of Environment, Climate Change and Water NSW.

building, road, dams etc.), the BD was determined for 5-15 cm and 15-30 cm layer on FarmLab range between 1.46 to 1.56 depending on the depth the location and depth (**Figure 5**).

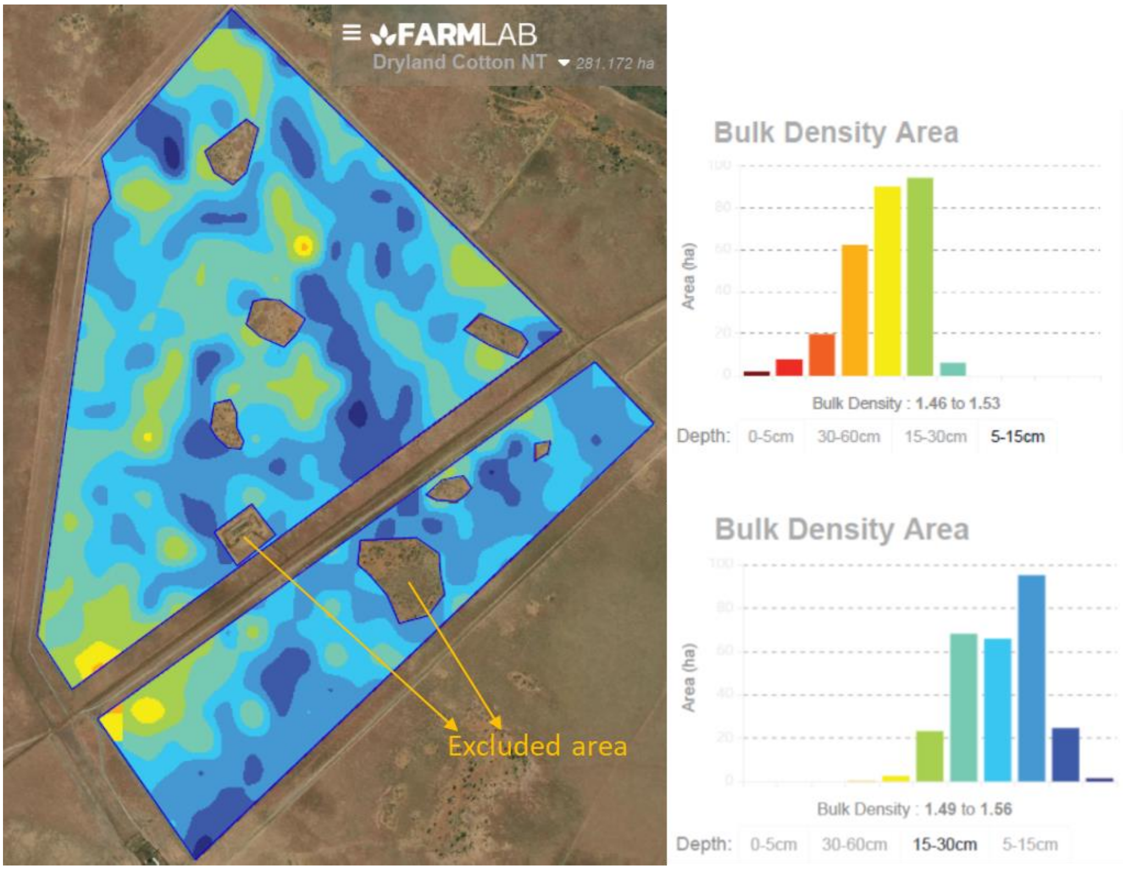

Figure 5. Soil bulk density map of Dry Paddock area for 5-15cm and 15-30 cm

5.2.3 Determination of soil sampling locations

Site-specific and representative soil sampling are crucial for the accurate measurement of soil organic carbon. In addition to the official guidance on soil sampling procedure by Clean Energy Regulator[23], we employ an innovative approach using FarmLab which assists identify different farm zones that are required for soil sampling. Particularly, a combination of soil bulk density, elevation and normalised difference vegetation index (NDVI) is used as a function for determining farm zones.

[23] The Clean Energy Regulator (2021) *Measurement of soil carbon sequestration in agricultural systems method*. Online. Available at: http://www.cleanenergyregulator.gov.au/ERF/Pages/Choosing a project type/Opportunities for the land sector/Agricultural methods/The-measurement-of-soil-carbon-sequestration-in-agricultural-systems-method.aspx (Accessed: 20 May 2021).

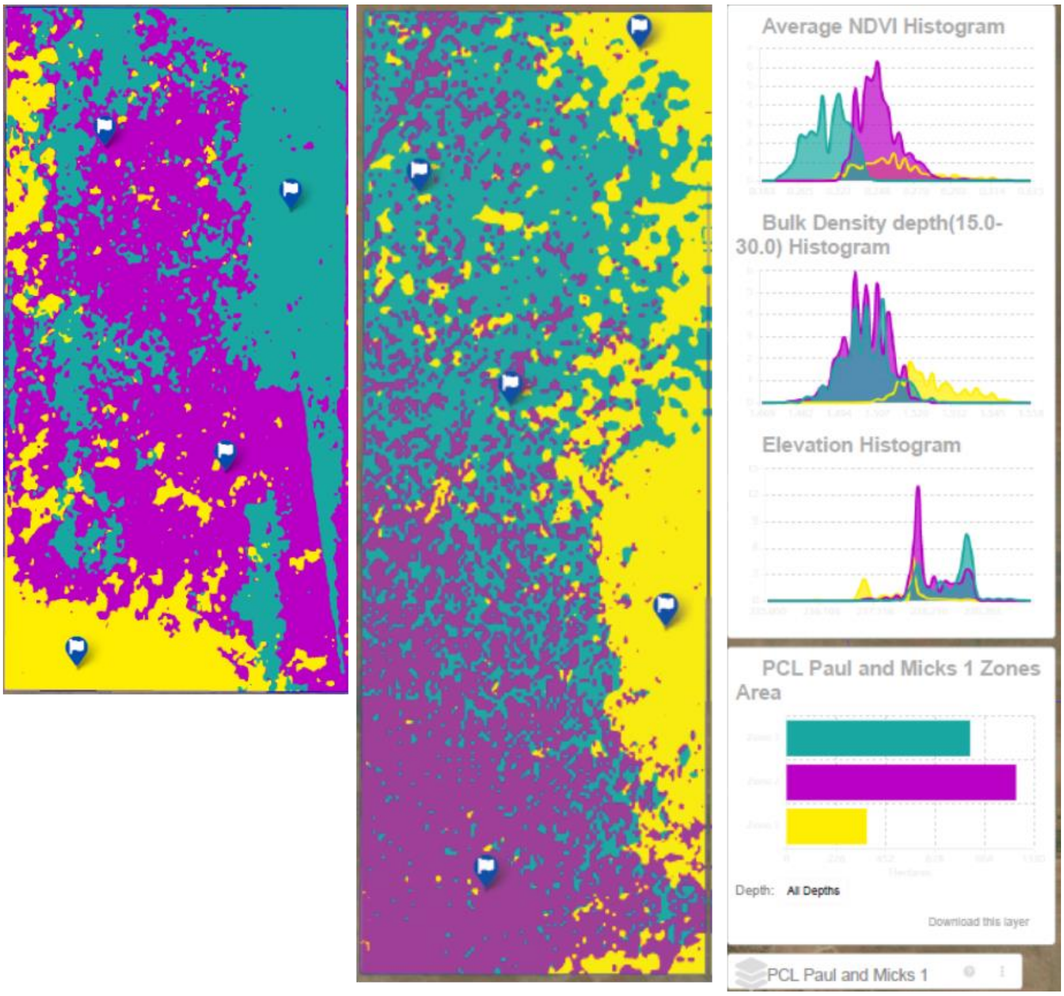

Figure 6. Determination of sampling location (blue pin/ flag on the map) based on different farm zones (in a different colour) as a function of NDVI, soil bulk density and elevation (an example of soil sampling location for Paul and Mick's Paddocks over 4,932 ha

5.3 Native Vegetation

There is increasing evidence in sequestration of atmospheric carbon to ecosystems from mature native vegetation systems (VEG)[24], which was previously believed that native stands are in equilibrium and do not sequester additional carbon. Extensive research studies[25][26] have provided guidelines on the carbon sequestration rates of the different native vegetation types. Five types of VEG systems, which sequester additional carbon from the atmosphere on an annual basis, were considered in our model including woody vegetation (woodland), shrub and savanna, native grasses, improved pasture, and riparian. Changes in these vegetation types or annual ground cover on-farm between the base year and an assessment year are determined using Google Earth Pro[27] and FarmLab, online platforms. These tools are increasingly used by farmers to evaluate the potential of carbon sequestration/ carbon credits generated from soil and native vegetation systems. Carbon sequestration is calculated for the VEG area (zones) suggested by Minister for

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[24] Smith, R. A., & Reid, N. (2013). Carbon storage value of native vegetation on a subhumid -semi-arid floodplain. *Crop and Pasture Science*, *64*(1209–1216). https://doi.org/10.1071/CP13075

[25] Luyssaert, S., Schulze, E. -., Börner, A., Knohl, A., Hessenmöller, D., Law, B. E., . . . Grace, J. (2008). Old-growth forests as global carbon sinks. *Nature, 455*(7210), 213-215. doi:10.1038/nature07276

[26] Zhou, G., Liu, S., Li, Z., Zhang, D., Tang, X., Zhou, C., Mo, J. (2006). Old-Growth Forests Can Accumulate Carbon in Soils. *Science, 314*(5804), 1417-1417. doi:10.1126/science.1130168

[27] Google Earth Pro. Google (2021). Available at: https://www.google.com/earth/download/gep/agree.html?hl=en-GB

the Environmental and Energy (2021)[28]. Following the estimation of VEG area for different vegetation types, we employ conservative sequestration to calculate the potential carbon sequestration for the VEG system. Carbon sequestration from the VEG system is allocated for the assessing production system based on either the mass allocation (e.g., cultivated area and/or mass of production) or the economic allocation (e.g., the value of commodity) approach following ISO 14044 framework for life cycle assessment (LCA) method.

In addition, FullCAM (Full Carbon Accounting Model)[29], which is suggested as a required tool for Emissions Reduction Fund (ERF) projects, is employed to estimate changes in carbon in the agricultural system about changes in ground cover and farming practices. Particularly, this official tool is used to estimate the above and belowground biomass, standing and decomposing debris and soil carbon resulting from land use and management activities. However, the obtained soil carbon results from FullCAM are considered as the reference points for verifying soil test results. The soil carbon results are preferable to use when soil carbon measurements are not available. In this case, scientific data to obtain carbon sequestration rates for each vegetative type specific to the soil type/production type / climatic conditions of a production system is required. For example, for cotton crops in Australia, in terms of the carbon sequestration rates per vegetation type, we largely rely on the research that was conducted by Smith *et al.*[30] for the main Australian cotton-growing regions.

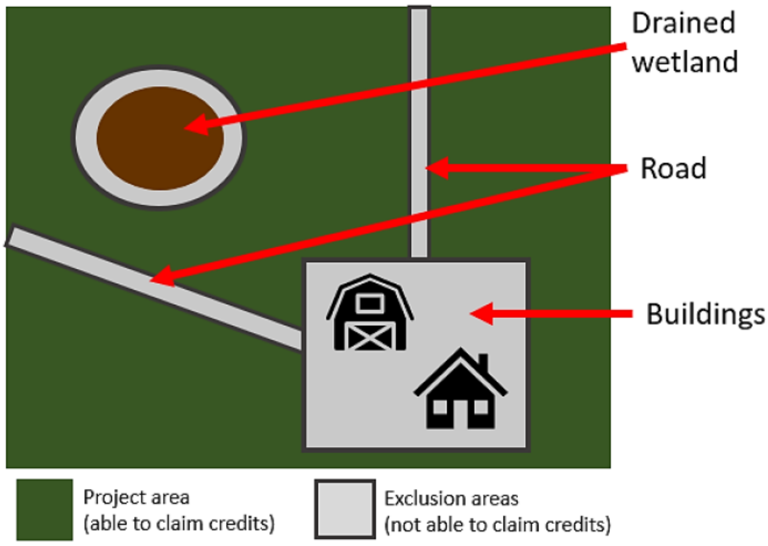

Figure 7. Project area and exclusions (the Clean Energy Regulator, 2021)

5.4 Calculation of emissions from fertiliser use

GHG emissions associated with fertilisers use was calculated for the direct and indirect emissions from the amount of fertiliser applied per year and upstream emissions related to the manufacturing of the fertilisers. For inorganic (synthetic) fertilisers Direct and indirect emissions of N_2O-fertiliser is calculated following Equation 6 and 8. Emissions factors (EF_{direct} and $EF_{indirect}$) for each of the fertilisers were taken from Wood and Annette (2004)[31] and the National Inventory Report (NIR 2019)[32] and adjusted to be site-specific which

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[28] Minister for the Environmental and Energy (2021) *Carbon Credits (Carbon Farming Initiative—Measurement of Soil Carbon Sequestration in Agricultural Systems) Methodology Determination 2018*. Attorney-General's Department. Available at: https://www.legislation.gov.au/Details/F2018L00089 (Accessed: 7 June 2021).

[29] Department of Industry Science Energy and Resources. (2020). Full Carbon Accounting Model (FullCAM). In Using FullCAM for Emissions Reduction Fund Projects. https://www.industry.gov.au/data-and-publications/full-carbon-accounting-model-fullcam

[30] Smith, R. A., & Reid, N. (2013). Carbon storage value of native vegetation on a subhumid -semi-arid floodplain. *Crop and Pasture Science*, *64*(1209–1216). https://doi.org/10.1071/CP13075

[31] Wood, S. and Annette, C. (2004) *A review of Greenhouse Gas Emissions Factors for Fertiliser Production*. Available at: http://large.stanford.edu/courses/2014/ph240/yuan2/docs/wood.pdf (Accessed: 7 June 2021).

[32] Commonwealth of Australia. National Inventory Report (NIR) 2019. Volume 2. https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-march-2020

is expected to represent different production systems and state-specific rather than the default value of national scale.

5.4.1 Direct N_2O emissions from fertilisers use.

$$\mathbf{E_{dfert} = TM \times EF_{direct} \times 1.57} \qquad \text{(Eq. 6)}$$

Where: E_{dfert} is the amount of N_2O emissions directly from fertiliser-N applied; TM is the total mass of N-fertiliser applied (kg N), EF_{direct} is the direct emissions factors for N-fertiliser applied and specific for each production system (e.g., irrigated and non-irrigated) and state-specific and 1.57 is the conversion factor of N_2O to CO_2-e.

For irrigated cotton, EF_{direct} of inorganic fertiliser-N is calculated based on the non-linear regression equation specifically for Australian cotton by Grace *et al.* (2016)[33], which was used in National Greenhouse Accounts 2019 (Commonwealth of Australia, 2021)[34].

$$\mathbf{EF_{direct}} = \mathbf{0.29 + 0.007} \times (\boldsymbol{e}^{\mathbf{0.0037} \times \boldsymbol{TN}} - \mathbf{1})/\boldsymbol{TN} \qquad \text{(Eq. 7)}$$

Where: EF_{direct} is the estimated direct emissions factor from the inorganic N-fertiliser applied; TN is the inorganic N-fertiliser application rate (kg N per ha).

For example, we assume a direct nitrous oxide emission factor of 0.55% of N applied for irrigated cotton in Australia as recommended by the Australian Department of Climate Change for the relevant carbon farming methodology[35], which is also in line with other scientific research studies for cotton in Australia.

5.4.2 Indirect N_2O emissions from fertilisers use.

Indirect emissions include emissions from leaching and run-off and ammonia volatilization of fertiliser-N applied. These emissions are calculated based on the following equation (NIR 2019, volume 1).

$$\mathbf{E_{ifert} = TM \times EF_{indirect} \times 1.57} \qquad \text{(Eq. 8)}$$

Where: E_{ifert} is the amount of N_2O emissions indirectly from fertiliser-N applied; TM is the total mass of inorganic N-fertiliser applied (kg N), $EF_{idirect}$ is the direct emissions factors for N-fertiliser applied and specific for each production system (e.g., irrigated and non-irrigated) and state; and 1.57 is the conversion factor of N_2O to CO_2-e.

5.4.3 Emissions from the production of fertilisers use.

Upstream emissions which are associated with the production of fertilisers used are included and calculated based on the secondary inventory database. Accordingly, the emissions factors for the use of each inorganic fertiliser are estimated and/or taken from national agricultural inventory data for fertilisers at regional storage, which included the transportations from manufacturing to markets and regional storage period to use. For organic fertilisers such as livestock manure and composts, we assumed that the emissions associated with the production and manufacturing is negligible and/or set to zero as these products often consider as the waste from other production systems e.g., livestock and cropping.

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[33] Grace, P. *et al.* (2016) 'Emission factors for estimating fertiliser-induced nitrous oxide emissions from clay soils in Australia's irrigated cotton industry', *Soil Research*, 54(5), pp. 598–603. doi: 10.1071/SR16091.
[34] Commonwealth of Australia (2021) *National Greenhouse Accounts 2019*. Available at: https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-2019/national-inventory-report-2019.
[35] Australian Government (2020). National Inventory Report 2018: Volume 1 (pp. 1-418, Rep.). Australian Government

5.5 Emissions from Energy use

Carbon Friendly™ emissions simulation model calculates both on-site fuel use emissions and supply chain fuel use emissions (transports). The on-site fuel amounts to the quantity of diesel, petrol and Avgas used in the normal farming operations, while the supply chain emissions account for fuel used to deliver all inputs onto the farm, as well as the delivery of the crop outputs to the point of processing or distribution. The emission factors for Diesel, Petrol and Avgas used to calculate our Fuel and Supply Chain Fuel Emissions are based on the Australian National Greenhouse Gas Inventory (**Table 11**). The emissions from fuel use are calculated as follows:

$$\mathbf{E_{ij} = \sum_{i=1}^{n}(Qi \times E_{ci} \times EF_{fuel} \times 10^{-3})} \qquad \text{(Eq. 9)}$$

Where: E_{ij} is the emissions of gas type; Q_i is the quantity of fuel type (litre); E_{ci} is the energy content factor of fuel type; EF_{fuel} is the emissions factor of the fuel.

Table 11. Energy content and Emissions factors for common fuel use

Fuel	MJ/L	CO_2	CH_4	N_2O
Diesel oil	38.6	69.9	0.1	0.2
Fuel oil	39.7	73.6	0.04	0.2
Avgas	33.1	67.0	0.2	0.2

Source: National Greenhouse Accounts factors (industry.gov.au)

5.6 Emissions from chemical use

In normal carbon accounting, we are not able to assess the atmospheric effects of the actual application of chemicals like herbicides. This is because the direct in-field emissions are often negligible. However, we account for the emissions generated in the manufacturing and transport of those products. The calculation of emissions is based on the active ingredient levels of the products, as well as the manufacturing category of the chemical as following:

$$\mathbf{E}_{chemi} = \sum_{i=1}^{n}(\mathbf{M}\boldsymbol{ci} \times \mathbf{D}\boldsymbol{ci} \times \mathbf{AI}\boldsymbol{i} \times \mathbf{EF}\boldsymbol{ci}) \qquad \text{(Eq. 10)}$$

Where: $\mathbf{E}_{chemi}$ is the emissions from chemical use associated with the production of a chemical (kg CO_2-e); M*ci* is the mass of chemical use (in kg or litre); AI*i* is the active ingredient level of the chemical (g/ litre); D*ci* and EF*ci* are the energy content and emissions factors of a chemical, expressed in MJ/ kg and kg CO_2-e/ MJ, respectively; *i* is the specific group of chemical which has different D*ci* such as insecticide and herbicide.

APPENDIX

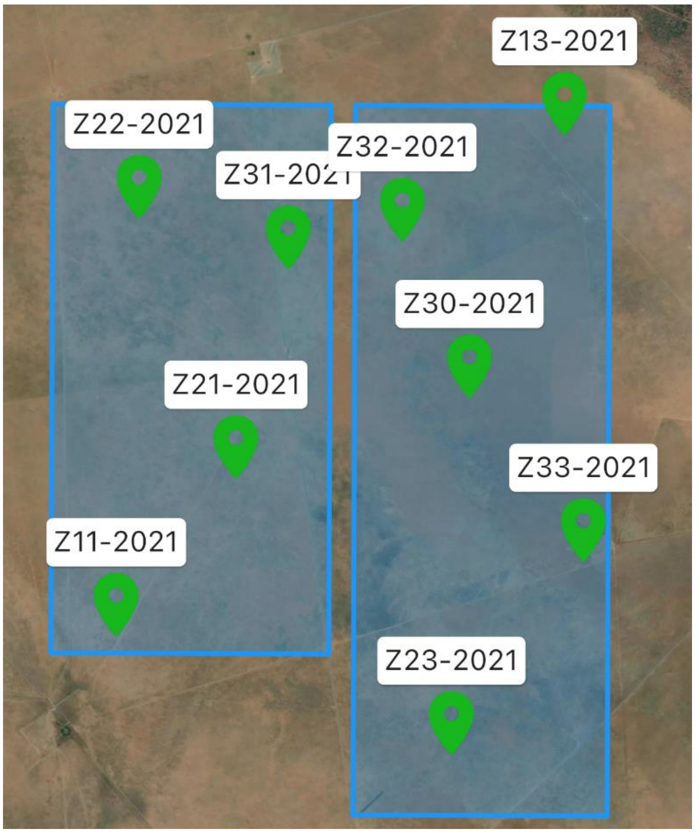


Fig S 1. Soil sample location at Pauls and Micks Paddock in 2021 based on three farm zones determined on FarmLab

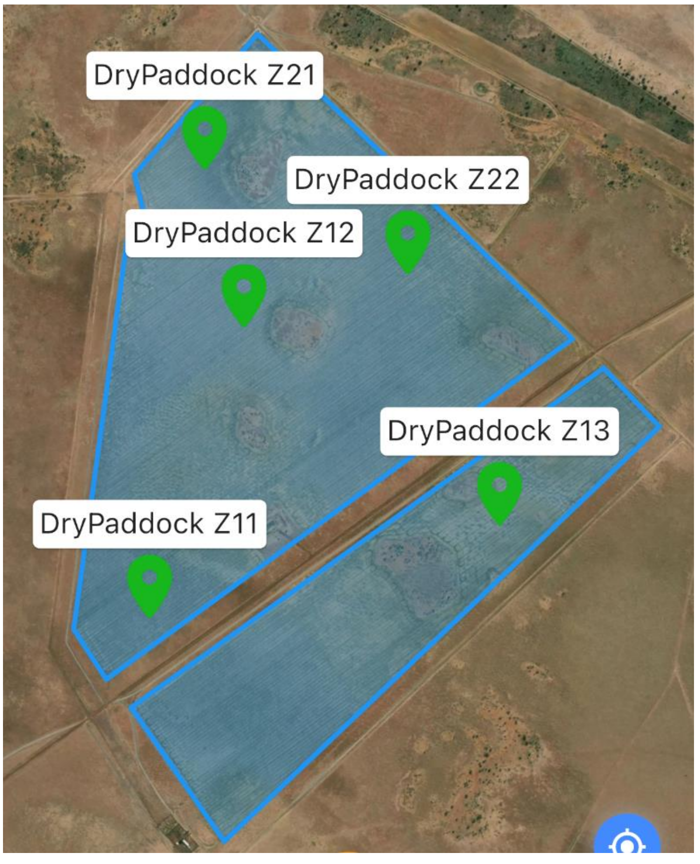


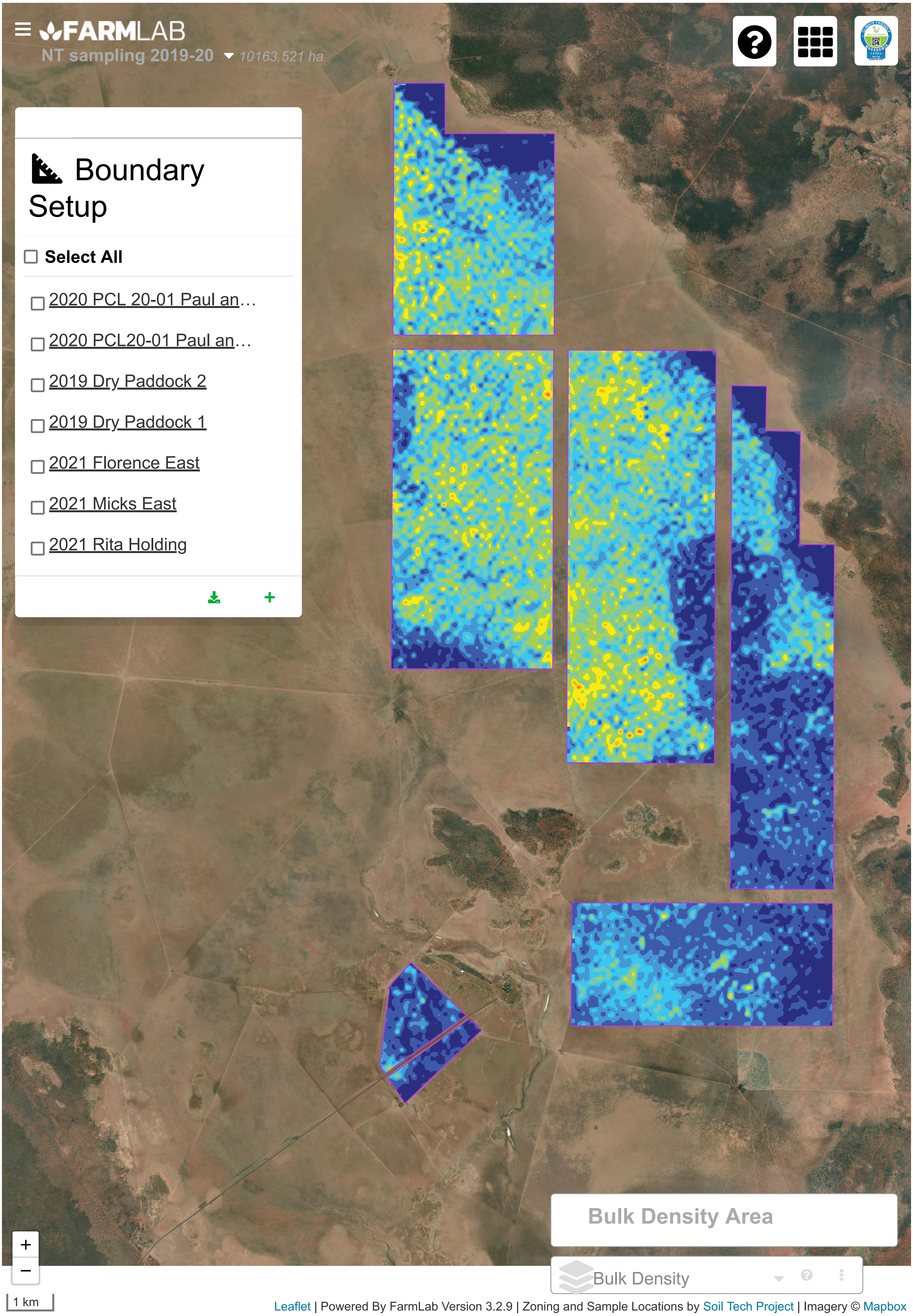
Fig S 2. Soil sampling location at Dry Paddock in 2021 based on three farm zones determined on FarmLab

Appendix A: Soil test results for soil organic carbon in 2019 and 2021

Table 12. Soil test results for total soil organic carbon (SOC) for 2019 and 2021

Sample detail	SOC (%)	depth	Paddock name	BD (g/cm^3)	Area (ha)	SOC (tonnes)
FL119646730003 (Z21-Dry3, Point 8)	0.22	0.3	Dry paddock Z21	1.50	128	1,267
FL119646730001 (Z13-Dry1)	0.25	0.3	Dry Paddock Z13	1.45	125	1,359
FL119646730002 (Z22-Dry2, POINT 1)	0.26	0.3	Dry Paddock Z22	1.50	128	1,498
FL119646730006 (Z11-Dry5)	0.24	0.3	Dry paddock Z11	1.45	125	1,305
FL119646730005 (Z12-DRY4)	0.18	0.3	Dry Paddock Z12	1.45	125	979
Z11-2021 (PAUL'S, NO1)	0.19	0.3	Mick & Paul's Z11	1.55	840	7,421
FL119746550002 (MICK'S NO5/16)	0.22	0.3	Mick & Paul's Z13	1.55	840	8,593
Z21-2011 (NO 2)	0.25	0.3	Mick & Paul's Z21	1.50	1950	21,938
Z22-2021 (NO 14, NO 3)	0.38	0.3	Mick & Paul's Z22	1.50	1950	33,345
Z23-2021 FL119746550006	0.30	0.3	Mick & Paul's Z23	1.50	1950	26,325
Z30-2021 FL119746550004	0.35	0.3	Mick & Paul's Z30	1.50	1770	27,878
Z31-2021 (NO 4) FL119746550001	0.30	0.3	Mick & Paul's Z31	1.50	1770	23,895
Z32-2021 FL119746550003	0.47	0.3	Mick & Paul's Z32	1.51	1770	37,685
Z33-2021 FL119740550005	0.36	0.3	Mick & Paul's Z33	1.55	1770	29,630
UCHA19 SITE3 (0-2CM)	0.59	0.02	Dry Paddoc 2019	1.50	320	566
UCHA19 SITE 16 (0-2CM)	0.41	0.02	Dry Paddoc 2019	1.50	320	394
SITE3 0619 (20-30CM)	0.16	0.3	Dry Paddoc 2019	1.50	320	2,304
UCHA19 SITE16 (20-30CM)	0.25	0.3	Dry Paddoc 2019	1.50	320	3,600
UCA 1	0.30	0.3	Ucharonidge	1.50	4898	66,123
UCA 3	0.20	0.3	Ucharonidge	1.50	4898	44,082
UCA 4	0.30	0.3	Ucharonidge	1.50	4898	66,123
UCA 5	0.20	0.3	Ucharonidge	1.50	4898	44,082
UCA 6	0.20	0.3	Ucharonidge	1.50	4898	44,082
UCA 8	0.18	0.3	Ucharonidge	1.50	4898	39,674
UCA 12	0.30	0.3	Ucharonidge	1.50	4898	66,123
ICA 16	0.20	0.3	Ucharonidge	1.50	4898	44,082

Appendix B: Estimated soil organic improvement per year over 25 years from LOOC-C



Leaflet | Powered By FarmLab Version 3.2.9 | Zoning and Sample Locations by Soil Tech Project | Imagery © Mapbox

LOOC-C

A landscape options and opportunities for carbon abatement calculator

Disclaimer

You acknowledge that LOOC-C is an experimental prototype and may contain errors. CSIRO makes no warranties, nor express or implied representations whatsoever, regarding the accuracy, completeness, currency, or usefulness of any information contained or referenced in LOOC-C.

You must not use LOOC-C in isolation. CSIRO does not assume any risk whatsoever for your use of LOOC-C. In using LOOC-C you agree that CSIRO is not nor will be liable or otherwise responsible for any decision made or any action taken or any action not taken due to your use of any information presented in LOOC-C.

If you are thinking of participating in the LRF please seek advice before committing to a project.

Reforestation by environmental or mallee plantings

Australian Carbon Credit Units: 581,003 tCO2-e over 25 years

Annual per ha estimate: 2.13 tCO2-e/ha/y

Note due to changes in the rate of tree growth over time, total ACCUs after 10 years are approximately 50% of the 25 year total.

Area modelled: 10,925 ha

Estimate date: 5/8/2021

Project Overview

This method removes carbon dioxide from the atmosphere and stores it as carbon in plants as they grow.

Project Requirements

The **reforestation by environmental or mallee plantings** action involves establishing and maintaining native vegetation such as trees or shrubs on land that has been clear of forest for at least five years. Plantings can either be a mix of trees, shrubs and understory species native to the local area, or species of mallee eucalypts.

Projects are required to meet a ‘permanence obligation’ meaning that the carbon stored in plants will last at least 25 years. For more information see Emissions Reduction Fund: Reforestation by Environmental or Mallee Plantings.

Farm co-benefits

Farm Profitability

Co-benefit	Description	Rating
Optimised Yield	Undertaking this activity can help you achieve maximum value for what is primarily produced on the farm.	Slight
Optimised land use efficiency	Undertaking this activity can help you achieve the best possible outputs given the inputs across the farm.	Slight
Optimised soil health via soil organic carbon	As part of the natural carbon cycle, increasing soil organic carbon (SOC) also increases soil fertility that is good for all types of farms. Increasing carbon storage in the soil can reduce the effects of global warming.	None
Product diversification / optimised income streams	For some farms, this activity may provide optimised revenue streams that include carbon offsets or alternate products.	Strong

Farm Resilience

Co-benefit	Description	Rating
Improved water quality	Undertaking this activity can improve the amount and condition of the local water supply.	Slight
Improved soil stability	Undertaking this activity helps to protect and enhance the farm's ground cover, leading to a range of benefits including soil health and protection from erosion.	Strong
Reduced chemical run off	Undertaking this activity helps to reduce the movement of pollutants into the local water supply.	Slight
Reduced dryland salinity	Most relevant to cropping regions, this activity can mitigate excess salt being absorbed into plants' root structures in times of heavy rains.	Strong

Enviro/Social Benefits

Co-benefit	Description	Rating
Optimised biodiversity / conservation	This activity may promote positive outcomes for both biodiversity (presence of healthy microbes, bugs, plants etc) and conservation (preserving natural resources, preventing destruction of habitats etc).	Strong
Optimised animal welfare	Animal health and stress levels can be improved with activities that provide access to shade, fresh water and habitat.	Slight
Climate adaptability	This activity promotes a reduction in greenhouse gas emissions, helping to mitigate the effects of global warming.	Strong

Disbenefits

Disbenefit	Description	Rating
Land use conflicts	The proposed activities are intended as long-term management options which may prevent alternate land use strategies from being implemented. This could lead to undesirable outcomes.	Slight
Reduced water yield	This activity may result in reduced local water availability.	Slight

LOOC-C

A landscape options and opportunities for carbon abatement calculator

Disclaimer

You acknowledge that LOOC-C is an experimental prototype and may contain errors. CSIRO makes no warranties, nor express or implied representations whatsoever, regarding the accuracy, completeness, currency, or usefulness of any information contained or referenced in LOOC-C.

You must not use LOOC-C in isolation. CSIRO does not assume any risk whatsoever for your use of LOOC-C. In using LOOC-C you agree that CSIRO is not nor will be liable or otherwise responsible for any decision made or any action taken or any action not taken due to your use of any information presented in LOOC-C.

If you are thinking of participating in the LRF please seek advice before committing to a project.

Measurement of soil carbon sequestration

Selected Target: 0.3 %

Estimated Soil Carbon Percentage: 0.4 %

Selected Soil Carbon Percentage: 0.2 %

Australian Carbon Credit Units: 179,823 tCO2-e over 25 years

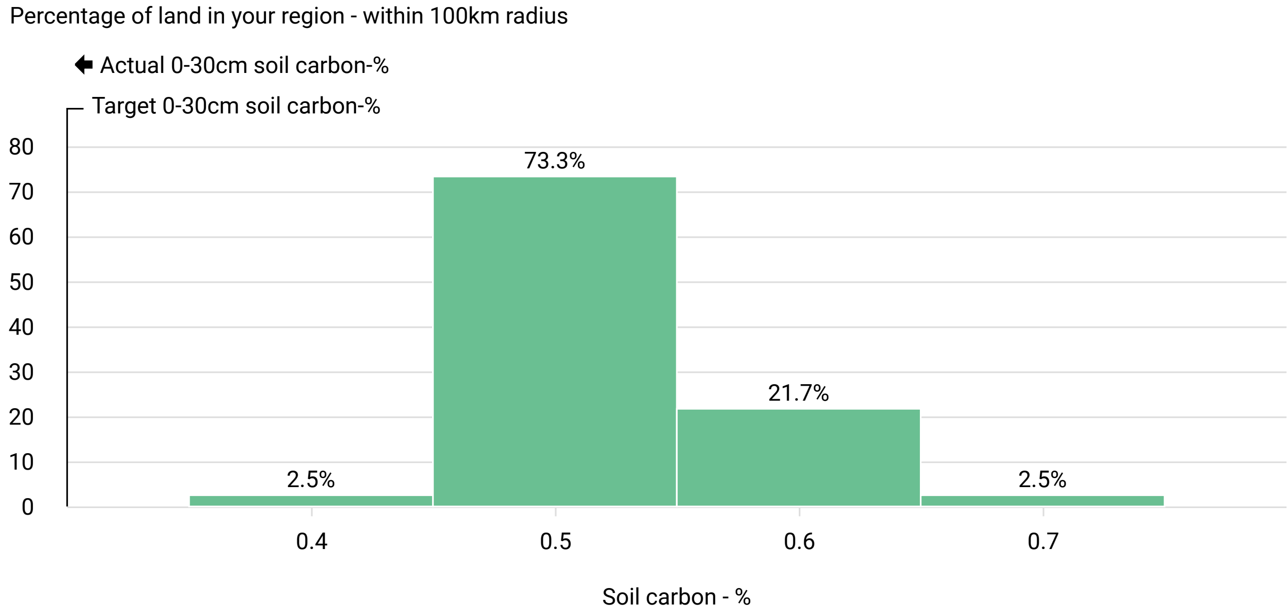
Annual per ha estimate: 0.66 tCO2-e/ha/y

Area modelled: 10,925 ha

Estimate date: 5/8/2021

Soil carbon in your region

The chart below shows the range of soil carbon percentages within 100km radius of your proposed project, and where both estimates of your current soil carbon and your proposed soil carbon increases are within the range of your region. This chart does not warrant that you will be able to achieve your target concentration of soil carbon. Users will need to do their own research on activities that might increase soil carbon in their situation. Factors affecting soil carbon increases include soil type, climate and management activities.



Project Overview

This method credits measured increases in soil carbon as a result of one or more new or materially different management activities in grazing or cropping land (including woody horticulture). Allowable activities include (but are not limited to):

- applying nutrients, lime or gypsum to the land,
- pasture rejuvenation,
- altering the stocking rate, duration or intensity of grazing,
- retaining stubble after a crop is harvested,
- converting from intensive tillage to reduced/no tillage,

- modification of landscape or landform features,
- use of mechanical methods to add or redistribute soil.

Project Requirements

In the 10 years prior to the project, land must have been under pasture, cropping or bare fallow, and not forested nor currently forest.

Soil carbon stocks must be estimated using specified soil sampling methods and samples must be measured for soil carbon content using specified laboratory techniques or calibrated in-field sensors. For more information see Emissions Reduction Fund: Measurement of Soil carbon Sequestration.

Farm co-benefits

Farm Profitability

Co-benefit	Description	Rating
Optimised Yield	Undertaking this activity can help you achieve maximum value for what is primarily produced on the farm.	Strong
Optimised land use efficiency	Undertaking this activity can help you achieve the best possible outputs given the inputs across the farm.	Slight
Optimised soil health via soil organic carbon	As part of the natural carbon cycle, increasing soil organic carbon (SOC) also increases soil fertility that is good for all types of farms. Increasing carbon storage in the soil can reduce the effects of global warming.	Strong
Product diversification / optimised income streams	For some farms, this activity may provide optimised revenue streams that include carbon offsets or alternate products.	Strong

Farm Resilience

Co-benefit	Description	Rating
Improved water quality	Undertaking this activity can improve the amount and condition of the local water supply.	Slight
Improved soil stability	Undertaking this activity helps to protect and enhance the farm's ground cover, leading to a range of benefits including soil health and protection from erosion.	Strong
Reduced chemical run off	Undertaking this activity helps to reduce the movement of pollutants into the local water supply.	Strong
Reduced dryland salinity	Most relevant to cropping regions, this activity can mitigate excess salt being absorbed into plants' root structures in times of heavy rains.	None

Enviro/Social Benefits

Co-benefit	Description	Rating
Optimised biodiversity / conservation	This activity may promote positive outcomes for both biodiversity (presence of healthy microbes, bugs, plants etc) and conservation (preserving natural resources, preventing destruction of habitats etc).	Strong
Optimised animal welfare	Animal health and stress levels can be improved with activities that provide access to shade, fresh water and habitat.	None
Climate adaptability	This activity promotes a reduction in greenhouse gas emissions, helping to mitigate the effects of global warming.	Slight

Disbenefits

Disbenefit	Description	Rating
Land use conflicts	The proposed activities are intended as long-term management options which may prevent alternate land use strategies from being implemented. This could lead to undesirable outcomes.	None
Reduced water yield	This activity may result in reduced local water availability.	None

(ALS)

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 3/1 Burma Road Pooraka SA 5095
Ph: 08 8162 5130 E: adelaide@alsglobal.com

☐BRISBANE 2 Byth Street Stafford QLD 4053
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☐NOWRA 4/13 Geary Place North Nowra NSW 2541
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☐PERTH 10 Hod Way Malaga WA 6090
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☐WOLLONGONG 1/19-21 Ralph Black Drive, Nth Wollongong NSW 2500
Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: Carbon Friendly

OFFICE:

PROJECT: Cleveland **PROJECT NO.:**

ORDER NUMBER: **PURCHASE ORDER NO.:**

PROJECT MANAGER: F. Vieser **CONTACT PH:** 0410175820

SAMPLER: **SAMPLER MOBILE:**

COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**

Email Reports to (will default to PM if no other addresses are listed): francois@carbonfriendly.com.au

Email Invoice to (will default to PM if no other addresses are listed):

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.:

COUNTRY OF ORIGIN:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt:	°C		
Other comment:			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
	Martin		
DATE/TIME: 8/7/21	DATE/TIME: 8/7/21 17:20	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).	Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc. TOC Total Organic Carbon &
	1	8/7 16:30					EP 003
	2	"					"
	3	"					"
	4	"					"
	5	"					"
	6	"					"
	7	"					"
	8	"					"
	9	"					"
	10	"					"
	11	"					"
	12	"					"
				TOTAL			

Environmental Division
Brisbane
Work Order Reference
EB2119211

Telephone : + 61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

CHAIN OF CUSTODY

ALS Laboratory: **please tick →**

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☐WOLLONGONG 1/19-21 Ralph Black Drive, Nth Wollongong NSW 2500
Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: Carter Freevolly
OFFICE:
PROJECT: **PROJECT NO.:**
ORDER NUMBER: **PURCHASE ORDER NO.:**
PROJECT MANAGER: **CONTACT PH:**
SAMPLER: **SAMPLER MOBILE:**
COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**
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OF: 1 2 3 4 5 6 7

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Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
	Martin		
DATE/TIME:	DATE/TIME: 8/7/21 17:20	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES									Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc. TOC EP003
	13													'
	14													/
	15													/
	16													/
	17													/
	18													/
														/
														/
														/
					TOTAL									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

CERTIFICATE OF ANALYSIS

Work Order	: **EB2119211**	Page	: 1 of 6
Client	: **CARBON FRIENDLY**	Laboratory	: Environmental Division Brisbane
Contact	: FRANCOIS VISSER	Contact	: Customer Services EB
Address	: 1/21 ENTERPRISE STREET CLEVELAND BRISBANE 4163	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: ----	Date Samples Received	: 08-Jul-2021 17:20
Order number	: ----	Date Analysis Commenced	: 13-Jul-2021
C-O-C number	: ----	Issue Date	: 14-Jul-2021 10:05
Sampler	: FRANCOIS VISSER		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 18		
No. of samples analysed	: 18		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	1	2	3	4	5
			Sampling date / time	08-Jul-2021 16:30	08-Jul-2021 16:30	08-Jul-2021 16:30	08-Jul-2021 16:30	08-Jul-2021 16:30
Compound	CAS Number	LOR	Unit	EB2119211-001	EB2119211-002	EB2119211-003	EB2119211-004	EB2119211-005
				Result	Result	Result	Result	Result
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.25**	**0.30**	**0.22**	**0.25**	**0.26**

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL)**

			Sample ID	6	7	8	9	10
			Sampling date / time	08-Jul-2021 16:30	08-Jul-2021 16:30	08-Jul-2021 16:30	08-Jul-2021 16:30	08-Jul-2021 16:30
Compound	CAS Number	LOR	Unit	EB2119211-006	EB2119211-007	EB2119211-008	EB2119211-009	EB2119211-010
				Result	Result	Result	Result	Result
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.19**	**0.22**	**0.38**	**0.24**	**0.18**

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

			Sample ID	11	12	13	14	15
			Sampling date / time	08-Jul-2021 16:30	08-Jul-2021 16:30	08-Jul-2021 16:30	08-Jul-2021 16:30	08-Jul-2021 16:30
Compound	CAS Number	LOR	Unit	EB2119211-011	EB2119211-012	EB2119211-013	EB2119211-014	EB2119211-015
				Result	Result	Result	Result	Result
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.47**	**0.35**	**0.36**	**0.30**	**0.59**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	16	17	18	----	----
			Sampling date / time	08-Jul-2021 04:30	08-Jul-2021 16:30	08-Jul-2021 16:30	----	----
Compound	CAS Number	LOR	Unit	EB2119211-016	EB2119211-017	EB2119211-018	--------	--------
				Result	Result	Result	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.16**	**0.25**	**0.41**	----	----

QUALITY CONTROL REPORT

Work Order	: **EB2119211**	Page	: 1 of 3
Client	: **CARBON FRIENDLY**	Laboratory	: Environmental Division Brisbane
Contact	: FRANCOIS VISSER	Contact	: Customer Services EB
Address	: 1/21 ENTERPRISE STREET CLEVELAND BRISBANE 4163	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: ----	Date Samples Received	: 08-Jul-2021
Order number	: ----	Date Analysis Commenced	: 13-Jul-2021
C-O-C number	: ----	Issue Date	: 14-Jul-2021
Sampler	: FRANCOIS VISSER		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 18		
No. of samples analysed	: 18		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 3788061)									
EB2118643-001	Anonymous	EP003: Total Organic Carbon	----	0.02	%	10.8	11.1	2.2	0% - 20%
EB2119211-010	10	EP003: Total Organic Carbon	----	0.02	%	0.18	0.19	0.0	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 3788061)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.56 %	100	70.0	130
				<0.02	0.2 %	101	70.0	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB2119211**	Page	: 1 of 4
Client	: **CARBON FRIENDLY**	Laboratory	: Environmental Division Brisbane
Contact	: FRANCOIS VISSER	Telephone	: +61-7-3243 7222
Project	: ----	Date Samples Received	: 08-Jul-2021
Site	: ----	Issue Date	: 14-Jul-2021
Sampler	: FRANCOIS VISSER	No. of samples received	: 18
Order number	: ----	No. of samples analysed	: 18

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)			*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EP003: Total Organic Carbon (TOC) in Soil								
Pulp Bag (EP003)								
1,	2,	**08-Jul-2021**	**13-Jul-2021**	05-Aug-2021	✓	**13-Jul-2021**	05-Aug-2021	✓
3,	4,							
5,	6,							
7,	8,							
9,	10,							
11,	12,							
13,	14,							
15,	16,							
17,	18							

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Total Organic Carbon	EP003	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Total Organic Carbon	EP003	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Total Organic Carbon	EP003	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Total Organic Carbon	EP003	SOIL	In house C-IR17. Dried and pulverised sample is reacted with acid to remove inorganic Carbonates, then combusted in a furnace in the presence of strong oxidants / catalysts. The evolved (Organic) Carbon (as CO_2) is automatically measured by infra-red detector.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Dry and Pulverise (up to 100g)	GEO30	SOIL	#

NUTRIENT REPORT

CLEVELAND ARG

CLEVELAND
QLD 4163

Service Provider: LANDMARK - St George
Advisor/Contact: Dale Clark
Phone: 0438 626 506
Purchase Order: TBA

Sample No		022197611	022197612	022197613
Paddock Name		UCMA 1	UCMA 1	UCMA 1
Sample Name		UCMA 1	UCMA 1	UCMA 1
Sample Depth (cm)		0 - 30	30 - 60	60 - 90
Sampling Date		22/11/2019	22/11/2019	22/11/2019
Test Code		E33	E33	E33
Sample Type		Soil	Soil	Soil
Analyte	**Unit**	**Result**	**Result**	**Result**
Soil Colour		Grey	Grey	Grey
Soil Texture		Clay	Clay	Clay
pH (1:5 Water)		7.0	8.1	8.3
pH (1:5 CaCl2)		6.0	6.8	7.1
Electrical Conductivity (1:5 water)	dS/m	0.06	0.05	0.11
Electrical Conductivity (Sat. Ext.)	dS/m	0.4	0.3	0.7
Chloride	mg/kg	11	<10	26
Organic Carbon (W&B)	%	0.3	<0.2	<0.2
Nitrate Nitrogen	mg/kg	10	1	1
Ammonium Nitrogen	mg/kg	3	1	1
Phosphorus (Colwell)	mg/kg	<5	<5	<5
Phosphorus (BSES)	mg/kg	5	<5	<5
Phosphorus Buffer Index		72	99	65
Sulphur (MCP)	mg/kg	4	3	20
Cation Exch. Cap. (CEC)	cmol(+)/kg	20.4	21.7	22.9
Calcium (Amm-acet.)	cmol(+)/kg	13.0	14.0	15.0
Magnesium (Amm-acet.)	cmol(+)/kg	6.8	6.1	6.0
Sodium (Amm-acet.)	cmol(+)/kg	0.40	1.10	1.50
Potassium (Amm-acet.)	cmol(+)/kg	0.51	0.29	0.31

NUTRIENT REPORT

CLEVELAND ARG

CLEVELAND
QLD 4163

Service Provider: LANDMARK - St George
Advisor/Contact: Dale Clark
Phone: 0438 626 506
Purchase Order: TBA

Available Potassium	mg/kg	200	110	120
Aluminium (KCl)	cmol(+)/kg	<0.1	<0.1	<0.1
Aluminium % of Cations	%	<1.0	<1.0	<1.0
Calcium % of Cations	%	62.0	66.0	66.0
Magnesium % of Cations	%	33.0	28.0	26.0
Sodium % of Cations (ESP)	%	2.00	4.90	6.60
Potassium % of Cations	%	2.50	1.30	1.30
Calcium/Magnesium Ratio		1.9	2.3	2.5
Zinc (DTPA)	mg/kg	0.10	0.10	<0.02
Copper (DTPA)	mg/kg	0.76	0.55	0.49
Iron (DTPA)	mg/kg	24.0	17.0	16.0
Manganese (DTPA)	mg/kg	41.0	16.0	7.2
Boron (Hot CaCl2)	mg/kg	0.5	0.9	1.4

The results in this report pertain only to the sample submitted. Analyses performed on soil dried at 40°C and ground to 2mm or less, excluding moisture tests, or as otherwise indicated. Analyses performed on plant dried at 70°C and ground to 1mm or less, excluding moisture tests, or as otherwise indicated. Water analyses performed on an 'as received' basis. Analytical results reported by the laboratory as 'less than' the level of reporting, will be deemed by NA Pro as being equivalent to the level of reporting for both calculation and interpretive purposes. This document shall not be reproduced except in full.

NUTRIENT REPORT

CLEVELAND ARG

CLEVELAND
QLD 4163

Service Provider: LANDMARK - St George
Advisor/Contact: Dale Clark
Phone: 0438 626 506
Purchase Order: TBA

Sample No		022197614	022197615	022197616
Paddock Name		UCMA 3	UCMA 3	UCMA 3
Sample Name		UCMA 3	UCMA 3	UCMA 3
Sample Depth (cm)		0 - 30	30 - 60	60 - 90
Sampling Date		22/11/2019	22/11/2019	22/11/2019
Test Code		E33	E33	E33
Sample Type		Soil	Soil	Soil
Analyte	**Unit**	**Result**	**Result**	**Result**
Soil Colour		Grey	Grey	Grey
Soil Texture		Clay	Clay	Clay
pH (1:5 Water)		7.2	7.8	7.7
pH (1:5 CaCl2)		6.1	6.5	6.6
Electrical Conductivity (1:5 water)	dS/m	0.04	0.04	0.10
Electrical Conductivity (Sat. Ext.)	dS/m	0.2	0.2	0.6
Chloride	mg/kg	<10	<10	<10
Organic Carbon (W&B)	%	0.2	<0.2	<0.2
Nitrate Nitrogen	mg/kg	3	1	2
Ammonium Nitrogen	mg/kg	3	1	3
Phosphorus (Colwell)	mg/kg	5	<5	<5
Phosphorus (BSES)	mg/kg	<5	<5	<5
Phosphorus Buffer Index		83	87	77
Sulphur (MCP)	mg/kg	3	3	28
Cation Exch. Cap. (CEC)	cmol(+)/kg	20.1	20.6	21.4
Calcium (Amm-acet.)	cmol(+)/kg	8.8	9.7	10.0
Magnesium (Amm-acet.)	cmol(+)/kg	10.0	9.8	9.5
Sodium (Amm-acet.)	cmol(+)/kg	0.45	0.84	1.20
Potassium (Amm-acet.)	cmol(+)/kg	0.54	0.36	0.39

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NUTRIENT REPORT

CLEVELAND ARG

CLEVELAND
QLD 4163

Service Provider: LANDMARK - St George
Advisor/Contact: Dale Clark
Phone: 0438 626 506
Purchase Order: TBA

Available Potassium	mg/kg	210	140	150
Aluminium (KCl)	cmol(+)/kg	<0.1	<0.1	<0.1
Aluminium % of Cations	%	<1.0	<1.0	<1.0
Calcium % of Cations	%	44.0	47.0	48.0
Magnesium % of Cations	%	51.0	47.0	45.0
Sodium % of Cations (ESP)	%	2.20	4.10	5.60
Potassium % of Cations	%	2.70	1.70	1.80
Calcium/Magnesium Ratio		0.9	1.0	1.1
Zinc (DTPA)	mg/kg	0.07	0.05	0.07
Copper (DTPA)	mg/kg	0.83	0.67	0.68
Iron (DTPA)	mg/kg	28.0	21.0	20.0
Manganese (DTPA)	mg/kg	50.0	29.0	24.0
Boron (Hot CaCl2)	mg/kg	0.5	0.8	1.2

The results in this report pertain only to the sample submitted. Analyses performed on soil dried at 40°C and ground to 2mm or less, excluding moisture tests, or as otherwise indicated. Analyses performed on plant dried at 70°C and ground to 1mm or less, excluding moisture tests, or as otherwise indicated. Water analyses performed on an 'as received' basis. Analytical results reported by the laboratory as 'less than' the level of reporting, will be deemed by NA Pro as being equivalent to the level of reporting for both calculation and interpretive purposes. This document shall not be reproduced except in full.

***Disclaimer:** Laboratory analyses and fertiliser recommendations are made in good faith, based on the best technical information available as at the date of this report. Incitec Pivot Limited, its officers, employees, consultants, Agents and Dealers do not accept any liability whatsoever arising fromor in connection with the analytical results, interpretations and recommendations provided, and the client takes the analytical results, interpretations and recommendations on these terms. In respect of liability which cannot be excluded by law, Incitec Pivot's liability is restricted to the re-supply of the laboratory analysis or the cost of having the analysis re-supplied.*

NUTRIENT REPORT

CLEVELAND ARG

CLEVELAND
QLD 4163

Service Provider: LANDMARK - St George
Advisor/Contact: Dale Clark
Phone: 0438 626 506
Purchase Order: TBA

Sample No		022197617	022197618	022197619
Paddock Name		UCMA 4	UCMA 4	UCMA 4
Sample Name		UCMA 4	UCMA 4	UCMA 4
Sample Depth (cm)		0 - 30	30 - 60	60 - 90
Sampling Date		22/11/2019	22/11/2019	22/11/2019
Test Code		E33	E33	E33
Sample Type		Soil	Soil	Soil
Analyte	**Unit**	**Result**	**Result**	**Result**
Soil Colour		Brown	Brown	Brown
Soil Texture		Clay	Clay	Clay
pH (1:5 Water)		7.1	7.8	8.4
pH (1:5 CaCl2)		6.1	6.5	7.1
Electrical Conductivity (1:5 water)	dS/m	0.05	0.03	0.06
Electrical Conductivity (Sat. Ext.)	dS/m	0.3	0.2	0.4
Chloride	mg/kg	<10	<10	22
Organic Carbon (W&B)	%	0.3	<0.2	<0.2
Nitrate Nitrogen	mg/kg	7	2	1
Ammonium Nitrogen	mg/kg	3	1	1
Phosphorus (Colwell)	mg/kg	<5	<5	<5
Phosphorus (BSES)	mg/kg	<5	<5	<5
Phosphorus Buffer Index		80	74	72
Sulphur (MCP)	mg/kg	4	1	2
Cation Exch. Cap. (CEC)	cmol(+)/kg	17.1	19.3	20.0
Calcium (Amm-acet.)	cmol(+)/kg	11.0	13.0	13.0
Magnesium (Amm-acet.)	cmol(+)/kg	5.8	5.8	5.5
Sodium (Amm-acet.)	cmol(+)/kg	0.08	0.43	1.20
Potassium (Amm-acet.)	cmol(+)/kg	0.51	0.26	0.19

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NUTRIENT REPORT

CLEVELAND ARG		**Service Provider:**	LANDMARK - St George
		Advisor/Contact:	Dale Clark
CLEVELAND		**Phone:**	0438 626 506
QLD 4163		**Purchase Order:**	TBA

Available Potassium	mg/kg	200	100	74
Aluminium (KCl)	cmol(+)/kg	<0.1	<0.1	<0.1
Aluminium % of Cations	%	<1.0	<1.0	<1.0
Calcium % of Cations	%	62.0	66.0	66.0
Magnesium % of Cations	%	34.0	30.0	28.0
Sodium % of Cations (ESP)	%	0.49	2.20	5.80
Potassium % of Cations	%	3.00	1.40	0.95
Calcium/Magnesium Ratio		1.9	2.2	2.4
Zinc (DTPA)	mg/kg	0.10	<0.02	<0.02
Copper (DTPA)	mg/kg	0.74	0.53	0.50
Iron (DTPA)	mg/kg	23.0	16.0	14.0
Manganese (DTPA)	mg/kg	29.0	14.0	8.2
Boron (Hot CaCl2)	mg/kg	0.3	0.6	0.9

The results in this report pertain only to the sample submitted. Analyses performed on soil dried at 40°C and ground to 2mm or less, excluding moisture tests, or as otherwise indicated. Analyses performed on plant dried at 70°C and ground to 1mm or less, excluding moisture tests, or as otherwise indicated. Water analyses performed on an 'as received' basis. Analytical results reported by the laboratory as 'less than' the level of reporting, will be deemed by NA Pro as being equivalent to the level of reporting for both calculation and interpretive purposes. This document shall not be reproduced except in full.

NUTRIENT REPORT

CLEVELAND ARG	**Service Provider:** LANDMARK - St George
	Advisor/Contact: Dale Clark
CLEVELAND	**Phone:** 0438 626 506
QLD 4163	**Purchase Order:** TBA

Sample No		022197620	022197621	022197622
Paddock Name		UCMA 5	UCMA 5	UCMA 5
Sample Name		UCMA 5	UCMA 5	UCMA 5
Sample Depth (cm)		0 - 30	30 - 60	60 - 90
Sampling Date		22/11/2019	22/11/2019	22/11/2019
Test Code		E33	E33	E33
Sample Type		Soil	Soil	Soil
Analyte	**Unit**	**Result**	**Result**	**Result**
Soil Colour		Grey	Grey	Grey
Soil Texture		Clay	Clay	Clay
pH (1:5 Water)		7.2	8.1	8.1
pH (1:5 CaCl2)		6.0	6.7	7.0
Electrical Conductivity (1:5 water)	dS/m	0.04	0.05	0.20
Electrical Conductivity (Sat. Ext.)	dS/m	0.2	0.3	1.2
Chloride	mg/kg	<10	18	140
Organic Carbon (W&B)	%	0.2	<0.2	<0.2
Nitrate Nitrogen	mg/kg	6	<1	1
Ammonium Nitrogen	mg/kg	2	1	1
Phosphorus (Colwell)	mg/kg	<5	<5	<5
Phosphorus (BSES)	mg/kg	<5	<5	<5
Phosphorus Buffer Index		92	80	78
Sulphur (MCP)	mg/kg	4	3	29
Cation Exch. Cap. (CEC)	cmol(+)/kg	18.5	18.0	22.7
Calcium (Amm-acet.)	cmol(+)/kg	9.2	9.1	11.0
Magnesium (Amm-acet.)	cmol(+)/kg	8.6	7.6	9.0
Sodium (Amm-acet.)	cmol(+)/kg	0.32	1.20	2.10
Potassium (Amm-acet.)	cmol(+)/kg	0.44	0.14	0.21

NUTRIENT REPORT

CLEVELAND ARG		**Service Provider:**	LANDMARK - St George
		Advisor/Contact:	Dale Clark
CLEVELAND		**Phone:**	0438 626 506
QLD 4163		**Purchase Order:**	TBA

Available Potassium	mg/kg	170	53	82
Aluminium (KCl)	cmol(+)/kg	<0.1	<0.1	<0.1
Aluminium % of Cations	%	<1.0	<1.0	<1.0
Calcium % of Cations	%	50.0	51.0	50.0
Magnesium % of Cations	%	46.0	42.0	40.0
Sodium % of Cations (ESP)	%	1.70	6.50	9.30
Potassium % of Cations	%	2.40	0.75	0.92
Calcium/Magnesium Ratio		1.1	1.2	1.2
Zinc (DTPA)	mg/kg	0.04	<0.02	<0.02
Copper (DTPA)	mg/kg	0.70	0.61	0.54
Iron (DTPA)	mg/kg	22.0	17.0	13.0
Manganese (DTPA)	mg/kg	39.0	17.0	8.0
Boron (Hot CaCl2)	mg/kg	0.4	0.9	1.4

The results in this report pertain only to the sample submitted. Analyses performed on soil dried at 40°C and ground to 2mm or less, excluding moisture tests, or as otherwise indicated. Analyses performed on plant dried at 70°C and ground to 1mm or less, excluding moisture tests, or as otherwise indicated. Water analyses performed on an 'as received' basis. Analytical results reported by the laboratory as 'less than' the level of reporting, will be deemed by NA Pro as being equivalent to the level of reporting for both calculation and interpretive purposes. This document shall not be reproduced except in full.

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NUTRIENT REPORT

CLEVELAND ARG

CLEVELAND
QLD 4163

Service Provider: LANDMARK - St George
Advisor/Contact: Dale Clark
Phone: 0438 626 506
Purchase Order: TBA

Sample No		022197623	022197624	022197625
Paddock Name		UCMA 6	UCMA 6	UCMA 6
Sample Name		UCA 6	UCA 6	UCA 6
Sample Depth (cm)		0 - 30	30 - 60	60 - 90
Sampling Date		22/11/2019	22/11/2019	22/11/2019
Test Code		E33	E33	E33
Sample Type		Soil	Soil	Soil
Analyte	**Unit**	**Result**	**Result**	**Result**
Soil Colour		Grey	Grey	Grey
Soil Texture		Clay	Clay	Clay
pH (1:5 Water)		7.0	8.0	7.4
pH (1:5 CaCl2)		5.9	6.6	7.0
Electrical Conductivity (1:5 water)	dS/m	0.04	0.05	0.54
Electrical Conductivity (Sat. Ext.)	dS/m	0.2	0.3	3.3
Chloride	mg/kg	<10	14	140
Organic Carbon (W&B)	%	0.2	<0.2	<0.2
Nitrate Nitrogen	mg/kg	2	<1	1
Ammonium Nitrogen	mg/kg	3	1	1
Phosphorus (Colwell)	mg/kg	<5	<5	<5
Phosphorus (BSES)	mg/kg	<5	<5	<5
Phosphorus Buffer Index		82	74	63
Sulphur (MCP)	mg/kg	3	3	370
Cation Exch. Cap. (CEC)	cmol(+)/kg	19.3	22.4	25.9
Calcium (Amm-acet.)	cmol(+)/kg	8.6	11.0	13.0
Magnesium (Amm-acet.)	cmol(+)/kg	9.8	10.0	9.6
Sodium (Amm-acet.)	cmol(+)/kg	0.36	1.30	2.40
Potassium (Amm-acet.)	cmol(+)/kg	0.50	0.37	0.36

DRAFT

NUTRIENT REPORT

CLEVELAND ARG		**Service Provider:**	LANDMARK - St George
		Advisor/Contact:	Dale Clark
CLEVELAND		**Phone:**	0438 626 506
QLD 4163		**Purchase Order:**	TBA

Available Potassium	mg/kg	200	150	140
Aluminium (KCl)	cmol(+)/kg	<0.1	<0.1	<0.1
Aluminium % of Cations	%	<1.0	<1.0	<1.0
Calcium % of Cations	%	44.0	47.0	52.0
Magnesium % of Cations	%	51.0	45.0	37.0
Sodium % of Cations (ESP)	%	1.90	5.80	9.30
Potassium % of Cations	%	2.60	1.70	1.40
Calcium/Magnesium Ratio		0.9	1.1	1.4
Zinc (DTPA)	mg/kg	0.06	<0.02	<0.02
Copper (DTPA)	mg/kg	0.80	0.64	0.54
Iron (DTPA)	mg/kg	23.0	18.0	15.0
Manganese (DTPA)	mg/kg	41.0	18.0	9.0
Boron (Hot CaCl2)	mg/kg	0.4	1.0	1.8

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NUTRIENT REPORT

CLEVELAND ARG		**Service Provider:**	LANDMARK - St George
		Advisor/Contact:	Dale Clark
CLEVELAND		**Phone:**	0438 626 506
QLD 4163		**Purchase Order:**	TBA

Sample No		022197626	022197627	022197628
Paddock Name		UCMA 8	UCMA 8	UCMA 8
Sample Name		UCMA 8	UCMA 8	UCMA 8
Sample Depth (cm)		0 - 30	30 - 60	60 - 90
Sampling Date		22/11/2019	22/11/2019	22/11/2019
Test Code		E33	E33	E33
Sample Type		Soil	Soil	Soil
Analyte	**Unit**	**Result**	**Result**	**Result**
Soil Colour		Grey	Grey	Grey
Soil Texture		Clay	Clay	Clay
pH (1:5 Water)		7.6	8.1	7.9
pH (1:5 CaCl2)		6.3	6.8	7.2
Electrical Conductivity (1:5 water)	dS/m	0.05	0.11	0.40
Electrical Conductivity (Sat. Ext.)	dS/m	0.3	0.7	2.5
Chloride	mg/kg	18	50	280
Organic Carbon (W&B)	%	<0.2	<0.2	<0.2
Nitrate Nitrogen	mg/kg	2	1	<1
Ammonium Nitrogen	mg/kg	1	2	1
Phosphorus (Colwell)	mg/kg	<5	<5	<5
Phosphorus (BSES)	mg/kg	<5	<5	<5
Phosphorus Buffer Index		81	74	72
Sulphur (MCP)	mg/kg	2	7	100
Cation Exch. Cap. (CEC)	cmol(+)/kg	21.6	23.5	25.7
Calcium (Amm-acet.)	cmol(+)/kg	10.0	12.0	12.0
Magnesium (Amm-acet.)	cmol(+)/kg	10.0	9.8	9.7
Sodium (Amm-acet.)	cmol(+)/kg	0.67	1.70	3.00
Potassium (Amm-acet.)	cmol(+)/kg	0.52	0.47	0.45

NUTRIENT REPORT

CLEVELAND ARG	**Service Provider:** LANDMARK - St George
	Advisor/Contact: Dale Clark
CLEVELAND	**Phone:** 0438 626 506
QLD 4163	**Purchase Order:** TBA

Available Potassium	mg/kg	200	180	180
Aluminium (KCl)	cmol(+)/kg	<0.1	<0.1	<0.1
Aluminium % of Cations	%	<1.0	<1.0	<1.0
Calcium % of Cations	%	48.0	49.0	49.0
Magnesium % of Cations	%	46.0	42.0	38.0
Sodium % of Cations (ESP)	%	3.10	7.00	12.00
Potassium % of Cations	%	2.40	2.00	1.80
Calcium/Magnesium Ratio		1.0	1.2	1.2
Zinc (DTPA)	mg/kg	0.04	<0.02	<0.02
Copper (DTPA)	mg/kg	0.71	0.57	0.51
Iron (DTPA)	mg/kg	21.0	16.0	15.0
Manganese (DTPA)	mg/kg	26.0	13.0	6.0
Boron (Hot CaCl2)	mg/kg	0.6	1.5	2.2

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NUTRIENT REPORT

CLEVELAND ARG

CLEVELAND
QLD 4163

Service Provider: LANDMARK - St George
Advisor/Contact: Dale Clark
Phone: 0438 626 506
Purchase Order: TBA

Sample No		022197629	022197630	022197631
Paddock Name		UCMA 12	UCMA 12	UCMA 12
Sample Name		UCMA 12	UCMA 12	UCMA 12
Sample Depth (cm)		0 - 30	30 - 60	60 - 90
Sampling Date		22/11/2019	22/11/2019	22/11/2019
Test Code		E33	E33	E33
Sample Type		Soil	Soil	Soil
Analyte	**Unit**	**Result**	**Result**	**Result**
Soil Colour		Brown	Brown	Brown
Soil Texture		Clay	Clay	Clay
pH (1:5 Water)		7.3	8.6	7.9
pH (1:5 CaCl2)		6.4	7.3	6.8
Electrical Conductivity (1:5 water)	dS/m	0.04	0.05	0.03
Electrical Conductivity (Sat. Ext.)	dS/m	0.2	0.3	0.2
Chloride	mg/kg	<10	<10	<10
Organic Carbon (W&B)	%	0.3	0.2	0.2
Nitrate Nitrogen	mg/kg	2	1	<1
Ammonium Nitrogen	mg/kg	2	1	1
Phosphorus (Colwell)	mg/kg	<5	<5	<5
Phosphorus (BSES)	mg/kg	<5	<5	6
Phosphorus Buffer Index		79	88	85
Sulphur (MCP)	mg/kg	2	<1	<1
Cation Exch. Cap. (CEC)	cmol(+)/kg	19.1	21.5	17.5
Calcium (Amm-acet.)	cmol(+)/kg	13.0	15.0	12.0
Magnesium (Amm-acet.)	cmol(+)/kg	5.7	5.5	5.4
Sodium (Amm-acet.)	cmol(+)/kg	0.09	0.64	0.26
Potassium (Amm-acet.)	cmol(+)/kg	0.27	0.07	0.05

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NUTRIENT REPORT

CLEVELAND ARG		**Service Provider:**	LANDMARK - St George
		Advisor/Contact:	Dale Clark
CLEVELAND		**Phone:**	0438 626 506
QLD 4163		**Purchase Order:**	TBA

Available Potassium	mg/kg	110	29	20
Aluminium (KCl)	cmol(+)/kg	<0.1	<0.1	<0.1
Aluminium % of Cations	%	<1.0	<1.0	<1.0
Calcium % of Cations	%	68.0	71.0	67.0
Magnesium % of Cations	%	30.0	26.0	31.0
Sodium % of Cations (ESP)	%	0.45	3.00	1.50
Potassium % of Cations	%	1.40	0.34	0.29
Calcium/Magnesium Ratio		2.3	2.7	2.2
Zinc (DTPA)	mg/kg	0.07	<0.02	<0.02
Copper (DTPA)	mg/kg	0.62	0.42	0.51
Iron (DTPA)	mg/kg	17.0	12.0	14.0
Manganese (DTPA)	mg/kg	21.0	5.6	10.0
Boron (Hot CaCl2)	mg/kg	0.3	0.7	0.5

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NUTRIENT REPORT

CLEVELAND ARG	**Service Provider:** LANDMARK - St George
	Advisor/Contact: Dale Clark
CLEVELAND	**Phone:** 0438 626 506
QLD 4163	**Purchase Order:** TBA

Sample No		022197660	022197659	022197658
Paddock Name		UCMA 16	UCMA 16	UCMA 16
Sample Name		UCMA 16	UCMA 16	UCMA 16
Sample Depth (cm)		0 - 30	30 - 60	60 - 90
Sampling Date		22/11/2019	22/11/2019	22/11/2019
Test Code		E33	E33	E33
Sample Type		Soil	Soil	Soil
Analyte	**Unit**	**Result**	**Result**	**Result**
Soil Colour		Grey	Grey	Grey
Soil Texture		Clay	Clay	Clay
pH (1:5 Water)		7.1	7.9	8.4
pH (1:5 CaCl2)		6.1	6.5	7.5
Electrical Conductivity (1:5 water)	dS/m	0.04	0.04	0.29
Electrical Conductivity (Sat. Ext.)	dS/m	0.2	0.2	1.8
Chloride	mg/kg	<10	<10	160
Organic Carbon (W&B)	%	0.3	<0.2	<0.2
Nitrate Nitrogen	mg/kg	5	2	2
Ammonium Nitrogen	mg/kg	6	1	2
Phosphorus (Colwell)	mg/kg	<5	<5	<5
Phosphorus (BSES)	mg/kg	8	<5	8
Phosphorus Buffer Index		80	75	62
Sulphur (MCP)	mg/kg	4	2	120
Cation Exch. Cap. (CEC)	cmol(+)/kg	19.1	19.2	23.9
Calcium (Amm-acet.)	cmol(+)/kg	10.0	11.0	14.0
Magnesium (Amm-acet.)	cmol(+)/kg	8.3	7.5	7.9
Sodium (Amm-acet.)	cmol(+)/kg	0.13	0.79	2.30
Potassium (Amm-acet.)	cmol(+)/kg	0.53	0.15	0.16

NUTRIENT REPORT

CLEVELAND ARG

CLEVELAND
QLD 4163

Service Provider: LANDMARK - St George
Advisor/Contact: Dale Clark
Phone: 0438 626 506
Purchase Order: TBA

Available Potassium	mg/kg	210	57	64
Aluminium (KCl)	cmol(+)/kg	<0.1	<0.1	<0.1
Aluminium % of Cations	%	<1.0	<1.0	<1.0
Calcium % of Cations	%	54.0	56.0	57.0
Magnesium % of Cations	%	43.0	39.0	33.0
Sodium % of Cations (ESP)	%	0.67	4.10	9.50
Potassium % of Cations	%	2.80	0.76	0.68
Calcium/Magnesium Ratio		1.2	1.5	1.8
Zinc (DTPA)	mg/kg	0.11	<0.02	0.04
Copper (DTPA)	mg/kg	0.84	0.62	0.46
Iron (DTPA)	mg/kg	25.0	18.0	12.0
Manganese (DTPA)	mg/kg	33.0	15.0	5.7
Boron (Hot CaCl2)	mg/kg	0.3	0.6	1.9

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