University of Southern Queensland
Faculty of Health, Engineering and Sciences

Combination Harvest and Bale Machinery's Impact on Cotton Productivity in High Clay Cotton Fields of Northern NSW

A Dissertation Submitted by

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ABSTRACT

This project aimed to explore the effects that combination harvest and baling machinery have on the compaction of a high clay soil common of the cotton industry in Australia and to investigate the effects it may have on overall cotton yield.

The project was comprised of two field trips to a research field at the Australian Cotton Research Institute near Narrabri, NSW: one before the 2022 harvest and one after. Soil samples were taking using a soil corer to depths of 80cm to create eight 10cm subsamples. These subsamples were analysed for bulk density and moisture content. Individual cores were also taken to record pH and electrical conductivity across the field to isolate them as variables. Penetration resistance was also recorded to depths across the field after the 2022 harvest to examine the difference in soil strength.

Cotton yield data was provided by the Australian Cotton Research Institute, which showed that the field that had been trafficked by the combination harvest and bale harvester did in fact have a lower overall cotton yield that the control section of the field. It was also observed that before harvest the field being trafficked by the combination harvester also had higher compaction indices, as well as having higher penetration resistance immediately after harvest.

No overall statistical significance was observed in the difference in bulk density and moisture content between the two fields. As such, no concrete conclusions could be made as to the compaction effect of the combination harvest.

LIMITATIONS OF USE

CERTIFICATION OF DISSERTATION

I certify that the ideas, designs and experimental work, results, analyses, and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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A. Henderson

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ACKNOWLEDGEMENTS

I would like to thank Dr. Stirling Roberton and John Bennett for the opportunity to undertake this project, and Tim Weaver of the Australian Cotton Research Institute who liaised with me in organising field access. I would also like to thank David West for his help in undertaking field work and access to the USQ soil labs.

Thank you to my family for also supporting me in my studies, without the love and support of you none of this would be possible.

Finally, thank you to Sophie, for giving me the motivation to succeed in all my endeavours and to be the best version of myself.

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1 INTRODUCTION

1.1 BACKGROUND

The cotton industry in Australia has both immense contemporary importance and deep historical roots, with cotton seed arriving onboard the first fleet in 1788 (Cotton Australia, n.d.). The industry was plagued with turbulence from its inception but hit its stride in the 1960's with the establishment of large-scale dam fed irrigation, increases in commercial cotton crops and the establishment of government-corporate industry bodies (Cotton Australia, n.d.). Today, the Australian cotton market operates with an average value of AUD $2 billion per annum (Cotton Australia, 2022b) and employs an estimated 12,000 workers (Cotton Australia, 2022). A significant advance in modern cotton agricultural machinery came in the form of the John Deere 7760 (JD7760), a combination harvest and baling cotton picker that debuted in 2009 (Bennet 2020) and offered land managers the prospect of significant efficiency increases at harvest time. The JD7760 quickly became popular in Australian cotton systems, being used to pick a reported 82% of Australian cotton in the 2013 picking season (Bennet et al 2014). This advance came with the caveat of a 50% increase in mass compared to previous cotton harvesting system, with the JD7760 weighing as much as 36.5 Mg when fully loaded during harvest (Bennet et al. 2019) and exerting up to 500 kPa of pressure on the soil surface at the rear wheels (Bennet 2018). A JD7760 is considered fully loaded when it is holding a 'module', also known as bale, of cotton externally, as well as 'building' a module of cotton internally.

Figure 1-1: John Deere 7760 with module on back (Ag-Accessories)

The process of building modules within the harvester is in contrast to earlier methods, which generally consist of harvesters with internal reservoirs that collect a load before transferring the load to an off-field module builder for compaction/baling. Most older harvesters do not have internal reservoirs and require a specialised tractor pulled trailer to collect the harvested material. Either of the earlier methods require extra equipment and labour to perform the process when compared to the combination harvest and baling machines like the JD7760. Importantly, all past research has been conducted on the JD7760 specifically, though a newer model of the JD7760, the CP690 is now in use. The CP690 is virtually identical to the JD7760, with modifications to the internal computing and a slightly larger engine. Within this work the term CP690 will be used to avoid confusion.

Figure 1-2: Cotton module builder being loaded by a tractor pulled cotton trailer (USDA NRCS Texas, 2010)

The dominant soil type in the cotton industry is a Vertosol (McKenzie 2001), a soil characterised by high clay content (> 35%) that exhibits strong shrinkage and cracking when dry and swelling when saturated (Isbell, 2021). Kirby (1991) states that Australian Vertosols have an average pre-compaction stress of 99.4 kPa, with pre-compaction stress being a proxy measure of the pressure that can be exerted on a soil before possible occurrence of compaction (Mosaddeghi et al. 2003).

Soil compaction is regarded as one of the “most serious environmental problem[s] caused by conventional agriculture”(McGarry et al. 2003), as well as the most costly and difficult to solve (McGarry et al. 2003). Research does currently exist that investigates the effect that compaction has on cotton system yields, for example, McGarry (1990) found that poor crop growth and yield, and distorted root systems were related to changes in measured indices of soil structure related to compaction. However, most research involves the comparison of different fields in different locations to assess the effects on yield and this research is an opportunity to limit the variables these differences produce. These variables will be limited by the study of a single field that has only historically used 'module builder' processes before the use of a CP690 in the 2020 season.

In determining the degree of compaction in soil, common methods include measuring the bulk density and penetration resistance of a soil (Alaoui et al, 2018). Bulk density is simply a measure of the dry material mass in a given volume of soil, generally expressed as kg/m^3. When soil is compacted the physical particles are pushed closer together, resulting in an increase in the amount and mass of dry matter in each unit of volume. This process makes bulk density a key indicator of compaction, while also being a simple measurement to take. Penetration resistance is an objective measure of the force required to penetrate a soil mass. It involves the use of a cone penetrometer which is plunged into the soil normal to the surface, measuring the soil strength as the cone descends. Soil strength is the ability of a soil to resist deformation and is a measure of a soil's susceptibility to compaction as well as magnitude of compaction. It is heavily dependent on soil moisture, with strength generally increasing as soil moisture content decreases (Agriculture Victoria 2020).

Typical methods of mitigating compaction involve physical tillage, or ripping, with tractor driven implements to physically disturb soil. This practice adds expense to farm operations as well possibly degrading soil structure and decreasing soil fauna (Loch, R 2022, pers. comm. 12 Feb) when done at greater depths, such as up to 500mm (Pagliai, et al., 2004). Delaying cotton defoliation has been shown to mitigate compaction through a reduction in soil moisture from extra evapotranspiration demand compared to standard defoliation practices (Bennet et al 2017). While this process is not physically disruptive to the soil resource there are agronomic considerations that may make it incompatible with land management strategies. Bio ripping, the use of deeper rooting crops such as wheat, to draw extra water from the surface profile has been shown to have some success in mitigating compaction (Bennet et al 2014). However, the degree of mitigation is limited, and again agronomic considerations may limit the viability of bio ripping as an option for land managers. Letting a field remain uncultivated and allow for the 'shrink swell' nature of Vertosols to naturally re-consolidate the soil to a pre compaction level of structure is another option to combat compaction. McHugh et al (2009) and Radford et al (2001) demonstrated that a timespan of 18-22 months is necessary for natural amelioration of compaction. As this time span is far greater than growing seasons permit there is a risk that ongoing use of heavy machinery such as a CP690 may accumulate structural degradation, namely the constriction of soil pores, through compaction over time in the absence of reasonable compaction mitigation processes.

Due to the risk of accumulation of compaction through cotton harvesting by use of a John Deere 7760, and the industry response indicating that the JD7760 systems "costs as much to run as previous basket systems" (Bennet et al 2014) it is important to fully understand the impacts of the harvesting technique on the soil resource to avoid the structural degradation of cotton systems without appreciable benefits.

1.2 Aims and Objectives

The aim of this thesis is to design and execute a field trial to provide a quality set of data that is useful in examining the effect that the John Deere 7760 has on cotton yield in cotton systems on Vertisols typical of Eastern Australia. This thesis, the associated field work, and literature review also aims to enhance the writers' skills in sample analysis, sample planning and use of graphical and numerical analysis techniques relevant to soil science and laboratory testing.

These aims will be achieved through the design of a sampling plan to study the physical properties of the study field that relate to compaction; that is bulk density and soil strength, before and after harvest by a CP690. The study field was segmented into a section that has been trafficked by a 2-row trial picker and a section that has had a single traffic by a CP690. Transects were made spanning two 'frontages' of each picking machinery through which soil cores were taken on every furrow.

The hypothesis to be tested is that traffic by a JD7760/CP690 has immediate and significant compaction effects that limit the growth of future cotton crops in the field, to the magnitude of causing economic losses for the land manager.

1.3 Consequences of this research

This research will provide a data point demonstrating the effects of the JD7760/CP690 on soil compaction and its relation to cotton crop yield. In addition to related research this data will aid decision making for farmers/land managers by enabling a better understanding of the negative consequences of utilising combination harvest and bale equipment on high clay content soils. Through increasing land managers ability to make more informed decisions this research will lead to better outcomes in terms of cotton yield and soil health.

1.4 Ethics

The consequences of poor or incorrect information can have large ramifications for land managers if information from this work is used to make decisions. Due to this, it is imperative that the work is carried out to the highest degree of scientific rigor to avoid potentially drawing incorrect conclusions as to the effect on yield.

2 Literature Review

This section will outline the current state of scientific knowledge regarding compaction and the effect it has on cotton growth. It will disseminate information on the mechanisms involved in compaction and the specific effects they have on soil structure.

2.1 Investigation Depth

Investigations in past research has generally been limited to 0.8m – 1.0m, with Bennet et al (2019) suggesting an effective rooting depth of cotton of 0.9m. This also corresponds with practical limits of investigation with handheld implements. As such, an investigation depth of 0.8m will be adopted.

2.2 Impact of the John Deere 7760/CP690

The John Deere 7760, when fully loaded, has a back wheel pressure of 500 kPa (Bennet et al 2019) exceeding the precompression stress of Australia Vertosols of 99.4 kPa proposed by Kirby (1991). Past research has shown that traffic by a JD7760 increases bulk density by an average of 11.1 % (Bennet et al 2019). The past research clearly demonstrates the hazard of JD7760 causing compaction during harvest. Newer models of the JD7760 are referred to as CP690 and include more advanced GPS and on-board computational abilities. A slightly larger engine is also equipped onto the CP690's compared the JD7760, however there is not a significant difference in weight across the two models and therefore the findings still apply.

2.3 Compaction Mechanics

Compaction of soil effectively decreases soil porosity, the connected void space, within the soil matrix (Kim et al 2010) as well as being destructive to pore connections (Antille et al 2016). Pores within soil are generally defined as macropore (> 1000 μm in diameter) and micropores (200 – 1000 μm in diameter). Kim et al (2010) found that under uniform loading the proportion of macropores and micropores decreased at the same magnitude (~70%). These decreases in pore space result in decreases in hydraulic conductivity, lower the plant available water and availability of mobile nutrients to the plant.

Compaction has been shown to decrease nitrification in soil, decreasing the available nitrogen for plant growth (CRDC 2018). Compaction also increases soil strength (Shar et al 2017), making it harder for plants to root, with 1490 kPa being the critical threshold at which plant roots cease exploration (McKenzie and McBratney 2001).

2.3.1 Compaction and Hydraulic Conductivity

As soil is compacted the pore space within is constricted, reducing the ability for water to flow through the soil matrix, with a non-linear relationship between compaction as measured by a change in bulk density and the effect on hydraulic conductivity. This non-linear relationship is show by Kim et al (2010) as a n 8% increase in bulk density reduced hydraulic conductivity by 69%. Further work by Awedat et al (2012) in which a 20% increase in bulk density corresponded to an 84% decrease in hydraulic conductivity. In both studies the soil had a clay content around 25%.

2.3.2 Soil Moisture and Compaction

A strong correlation (R^2=0.85) between soil moisture pre harvest and bulk density after traffic was shown by Roberton & Bennet (2017), who also demonstrated that soil moisture was found to be more impactful in compaction then contact pressure/wheel load, with clay content also being a significant factor in compaction.

2.4 Compaction's Effect on Yield

A literature review by Antille et al (2016) shows that compaction can cause a 5% reduction in nutrient uptake by cotton crops and that traffic induced compaction in Vertosols can take over 5 years to 'self-ameliorate'. This review also notes multiple studies examining yield penalties of traffic induced compaction on Australian clay soils, which may be broadly comparable to Vertosols. Within these studies it was found that non trafficked fields produced 100 - 175%

compared to trafficked fields. Furthermore, McGarry (1990) observed a 73% reduction in cotton yield in Australian Vertosols that had compaction occur in the 0.2m – 0.4m depth range.

While research into the effects of compaction on yield of cotton, as well as other crops, is mature and widespread very rarely is the comparison made on the same field. The overwhelming majority of research makes comparisons of yield between compacted and non-compacted fields do so across different fields, introducing cultivation history as a variable that affects the field performance. This research is unique in that it will be assessing the effects on compaction on yield in which the ‘control’ and ‘experimental’ sections of the field have the same cultivation history, thus making it a more direct comparison.

2.5 Current Methods of Mitigation and Amelioration

Current literature points to 4 methods suitable to mitigate or ameliorate effects of JD7760 and other heavy machinery traffic on compaction:

- Bio-ripping
- Controlled traffic farming
- Delayed defoliation
- Organic matter sequestration

2.5.1 Bio-ripping

Bio-ripping is the name given to the practice of crop rotation in which the sacrificial, or secondary, crop is deeper rooting to instigate deep drainage, lowering the soil moisture content and mitigating compaction. The most common rotation crop is wheat. There is little data cataloguing this phenomenon and its effect on soil compaction outside of multiple mentions by soil researcher John McLean Bennet (Bennet et al 2014 & Bennet et al 2017). It is apparent that bio-ripping is a practice that is somewhat known to the industry and better quantifying its effect on compaction amelioration may be a field of further research.

2.5.2 Controlled Traffic Farming

Controlled traffic farming (CTF) is a farming system in which row spacings are designed such that the same rows are being ‘trafficked’ by the wheels of machinery each year. This process often involves modification of wheel tracks of certain farm machinery such that all equipment share a common wheel spacing.

CTF has been shown by McKenzie et al (1998) to be an effective strategy of maintaining yield from a cotton system, and in turn the gross margin. Bennet et al (2017) demonstrated no significant difference in levels of compaction between a 1m spacing system and a 1.5m spacing system. This research did note a 60% increase in wheat rotation crop yield, indicating possible enhancement of the bio-ripping provided by the rotation crop under this CTF configuration.

2.5.3 Delayed Defoliation

Cotton defoliation is the application of chemicals to force cotton plants to drop its leaves, allowing for harvest of the cotton bolls (Edmisten & Collins 2022). This effectively kills the plant, resulting in a cease of evapotranspiration.

Due to the high proportion of meso- and micropores in many Vertosols deep drainage is not a reliable source of soil moisture reduction. Thus, a delay in defoliation of the cotton crop may be used to reduce soil moisture due to an increase in overall evapotranspiration (Roberton & Bennett 2017). It was found by Roberton & Bennett (2017) that by delaying the defoliation by 21 days the soil moisture content down to 0.4m reduced by 2%. While this may seem insignificant, it has been shown that small effect on soil moisture can result in significant effects to the compaction under traffic, up until the optimum moisture content (Hamza & Anderson, 2005).

Timing of defoliation is governed mainly by the 'crop boll maturity and accumulated heat units over the season in order to maximise yield' (Roberton & Bennett 2017). Thus, it is apparent that defoliation may not be a suitable option in every case.

2.5.4 Organic Matter Sequestration

Chamen (2015) noted several studies showing positive effects of adding organic matter to soils to mitigate soil compaction. Organic matter sequestration functions primarily by improving drainage conditions allowing for soil moisture levels to decrease. It is noted that a study by Leskiw et al. (2012) found that fields which had been subsoiled (tillage to at least 35cm) and injected with pelletised organic matter had almost 20% lower density after 5 months compared to a field that was subsoiled only. This method has additional benefits, in that it increases available carbon in the soil, in turn encouraging bacterial activity (Chamen 2015).

3 METHODOLOGY

This methodology aims to outline and explain the actions undertaken in the field, in the laboratory and in technical analysis of the data. Resources were planned with Mr. David West (USQ).

3.1 FIELD METHODS

Field methods for this research include information on the field being studied and the methods for obtaining moisture content, bulk density and soil penetration resistance measurements.

3.1.1 Study Field

The field being studied was field B2 at the Australian Cotton Research Institute (ACRI) near Narrabri, NSW. At the time of study, the field was undergoing a comparative analysis of different cotton cultivars and nitrogen application rates. Plots were selected based on having no nitrogen application and of being the same cultivar. A detailed view of the field plan is included in Appendix D.

3.1.1.1 Location

The field is located just over 14km North-West of Narrabri in Northern NSW. The field had an area of 74,000 m^2, or 7.4 ha.

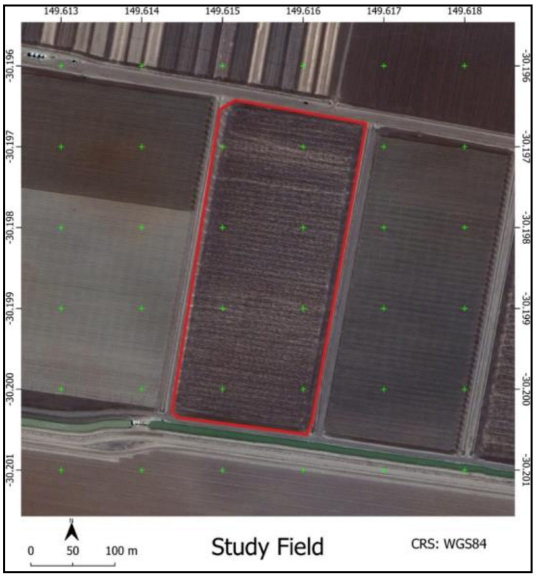

Figure 3-1: Aerial image of study field

Figure 3-2: Relative position of the study field to Narrabri, NSW

3.1.1.2 Vertosol Soil Classification

The study field has been classified as a Vertosol by State of the Environment (2016) and the associated mapping database:

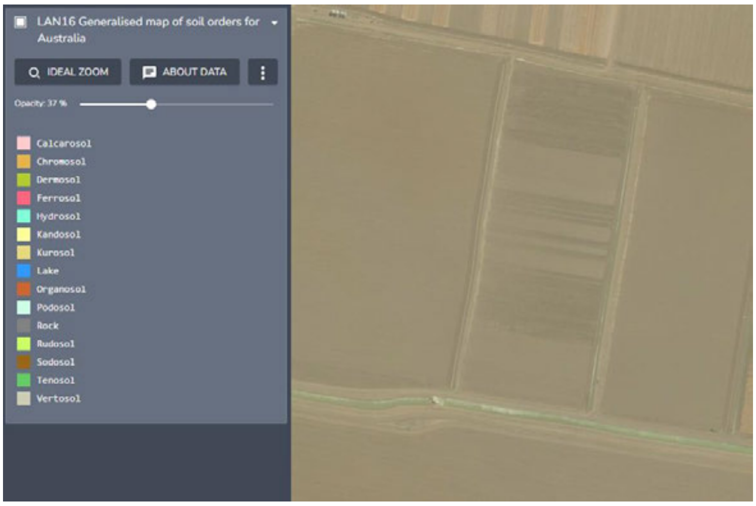

Figure 3-3: National Map showing Vertosol classification based on State of The Environment (2016)

In Australia, the preferred standard of soil classification is the Australian Soil Classification (Isbell 2021). This classification system broadly classifies soil into orders, based upon physical and chemical characteristics. The Australian Soil Classification (ASC) defines Vertosols as being ‘clay soils with shrink-swell properties that exhibits strong cracking when dry’. This cracking phenomenon creates large deep drainage channels when a dry surface is subject to rainfall. A clay content of > 35% is a necessary physical quality of a soil to be classified as a Vertosol. Further sub classification by colour is common, e.g., red/grey/black. To verify the clay content of the study field 4 random samples of topsoil were taken. Particle size analyses were done using the settling column method (Loch, 2001) to estimate the clay content within the samples. This method uses the falling velocity of suspended soil particles to estimate the equivalent spherical diameter. The method employs the settling velocity equation developed by Gibbs et al (1971):

$$V = \frac{-3\eta + \left[9\eta^2 + gr^2 P_f\left(P_s - P_f\right)(0.015476 + 0.19481r)\right]^2}{P_f(0.016607 + 0.14881r)}$$

Where:

- V : settling velocity (cm/s)
- η : dynamic viscosity of the fluid (poises) [assume 0.01
- g : acceleration due to gravity (m/s^2) [assume 9.81]

- r : particle radius (cm)
- P_f : density of fluid (g/cm^3) [assume 1]
- P_s : density of particle (g/cm^3) [assume 1.6]

(Loch 2001)

The results of the samples are:

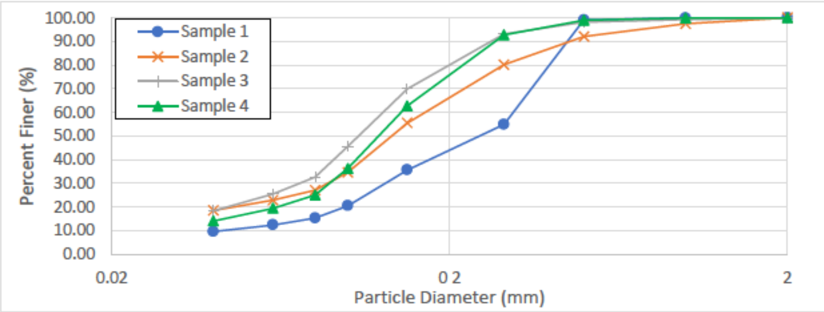

Figure 3-4: Particle size distribution of surface soil

As clay is the fraction of particles with a diameter of less than 0.002mm it is impossible for any of the samples to be over 20% clay as this method is only able to investigate to 0.04mm. This finding is in conflict with the feel of the soil in the hand and the instances of surface cracking across the field:

Figure 3-5: Surface cracking of topsoil at ACRI B2

This may be due to the observed property of many soils of which clay content is generally low in the upper layers and increases with depth (Nelson, et al., 1994).

It is important to note that as moisture content varies within a Vertosol, so does bulk density (Bennet et al 2019), as the ‘shrink-swell’ mechanics transport soil particles closer and further apart. With this knowledge it is imperative that moisture content is determined before and after harvest in order to control for moisture content as a variable.

3.1.1.3 Planting History

The study field follows a typical pattern of fallows and wheat crops between the cotton crops. The most recent cropping history of the field is:

- 2018-29 Season: Cotton
- 2019 Winter: Fallow
- 2019-20 Season: Fallow
- 2020 Winter: Fallow
- 2020-21 Season: Cotton (first traffic by CP690)
- 2021 Winter: Wheat
- 2021-22 Season: Cotton (second traffic by CP690)

3.1.2 Methods for Estimating Cotton Yield

Current scientific literature reference methods of estimating cotton yield by using high resolution cameras and multispectral analysis with varying levels of success. Huang et al (2013) used multispectral imagery to create a ‘ratio of vegetable index’ (RVI) to estimate cotton yield with a correlation factor R^2 of 0.47 between RVI and cotton yield.

Feng et al (2019) created a model of estimating cotton yield using unmanned aerial vehicles (UAV, aka drones) and photomosaic techniques. This technique involves creating a photomosaic and digital elevation model (DEM), in other words a ‘panorama’ with the view facing the ground from above and a 3D model of the field. This information set was then used to estimate plant height throughout the crop and relate this to an estimated yield, with a range of Pearson correlation coefficients of 0.54 – 0.95.

Yang et al (2006) used a combination of the two above techniques using satellite imagery and multispectral sensing from a satellite with an effective pixel size of 8.4m. A model to estimate cotton yield utilizing this data was created and compared to actual cotton yield with R^2 values of 0.432 – 0.621.

Due to uncertainties in the above methods and the inherent complexities of the data acquisition these methods are not considered adequate or possible for this project. Yield data instead was captured from the CP690's internal systems and the trial picker internals systems for the control field.

Picked cotton is constituted by three components:

- Lint
- Trash
- Seed

In order to sell the cotton, it must be processed by a cotton gin to remove the trash and seed from the lint (fibre) before being packed in 227kg 'bales' (Cotton Australia, n.d.). The economically important element thus is lint. The recorded yield values of lint/ha will be compared across the test and control field to determine the effective difference that the compaction may have on land managers. Notably, the lint content of the control field was derived from average proportions determined by handpicking assessments, with a lint content of 47-51%, and an average of 49%. The average value was used to derive the kg lint/ha value for the control field.

3.1.3 Soil Sampling

The methodology of this research aimed to employ similar techniques as those adopted in the aforementioned research of Bennet and Roberton (2019). Soil sampling occurred before harvesting in the 2012-22 Season and again post harvest, for a total of 2 sampling sets. The study field is delineated into two sections; one which has only been trafficked by a converted 2 row trial picker (referred to as the control field), and one which has had 2 traffics by a CP690 (referred to as the test field), 1 traffic before sampling occurred and 1 in between the sampling.

Transects were made across the study field to provide 3 sets of measurements for the control field and the test field. The transects within the test field spanned along 2 frontages of a JD7760 with soil cores taken in each furrow. The transects within the control field were inherently limited by proximity to sections of differing cultivars and nitrogen applications. As such, 2 rows of soil cores were taken within the 3 interior furrows, for a total of 6 cores in each section. Refer to Appendix B for the locations of the sampling.

Soil cores were taken using a Christies Engineering CHPD78 Post Driver and a 1m soil scoring sleeve with 47mm cutting tip internal diameter. Soil cores were split into 0.1m sections using a purpose built core ruler and a paint scraper before being stored in foil-lined bags to reduce moisture loss.

Figure 3-6: Converted Christie CHPD78 post driver with soil core attached

Figure 3-7: Soil core immediately after sampling

Figure 3-8: Soil core after being sub-sampled into 10cm sections

The depth of the holes created by the soil corer were measured in three randomly selected cores to ensure that the length of extracted core matched the depth of the respective hole. This was done to ensure no compaction was being imparted on the samples by the action of the soil corer/post driver. It was found across the three measurements that variations were < 2% and as such it was considered that it did not represent a significant source of error.

Along with soil cores at each sample point, soil strength measurements were made by a soil penetrometer along the transects every 0.2m down to a depth of 0.7m. The soil penetrometer logs the soil strength with depth every 0.01m. The crop hills were dug flat to ensure an even surface for the penetrometer to travel across, and to ensure the surface level was consistent across all readings. Care was taken such that the penetrometer testing was not near the void space created by soil coring to avoid inaccurate soil strength readings. Soil strength measurements were taken across 6 rows in the test field, corresponding to a single frontage of a CP690, and across 3 rows in the control field. Due to equipment failure penetrometer readings were not completed on the first sampling trip.

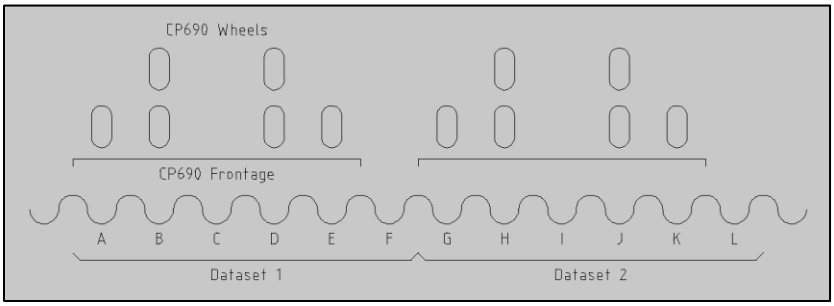

Figure 3-9: Layout of sample points relative to furrow spacing for test field

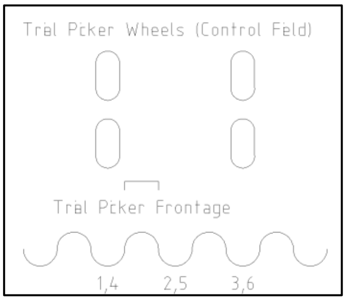

Figure 3-10: Layout of sample points relative to furrow spacing for control field

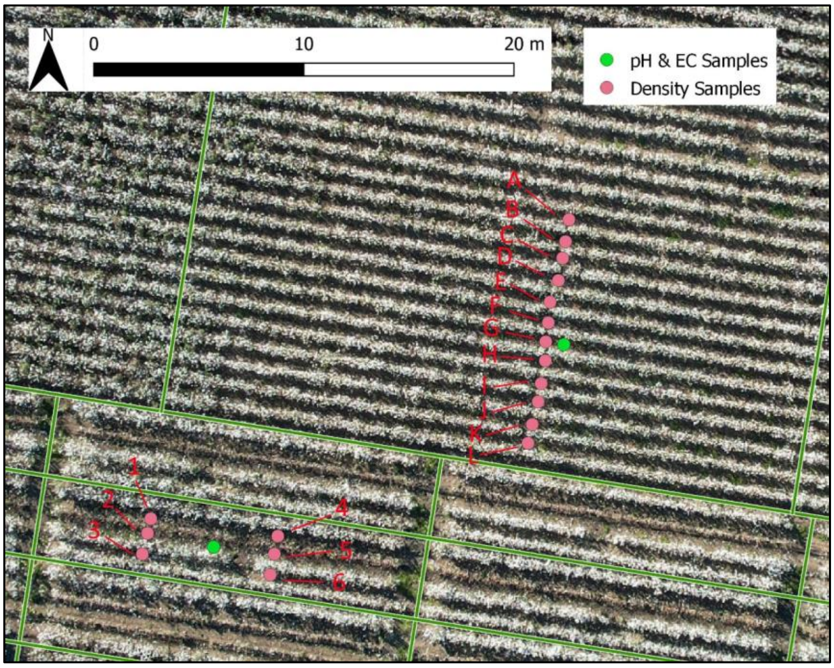

Figure 3-11: Aerial depiction of sample layout

Using the soil corer method to take multiple bulk density measurements has been shown in past research to be accurate to ± < 1% compared to singular bulk density measurements using bulk density rings (Roberton & Bennet 2017). Along with bulk density this method also allows for concurrent derivation of moisture content, a property that has significant impact on compaction. Collection of this data allowed for the control of moisture content as a variable of compaction. In total, 432 soil core subsamples were taken per trip for a total of 864 subsamples, and a total of 10,150 electronic measurements of soil strength.

3.2 LABORATORY METHODS

The laboratory work to analyse these samples included work to determine:

i) Average weight of subsample bag, g
ii) Gravimetric water content, %
iii) Bulk density, $g.cm^{-3}$
iv) Volumetric water content, %
v) Topsoil particle size distribution

3.2.1 Average Weight of Sample Bag

A collection of 20 standard foil lined sample bags with labels were weighed to determine a mean weight. This weight was found to be 6.42g with a coefficient of variance (CV) of 0.8%. As the CV was low it was determined that using the mean weight to determine the weight of the actual sample was valid across all samples.

3.2.2 Gravimetric Water Content

Gravimetric water content is a measure of the weight of water in a unit of soil per weight of soil. To determine this in the laboratory the weight of water was found as the difference in the subsample weight pre and post oven drying at 105° C for 72 hours:

$$\begin{aligned} &Water\ Weight\ (Subsample) \\ &\quad = Pre\ Oven\ Dry\ Weight\ (Subsample + Bag) \\ &\quad - Post\ Oven\ Dry\ Weight\ (Subsample + Bag) \end{aligned}$$

The weight of the soil was determined by as the average weight of sample bag taken from the oven dry weight of subsample in bag:

$$Dry\ Weight\ (Subsample) = Dry\ Weight\ (Subsample + Bag) - Ave.Weight\ (Bag)$$

Thus, to determine the gravimetric water content (GWC):

$$GWC\ (Subsample), \% = \frac{Water\ Weight\ (Subsample)}{Dry\ Weight\ (Subsample)}$$

3.2.3 Bulk Density

Bulk density is a measure of the dry soil mass per unit volume, with the most common reporting units of $g.cm^{-1}$ in the field of soil science. This research will use the common method described by Soil Quality Australia (Brown, K & Wherrett, A 2022).

In order to determine the bulk density for each subsample the weight of dry soil must be known as well as the contributing volume of each subsample. To derive the dry weight of soil in each subsample the average weight of sample bag is taken from the oven dry weight of subsample in bag:

$$Dry\ Weight\ (Subsample) = Dry\ Weight\ (Subsample + Bag) - Ave.Weight\ (Bag)$$

Having the dry weight, the density is simply this divided by the known volume of the sample:

$$\begin{aligned} &Bulk\ Density\ (Subsample), g.cm^{-3} \\ &\quad = \frac{Dry\ Weight\ (Subsample), g}{Soil\ Corer\ Internal\ Diameter^2,\ cm^2 * \frac{1}{4} * \pi * Subsample\ Length, cm} \end{aligned}$$

$$Bulk\ Density\ (Subsample), g.cm^{-3} = \frac{Dry\ Weight\ (Subsample), g}{4.27^2 * \frac{1}{4} * \pi * 10}$$

3.2.4 Volumetric Water Content

Volumetric water content (VWC) is the volume of water per volume of soil and is simply the product of the gravimetric water content and the bulk density (*Gravimetric & Volumetric Soil Water Content* n.d.). This relationship relies on the assumption that the density of the soil water is $1g/cm^3$.

$$VWC\ (Subsample)\% = GWC\ (Subsample)\% * Bulk\ Density(Subsample)$$

3.3 Technical Analysis

In order to derive technical insights and to understand and display data multiple software packages were used to understand and display the data.

3.3.1 WebODM

WebODM is an open-source photogrammetry tool used to create 3D and 2D models of a landscape or object from a collection of photos. On both trips a DJI Air 2S was used to collect a set of photos from 40m above the field looking down to create georeferenced photomosaics of the field with a spatial resolution of 2.5cm/pixel.

3.3.2 QGIS

QGIS is an open-source geographic interpretation software that can easily ingest and display geo-tagged data overlayed on satellite imagery. QGIS was used to create figures using the derived photomosaics and GPS locations taken during field testing. QGIS was also used to ingest and analyse the spatial data given by the John Deere CP690.

The data output of the John Deere CP690 consisted of singular GPS points with attached values of kg lint/ha for each frontage with a resolution of 1 point/1.5m. The trial layout was mapped, and the corresponding plots were found using figures provided by ACRI. The data points for each of the test plots were clipped and each plot had the data points within its area averaged to derive a value of kg lint/ha for the corresponding plots. Data point density within the plot are represented in figure 3-11:

Figure 3-12: Individual data points output by CP690

4 RESULTS

This section aims to outline the key results obtained through testing. It will disseminate information obtained on soil constraints, compaction indices and cotton yield value.

4.1 SOIL CONSTRAINTS

To ensure that growth differences are not a result of differences in the chemical properties of the soil a single core was taken for each of the 3 control and test plots (refer to Appendix C). These chemical property cores were tested for pH using soil testing methods 4A1 & 4B2 (Rayment & Lyons, 2011) and for electrical conductivity [EC] using soil testing method 3A1 (Rayment & Lyons, 2011). The results have been compared across the different plots:

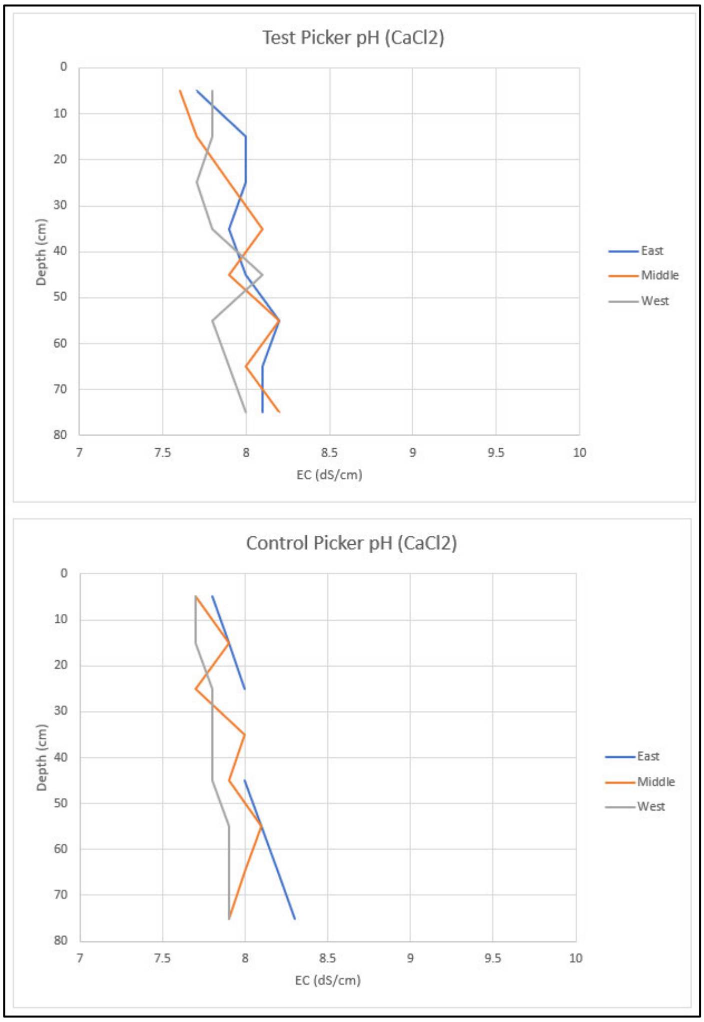

Figure 4-1: pH results in a 0.01M CaCl2 solution

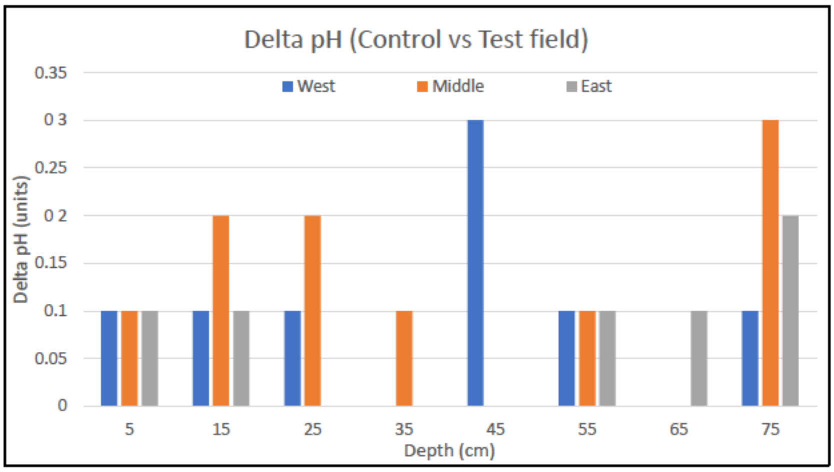

Figure 4-2: Difference of 0.01M CaCl2 pH at each point across test sites

No significant difference is observed between the test field and the control field. This is evident in figure 4-3 which shows the difference between 0.01M soil pH at each depth across each test location, with a maximum of 0.3 pH units. The optimal pH range for cotton growth is generally regarded as 5.5-7.0 when measured in a 0.01M CaCl2 solution (Davis, 1998), and as the pH range of the fields is 7.6 – 8.4 this may represent a restraint on growth overall within the field. This does not constitute a restraint difference across the test and control plots.

The results of the EC testing are below:

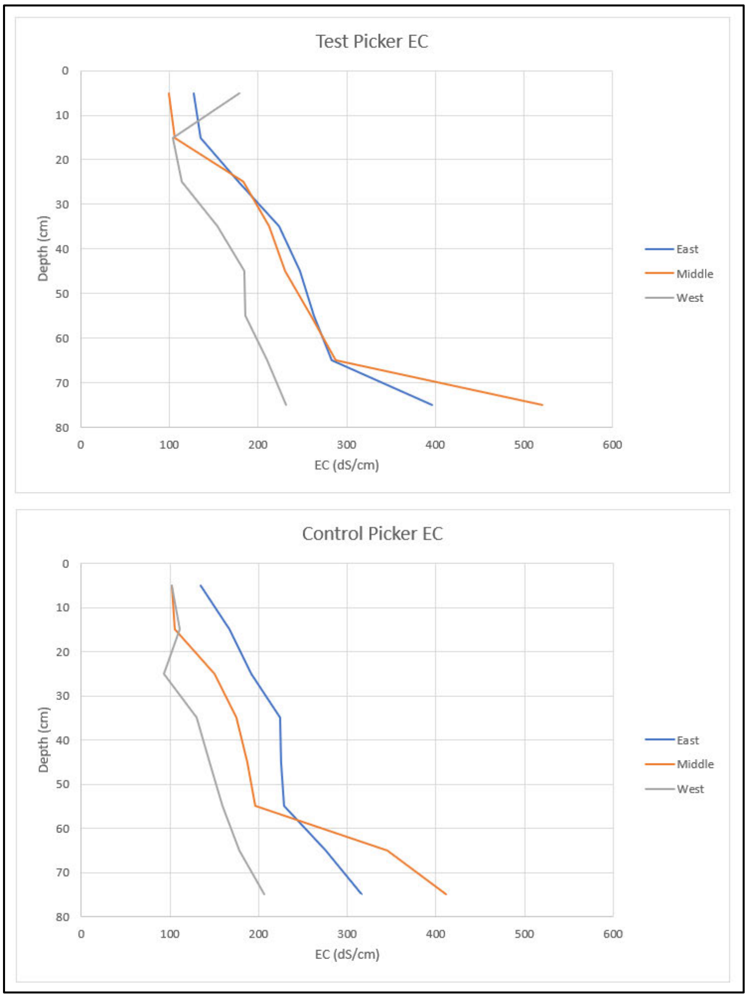

Figure 4-3: EC results in a DI solution

Figure 4-3 shows the results of $EC_{1\,5}$ of the soil samples, with the methodology being described in section 3. As the texture of soil can have a large impact on the it is standard to convert the $EC_{1\,5}$ to an EC_e (equivalent EC) value for better comparison across different soil textures. This conversion is common in literature on soil salinity and crop growth, and is computed as:

$$EC_e = Conversion\ Factor\ (Soil\ Texture) * EC_{1.5}$$

The conversion factors are:

Soil Texture	Conversion Factor
Sand	15
Sandy Loam	12
Loam	10
Clay Loam	9
Light-medium Clay	8
Heavy Clay	6

Table 4-1: Conversion factors for different soil textures (Simon & Don, n.d.)

Based upon hand-texturing methods it is believed that the most accurate soil texture class is light-medium clay. After adjusting the $EC_{1\,5}$ the results can be replotted:

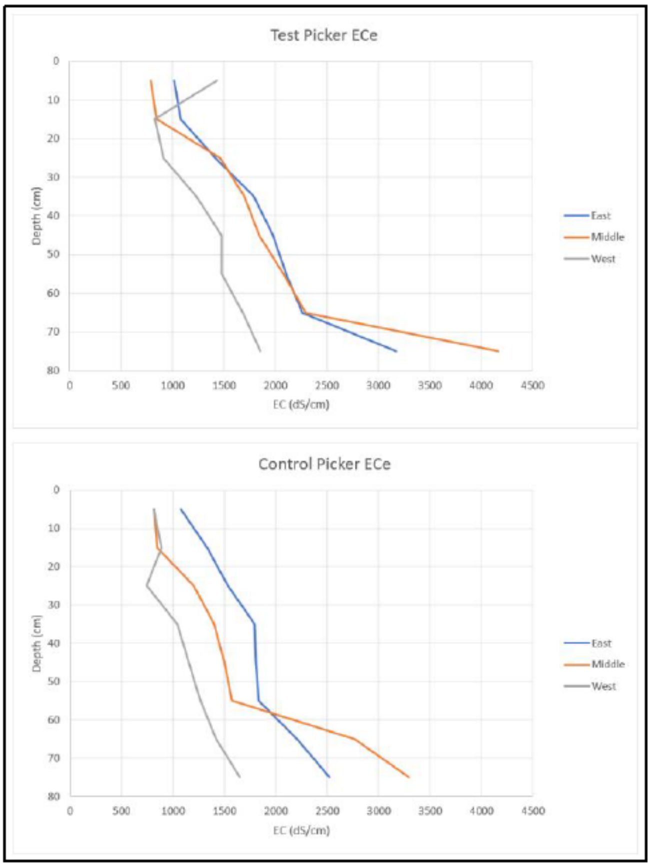

Figure 4-4: ECe results in a DI solution

Figure 4-4 shows an overall similarity between the control and test plot results. The results also indicate a low salinity soil. Literary sources indicates a high tolerance of cotton to saline soils, with growth limitations beginning at approximately 2,400 dS/cm ECe (Tenison & Wild, 2014) and the tolerance threshold regarded as 7,700 dS/cm EC_e (Chinnusamy, et al., 2005). The growth limitation threshold is crossed at 60cm depth in the control field and 65cm depth in the test field, in both cases only occurring the east and middle plot.

4.2 Compaction Across Control and Test Field

To determine the difference in levels of compaction across the control and test fields before the 2021-22 season harvest the bulk density measurements will be used as a proxy for compaction. The moisture content was also examined, with testing for statistical significance of moisture differences in later sections.

Figure 4-5: Test field bulk density to depth before harvest by plot and dataset

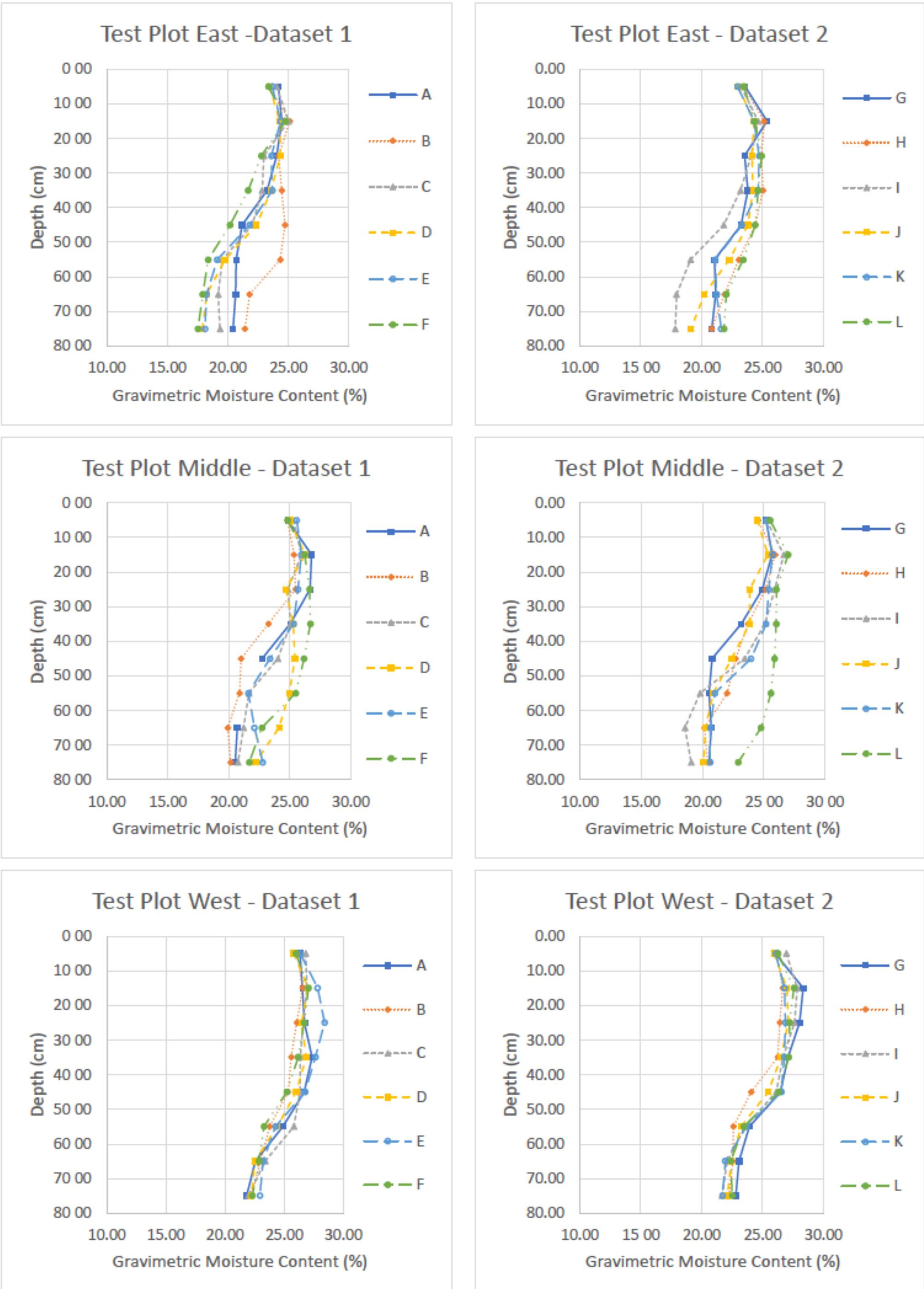

Figure 4-6: Test field moisture to depth before harvest by plot and frontage

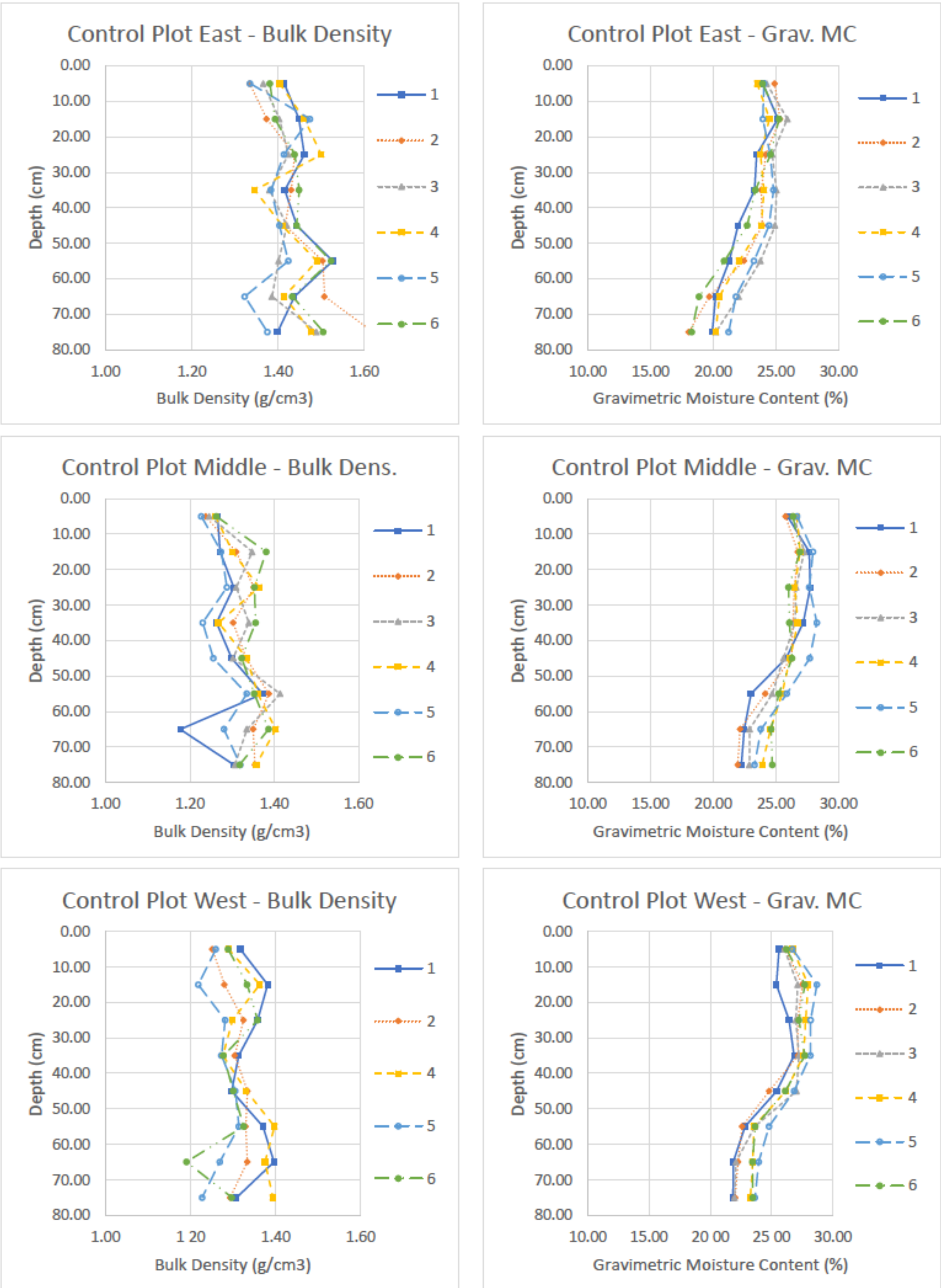

Figure 4-7: Control field data before harvest

The average of the density and moisture content values shows a concise version of the above results:

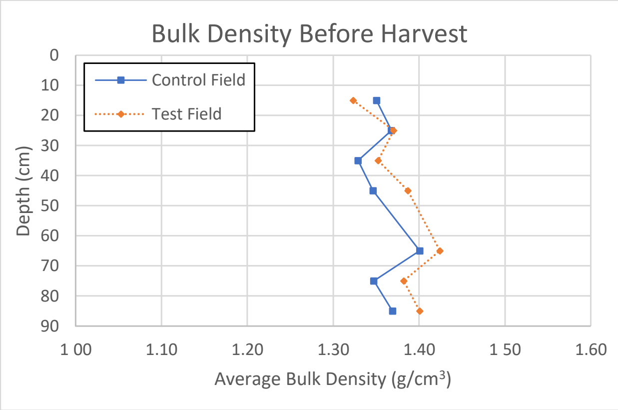

Figure 4-8: Average bulk density before harvest

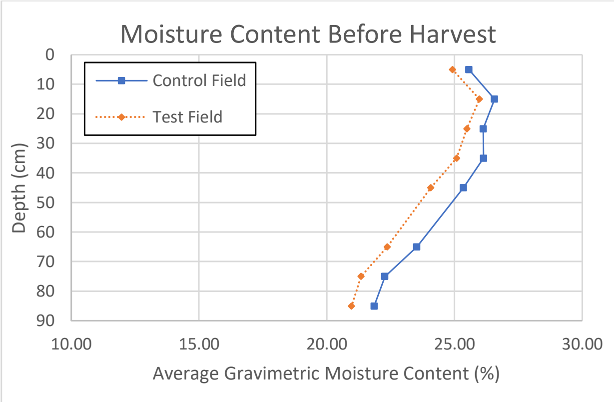

Figure 4-9: Average gravimetric moisture content before harvest

Figure 4-8 clearly shows a trend of the test field having a higher bulk density throughout the profile, with the notable distinction of having lower bulk densities in the top 25cm. This is in line with the results seen in previous research (Bennett et al 2017). It also shows two distinct elements of increased bulk density, occurring at 25cm and 65cm. It is unclear what has caused this behaviour. Figure 4-9 however demonstrates a generally more saturated condition throughout the profiles within the test field. As mentioned before, a soil with a higher moisture content is prone to higher levels of compaction under the same load compared to a soil with a lower moisture content. The statistical significance of this difference is explored in the next section.

4.3 Compaction Due to Harvest

The instantaneous compaction will be determined by examining the results outlined in section 4.2, as well comparing the increases in bulk density as a percentage of the original value:

Figure 4-10: Test field bulk density to depth after harvest by plot and dataset

Figure 4-11: Test field moisture to depth after harvest by plot and frontage

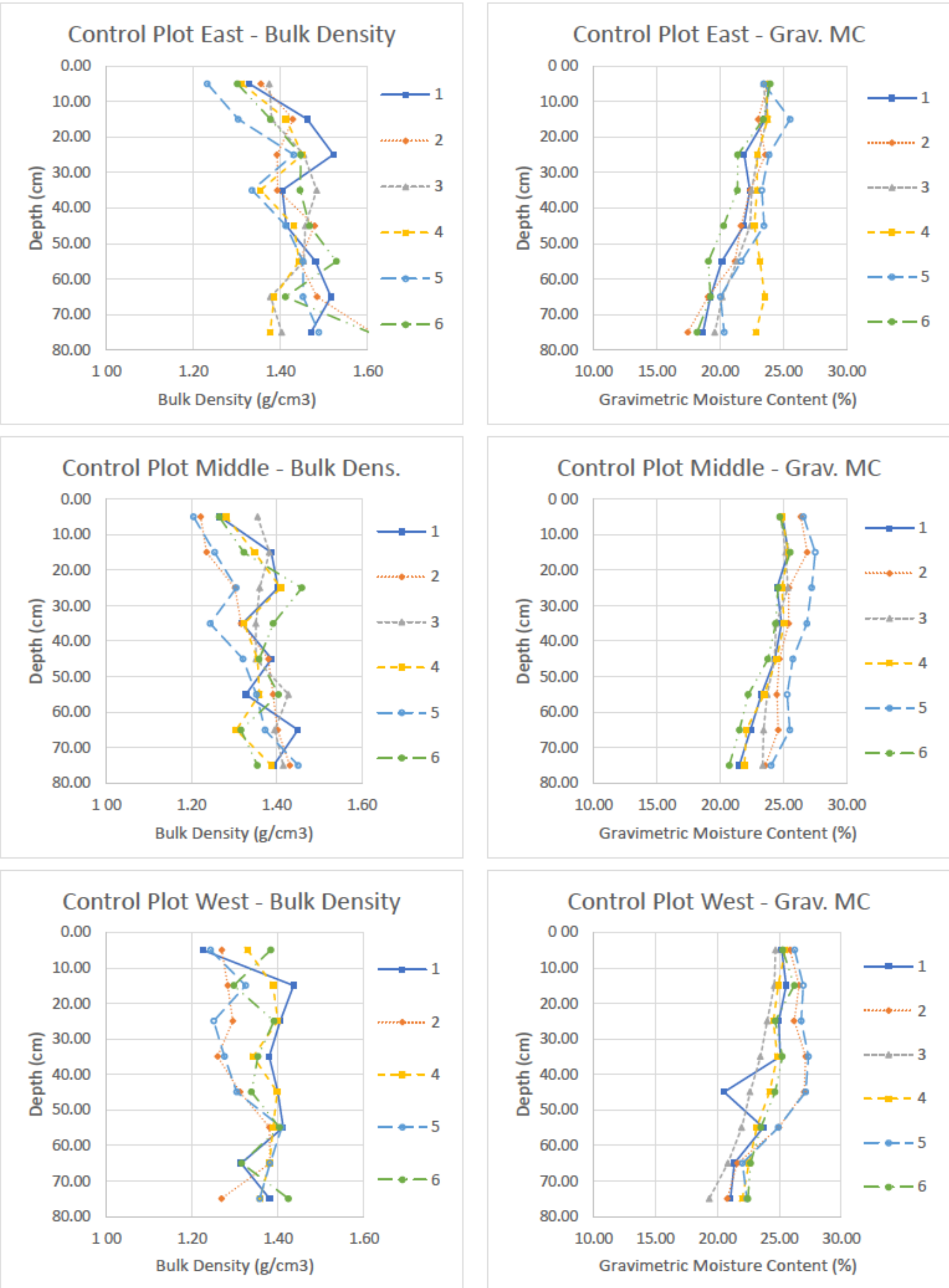

Figure 4-12: Control field data after harvest

The average of the density and moisture content values again shows a concise version of the above results:

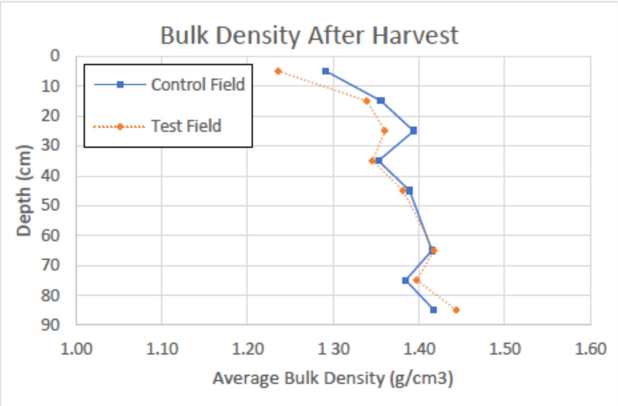

Figure 4-13: Average bulk density after harvest

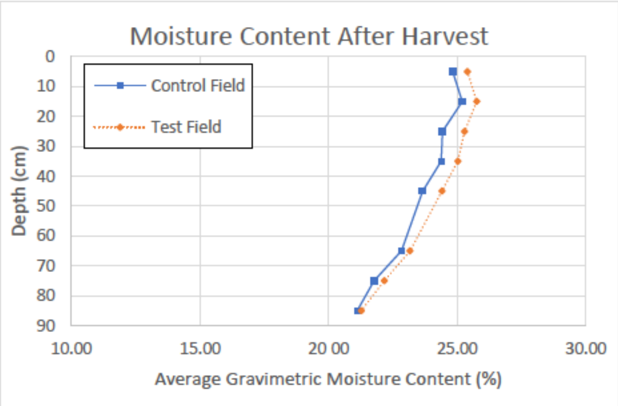

Figure 4-14: Average gravimetric moisture content after harvest

Notably, the control field has shifted to have a higher average bulk density after harvest. This is likely due to the higher moisture content within the control field before harvest. Examining the changes in bulk density and moisture across the test and control field before and after harvest may be useful:

Changes In Bulk Density After Harvest					
Test East Site 1		Test East Site 2		Test East Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-2.93	0-10	-0.44	0-10	-0.45
10-20	-4.40	10-20	0.57	10-20	-3.25
20-30	0.11	20-30	-2.51	20-30	-2.51
30-40	-7.91	30-40	2.00	30-40	0.08

40-50	-3.59	40-50	5.04	40-50	-5.10
50-60	-3.17	50-60	2.54	50-60	1.60
60-70	0.08	60-70	5.15	60-70	2.42
70-80	4.86	70-80	14.62	70-80	2.57
Test East Site 4		Test East Site 5		Test East Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	0.12	0-10	-9.07	0-10	-13.56
10-20	-9.09	10-20	-7.65	10-20	-3.84
20-30	-6.19	20-30	-6.20	20-30	1.92
30-40	-5.61	30-40	-1.34	30-40	0.41
40-50	-0.48	40-50	-1.06	40-50	-1.58
50-60	-5.64	50-60	5.53	50-60	-2.15
60-70	-10.59	60-70	-0.07	60-70	-0.02
70-80	1.01	70-80	-0.26	70-80	1.54
Test East Site 7		Test East Site 8		Test East Site 9	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	12.64	0-10	-10.90	0-10	-3.75
10-20	11.40	10-20	6.28	10-20	7.89
20-30	0.93	20-30	0.27	20-30	5.83
30-40	0.21	30-40	-0.10	30-40	-2.60
40-50	0.49	40-50	-5.04	40-50	-2.56
50-60	1.02	50-60	-2.08	50-60	-0.41
60-70	-7.34	60-70	-3.92	60-70	-5.08
70-80	-3.77	70-80	1.85	70-80	0.69
Test East Site 10		Test East Site 11		Test East Site 12	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-0.44	0-10	9.13	0-10	-2.08
10-20	-3.70	10-20	5.72	10-20	7.36
20-30	-4.22	20-30	7.26	20-30	-3.87
30-40	-3.47	30-40	6.65	30-40	-4.00
40-50	-3.39	40-50	-0.91	40-50	1.12
50-60	-6.76	50-60	0.16	50-60	2.78
60-70	-3.81	60-70	1.60	60-70	-0.50
70-80	-2.38	70-80	6.15	70-80	-0.47

Table 4-2: Bulk density change at Test East

Changes In Bulk Density After Harvest					
Test Middle Site 1		Test Middle Site 2		Test Middle Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-8.46	0-10	-0.42	0-10	7.44
10-20	-3.82	10-20	5.24	10-20	-0.71
20-30	1.25	20-30	6.68	20-30	-4.65
30-40	0.64	30-40	-3.43	30-40	5.61
40-50	-3.49	40-50	-1.76	40-50	-0.70
50-60	0.13	50-60	3.31	50-60	2.21
60-70	0.27	60-70	5.29	60-70	7.64
70-80	-0.85	70-80	10.76	70-80	13.56
Test Middle Site 4		Test Middle Site 5		Test Middle Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	2.26	0-10	2.13	0-10	5.52
10-20	-5.77	10-20	-7.28	10-20	-0.50
20-30	-1.99	20-30	-9.34	20-30	-3.29

30-40	-4.40	30-40	-8.86	30-40	4.21
40-50	-1.55	40-50	3.97	40-50	-3.09
50-60	-0.41	50-60	-1.27	50-60	-1.57
60-70	-6.11	60-70	-4.09	60-70	11.67
70-80	-0.44	70-80	-1.42	70-80	-0.20
Test Middle Site 7		Test Middle Site 8		Test Middle Site 9	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-1.20	0-10	-2.79	0-10	-2.30
10-20	-2.15	10-20	0.22	10-20	13.52
20-30	-4.05	20-30	4.68	20-30	5.35
30-40	-3.85	30-40	-4.11	30-40	-0.33
40-50	-6.69	40-50	-0.72	40-50	2.22
50-60	-1.35	50-60	1.69	50-60	-6.87
60-70	0.42	60-70	2.78	60-70	6.07
70-80	-2.92	70-80	12.38	70-80	0.12
Test Middle Site 10		Test Middle Site 11		Test Middle Site 12	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-4.65	0-10	3.19	0-10	-7.74
10-20	0.66	10-20	9.79	10-20	10.58
20-30	-0.86	20-30	-0.90	20-30	-8.36
30-40	-2.79	30-40	-0.80	30-40	1.63
40-50	-2.03	40-50	-4.39	40-50	-1.09
50-60	4.51	50-60	-4.35	50-60	-0.14
60-70	9.00	60-70	3.87	60-70	0.11
70-80	6.88	70-80	10.56	70-80	-3.05

Table 4-3: Bulk density change at Test Middle

Changes In Bulk Density After Harvest					
Test West Site 1		Test West Site 2		Test West Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-7.11	0-10	-6.12	0-10	-2.42
10-20	4.65	10-20	1.79	10-20	5.52
20-30	-1.39	20-30	-0.23	20-30	1.32
30-40	7.17	30-40	4.67	30-40	-1.37
40-50	0.29	40-50	4.19	40-50	9.18
50-60	-0.64	50-60	11.84	50-60	-2.43
60-70	7.78	60-70	5.32	60-70	-1.09
70-80	3.28	70-80	12.57	70-80	7.61
Test West Site 4		Test West Site 5		Test West Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-2.92	0-10	3.70	0-10	-3.15
10-20	3.35	10-20	-1.77	10-20	0.06
20-30	-4.29	20-30	-5.86	20-30	4.25
30-40	0.23	30-40	-2.12	30-40	1.36
40-50	13.21	40-50	0.24	40-50	0.90
50-60	2.79	50-60	-2.75	50-60	6.16
60-70	-8.65	60-70	0.87	60-70	5.96
70-80	2.66	70-80	4.97	70-80	2.93
Test West Site 7		Test West Site 8		Test West Site 9	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	13.25	0-10	17.24	0-10	11.47
10-20	2.77	10-20	-6.26	10-20	1.72

20-30	-0.21	20-30	-6.32	20-30	-1.43
30-40	-8.23	30-40	5.10	30-40	2.05
40-50	0.70	40-50	-1.15	40-50	4.46
50-60	-9.63	50-60	-0.88	50-60	-5.24
60-70	-6.87	60-70	9.10	60-70	0.43
70-80	3.65	70-80	-2.32	70-80	2.54
Test West Site 10		Test West Site 11		Test West Site 12	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	3.56	0-10	7.41	0-10	0.67
10-20	2.89	10-20	-3.17	10-20	-6.49
20-30	4.89	20-30	-0.99	20-30	-1.87
30-40	5.90	30-40	1.66	30-40	-4.48
40-50	2.22	40-50	6.62	40-50	-3.28
50-60	4.75	50-60	1.85	50-60	1.63
60-70	13.38	60-70	1.03	60-70	-3.08
70-80	-1.95	70-80	1.88	70-80	0.37

Table 4-4: Bulk density change at Test West

Changes In Bulk Density After Harvest					
Control East Site 1		Control East Site 2		Control East Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-6.11	0-10	1.57	0-10	0.61
10-20	0.85	10-20	3.98	10-20	-1.72
20-30	4.12	20-30	-3.21	20-30	2.06
30-40	-0.83	30-40	-2.66	30-40	7.39
40-50	-2.14	40-50	4.33	40-50	2.56
50-60	-3.06	50-60	-4.05	50-60	3.68
60-70	5.38	60-70	-1.62	60-70	-0.64
70-80	5.06	70-80	-0.65	70-80	-5.79
Control East Site 4		Control East Site 5		Control East Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-6.62	0-10	-12.27	0-10	-5.84
10-20	-3.37	10-20	-10.85	10-20	-1.19
20-30	-3.35	20-30	-4.68	20-30	0.51
30-40	0.59	30-40	-0.88	30-40	-0.30
40-50	1.49	40-50	0.16	40-50	1.58
50-60	-3.24	50-60	-2.62	50-60	0.32
60-70	-2.05	60-70	2.64	60-70	-1.56
70-80	-6.86	70-80	0.69	70-80	6.54

Table 4-5: Bulk density change at Control East

Changes In Bulk Density After Harvest					
Control Middle Site 1		Control Middle Site 2		Control Middle Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	0.11	0-10	-1.31	0-10	8.74
10-20	9.06	10-20	-5.68	10-20	2.57
20-30	7.60	20-30	-3.73	20-30	3.83
30-40	4.43	30-40	1.05	30-40	0.82
40-50	6.86	40-50	3.53	40-50	3.76
50-60	-3.25	50-60	0.27	50-60	0.93
60-70	23.13	60-70	3.82	60-70	4.50
70-80	6.80	70-80	5.63	70-80	8.29

Control Middle Site 4		Control Middle Site 5		Control Middle Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	1.60	0-10	-4.46	0-10	0.17
10-20	3.62	10-20	-3.57	10-20	-4.22
20-30	3.32	20-30	-4.36	20-30	7.79
30-40	4.34	30-40	-1.91	30-40	2.65
40-50	1.54	40-50	-1.02	40-50	2.71
50-60	-0.13	50-60	-0.67	50-60	3.82
60-70	-7.02	60-70	-2.21	60-70	-5.10
70-80	2.22	70-80	6.84	70-80	2.77

Table 4-6: Bulk density change at Control Middle

Changes In Bulk Density After Harvest					
Control West Site 1		Control West Site 2		Control West Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-7.04	0-10	1.42	0-10	-3.99
10-20	3.93	10-20	0.23	10-20	7.47
20-30	3.47	20-30	-2.25	20-30	4.98
30-40	5.00	30-40	-3.47	30-40	5.63
40-50	7.91	40-50	-1.70	40-50	12.97
50-60	2.99	50-60	3.78	50-60	3.10
60-70	-5.92	60-70	3.54	60-70	3.00
70-80	5.49	70-80	-1.97	70-80	4.25
Control West Site 4		Control West Site 5		Control West Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	3.10	0-10	-3.61	0-10	7.33
10-20	1.88	10-20	-2.81	10-20	-2.76
20-30	7.77	20-30	-3.73	20-30	2.42
30-40	5.16	30-40	-0.06	30-40	5.91
40-50	4.99	40-50	-2.08	40-50	2.90
50-60	-0.66	50-60	0.77	50-60	5.87
60-70	0.33	60-70	0.42	60-70	10.49
70-80	-2.58	70-80	-2.62	70-80	9.80

Table 4-7: Bulk density change at Control West

The key point to be taken from this data is that there is no clear, consistent magnitude of change in the bulk density across either the test or control when comparing the values before and after harvest. This is seen in the almost random spread of positive and negative differences in the data. Examining moisture:

Changes In Moisture Content After Harvest					
Test East Site 1		Test East Site 2		Test East Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	0.58	0-10	1.57	0-10	4.32
10-20	1.72	10-20	0.98	10-20	1.90
20-30	-3.64	20-30	1.34	20-30	5.56
30-40	3.73	30-40	-0.67	30-40	1.78
40-50	19.60	40-50	-2.24	40-50	-0.68
50-60	19.59	50-60	-6.81	50-60	3.36
60-70	13.06	60-70	6.40	60-70	2.46
70-80	-3.72	70-80	7.52	70-80	0.14

Test East Site 4		Test East Site 5		Test East Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-1.66	0-10	6.01	0-10	-2.26
10-20	3.57	10-20	5.58	10-20	1.52
20-30	5.63	20-30	1.91	20-30	-2.04
30-40	8.42	30-40	4.60	30-40	-3.34
40-50	8.95	40-50	2.59	40-50	-0.14
50-60	25.65	50-60	5.91	50-60	5.21
60-70	23.22	60-70	1.40	60-70	1.14
70-80	7.13	70-80	4.27	70-80	2.56
Test East Site 7		Test East Site 8		Test East Site 9	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-2.05	0-10	-0.39	0-10	7.75
10-20	-6.41	10-20	-2.16	10-20	3.49
20-30	-0.25	20-30	5.12	20-30	0.33
30-40	-1.43	30-40	4.17	30-40	-0.86
40-50	5.46	40-50	5.27	40-50	4.47
50-60	9.46	50-60	2.79	50-60	8.67
60-70	7.81	60-70	6.03	60-70	6.77
70-80	-4.40	70-80	-0.41	70-80	10.09
Test East Site 10		Test East Site 11		Test East Site 12	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	3.75	0-10	7.30	0-10	3.02
10-20	2.26	10-20	-1.28	10-20	2.27
20-30	4.44	20-30	-5.70	20-30	3.17
30-40	5.03	30-40	-7.40	30-40	4.25
40-50	4.04	40-50	-7.61	40-50	1.49
50-60	4.48	50-60	0.58	50-60	-1.71
60-70	0.19	60-70	1.42	60-70	-0.74
70-80	7.06	70-80	1.56	70-80	-2.20

Table 4-8: Moisture change at Test East

Changes In Moisture Content After Harvest					
Test Middle Site 1		Test Middle Site 2		Test Middle Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	8.69	0-10	8.54	0-10	5.22
10-20	5.39	10-20	0.49	10-20	3.95
20-30	-2.00	20-30	-2.21	20-30	-0.60
30-40	1.96	30-40	3.19	30-40	-5.94
40-50	9.99	40-50	11.30	40-50	-11.15
50-60		50-60	3.36	50-60	-5.16
60-70	17.02	60-70	1.26	60-70	-5.55
70-80	16.75	70-80	0.25	70-80	-4.95
Test Middle Site 4		Test Middle Site 5		Test Middle Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	4.54	0-10	8.60	0-10	0.56
10-20	1.99	10-20	4.46	10-20	3.08
20-30	3.95	20-30	8.69	20-30	2.80
30-40	2.23	30-40	5.93	30-40	2.83
40-50	2.16	40-50	-2.14	40-50	5.31
50-60	4.40	50-60	-8.57	50-60	5.53
60-70	7.11	60-70	-5.96	60-70	13.57
70-80	5.36	70-80	0.11	70-80	14.96

Test Middle Site 7		Test Middle Site 8		Test Middle Site 9	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	4.65	0-10	4.47	0-10	4.59
10-20	5.90	10-20	-1.66	10-20	-5.16
20-30	6.21	20-30	-3.33	20-30	-3.63
30-40	10.18	30-40	2.72	30-40	-3.42
40-50	23.89	40-50	6.21	40-50	-1.96
50-60	25.19	50-60	-3.66	50-60	3.13
60-70	24.27	60-70	2.04	60-70	3.86
70-80	14.32	70-80	-0.87	70-80	1.21
Test Middle Site 10		Test Middle Site 11		Test Middle Site 12	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	2.38	0-10	4.23	0-10	3.41
10-20	0.70	10-20	0.26	10-20	-0.13
20-30	1.37	20-30	1.31	20-30	6.34
30-40	-3.54	30-40	0.48	30-40	2.59
40-50	1.91	40-50	4.49	40-50	2.94
50-60	-0.53	50-60	11.04	50-60	3.21
60-70	-5.30	60-70	5.50	60-70	4.79
70-80	-2.20	70-80	4.47	70-80	8.49

Table 4-9: Moisture change at Test Middle

Changes In Moisture Content After Harvest					
Test West Site 1		Test West Site 2		Test West Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-5.51	0-10	-0.59	0-10	-2.01
10-20	-2.97	10-20	-4.71	10-20	-6.47
20-30	-4.31	20-30	-2.93	20-30	-5.20
30-40	-4.86	30-40	-4.64	30-40	-5.82
40-50	-5.15	40-50	-5.81	40-50	-8.65
50-60	3.23	50-60	-8.48	50-60	-5.11
60-70	14.11	60-70	-7.52	60-70	-2.90
70-80	10.12	70-80	-6.10	70-80	-2.83
Test West Site 4		Test West Site 5		Test West Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-1.14	0-10	1.47	0-10	-2.25
10-20	-6.38	10-20	-4.49	10-20	-9.67
20-30	-4.25	20-30	-2.29	20-30	-9.32
30-40	-0.62	30-40	-5.78	30-40	-5.73
40-50	-1.61	40-50	-3.49	40-50	-7.69
50-60	-4.06	50-60	-2.25	50-60	-2.65
60-70	-2.11	60-70	-2.43	60-70	-2.60
70-80	-5.05	70-80	-3.42	70-80	-9.78
Test West Site 7		Test West Site 8		Test West Site 9	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-1.42	0-10	-5.41	0-10	-1.13
10-20	-3.99	10-20	-0.72	10-20	-8.18
20-30	-4.22	20-30	0.85	20-30	-8.60
30-40	1.36	30-40	-1.43	30-40	-4.49
40-50	4.26	40-50	3.12	40-50	-8.59
50-60	10.47	50-60	-2.55	50-60	-2.52
60-70	11.35	60-70	-5.83	60-70	-5.12
70-80	1.04	70-80	-5.71	70-80	-4.69

Test West Site 10		Test West Site 11		Test West Site 12	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-3.48	0-10	5.78	0-10	4.90
10-20	-9.12	10-20	-1.86	10-20	2.39
20-30	-9.38	20-30	-4.32	20-30	3.96
30-40	-7.47	30-40	-2.93	30-40	4.34
40-50	-2.65	40-50	-6.76	40-50	3.28
50-60	5.69	50-60	-0.78	50-60	5.97
60-70	4.93	60-70	-2.52	60-70	5.55
70-80	0.36	70-80	-1.04	70-80	2.05

Table 4-10: Moisture change at Test West

Changes In Moisture Content After Harvest					
Control East Site 1		Control East Site 2		Control East Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-0.62	0-10	-4.68	0-10	-3.51
10-20	-6.42	10-20	-9.25	10-20	-8.59
20-30	-6.81	20-30	-2.67	20-30	-7.06
30-40	-4.09	30-40	-6.15	30-40	-10.33
40-50	-0.57	40-50	-9.57	40-50	-10.37
50-60	-5.39	50-60	-5.81	50-60	-10.36
60-70	-4.77	60-70	-3.37	60-70	-8.55
70-80	-6.53	70-80	-3.48	70-80	-3.28
Control East Site 4		Control East Site 5		Control East Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	0.46	0-10	-0.40	0-10	-0.02
10-20	-3.06	10-20	4.15	10-20	-7.32
20-30	-3.55	20-30	0.34	20-30	-13.00
30-40	-4.82	30-40	-3.24	30-40	-8.66
40-50	-4.87	40-50	-1.66	40-50	-10.82
50-60	4.84	50-60	-1.91	50-60	-8.78
60-70	14.71	60-70	-2.35	60-70	1.81
70-80	12.85	70-80	0.49	70-80	-0.56

Table 4-11: Moisture change at Control East

Changes In Moisture Content After Harvest					
Control Middle Site 1		Control Middle Site 2		Control Middle Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-3.92	0-10	2.24	0-10	-6.28
10-20	-8.28	10-20	0.42	10-20	-7.73
20-30	-11.83	20-30	-3.96	20-30	-4.88
30-40	-8.66	30-40	-3.65	30-40	-7.99
40-50	-5.91	40-50	-6.04	40-50	-5.24
50-60	0.99	50-60	1.32	50-60	-4.14
60-70	-0.44	60-70	10.94	60-70	2.26
70-80	-3.39	70-80	7.32	70-80	1.95
Control Middle Site 4		Control Middle Site 5		Control Middle Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-6.68	0-10	-0.38	0-10	-6.32
10-20	-5.76	10-20	2.08	10-20	-5.27
20-30	-6.27	20-30	2.66	20-30	-5.68
30-40	-6.41	30-40	0.25	30-40	-6.58
40-50	-6.37	40-50	-1.53	40-50	-9.63

50-60	-7.98	50-60	-0.82	50-60	-12.03
60-70	-10.26	60-70	3.77	60-70	-12.63
70-80	-8.38	70-80	0.36	70-80	-16.26

Table 4-12: Moisture change at Control Middle

Changes In Moisture Content After Harvest					
Control West Site 1		Control West Site 2		Control West Site 3	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-1.60	0-10	-0.86	0-10	-5.21
10-20	0.58	10-20	-3.37	10-20	-9.33
20-30	-5.54	20-30	-3.43	20-30	-10.95
30-40	-6.58	30-40	-0.13	30-40	-13.79
40-50	-19.20	40-50	8.89	40-50	-16.30
50-60	3.83	50-60	10.43	50-60	-7.13
60-70	-2.38	60-70	-2.93	60-70	-5.68
70-80	-3.73	70-80	-5.60	70-80	-12.06
Control West Site 4		Control West Site 5		Control West Site 6	
Depth (cm)	% Change	Depth (cm)	% Change	Depth (cm)	% Change
0-10	-4.70	0-10	-1.81	0-10	-3.56
10-20	-11.02	10-20	-3.74	10-20	-5.46
20-30	-11.68	20-30	-3.62	20-30	-9.39
30-40	-10.01	30-40	-0.91	30-40	-8.92
40-50	-7.43	40-50	3.68	40-50	-5.65
50-60	-1.65	50-60	5.77	50-60	-0.63
60-70	-3.90	60-70	-6.11	60-70	-3.36
70-80	-5.44	70-80	-3.87	70-80	-4.26

Table 4-13: Moisture change at Control West

The differences in moisture have similarities to the differences in density in that no clear pattern has emerged within the data, with some plots gaining moisture, and some losing moisture. To attempt to better understand the overall picture the averages of the values by plot to depth have been graphed:

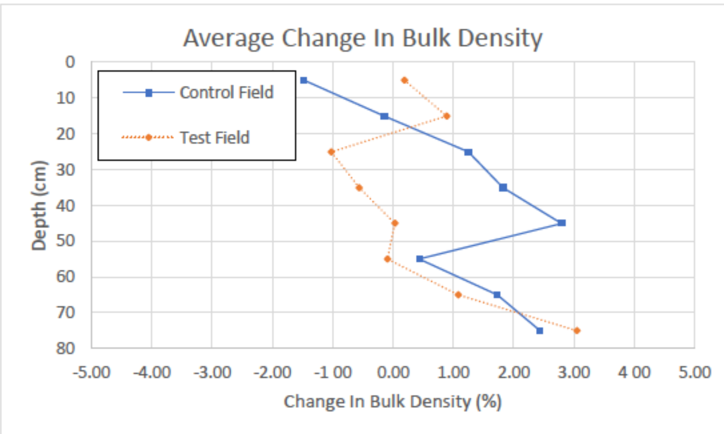

Figure 4-15: Average change in bulk density

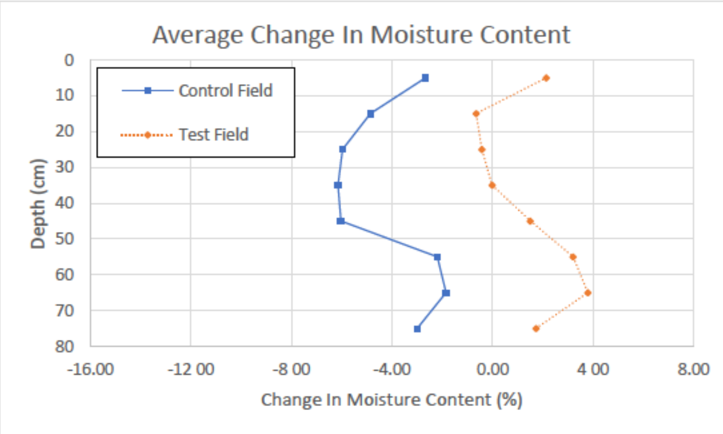

Figure 4-16: Average change in moisture content

From the graphs of the average values, it is clearer that there is indeed a pattern in the moisture content. In both the control and test plots the changes throughout the profile generally have the same 'shape', however the control plots tended to be drier, while the test plots tended to increase in moisture.

4.4 Testing Moisture and Compaction for Statistical Significance

Single T-tests were done on the data to determine the significance of the different moisture contents within the field plots:

Commented [AH1]: Check the tables arent broken

	Moisture						Bulk Density					
	Test		Control				Test		Control			
Depth (cm)	No.obs	Mean	No.obs	Mean	Mean diff	p-val	No.obs	Mean	No.obs	Mean	Mean diff	p-val
0-10	36	24.92	18	25.56	0.64	0.06	36	1.23	18	1.31	0.08	0
10-20	36	25.97	18	26.57	0.59	0.12	36	1.32	18	1.35	0.03	0.22
20-30	36	25.49	18	26.12	0.63	0.15	36	1.37	18	1.37	0	0.8
30-40	36	25.09	18	26.14	1.05	0.03	36	1.35	18	1.33	-0.02	0.23
40-50	36	24.07	18	25.35	1.28	0.01	36	1.39	18	1.35	-0.04	0.03
50-60	36	21.29	18	23.53	2.24	0.07	36	1.42	18	1.4	-0.02	0.22
60-70	36	21.35	18	22.27	0.93	0.06	36	1.38	18	1.35	-0.03	0.19
70-80	36	20.98	18	21.86	0.88	0.1	36	1.4	18	1.37	-0.03	0.25

Table 4-14: Summary statistics of before-harvest data

`	Moisture						BD					
	Test		Control				Test		Control			
Depth (cm)	No.obs	Mean	No.obs	Mean	Mean diff	p-val	No.obs	Mean	No.obs	Mean	Mean diff	p-val
0-10	36	25.4	18	24.84	-0.56	0.09	36	1.24	18	1.29	0.05	0
10-20	36	25.76	18	25.2	-0.56	0.14	36	1.34	18	1.36	0.02	0.41
20-30	36	25.31	18	24.43	-0.88	0.05	36	1.36	18	1.39	0.03	0.1
30-40	36	25.08	18	24.38	-0.7	0.15	36	1.35	18	1.35	0	0.82
40-50	36	24.45	18	23.65	-0.8	0.15	36	1.38	18	1.39	0.01	0.62
50-60	36	23.27	18	22.84	-0.43	0.42	36	1.41	18	1.41	0	0.94
60-70	36	22.27	18	21.77	-0.51	0.37	36	1.39	18	1.39	-0.01	0.63
70-80	36	21.32	18	21.12	-0.2	0.71	36	1.44	18	1.42	-0.02	0.34

Table 4-15: Summary statistics of after-harvest sample data

	Moisture						BD					
	Before		After				Before		After			
Depth (cm)	No.obs	Mean	No.obs	Mean	Mean diff	p-val	No.obs	Mean	No.obs	Mean	Mean diff	p-val
0-10	18	25.56	18	24.84	0.72	0.05	18	1.31	18	1.29	0.02	0.42
10-20	18	26.57	18	25.2	1.37	0	18	1.35	18	1.36	-0.01	0.77
20-30	18	26.12	18	24.43	1.7	0	18	1.37	18	1.39	-0.03	0.24
30-40	18	26.14	18	24.38	1.76	0	18	1.33	18	1.35	-0.02	0.29
40-50	18	25.35	18	23.65	1.69	0.01	18	1.35	18	1.39	-0.04	0.03
50-60	18	23.53	18	22.84	0.68	0.2	18	1.4	18	1.41	-0.01	0.45
60-70	18	22.27	18	21.77	0.51	0.39	18	1.35	18	1.39	-0.04	0.15
70-80	18	21.86	18	21.12	0.74	0.25	18	1.37	18	1.42	-0.05	0.12

Table 4-16: Summary statistics for control plots comparing before and harvest sample data

	Moisture						BD					
	Before		After				Before		After			
Depth (cm)	No.obs	Mean	No obs	Mean	Mean diff	p-val	No.obs	Mean	No.obs	Mean	Mean diff	p-val
0-5	36	24.92	36	25.4	-0.48	0.11	36	1.23	36	1.24	-0.01	0.47
42125	36	25.97	36	25.76	0.22	0.41	36	1.32	36	1.34	-0.02	0.26
15-25	36	25.49	36	25.31	0.19	0.56	36	1.37	36	1.36	0.01	0.43
25-35	36	25.09	36	25.08	0.01	0.98	36	1.35	36	1.35	0	0.78
35-45	36	24.07	36	24.45	-0.38	0.37	36	1.39	36	1.38	0.01	0.68
45-55	36	21.29	36	23.27	-1.98	0.1	36	1.42	36	1.41	0.01	0.48
55-65	36	21.35	36	22.27	-0.93	0.05	36	1.38	36	1.39	-0.01	0.48
65-75	36	20.98	36	21.32	-0.34	0.38	36	1.4	36	1.44	-0.04	0.04

Table 4-17:Summary statistics for test plots comparing before and after harvest sample data

This method of testing tests the null hypothesis, that is the moisture differences accounted for the bulk density differences, against the alternative hypothesis, that is the weight differences of the machines accounted for the bulk density differences. To reject the null hypothesis and that say that the weight differences of the machines were the driving variable a goal

significance value must be chosen. Largely, scientific research uses a value of 5%, or a p-value of 0.05 (Shrestha, 2019). Some studies in agricultural research however have used a significance value of 20%, or 0.2 (Bennett et al, 2017).
It is observed in tables 5 – 14 through 5 – 17 that neither of the selected levels of significance were consistently observed in any of the statistical testing.

4.5 Penetration Resistance

On the second trip, after the harvesting of cotton, a penetrometer was used to determine the penetration resistance of the control and test fields. As stated in the literature review, the soil strength at which crop roots tend to cease exploration is 1490 kPa. As such, this was the main point of investigation, i.e., that soil penetrometer data was analysed to determine where and how often the soil strength of the plots approached or exceeded this soil strength limit.

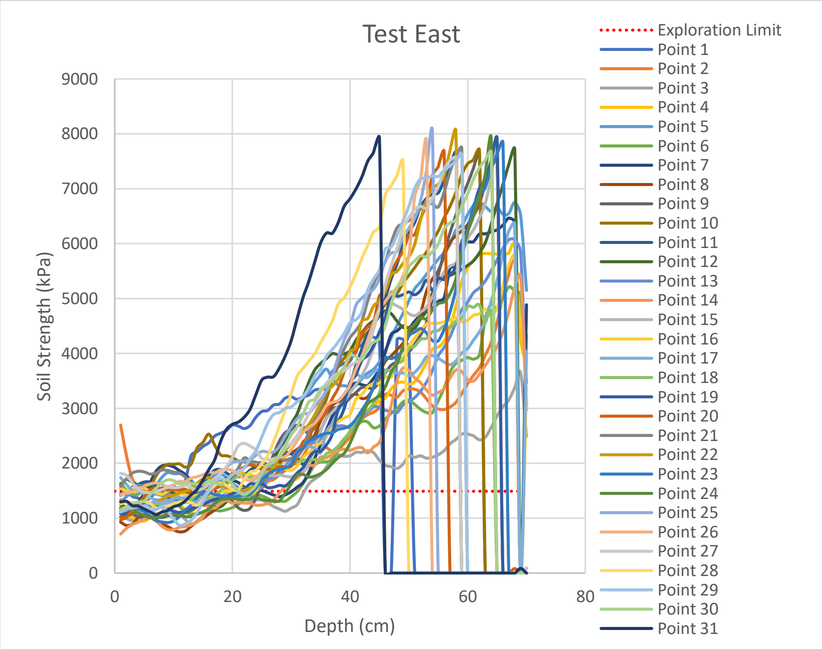

Figure 4-17: Penetration resistance for Test East

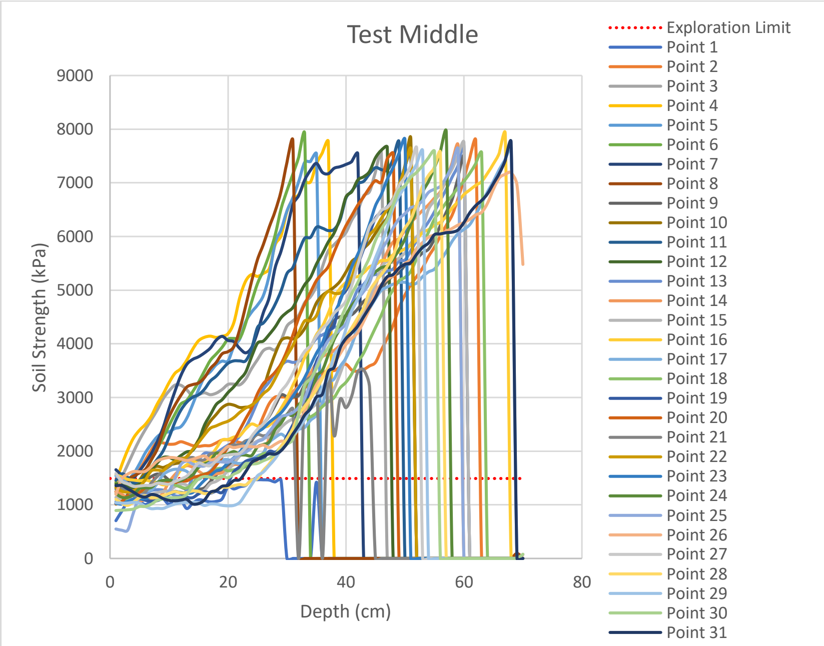

Figure 4-18: Penetration resistance for Test Middle

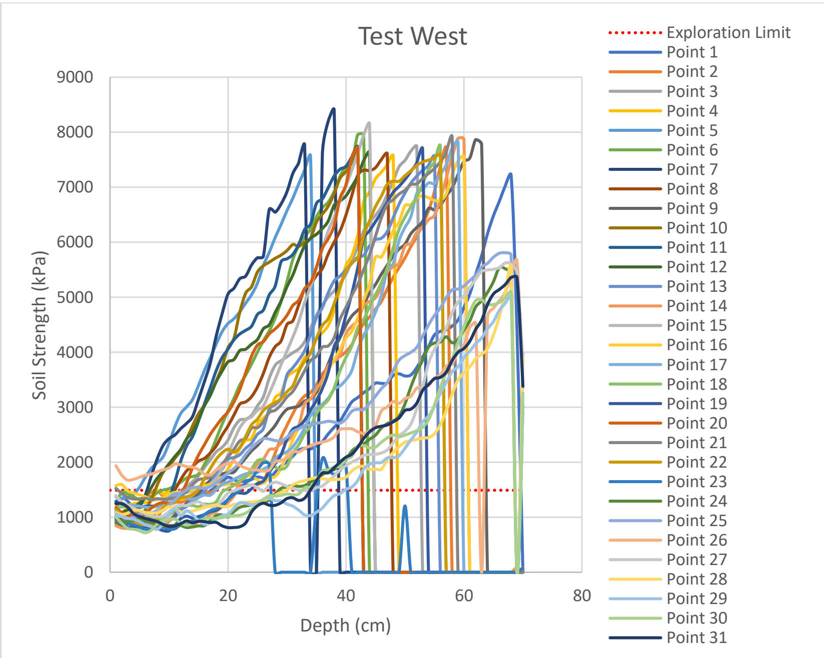

Figure 4-19: Penetration resistance for Test West

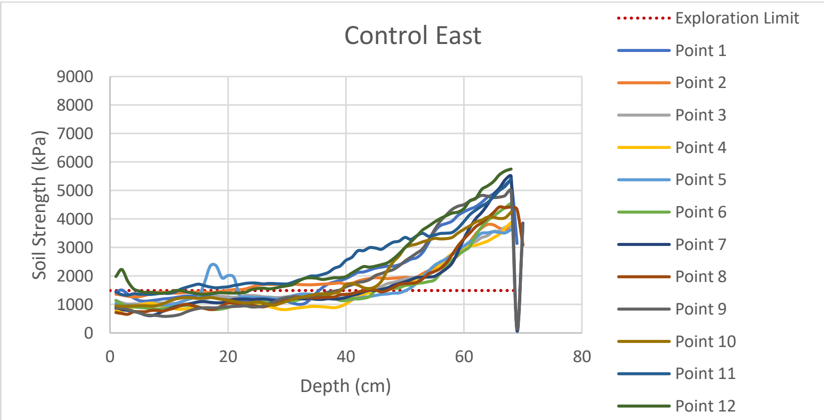

Figure 4-20: Penetration resistance for Control East

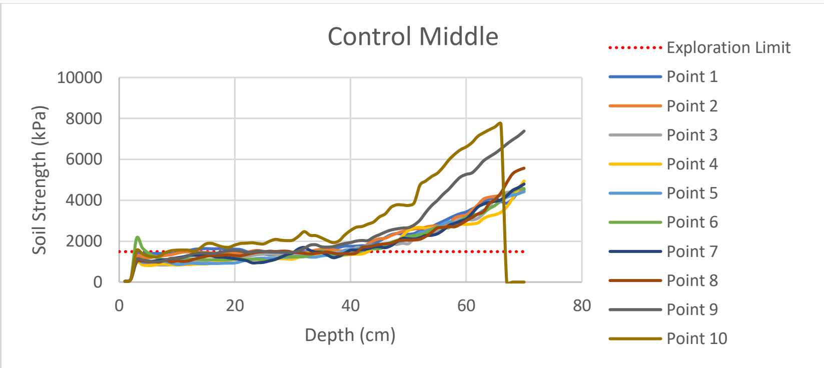

Figure 4-21: Penetration resistance for Control Middle

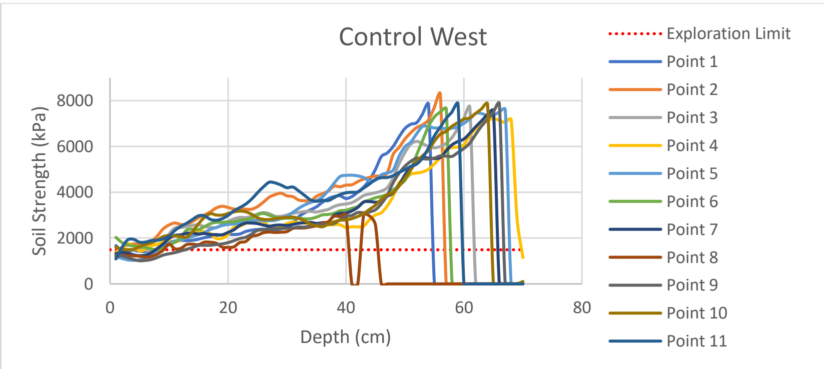

Figure 4-22: Penetration resistance for Control West

It is clear from the above figures that the majority of the resistance measurements were above the reported limit for root exploration. To determine if there was a measurable difference between the control and test plots the averages were graphed:

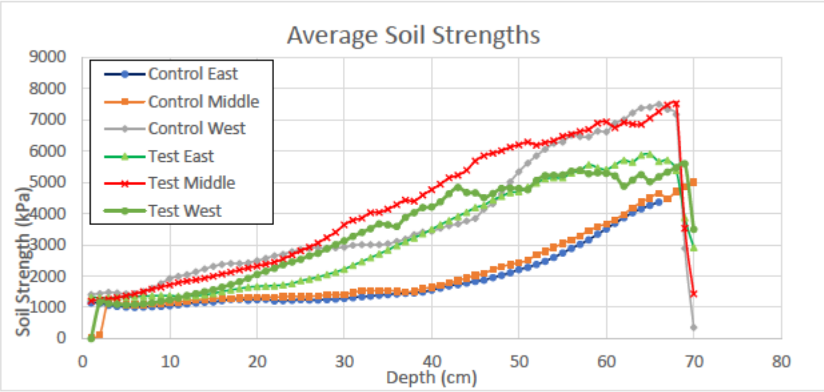

Figure 4-23: Average penetration resistance value by plot

The above figure shows that, on average, the test plots have a higher penetration resistance throughout most of the profile, with the upper 10cm being similar to the resistance of the control plots.

4.6 Cotton Yield

Yield quantities in the test field were recorded at points throughout the field by the onboard sensors of the CP690. The averaged values across the test fields can be seen below:

Plot	Number of Recordings	Average Yield (kg lint/ha)
East-Large	134	1099
Middle-Large	136	1057
West-Large	137	1038

Table 4-18: Yield data for test field

Yield quantities in the control field were derived in a different manner. The 2-row trial picker recorded the value of kg lint + seed + trash across each plot. An average proportion of lint/seed + trash was found during ginning of the cotton and this proportion was applied to each plot to find a final kg lint/ha for each of the control plots.

The values for each plot are:

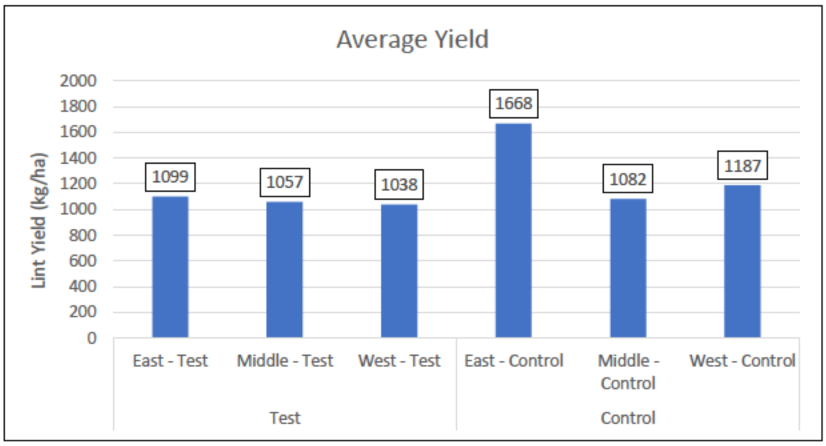

Figure 4-24: Plot values for cotton yield

Comparing the average values across the test and control field:

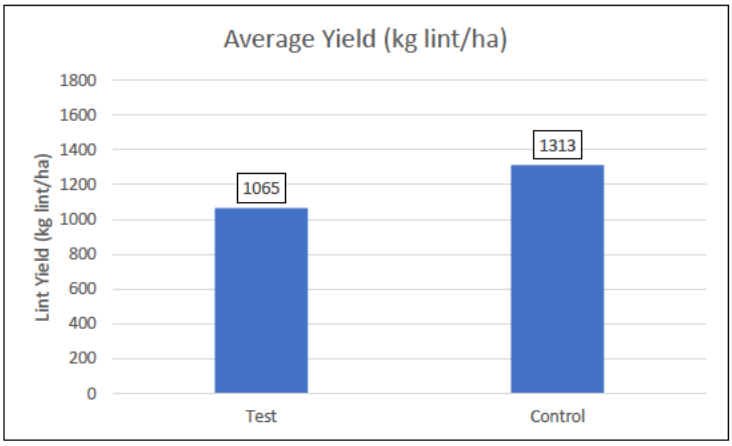

Figure 4-25: Average values for cotton yield across test and control field

The values in figure 4-14 show an 18% decrease in average lint yield within the test field compared to the control field. As the value for 'East-Control' within figure 4-13 is exceptionally high it is possibly an outlier. Recalculating the average values without 'East-Control':

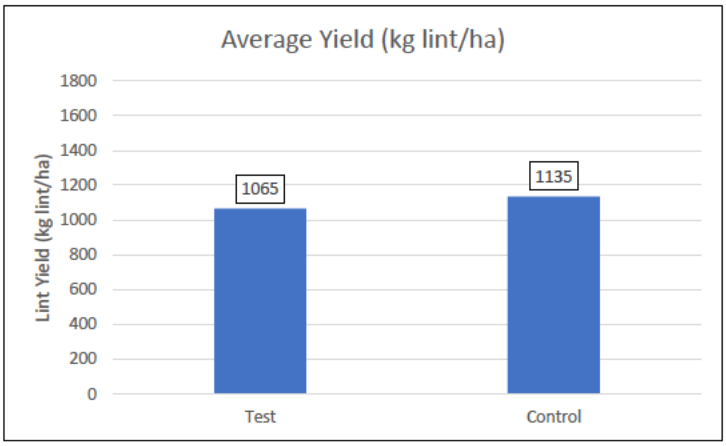

Figure 4-26: Average values for cotton yield across test and control field minus outlier

The values in figure 4-15 show that, under the assumption that 'East-Control' is an outlier, the decrease in lint yield is reduced to 6%.

5 Discussion

Figures 5-8 and 5-9 show that prior to harvest the test field had a measurably higher average bulk density throughout the profile, as well as being overall drier. Prior to this season the test field had had a single traffic by the CP690. Past research (Bennet et al, 2017) indicate that a single traffic event by a combination harvest and bale cotton harvester can cause immediate compaction.

This trend was not observed after the 2022 seasons harvest however, as figures 5-13 and 5-14 show that the bulk densities throughout the test and control field were broadly similar. This similarity was confirmed by the statistical testing reported in table 5-15 showing that there was no statistical difference between the two sets of plots. It should be noted that no statistical difference across the two sets of plots were observed before harvest, as reported in table 5-14, however the difference reduced after harvest. A measurable increase in penetration resistance was seen in the test plots compared to the control plots, as measured in figure 5-23.

It is apparent that, at least in pre-harvest conditions, there was some measurable difference in bulk density across the test and control fields, though it is not strictly statistically significant.

A difference in penetration resistance post-harvest was recorded and conflicts with the lack of difference in bulk density values. It is unclear why these indices do not correlate in these circumstances, though it is likely due to the different moisture levels observed in post-harvest conditions.

A difference in yield was observed based upon the data provided by the Australian Cotton Research Institute. This difference was reported in figures 5-24 and 5-25 and constituted an 18% increase in average lint yield within the test field compared to the control yield. This increase related to an extra 248 kg of lint per hectare of cropped land. A singular cotton yield result, East-Control, as seen in figure 5-24 was exceedingly higher than the other control field plots. The East-Control value was 40% higher than the next highest control value, West-Control. It is possible that this measurement constitutes an outlier, either in the quality of the plants within this section or in a fault in the measurement of lint yield for this plot. When the data was re-examined without the East-Control figure the difference in lint yield dropped to 6%, or an extra 70kg of lint per hectare of cropped land. It is likely that this is a more accurate representation of the difference in yield in a field that has had no traffics by a CP690/JD7760 or another similar machine compared to a field that has.

Under the assumption that these results are accurate the economics of what this difference would mean for land managers will be invested. In the 2019-2020 cotton season the cost of cotton lint was an average of $597/bale, with 227kg/bale (AgEcon, 2019). This constitutes an average cost of $2.63/kg of lint. Under a scenario in which the yield difference of 6% is seen in a real-world scenario this would constitute an extra $184/ha of value extracted from the extra lint yield in a field that has not been trafficked by a CP690. Comparing this to an average cotton field, which is reportedly 467 ha (Cotton Australia, 2012) this would constitute a difference of $85,928 difference in the value of lint yield in a field that hasn't been trafficked by a CP690 compared to a field that has. It should be noted that the economic consideration of cotton is much more complicated, with spraying costs, licencing costs for cotton seeds and cost of labour at planting and harvest all being large factors.

Ultimately, while the trial showed a measured decrease in cotton yield in the field trafficked by the CP690 it was not able to be confirmed that differences in compaction indices were the result of the different machine weights alone. If further research was to be undertaken in this field, it is recommended that a larger data set is tested using the same methodology. This is recommended to increase the effectiveness of statistical testing as well as decreasing the effect of natural variability in cotton growth.

6 CONCLUSIONS

In this study bulk density and penetration resistance were used as proxy measures for the compaction of a clay soil cotton field near Narrabri, NSW. Compaction values and cotton lint yields were compared to determine if traffic by combination harvest and bale cotton harvesters, such as the CP690/JD7760 had a measurable impact on the level of compaction in the soil, and if this compaction relates to a decrease in cotton lint yield. It was found that some measurable increase in compaction in a field trafficked by a CP690 compared to a field trafficked by a 2-row trial picker existed in pre-harvest conditions. This increase was negated in the investigations of post-harvest conditions. The observed differences in density measurements, and the associated moisture content measurements did not satisfy statistical significance values of $p = 0.05$ or $=p = 0.2$. This results in a lack of sufficient evidence to conclude that the compaction difference observed is solely the response of the increased machinery weight, and it is likely that differences in moisture content throughout the fields were indeed the primary factor.

A measurable decrease in cotton yield was observed in the field trafficked by the CP690 compared to the trail picker field. However, with a relatively small sample size of 3 field sections in the test field (CP690 field) and the control field (trial picker field) it is not possible to conclude that this yield reduction can be expected in other cropping systems. This research does represent a point of data that suggests yield deficits can be expected in fields trafficked by JD7760's/CP690's however further research must be conducted before concrete conclusions can be made and data confidently used for economic evaluation of the cost/benefits of this machinery.

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8 APPENDIX

8.1 PROJECT SPECIFICATION

ENG4111/ENG4112 Research Project

Project Specification

For:	Adam Henderson
Title:	Combination Harvest and Baling Machinery's Impact on Soil Health and Productivity in High Clay Content Cotton Fields of Northern NSW
Major:	Environmental Engineering
Supervisor(s):	Stirling Roberton
Sponsorship:	Cotton Research and Development Corporation
Enrolment:	ENG4111 – ONC S1, 2022 ENG4112 – ONC S2, 2022
Project Aim:	To use soil sampling/analysis techniques to determine the changes in bulk density/water holding capacity of high clay percent cotton fields after having much higher loads placed on it soil surface during harvest; to analyse the effect these changes have on cotton productivity and to represent the pertinent data using modern GIS and programming solutions.

Programme: Version 1, 14th March 2022

1. Review existing literature on soil compaction regarding its causes, effects and what metrics can be used to best represent these extents.
2. Review current best methods for determining these metrics in a field environment, including sampling techniques for later laboratory analysis and use this information to create a 'sampling analysis plan' or similar.
3. Co-ordinate with farming co-operator representative to determine field access availability and possible times.
4. Attend field site.
5. Use the P13 and P12 laboratory facilities at the discretion of staff i.e. Alla Marchuk to obtain necessary laboratory results.
6. Develop numerical and graphical analysis of complete data set using R and QGIS respectively.
7. Conclude findings based on analysis.

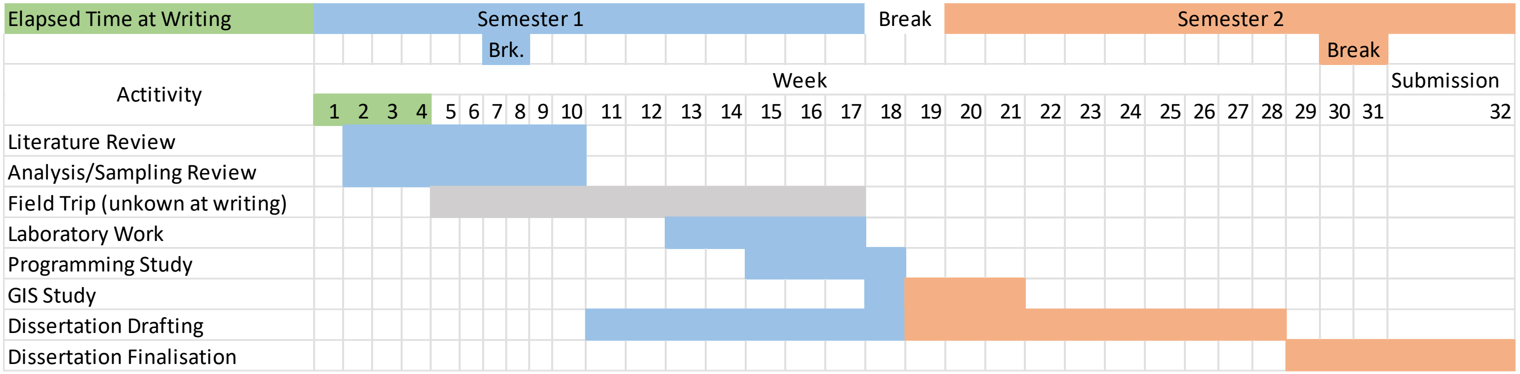
If time and resources permit:

8. Develop and install a row-by-row cotton yield monitor in commercial cotton picker and analyse diff

Alternatively, if field access is unavailable:

9. Supervisor (Sterling Roberton) has noted that some data already exists for ______. In the case of the field access falling through obtain this data for analysis.
10. Create mapping and analysis based on data. This depends on data type.

Project Plan



Submission Note: Due to uncertainty of field access times this chart is only indicative for the initial revision and will become more detailed.

Project Resources

Field Access

- This is currently under coordination by Dr. Stirling Roberton and is slated to be sometime in April/May.
- Lodging and food need to be sorted for this trip/
- Most likely to be in company of David West and possibly Stirling for field trip.

Field Equipment

- University equipment is to be used for data collection in field and as such the coordinating of availability of pertinent equipment is necessary.

Laboratory Access

- I'm already fully inducted into P12, P13 with security access. This allows for the initialization of lab data collection as soon as possible.

Study Material for R/GIS

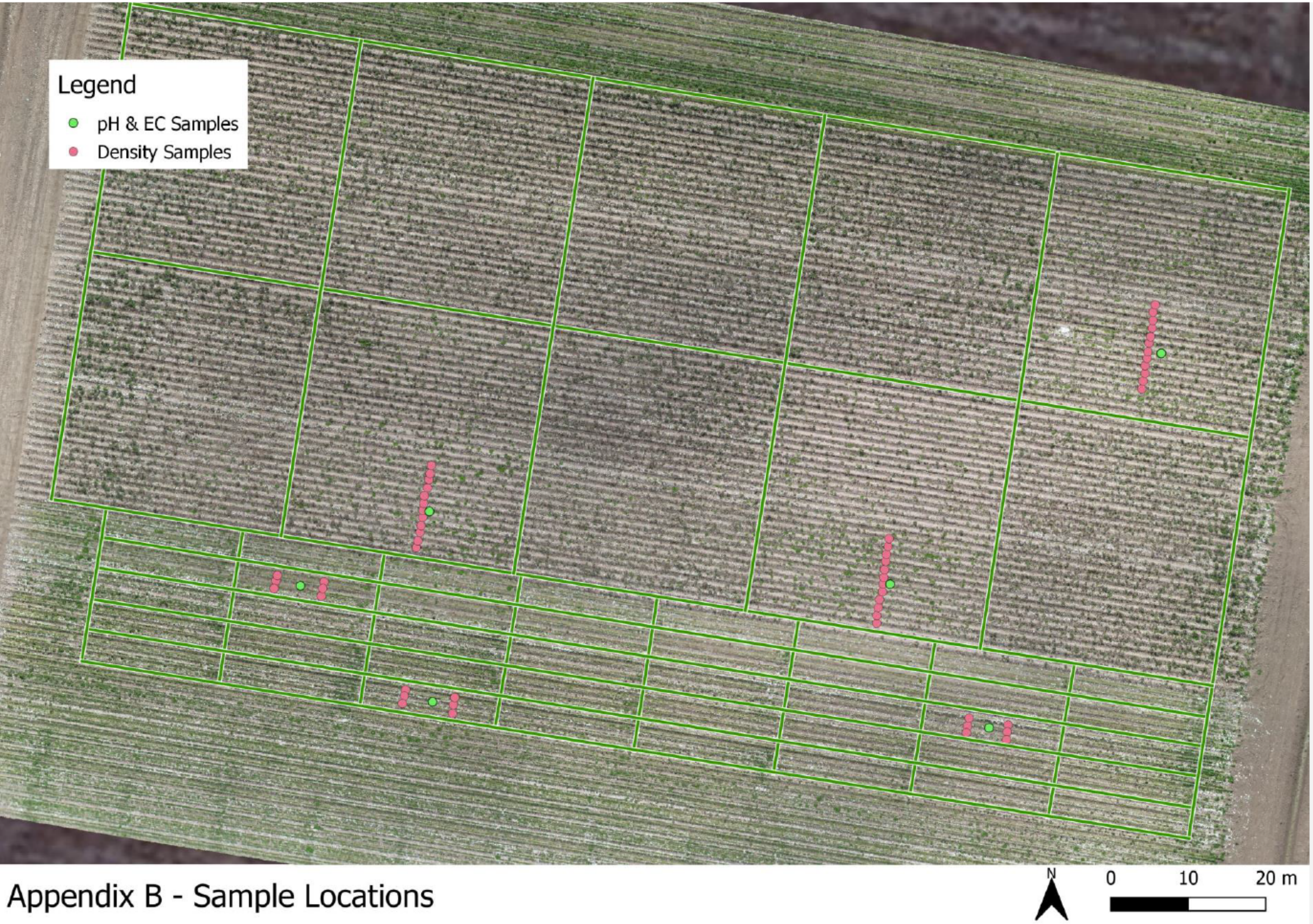
- Textbook for R has already been acquired.
- Possible use of 'non-academic' resources such as skillshare, youtube, forums are likely to be helpful for the learning of these and I should begin cultivating an information network.

Study Time

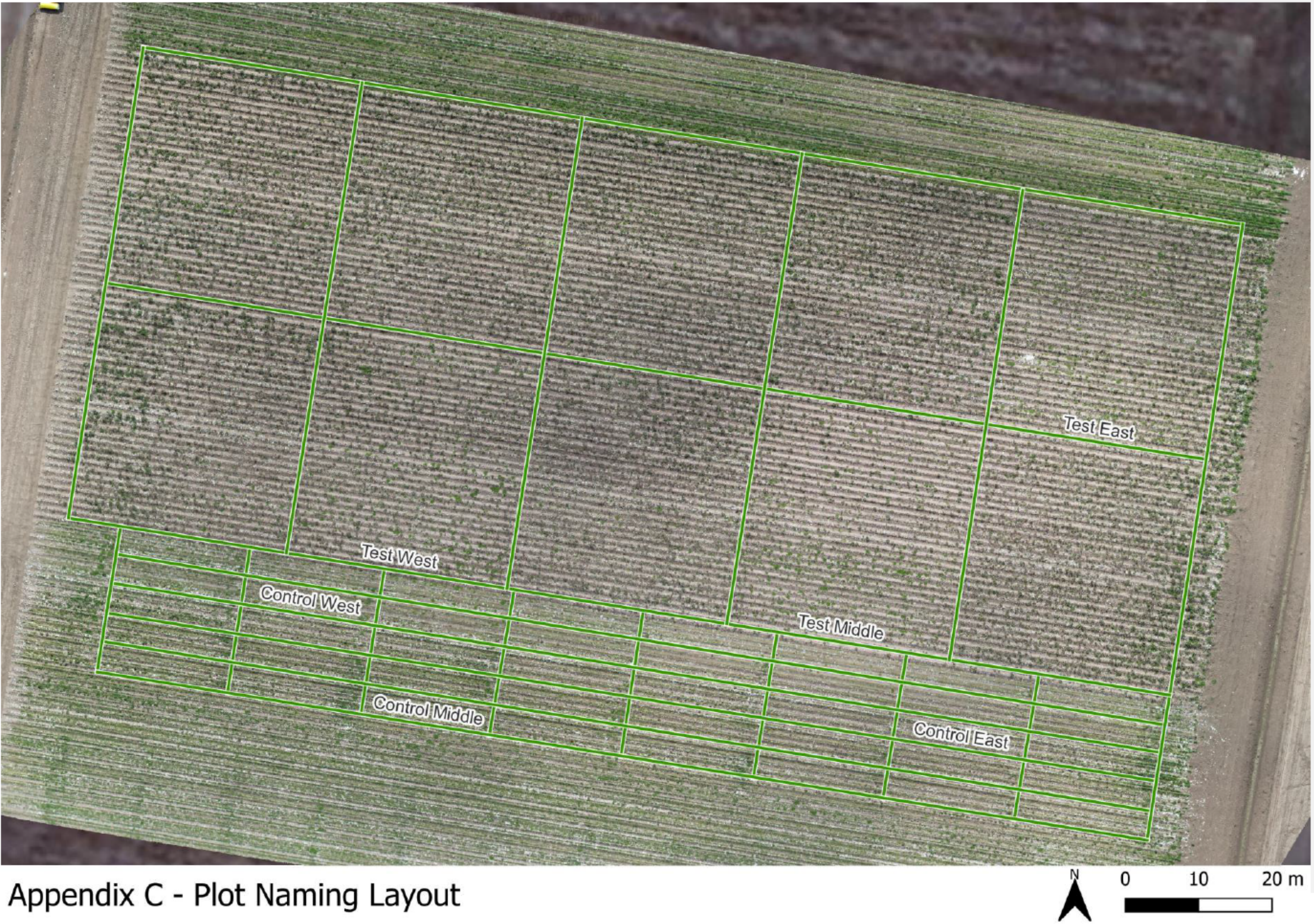
- Coordinate with work to allow for extra time when nearing completion and to allow for field trip.

Contingency

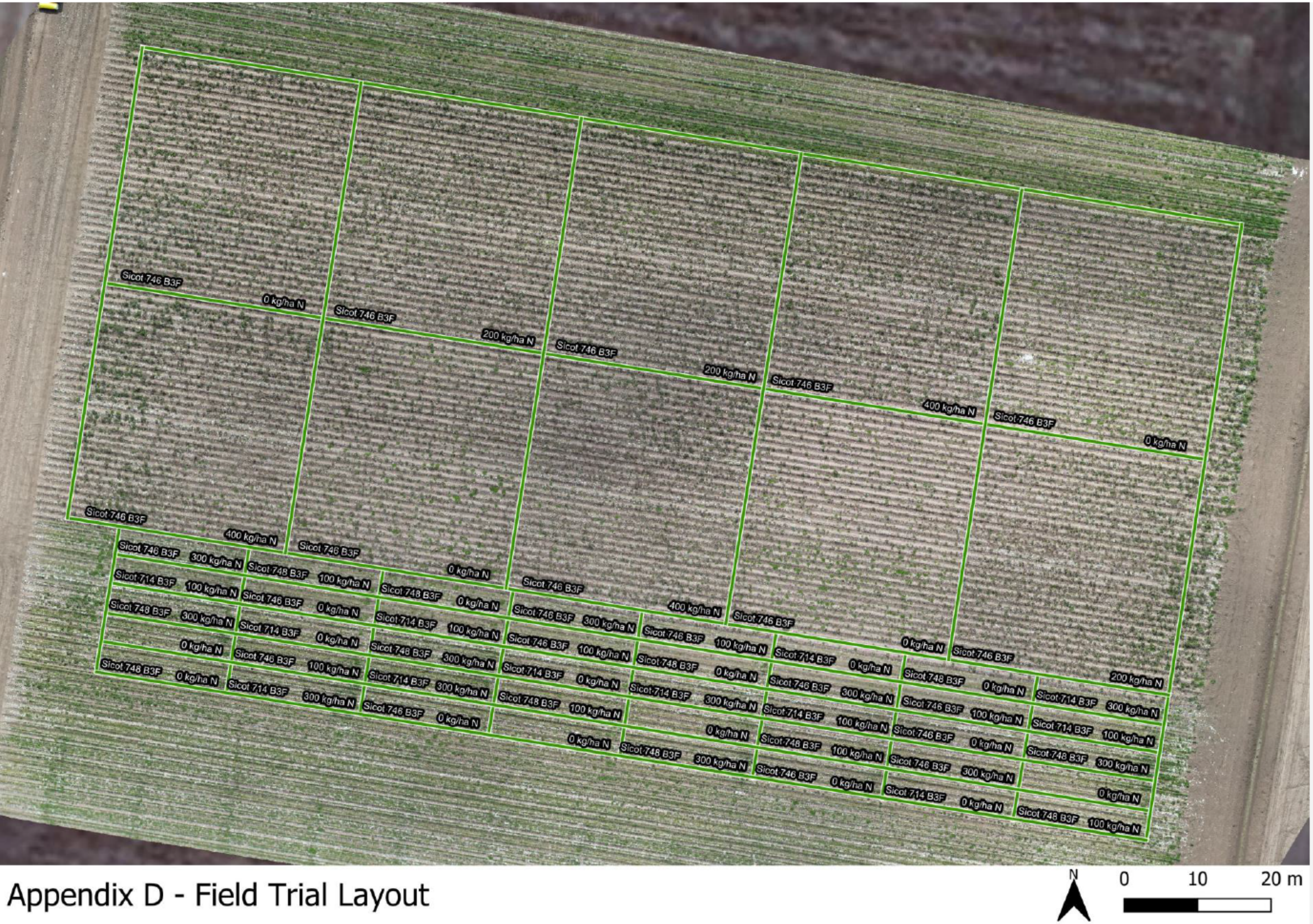
- Due to field access being a linchpin of this thesis it will be wise to begin planning for contingency as the field access dates get closer.



Appendix B - Sample Locations



Appendix C - Plot Naming Layout



Appendix D - Field Trial Layout

8.5 Appendix E – Before Harvest Data

	Before Harvest			
Sample	Adj. Wet Wt (g)	Adj. Dry Wt (g)	Moisture %	Bulk Density (g/cm3)
B2-I-E-L-1-0	245.79	186.34	24.19	1.30
B2-I-E-L-10-0	233.90	180.13	22.99	1.26
B2-I-E-L-10-1	272.39	206.18	24.31	1.44
B2-I-E-L-10-2	267.30	202.80	24.13	1.42
B2-I-E-L-10-3	262.56	199.00	24.21	1.39
B2-I-E-L-10-4	266.84	203.36	23.79	1.42
B2-I-E-L-10-5	272.80	212.02	22.28	1.48
B2-I-E-L-10-6	261.02	208.18	20.24	1.45
B2-I-E-L-10-7	266.45	215.50	19.12	1.51
B2-I-E-L-10-8	219.04	178.00	18.74	1.24
B2-I-E-L-1-1	267.91	202.37	24.46	1.41
B2-I-E-L-11-0	221.97	171.01	22.96	1.19
B2-I-E-L-11-1	252.93	191.45	24.31	1.34
B2-I-E-L-11-2	251.30	189.17	24.72	1.32
B2-I-E-L-11-3	251.17	189.28	24.64	1.32
B2-I-E-L-11-4	269.68	206.83	23.31	1.45
B2-I-E-L-11-5	262.87	207.37	21.11	1.45
B2-I-E-L-11-6	254.87	200.75	21.23	1.40
B2-I-E-L-11-7	248.49	194.80	21.61	1.36
B2-I-E-L-11-8	267.00	210.28	21.24	1.47
B2-I-E-L-11-9	122.53	96.44	21.29	0.67
B2-I-E-L-1-2	270.60	205.59	24.02	1.44
B2-I-E-L-12-0	248.90	190.49	23.47	1.33
B2-I-E-L-12-1	250.03	189.14	24.35	1.32
B2-I-E-L-12-2	266.68	200.20	24.93	1.40
B2-I-E-L-12-3	259.22	195.34	24.64	1.36
B2-I-E-L-12-4	264.51	199.98	24.40	1.40
B2-I-E-L-12-5	260.43	199.47	23.41	1.39
B2-I-E-L-12-6	248.27	193.56	22.04	1.35
B2-I-E-L-12-7	262.17	204.91	21.84	1.43
B2-I-E-L-12-8	238.06	185.73	21.98	1.30
B2-I-E-L-12-9	140.21	109.42	21.96	0.76
B2-I-E-L-1-3	267.23	205.10	23.25	1.43
B2-I-E-L-1-4	267.32	210.73	21.17	1.47
B2-I-E-L-1-5	258.70	205.19	20.68	1.43
B2-I-E-L-1-6	254.55	202.01	20.64	1.41
B2-I-E-L-1-7	258.37	205.58	20.43	1.44
B2-I-E-L-1-8	243.55	193.48	20.56	1.35

B2-I-E-L-2-0	229.51	175.81	23.40	1.23
B2-I-E-L-2-1	267.23	200.12	25.11	1.40
B2-I-E-L-2-2	272.76	206.71	24.22	1.44
B2-I-E-L-2-3	255.70	193.19	24.45	1.35
B2-I-E-L-2-4	258.68	194.73	24.72	1.36
B2-I-E-L-2-5	263.61	199.48	24.33	1.39
B2-I-E-L-2-6	248.67	194.44	21.81	1.36
B2-I-E-L-2-7	234.69	184.43	21.42	1.29
B2-I-E-L-2-8	240.70	189.25	21.38	1.32
B2-I-E-L-2-9	145.32	114.80	21.00	0.80
B2-I-E-L-3-0	236.05	179.33	24.03	1.25
B2-I-E-L-3-1	263.99	197.97	25.01	1.38
B2-I-E-L-3-2	273.78	210.84	22.99	1.47
B2-I-E-L-3-3	263.22	203.13	22.83	1.42
B2-I-E-L-3-4	277.08	216.07	22.02	1.51
B2-I-E-L-3-5	267.70	215.38	19.54	1.50
B2-I-E-L-3-6	262.26	211.90	19.20	1.48
B2-I-E-L-3-7	261.79	211.12	19.36	1.48
B2-I-E-L-3-8	253.27	204.19	19.38	1.43
B2-I-E-L-4-0	245.76	188.11	23.46	1.31
B2-I-E-L-4-1	271.31	205.47	24.27	1.44
B2-I-E-L-4-2	263.57	199.41	24.34	1.39
B2-I-E-L-4-3	260.53	199.12	23.57	1.39
B2-I-E-L-4-4	263.80	204.79	22.37	1.43
B2-I-E-L-4-5	258.80	207.69	19.75	1.45
B2-I-E-L-4-6	271.99	222.37	18.24	1.55
B2-I-E-L-4-7	262.97	215.91	17.90	1.51
B2-I-E-L-4-8	263.82	217.86	17.42	1.52
B2-I-E-L-4-9	85.50	70.87	17.11	0.50
B2-I-E-L-5-0	216.06	164.92	23.67	1.15
B2-I-E-L-5-1	249.48	188.69	24.37	1.32
B2-I-E-L-5-2	263.30	201.17	23.60	1.41
B2-I-E-L-5-3	238.54	182.06	23.68	1.27
B2-I-E-L-5-4	281.70	220.31	21.79	1.54
B2-I-E-L-5-5	264.02	213.55	19.12	1.49
B2-I-E-L-5-6	256.06	209.36	18.24	1.46
B2-I-E-L-5-7	266.56	218.31	18.10	1.53
B2-I-E-L-5-8	255.12	211.27	17.19	1.48
B2-I-E-L-6-0	247.67	189.82	23.36	1.33
B2-I-E-L-6-1	270.74	203.66	24.78	1.42
B2-I-E-L-6-2	267.05	206.25	22.77	1.44
B2-I-E-L-6-3	272.53	213.43	21.69	1.49

B2-I-E-L-6-4	269.41	215.05	20.18	1.50
B2-I-E-L-6-5	262.07	213.91	18.38	1.49
B2-I-E-L-6-6	267.12	219.24	17.92	1.53
B2-I-E-L-6-7	273.55	225.60	17.53	1.58
B2-I-E-L-6-8	262.93	216.76	17.56	1.51
B2-I-E-L-7-0	206.72	157.99	23.57	1.10
B2-I-E-L-7-1	236.44	176.45	25.37	1.23
B2-I-E-L-7-2	255.67	195.51	23.53	1.37
B2-I-E-L-7-3	259.18	197.48	23.81	1.38
B2-I-E-L-7-4	266.39	204.50	23.23	1.43
B2-I-E-L-7-5	265.77	209.80	21.06	1.47
B2-I-E-L-7-6	273.00	215.23	21.16	1.50
B2-I-E-L-7-7	284.50	225.21	20.84	1.57
B2-I-E-L-7-8	243.86	193.27	20.75	1.35
B2-I-E-L-8-0	239.78	183.48	23.48	1.28
B2-I-E-L-8-1	253.94	190.12	25.13	1.33
B2-I-E-L-8-2	258.72	194.28	24.91	1.36
B2-I-E-L-8-3	249.39	186.93	25.05	1.31
B2-I-E-L-8-4	258.48	195.37	24.42	1.36
B2-I-E-L-8-5	261.67	201.38	23.04	1.41
B2-I-E-L-8-6	258.09	201.60	21.89	1.41
B2-I-E-L-8-7	249.63	197.66	20.82	1.38
B2-I-E-L-8-8	259.63	204.86	21.10	1.43
B2-I-E-L-9-0	231.70	177.84	23.25	1.24
B2-I-E-L-9-1	247.44	186.45	24.65	1.30
B2-I-E-L-9-2	252.26	191.52	24.08	1.34
B2-I-E-L-9-3	262.81	201.86	23.19	1.41
B2-I-E-L-9-4	269.18	210.45	21.82	1.47
B2-I-E-L-9-5	269.91	218.36	19.10	1.53
B2-I-E-L-9-6	276.07	226.54	17.94	1.58
B2-I-E-L-9-7	270.23	222.01	17.84	1.55
B2-I-E-L-9-8	251.29	208.17	17.16	1.45
B2-I-E-L-9-9	118.58	99.37	16.20	0.69
B2-I-E-S-1-0	266.29	202.43	23.98	1.41
B2-I-E-S-1-1	277.15	207.39	25.17	1.45
B2-I-E-S-1-2	273.34	209.15	23.48	1.46
B2-I-E-S-1-3	264.23	202.66	23.30	1.42
B2-I-E-S-1-4	264.92	206.66	21.99	1.44
B2-I-E-S-1-5	277.66	218.56	21.29	1.53
B2-I-E-S-1-6	257.98	205.85	20.21	1.44
B2-I-E-S-1-7	250.17	200.28	19.94	1.40
B2-I-E-S-1-8	252.92	202.25	20.03	1.41

B2-I-E-S-1-9	69.56	55.48	20.24	0.39
B2-I-E-S-2-0	254.36	190.99	24.91	1.33
B2-I-E-S-2-1	263.41	196.65	25.34	1.37
B2-I-E-S-2-2	271.65	205.87	24.22	1.44
B2-I-E-S-2-3	268.93	204.80	23.85	1.43
B2-I-E-S-2-4	266.59	202.78	23.94	1.42
B2-I-E-S-2-5	277.64	215.26	22.47	1.50
B2-I-E-S-2-6	268.87	215.85	19.72	1.51
B2-I-E-S-2-7	283.04	231.89	18.07	1.62
B2-I-E-S-2-8	263.81	216.02	18.12	1.51
B2-I-E-S-2-9	154.49	126.11	18.37	0.88
B2-I-E-S-3-0	258.19	195.50	24.28	1.37
B2-I-E-S-3-1	271.16	200.86	25.93	1.40
B2-I-E-S-3-2	270.82	203.86	24.73	1.42
B2-I-E-S-3-3	263.74	197.64	25.06	1.38
B2-I-E-S-3-4	270.96	203.35	24.95	1.42
B2-I-E-S-3-5	263.21	200.61	23.78	1.40
B2-I-E-S-3-6	254.53	198.40	22.05	1.39
B2-I-E-S-3-7	267.23	213.14	20.24	1.49
B2-I-E-S-3-8	243.28	195.03	19.83	1.36
B2-I-E-S-3-9	177.61	141.67	20.24	0.99
B2-I-E-S-4-0	262.80	200.99	23.52	1.40
B2-I-E-S-4-1	277.04	209.15	24.51	1.46
B2-I-E-S-4-2	281.78	214.77	23.78	1.50
B2-I-E-S-4-3	253.79	192.71	24.07	1.35
B2-I-E-S-4-4	265.03	201.80	23.86	1.41
B2-I-E-S-4-5	273.81	213.36	22.08	1.49
B2-I-E-S-4-6	254.64	202.44	20.50	1.41
B2-I-E-S-4-7	265.09	211.51	20.21	1.48
B2-I-E-S-4-8	245.16	195.01	20.46	1.36
B2-I-E-S-4-9	170.47	135.87	20.30	0.95
B2-I-E-S-5-0	251.76	191.15	24.07	1.34
B2-I-E-S-5-1	277.50	210.98	23.97	1.47
B2-I-E-S-5-2	268.24	202.37	24.56	1.41
B2-I-E-S-5-3	263.57	198.13	24.83	1.38
B2-I-E-S-5-4	266.02	200.92	24.47	1.40
B2-I-E-S-5-5	265.69	203.87	23.27	1.42
B2-I-E-S-5-6	242.29	189.39	21.83	1.32
B2-I-E-S-5-7	250.02	196.90	21.25	1.38
B2-I-E-S-5-8	237.33	186.80	21.29	1.31
B2-I-E-S-6-0	259.95	197.71	23.94	1.38
B2-I-E-S-6-1	266.86	199.44	25.26	1.39

B2-I-E-S-6-2	273.11	205.96	24.59	1.44
B2-I-E-S-6-3	270.75	207.43	23.39	1.45
B2-I-E-S-6-4	267.38	206.61	22.73	1.44
B2-I-E-S-6-5	275.66	218.04	20.90	1.52
B2-I-E-S-6-6	252.93	205.16	18.89	1.43
B2-I-E-S-6-7	263.69	215.46	18.29	1.51
B2-I-E-S-6-8	260.36	211.57	18.74	1.48
B2-I-E-S-6-9	88.51	71.67	19.03	0.50
B2-I-M-L-1-0	224.45	168.71	24.83	1.18
B2-I-M-L-10-0	237.66	179.52	24.46	1.25
B2-I-M-L-10-1	267.63	199.84	25.33	1.40
B2-I-M-L-10-2	268.39	204.43	23.83	1.43
B2-I-M-L-10-3	265.56	202.26	23.84	1.41
B2-I-M-L-10-4	269.61	209.31	22.37	1.46
B2-I-M-L-10-5	262.96	208.09	20.87	1.45
B2-I-M-L-10-6	247.29	197.27	20.23	1.38
B2-I-M-L-10-7	261.71	209.14	20.09	1.46
B2-I-M-L-10-8	247.80	197.57	20.27	1.38
B2-I-M-L-1-1	247.23	181.00	26.79	1.26
B2-I-M-L-11-0	235.82	176.40	25.20	1.23
B2-I-M-L-11-1	240.41	178.65	25.69	1.25
B2-I-M-L-11-2	261.41	194.99	25.41	1.36
B2-I-M-L-11-3	260.50	194.91	25.18	1.36
B2-I-M-L-11-4	263.64	200.50	23.95	1.40
B2-I-M-L-11-5	274.53	216.90	20.99	1.52
B2-I-M-L-11-6	234.09	185.77	20.64	1.30
B2-I-M-L-11-7	241.65	191.85	20.61	1.34
B2-I-M-L-11-8	168.71	133.44	20.91	0.93
B2-I-M-L-1-2	267.44	196.14	26.66	1.37
B2-I-M-L-12-0	243.59	181.45	25.51	1.27
B2-I-M-L-12-1	250.67	183.04	26.98	1.28
B2-I-M-L-12-2	270.36	200.01	26.02	1.40
B2-I-M-L-12-3	250.01	184.99	26.01	1.29
B2-I-M-L-12-4	255.24	189.20	25.87	1.32
B2-I-M-L-12-5	266.89	198.62	25.58	1.39
B2-I-M-L-12-6	248.10	186.65	24.77	1.30
B2-I-M-L-12-7	250.06	192.79	22.90	1.35
B2-I-M-L-12-8	223.26	173.23	22.41	1.21
B2-I-M-L-12-9	86.55	67.52	21.99	0.47
B2-I-M-L-1-3	254.06	190.41	25.05	1.33
B2-I-M-L-1-4	259.66	200.62	22.74	1.40
B2-I-M-L-1-5	177.96	207.76	-16.75	1.45

B2-I-M-L-1-6	262.37	208.06	20.70	1.45
B2-I-M-L-1-7	263.42	209.35	20.53	1.46
B2-I-M-L-1-8	188.26	149.88	20.39	1.05
B2-I-M-L-2-0	241.48	181.57	24.81	1.27
B2-I-M-L-2-1	265.88	198.48	25.35	1.39
B2-I-M-L-2-2	253.56	188.96	25.48	1.32
B2-I-M-L-2-3	272.32	209.00	23.25	1.46
B2-I-M-L-2-4	249.33	196.94	21.01	1.38
B2-I-M-L-2-5	263.78	208.72	20.87	1.46
B2-I-M-L-2-6	254.29	203.63	19.92	1.42
B2-I-M-L-2-7	237.09	189.31	20.15	1.32
B2-I-M-L-2-8	264.99	211.92	20.03	1.48
B2-I-M-L-2-9	108.17	86.57	19.97	0.60
B2-I-M-L-3-0	224.67	167.88	25.28	1.17
B2-I-M-L-3-1	244.61	181.08	25.97	1.27
B2-I-M-L-3-2	279.33	209.89	24.86	1.47
B2-I-M-L-3-3	252.01	188.81	25.08	1.32
B2-I-M-L-3-4	272.60	207.08	24.04	1.45
B2-I-M-L-3-5	253.11	198.32	21.65	1.39
B2-I-M-L-3-6	253.02	199.35	21.21	1.39
B2-I-M-L-3-7	247.40	196.05	20.76	1.37
B2-I-M-L-3-8	245.53	196.05	20.15	1.37
B2-I-M-L-3-9	66.65	52.69	20.95	0.37
B2-I-M-L-4-0	234.37	175.79	24.99	1.23
B2-I-M-L-4-1	267.38	197.21	26.24	1.38
B2-I-M-L-4-2	270.21	203.53	24.68	1.42
B2-I-M-L-4-3	264.24	197.43	25.28	1.38
B2-I-M-L-4-4	259.19	193.29	25.43	1.35
B2-I-M-L-4-5	263.00	197.33	24.97	1.38
B2-I-M-L-4-6	261.87	198.68	24.13	1.39
B2-I-M-L-4-7	262.38	204.13	22.20	1.43
B2-I-M-L-4-8	247.42	193.78	21.68	1.35
B2-I-M-L-4-9	175.39	137.17	21.79	0.96
B2-I-M-L-5-0	215.43	160.35	25.57	1.12
B2-I-M-L-5-1	255.08	188.89	25.95	1.32
B2-I-M-L-5-2	266.95	198.41	25.68	1.39
B2-I-M-L-5-3	262.16	195.78	25.32	1.37
B2-I-M-L-5-4	270.12	206.98	23.37	1.45
B2-I-M-L-5-5	274.15	214.93	21.60	1.50
B2-I-M-L-5-6	261.12	203.40	22.10	1.42
B2-I-M-L-5-7	246.38	190.26	22.78	1.33
B2-I-M-L-5-8	226.53	173.84	23.26	1.21

B2-I-M-L-5-9	103.06	79.06	23.29	0.55
B2-I-M-L-6-0	235.69	177.18	24.83	1.24
B2-I-M-L-6-1	253.44	186.96	26.23	1.31
B2-I-M-L-6-2	262.88	192.88	26.63	1.35
B2-I-M-L-6-3	250.75	183.82	26.69	1.28
B2-I-M-L-6-4	259.62	191.67	26.17	1.34
B2-I-M-L-6-5	252.22	187.93	25.49	1.31
B2-I-M-L-6-6	226.03	174.68	22.72	1.22
B2-I-M-L-6-7	249.82	195.66	21.68	1.37
B2-I-M-L-7-0	234.90	175.75	25.18	1.23
B2-I-M-L-7-1	247.77	184.19	25.66	1.29
B2-I-M-L-7-2	264.43	198.67	24.87	1.39
B2-I-M-L-7-3	272.86	209.65	23.17	1.46
B2-I-M-L-7-4	266.78	211.35	20.78	1.48
B2-I-M-L-7-5	255.29	202.88	20.53	1.42
B2-I-M-L-7-6	250.98	199.00	20.71	1.39
B2-I-M-L-7-7	255.53	203.02	20.55	1.42
B2-I-M-L-7-8	243.88	194.00	20.45	1.36
B2-I-M-L-8-0	246.50	186.07	24.52	1.30
B2-I-M-L-8-1	263.49	195.22	25.91	1.36
B2-I-M-L-8-2	263.59	197.30	25.15	1.38
B2-I-M-L-8-3	267.26	203.88	23.71	1.42
B2-I-M-L-8-4	270.08	208.78	22.70	1.46
B2-I-M-L-8-5	259.36	202.30	22.00	1.41
B2-I-M-L-8-6	241.49	192.80	20.16	1.35
B2-I-M-L-8-7	233.69	185.98	20.42	1.30
B2-I-M-L-8-8	210.28	167.78	20.21	1.17
B2-I-M-L-9-0	233.97	174.98	25.21	1.22
B2-I-M-L-9-1	231.51	169.89	26.62	1.19
B2-I-M-L-9-2	255.88	189.67	25.88	1.33
B2-I-M-L-9-3	258.07	193.33	25.09	1.35
B2-I-M-L-9-4	260.02	199.09	23.43	1.39
B2-I-M-L-9-5	280.52	225.01	19.79	1.57
B2-I-M-L-9-6	241.16	196.39	18.56	1.37
B2-I-M-L-9-7	265.16	214.60	19.07	1.50
B2-I-M-L-9-8	255.16	205.35	19.52	1.43
B2-I-M-S-1-0	244.57	181.08	25.96	1.27
B2-I-M-S-1-1	251.67	182.04	27.67	1.27
B2-I-M-S-1-2	258.34	186.62	27.76	1.30
B2-I-M-S-1-3	248.34	180.78	27.20	1.26
B2-I-M-S-1-4	250.73	185.93	25.84	1.30
B2-I-M-S-1-5	255.21	196.42	23.04	1.37

B2-I-M-S-1-6	217.40	168.49	22.50	1.18
B2-I-M-S-1-7	240.13	186.67	22.26	1.30
B2-I-M-S-1-8	241.25	186.82	22.56	1.31
B2-I-M-S-1-9	64.61	49.82	22.89	0.35
B2-I-M-S-2-0	238.67	177.12	25.79	1.24
B2-I-M-S-2-1	255.95	187.45	26.76	1.31
B2-I-M-S-2-2	263.27	193.53	26.49	1.35
B2-I-M-S-2-3	253.28	186.47	26.38	1.30
B2-I-M-S-2-4	258.72	190.79	26.26	1.33
B2-I-M-S-2-5	261.85	198.59	24.16	1.39
B2-I-M-S-2-6	248.28	193.26	22.16	1.35
B2-I-M-S-2-7	248.43	193.86	21.97	1.35
B2-I-M-S-2-8	247.57	193.44	21.86	1.35
B2-I-M-S-2-9	94.46	73.70	21.98	0.51
B2-I-M-S-3-0	242.45	178.36	26.43	1.25
B2-I-M-S-3-1	265.27	192.92	27.27	1.35
B2-I-M-S-3-2	255.57	187.49	26.64	1.31
B2-I-M-S-3-3	261.05	191.78	26.54	1.34
B2-I-M-S-3-4	250.66	186.41	25.63	1.30
B2-I-M-S-3-5	268.92	202.41	24.73	1.41
B2-I-M-S-3-6	247.91	191.09	22.92	1.34
B2-I-M-S-3-7	242.65	187.07	22.91	1.31
B2-I-M-S-3-8	235.73	181.65	22.94	1.27
B2-I-M-S-3-9	137.32	105.68	23.04	0.74
B2-I-M-S-4-0	246.10	180.46	26.67	1.26
B2-I-M-S-4-1	254.85	186.18	26.95	1.30
B2-I-M-S-4-2	265.74	195.28	26.51	1.36
B2-I-M-S-4-3	247.84	181.50	26.77	1.27
B2-I-M-S-4-4	258.58	190.99	26.14	1.33
B2-I-M-S-4-5	261.53	194.83	25.50	1.36
B2-I-M-S-4-6	266.39	200.90	24.58	1.40
B2-I-M-S-4-7	255.39	194.28	23.93	1.36
B2-I-M-S-4-8	258.14	196.70	23.80	1.37
B2-I-M-S-4-9	141.83	108.18	23.73	0.76
B2-I-M-S-5-0	239.66	175.66	26.70	1.23
B2-I-M-S-5-1	253.22	182.38	27.98	1.27
B2-I-M-S-5-2	254.88	184.32	27.68	1.29
B2-I-M-S-5-3	245.56	176.12	28.28	1.23
B2-I-M-S-5-4	248.70	179.75	27.72	1.26
B2-I-M-S-5-5	257.82	191.07	25.89	1.33
B2-I-M-S-5-6	240.70	183.36	23.82	1.28
B2-I-M-S-5-7	246.26	188.84	23.32	1.32

B2-I-M-S-5-8	243.68	187.19	23.18	1.31
B2-I-M-S-5-9	54.37	41.43	23.80	0.29
B2-I-M-S-6-0	245.47	180.72	26.38	1.26
B2-I-M-S-6-1	270.60	197.66	26.96	1.38
B2-I-M-S-6-2	261.85	193.69	26.03	1.35
B2-I-M-S-6-3	262.58	194.05	26.10	1.36
B2-I-M-S-6-4	256.95	189.36	26.30	1.32
B2-I-M-S-6-5	259.02	193.61	25.25	1.35
B2-I-M-S-6-6	263.32	198.46	24.63	1.39
B2-I-M-S-6-7	250.69	188.68	24.74	1.32
B2-I-M-S-6-8	257.94	194.27	24.68	1.36
B2-I-M-S-6-9	72.80	54.63	24.96	0.38
B2-I-W-L-1-0	258.42	190.32	26.35	1.33
B2-I-W-L-10-0	240.19	177.89	25.94	1.24
B2-I-W-L-10-1	266.00	194.20	26.99	1.36
B2-I-W-L-10-2	266.94	194.53	27.13	1.36
B2-I-W-L-10-3	252.49	185.53	26.52	1.30
B2-I-W-L-10-4	255.36	190.29	25.48	1.33
B2-I-W-L-10-5	255.39	196.02	23.25	1.37
B2-I-W-L-10-6	236.65	183.55	22.44	1.28
B2-I-W-L-10-7	251.28	195.70	22.12	1.37
B2-I-W-L-10-8	231.07	180.90	21.71	1.26
B2-I-W-L-1-1	242.08	177.81	26.55	1.24
B2-I-W-L-11-0	225.66	166.82	26.07	1.17
B2-I-W-L-11-1	259.75	190.13	26.80	1.33
B2-I-W-L-11-2	258.14	188.74	26.88	1.32
B2-I-W-L-11-3	250.90	183.71	26.78	1.28
B2-I-W-L-11-4	242.24	177.93	26.55	1.24
B2-I-W-L-11-5	259.66	198.17	23.68	1.38
B2-I-W-L-11-6	249.39	194.66	21.95	1.36
B2-I-W-L-11-7	252.36	197.57	21.71	1.38
B2-I-W-L-11-8	242.36	188.79	22.10	1.32
B2-I-W-L-11-9	95.00	74.15	21.95	0.52
B2-I-W-L-1-2	257.00	188.34	26.72	1.32
B2-I-W-L-12-0	234.24	172.69	26.28	1.21
B2-I-W-L-12-1	267.72	193.88	27.58	1.35
B2-I-W-L-12-2	259.88	189.14	27.22	1.32
B2-I-W-L-12-3	253.28	184.51	27.15	1.29
B2-I-W-L-12-4	265.67	195.71	26.33	1.37
B2-I-W-L-12-5	246.92	188.98	23.47	1.32
B2-I-W-L-12-6	250.05	194.07	22.39	1.36
B2-I-W-L-12-7	251.99	195.24	22.52	1.36

B2-I-W-L-12-8	232.64	179.90	22.67	1.26
B2-I-W-L-12-9	100.69	77.93	22.60	0.54
B2-I-W-L-1-3	254.89	185.15	27.36	1.29
B2-I-W-L-1-4	259.65	190.38	26.68	1.33
B2-I-W-L-1-5	256.96	193.01	24.89	1.35
B2-I-W-L-1-6	227.96	176.53	22.56	1.23
B2-I-W-L-1-7	252.09	197.08	21.82	1.38
B2-I-W-L-1-8	238.07	187.04	21.44	1.31
B2-I-W-L-2-0	244.18	180.49	26.08	1.26
B2-I-W-L-2-1	263.33	193.37	26.57	1.35
B2-I-W-L-2-2	262.07	193.77	26.06	1.35
B2-I-W-L-2-3	251.92	187.46	25.59	1.31
B2-I-W-L-2-4	256.32	191.38	25.34	1.34
B2-I-W-L-2-5	242.66	184.99	23.77	1.29
B2-I-W-L-2-6	245.04	188.63	23.02	1.32
B2-I-W-L-2-7	238.11	185.20	22.22	1.29
B2-I-W-L-2-8	220.22	171.20	22.26	1.20
B2-I-W-L-3-0	244.15	178.67	26.82	1.25
B2-I-W-L-3-1	243.20	177.71	26.93	1.24
B2-I-W-L-3-2	254.55	186.81	26.61	1.31
B2-I-W-L-3-3	262.73	193.47	26.36	1.35
B2-I-W-L-3-4	242.29	178.47	26.34	1.25
B2-I-W-L-3-5	277.69	205.97	25.83	1.44
B2-I-W-L-3-6	256.40	196.42	23.39	1.37
B2-I-W-L-3-7	242.12	188.89	21.99	1.32
B2-I-W-L-3-8	238.57	187.68	21.33	1.31
B2-I-W-L-3-9	100.82	78.66	21.98	0.55
B2-I-W-L-4-0	242.91	180.23	25.80	1.26
B2-I-W-L-4-1	255.89	186.71	27.04	1.30
B2-I-W-L-4-2	267.15	196.46	26.46	1.37
B2-I-W-L-4-3	253.23	185.21	26.86	1.29
B2-I-W-L-4-4	256.88	190.06	26.01	1.33
B2-I-W-L-4-5	261.55	197.72	24.40	1.38
B2-I-W-L-4-6	252.28	195.51	22.50	1.37
B2-I-W-L-4-7	237.98	185.07	22.23	1.29
B2-I-W-L-5-0	233.41	171.90	26.35	1.20
B2-I-W-L-5-1	245.06	176.86	27.83	1.24
B2-I-W-L-5-2	244.65	175.12	28.42	1.22
B2-I-W-L-5-3	265.29	191.95	27.65	1.34
B2-I-W-L-5-4	248.37	181.90	26.76	1.27
B2-I-W-L-5-5	259.73	196.70	24.27	1.37
B2-I-W-L-5-6	242.49	186.20	23.21	1.30

B2-I-W-L-5-7	238.78	183.99	22.95	1.29
B2-I-W-L-5-8	253.37	195.23	22.95	1.36
B2-I-W-L-5-9	117.31	90.27	23.05	0.63
B2-I-W-L-6-0	253.60	187.69	25.99	1.31
B2-I-W-L-6-1	265.97	194.00	27.06	1.36
B2-I-W-L-6-2	264.38	193.79	26.70	1.35
B2-I-W-L-6-3	263.08	194.20	26.18	1.36
B2-I-W-L-6-4	259.51	194.07	25.22	1.36
B2-I-W-L-6-5	253.82	194.71	23.29	1.36
B2-I-W-L-6-6	247.63	191.01	22.86	1.33
B2-I-W-L-6-7	257.96	200.43	22.30	1.40
B2-I-W-L-6-8	240.80	186.25	22.65	1.30
B2-I-W-L-6-9	89.07	68.71	22.86	0.48
B2-I-W-L-7-0	206.68	152.84	26.05	1.07
B2-I-W-L-7-1	243.81	174.70	28.35	1.22
B2-I-W-L-7-2	254.08	182.83	28.04	1.28
B2-I-W-L-7-3	263.62	192.20	27.09	1.34
B2-I-W-L-7-4	248.75	182.89	26.48	1.28
B2-I-W-L-7-5	271.14	206.31	23.91	1.44
B2-I-W-L-7-6	261.99	201.54	23.07	1.41
B2-I-W-L-7-7	247.25	190.86	22.81	1.33
B2-I-W-L-7-8	180.29	139.01	22.90	0.97
B2-I-W-L-8-0	212.43	156.85	26.16	1.10
B2-I-W-L-8-1	269.75	197.81	26.67	1.38
B2-I-W-L-8-2	264.26	194.43	26.42	1.36
B2-I-W-L-8-3	248.46	183.24	26.25	1.28
B2-I-W-L-8-4	254.02	192.88	24.07	1.35
B2-I-W-L-8-5	254.07	196.60	22.62	1.37
B2-I-W-L-8-6	224.15	173.60	22.55	1.21
B2-I-W-L-8-7	252.87	196.59	22.26	1.37
B2-I-W-L-8-8	251.73	195.65	22.28	1.37
B2-I-W-L-9-0	219.89	160.61	26.96	1.12
B2-I-W-L-9-1	247.65	178.67	27.85	1.25
B2-I-W-L-9-2	274.75	198.86	27.62	1.39
B2-I-W-L-9-3	246.82	180.98	26.68	1.26
B2-I-W-L-9-4	247.79	183.03	26.14	1.28
B2-I-W-L-9-5	271.12	207.18	23.58	1.45
B2-I-W-L-9-6	243.05	189.35	22.09	1.32
B2-I-W-L-9-7	251.82	197.28	21.66	1.38
B2-I-W-L-9-8	252.48	197.91	21.61	1.38
B2-I-W-L-9-9	127.15	99.49	21.75	0.70
B2-I-W-S-1-0	253.48	188.55	25.62	1.32

B2-I-W-S-1-1	265.13	197.77	25.41	1.38
B2-I-W-S-1-2	264.21	194.38	26.43	1.36
B2-I-W-S-1-3	257.00	188.03	26.84	1.31
B2-I-W-S-1-4	248.92	185.64	25.42	1.30
B2-I-W-S-1-5	254.28	196.20	22.84	1.37
B2-I-W-S-1-6	255.89	199.89	21.88	1.40
B2-I-W-S-1-7	239.66	187.26	21.86	1.31
B2-I-W-S-1-8	145.42	112.98	22.31	0.79
B2-I-W-S-2-0	242.36	179.09	26.11	1.25
B2-I-W-S-2-1	252.78	183.21	27.52	1.28
B2-I-W-S-2-2	260.19	189.59	27.13	1.32
B2-I-W-S-2-3	256.33	186.70	27.16	1.30
B2-I-W-S-2-4	253.95	190.94	24.81	1.33
B2-I-W-S-2-5	245.94	190.36	22.60	1.33
B2-I-W-S-2-6	245.64	190.93	22.27	1.33
B2-I-W-S-2-7	237.45	185.16	22.02	1.29
B2-I-W-S-2-8	261.53	203.19	22.31	1.42
B2-I-W-S-2-9	195.68	151.89	22.38	1.06
B2-I-W-S-3-0	262.89	194.40	26.05	1.36
B2-I-W-S-3-1	253.07	184.41	27.13	1.29
B2-I-W-S-3-2	264.51	193.15	26.98	1.35
B2-I-W-S-3-3	257.50	187.37	27.24	1.31
B2-I-W-S-3-4	250.79	182.96	27.05	1.28
B2-I-W-S-3-5	258.99	197.74	23.65	1.38
B2-I-W-S-3-6	229.17	178.53	22.10	1.25
B2-I-W-S-3-7	237.54	185.30	21.99	1.29
B2-I-W-S-3-8	232.93	181.68	22.00	1.27
B2-I-W-S-3-9	181.94	142.55	21.65	1.00
B2-I-W-S-4-0	251.85	184.53	26.73	1.29
B2-I-W-S-4-1	270.93	195.10	27.99	1.36
B2-I-W-S-4-2	257.34	185.87	27.77	1.30
B2-I-W-S-4-3	252.36	182.68	27.61	1.28
B2-I-W-S-4-4	258.10	190.57	26.16	1.33
B2-I-W-S-4-5	261.73	200.07	23.56	1.40
B2-I-W-S-4-6	257.23	196.88	23.46	1.38
B2-I-W-S-4-7	260.02	199.50	23.28	1.39
B2-I-W-S-4-8	252.51	193.31	23.44	1.35
B2-I-W-S-4-9	227.00	174.35	23.19	1.22
B2-I-W-S-5-0	246.02	180.30	26.71	1.26
B2-I-W-S-5-1	244.57	174.37	28.70	1.22
B2-I-W-S-5-2	255.52	183.47	28.20	1.28
B2-I-W-S-5-3	253.66	182.20	28.17	1.27

B2-I-W-S-5-4	255.45	186.89	26.84	1.31
B2-I-W-S-5-5	250.09	188.07	24.80	1.31
B2-I-W-S-5-6	238.91	181.67	23.96	1.27
B2-I-W-S-5-7	230.16	175.72	23.65	1.23
B2-I-W-S-5-8	99.43	75.88	23.69	0.53
B2-I-W-S-6-0	249.96	184.44	26.21	1.29
B2-I-W-S-6-1	264.07	190.87	27.72	1.33
B2-I-W-S-6-2	267.10	194.36	27.23	1.36
B2-I-W-S-6-3	253.00	182.89	27.71	1.28
B2-I-W-S-6-4	252.03	186.16	26.14	1.30
B2-I-W-S-6-5	248.58	189.73	23.67	1.33
B2-I-W-S-6-6	222.61	170.40	23.45	1.19
B2-I-W-S-6-7	242.62	185.68	23.47	1.30
B2-I-W-S-6-8	235.93	180.09	23.67	1.26
B2-I-W-S-6-9	215.68	164.70	23.64	1.15

8.6 APPENDIX E – AFTER HARVEST DATA

	After Harvest			
Sample	Adj. Wet Wt (g)	Adj. Dry Wt (g)	Moisture %	Bulk Density (g/cm3)
B2-A-E-L-1-0	245.73	180.86	26.40	1.26
B2-A-E-L-10-0	242.21	179.32	25.97	1.25
B2-A-E-L-10-1	270.93	198.53	26.72	1.39
B2-A-E-L-10-2	266.40	194.23	27.09	1.36
B2-A-E-L-10-3	264.29	192.08	27.32	1.34
B2-A-E-L-10-4	267.79	196.45	26.64	1.37
B2-A-E-L-10-5	264.38	197.68	25.23	1.38
B2-A-E-L-10-6	257.91	200.24	22.36	1.40
B2-A-E-L-10-7	271.22	210.35	22.44	1.47
B2-A-E-L-10-8	263.03	204.46	22.27	1.43
B2-A-E-L-1-1	264.26	193.45	26.80	1.35
B2-A-E-L-11-0	254.33	186.61	26.63	1.30
B2-A-E-L-11-1	273.01	202.39	25.87	1.41
B2-A-E-L-11-2	271.30	202.89	25.22	1.42
B2-A-E-L-11-3	268.26	201.86	24.75	1.41
B2-A-E-L-11-4	267.90	204.94	23.50	1.43
B2-A-E-L-11-5	270.41	207.69	23.19	1.45
B2-A-E-L-11-6	266.65	203.95	23.51	1.42
B2-A-E-L-11-7	271.62	206.77	23.88	1.44
B2-A-E-L-11-8	268.98	205.19	23.72	1.43
B2-A-E-L-1-2	274.52	205.80	25.03	1.44
B2-A-E-L-12-0	252.70	186.51	26.19	1.30
B2-A-E-L-12-1	277.11	203.04	26.73	1.42
B2-A-E-L-12-2	265.80	192.44	27.60	1.34
B2-A-E-L-12-3	259.06	187.51	27.62	1.31
B2-A-E-L-12-4	275.46	202.20	26.60	1.41
B2-A-E-L-12-5	273.00	205.01	24.91	1.43
B2-A-E-L-12-6	253.22	192.58	23.95	1.35
B2-A-E-L-12-7	266.06	203.94	23.35	1.42
B2-A-E-L-12-8	249.18	189.06	24.13	1.32
B2-A-E-L-1-3	255.62	188.87	26.11	1.32
B2-A-E-L-1-4	278.76	203.16	27.12	1.42
B2-A-E-L-1-5	270.69	198.67	26.61	1.39
B2-A-E-L-1-6	270.42	202.16	25.24	1.41
B2-A-E-L-1-7	275.06	215.55	21.64	1.51
B2-A-E-L-1-8	240.76	187.21	22.24	1.31
B2-A-E-L-2-0	236.32	175.03	25.94	1.22

B2-A-E-L-2-1	276.34	201.24	27.18	1.41
B2-A-E-L-2-2	273.78	201.52	26.39	1.41
B2-A-E-L-2-3	266.96	197.04	26.19	1.38
B2-A-E-L-2-4	276.44	204.53	26.01	1.43
B2-A-E-L-2-5	271.22	204.53	24.59	1.43
B2-A-E-L-2-6	272.95	204.45	25.10	1.43
B2-A-E-L-2-7	281.34	211.38	24.87	1.48
B2-A-E-L-2-8	260.68	196.13	24.76	1.37
B2-A-E-L-3-0	244.95	178.51	27.12	1.25
B2-A-E-L-3-1	263.76	191.53	27.39	1.34
B2-A-E-L-3-2	278.13	205.54	26.10	1.44
B2-A-E-L-3-3	271.55	203.29	25.14	1.42
B2-A-E-L-3-4	269.14	205.03	23.82	1.43
B2-A-E-L-3-5	280.94	218.82	22.11	1.53
B2-A-E-L-3-6	276.89	217.01	21.63	1.52
B2-A-E-L-3-7	275.31	216.53	21.35	1.51
B2-A-E-L-3-8	270.15	214.49	20.60	1.50
B2-A-E-L-4-0	251.53	188.33	25.13	1.32
B2-A-E-L-4-1	256.22	186.79	27.10	1.31
B2-A-E-L-4-2	258.53	187.06	27.65	1.31
B2-A-E-L-4-3	259.18	187.94	27.49	1.31
B2-A-E-L-4-4	276.20	203.80	26.21	1.42
B2-A-E-L-4-5	267.36	195.96	26.71	1.37
B2-A-E-L-4-6	263.20	198.82	24.46	1.39
B2-A-E-L-4-7	276.53	218.08	21.14	1.52
B2-A-E-L-4-8	248.42	197.83	20.37	1.38
B2-A-E-L-5-0	234.38	171.04	27.03	1.20
B2-A-E-L-5-1	261.81	189.73	27.53	1.33
B2-A-E-L-5-2	255.46	187.03	26.79	1.31
B2-A-E-L-5-3	267.45	196.44	26.55	1.37
B2-A-E-L-5-4	269.67	202.60	24.87	1.42
B2-A-E-L-5-5	283.86	219.17	22.79	1.53
B2-A-E-L-5-6	279.36	222.20	20.46	1.55
B2-A-E-L-5-7	271.45	215.33	20.67	1.50
B2-A-E-L-5-8	275.16	219.31	20.30	1.53
B2-A-E-L-6-0	219.33	164.07	25.20	1.15
B2-A-E-L-6-1	268.35	195.82	27.03	1.37
B2-A-E-L-6-2	277.26	210.20	24.19	1.47
B2-A-E-L-6-3	277.86	214.30	22.88	1.50
B2-A-E-L-6-4	271.77	211.64	22.13	1.48
B2-A-E-L-6-5	266.19	209.30	21.37	1.46
B2-A-E-L-6-6	274.44	219.18	20.14	1.53

B2-A-E-L-6-7	285.99	229.06	19.91	1.60
B2-A-E-L-6-8	270.89	218.32	19.41	1.53
B2-A-E-L-7-0	238.10	177.95	25.26	1.24
B2-A-E-L-7-1	264.48	196.55	25.68	1.37
B2-A-E-L-7-2	264.55	197.31	25.42	1.38
B2-A-E-L-7-3	265.29	197.89	25.41	1.38
B2-A-E-L-7-4	278.90	205.49	26.32	1.44
B2-A-E-L-7-5	282.13	211.92	24.89	1.48
B2-A-E-L-7-6	265.09	199.42	24.77	1.39
B2-A-E-L-7-7	277.35	216.71	21.86	1.51
B2-A-E-L-7-8	258.11	200.92	22.16	1.40
B2-A-E-L-8-0	220.10	163.47	25.73	1.14
B2-A-E-L-8-1	274.64	202.04	26.44	1.41
B2-A-E-L-8-2	270.61	194.79	28.02	1.36
B2-A-E-L-8-3	259.37	186.73	28.01	1.30
B2-A-E-L-8-4	256.41	185.51	27.65	1.30
B2-A-E-L-8-5	265.08	197.17	25.62	1.38
B2-A-E-L-8-6	258.94	193.68	25.20	1.35
B2-A-E-L-8-7	260.69	201.31	22.78	1.41
B2-A-E-L-8-8	248.58	193.18	22.29	1.35
B2-A-E-L-9-0	235.08	171.16	27.19	1.20
B2-A-E-L-9-1	276.74	201.14	27.32	1.41
B2-A-E-L-9-2	273.95	202.67	26.02	1.42
B2-A-E-L-9-3	262.04	196.61	24.97	1.37
B2-A-E-L-9-4	272.31	205.05	24.70	1.43
B2-A-E-L-9-5	281.14	217.46	22.65	1.52
B2-A-E-L-9-6	272.68	215.01	21.15	1.50
B2-A-E-L-9-7	284.89	223.52	21.54	1.56
B2-A-E-L-9-8	268.26	214.38	20.09	1.50
B2-A-E-S-1-0	256.24	190.05	25.83	1.33
B2-A-E-S-1-1	280.31	209.14	25.39	1.46
B2-A-E-S-1-2	285.48	217.75	23.73	1.52
B2-A-E-S-1-3	265.52	200.96	24.32	1.40
B2-A-E-S-1-4	265.55	202.23	23.85	1.41
B2-A-E-S-1-5	272.02	211.87	22.11	1.48
B2-A-E-S-1-6	275.32	216.91	21.22	1.52
B2-A-E-S-1-7	265.34	210.41	20.70	1.47
B2-A-E-S-1-8	243.78	193.32	20.70	1.35
B2-A-E-S-2-0	261.10	193.97	25.71	1.36
B2-A-E-S-2-1	272.27	204.47	24.90	1.43
B2-A-E-S-2-2	267.43	199.26	25.49	1.39
B2-A-E-S-2-3	263.55	199.35	24.36	1.39

B2-A-E-S-2-4	276.71	211.55	23.55	1.48
B2-A-E-S-2-5	268.68	206.52	23.14	1.44
B2-A-E-S-2-6	269.06	212.35	21.08	1.48
B2-A-E-S-2-7	285.78	230.38	19.39	1.61
B2-A-E-S-2-8	248.05	199.96	19.39	1.40
B2-A-E-S-3-0	263.58	196.68	25.38	1.37
B2-A-E-S-3-1	265.44	197.40	25.63	1.38
B2-A-E-S-3-2	276.85	208.05	24.85	1.45
B2-A-E-S-3-3	280.48	212.23	24.33	1.48
B2-A-E-S-3-4	275.34	208.54	24.26	1.46
B2-A-E-S-3-5	271.06	207.98	23.27	1.45
B2-A-E-S-3-6	253.64	197.12	22.28	1.38
B2-A-E-S-3-7	256.38	200.78	21.69	1.40
B2-A-E-S-3-8	253.78	199.41	21.42	1.39
B2-A-E-S-4-0	252.47	187.68	25.66	1.31
B2-A-E-S-4-1	271.78	202.09	25.64	1.41
B2-A-E-S-4-2	276.06	207.56	24.81	1.45
B2-A-E-S-4-3	258.16	193.84	24.92	1.35
B2-A-E-S-4-4	271.65	204.80	24.61	1.43
B2-A-E-S-4-5	275.34	206.44	25.02	1.44
B2-A-E-S-4-6	265.95	198.27	25.45	1.39
B2-A-E-S-4-7	261.91	196.98	24.79	1.38
B2-A-E-S-4-8	249.64	192.31	22.97	1.34
B2-A-E-S-5-0	236.97	176.31	25.60	1.23
B2-A-E-S-5-1	257.07	186.45	27.47	1.30
B2-A-E-S-5-2	275.59	204.71	25.72	1.43
B2-A-E-S-5-3	255.72	191.01	25.31	1.33
B2-A-E-S-5-4	270.79	202.11	25.36	1.41
B2-A-E-S-5-5	271.90	207.75	23.59	1.45
B2-A-E-S-5-6	266.51	207.78	22.04	1.45
B2-A-E-S-5-7	273.95	212.95	22.27	1.49
B2-A-E-S-5-8	261.72	203.33	22.31	1.42
B2-A-E-S-6-0	251.47	186.16	25.97	1.30
B2-A-E-S-6-1	264.02	197.05	25.37	1.38
B2-A-E-S-6-2	270.04	206.99	23.35	1.45
B2-A-E-S-6-3	269.69	206.79	23.32	1.44
B2-A-E-S-6-4	269.95	209.87	22.26	1.47
B2-A-E-S-6-5	276.97	218.72	21.03	1.53
B2-A-E-S-6-6	256.75	201.95	21.34	1.41
B2-A-E-S-6-7	287.28	229.53	20.10	1.60
B2-A-E-S-6-8	263.03	209.38	20.40	1.46
B2-A-M-L-1-0	218.25	154.43	29.24	1.08

B2-A-M-L-10-0	253.98	185.39	27.01	1.30
B2-A-M-L-10-1	274.35	199.98	27.11	1.40
B2-A-M-L-10-2	275.74	202.71	26.49	1.42
B2-A-M-L-10-3	277.44	204.04	26.46	1.43
B2-A-M-L-10-4	276.39	203.89	26.23	1.42
B2-A-M-L-10-5	268.80	198.37	26.20	1.39
B2-A-M-L-10-6	265.71	199.05	25.09	1.39
B2-A-M-L-10-7	268.90	206.40	23.24	1.44
B2-A-M-L-10-8	252.82	193.79	23.35	1.35
B2-A-M-L-1-1	249.27	174.07	30.17	1.22
B2-A-M-L-11-0	253.56	182.01	28.22	1.27
B2-A-M-L-11-1	270.90	196.13	27.60	1.37
B2-A-M-L-11-2	266.94	193.23	27.61	1.35
B2-A-M-L-11-3	265.53	193.33	27.19	1.35
B2-A-M-L-11-4	262.38	191.68	26.95	1.34
B2-A-M-L-11-5	277.24	207.46	25.17	1.45
B2-A-M-L-11-6	253.39	192.95	23.85	1.35
B2-A-M-L-11-7	277.02	212.10	23.44	1.48
B2-A-M-L-11-8	246.39	189.42	23.12	1.32
B2-A-M-L-1-2	275.55	198.59	27.93	1.39
B2-A-M-L-12-0	234.11	167.40	28.50	1.17
B2-A-M-L-12-1	283.78	202.40	28.68	1.41
B2-A-M-L-12-2	260.11	183.27	29.54	1.28
B2-A-M-L-12-3	263.14	188.00	28.56	1.31
B2-A-M-L-12-4	261.78	187.12	28.52	1.31
B2-A-M-L-12-5	276.21	198.34	28.19	1.39
B2-A-M-L-12-6	259.07	186.85	27.88	1.31
B2-A-M-L-12-7	255.42	186.90	26.83	1.31
B2-A-M-L-12-8	259.86	195.55	24.75	1.37
B2-A-M-L-1-3	264.07	191.61	27.44	1.34
B2-A-M-L-1-4	264.89	193.60	26.91	1.35
B2-A-M-L-1-5	282.32	208.02	26.32	1.45
B2-A-M-L-1-6	282.02	208.61	26.03	1.46
B2-A-M-L-1-7	279.69	207.55	25.79	1.45
B2-A-M-L-1-8	275.23	212.91	22.64	1.49
B2-A-M-L-2-0	254.15	180.80	28.86	1.26
B2-A-M-L-2-1	286.99	208.87	27.22	1.46
B2-A-M-L-2-2	275.18	201.57	26.75	1.41
B2-A-M-L-2-3	272.24	201.81	25.87	1.41
B2-A-M-L-2-4	259.25	193.47	25.37	1.35
B2-A-M-L-2-5	281.66	215.62	23.45	1.51
B2-A-M-L-2-6	275.29	214.39	22.12	1.50

B2-A-M-L-2-7	269.48	209.67	22.20	1.46
B2-A-M-L-2-8	258.54	202.83	21.55	1.42
B2-A-M-L-3-0	252.44	180.36	28.55	1.26
B2-A-M-L-3-1	253.01	179.79	28.94	1.26
B2-A-M-L-3-2	272.51	200.11	26.57	1.40
B2-A-M-L-3-3	267.68	199.40	25.51	1.39
B2-A-M-L-3-4	268.18	205.62	23.33	1.44
B2-A-M-L-3-5	261.79	202.70	22.57	1.42
B2-A-M-L-3-6	275.04	214.56	21.99	1.50
B2-A-M-L-3-7	284.06	222.62	21.63	1.56
B2-A-M-L-3-8	277.78	216.49	22.06	1.51
B2-A-M-L-4-0	250.06	179.75	28.12	1.26
B2-A-M-L-4-1	260.46	185.82	28.66	1.30
B2-A-M-L-4-2	275.00	199.46	27.47	1.39
B2-A-M-L-4-3	261.24	188.73	27.76	1.32
B2-A-M-L-4-4	263.77	190.28	27.86	1.33
B2-A-M-L-4-5	272.51	196.50	27.89	1.37
B2-A-M-L-4-6	258.27	186.53	27.78	1.30
B2-A-M-L-4-7	271.99	203.22	25.28	1.42
B2-A-M-L-4-8	256.22	193.15	24.62	1.35
B2-A-M-L-5-0	253.14	179.53	29.08	1.25
B2-A-M-L-5-1	258.62	182.84	29.30	1.28
B2-A-M-L-5-2	258.85	184.50	28.72	1.29
B2-A-M-L-5-3	252.46	179.92	28.73	1.26
B2-A-M-L-5-4	274.25	200.96	26.72	1.40
B2-A-M-L-5-5	259.17	194.81	24.83	1.36
B2-A-M-L-5-6	253.21	190.55	24.75	1.33
B2-A-M-L-5-7	265.43	201.21	24.20	1.41
B2-A-M-L-5-8	258.61	195.00	24.60	1.36
B2-A-M-L-6-0	255.86	186.94	26.94	1.31
B2-A-M-L-6-1	261.67	186.01	28.91	1.30
B2-A-M-L-6-2	263.55	186.52	29.23	1.30
B2-A-M-L-6-3	270.73	191.54	29.25	1.34
B2-A-M-L-6-4	263.13	185.73	29.42	1.30
B2-A-M-L-6-5	259.76	184.97	28.79	1.29
B2-A-M-L-6-6	269.60	195.05	27.65	1.36
B2-A-M-L-6-7	266.79	195.25	26.82	1.36
B2-A-M-L-6-8	251.74	187.25	25.62	1.31
B2-A-M-L-7-0	242.48	173.63	28.39	1.21
B2-A-M-L-7-1	254.18	180.21	29.10	1.26
B2-A-M-L-7-2	265.77	190.62	28.28	1.33
B2-A-M-L-7-3	277.38	201.57	27.33	1.41

B2-A-M-L-7-4	272.27	197.19	27.58	1.38
B2-A-M-L-7-5	276.07	200.12	27.51	1.40
B2-A-M-L-7-6	275.81	199.83	27.55	1.40
B2-A-M-L-7-7	264.32	197.08	25.44	1.38
B2-A-M-L-7-8	251.34	192.52	23.40	1.35
B2-A-M-L-8-0	249.85	180.86	27.61	1.26
B2-A-M-L-8-1	269.26	195.64	27.34	1.37
B2-A-M-L-8-2	279.58	206.52	26.13	1.44
B2-A-M-L-8-3	265.17	195.49	26.28	1.37
B2-A-M-L-8-4	279.82	207.26	25.93	1.45
B2-A-M-L-8-5	267.76	205.71	23.17	1.44
B2-A-M-L-8-6	256.20	198.15	22.66	1.38
B2-A-M-L-8-7	268.74	208.99	22.23	1.46
B2-A-M-L-8-8	258.51	201.00	22.25	1.40
B2-A-M-L-9-0	238.89	170.94	28.44	1.19
B2-A-M-L-9-1	264.68	192.84	27.14	1.35
B2-A-M-L-9-2	272.91	199.81	26.79	1.40
B2-A-M-L-9-3	261.03	192.69	26.18	1.35
B2-A-M-L-9-4	270.91	203.49	24.89	1.42
B2-A-M-L-9-5	269.98	209.53	22.39	1.46
B2-A-M-L-9-6	264.78	208.30	21.33	1.46
B2-A-M-L-9-7	272.95	214.85	21.29	1.50
B2-A-M-L-9-8	254.99	199.42	21.79	1.39
B2-A-M-S-1-0	248.23	181.27	26.98	1.27
B2-A-M-S-1-1	272.77	198.53	27.22	1.39
B2-A-M-S-1-2	272.61	200.80	26.34	1.40
B2-A-M-S-1-3	257.91	188.77	26.81	1.32
B2-A-M-S-1-4	269.23	198.67	26.21	1.39
B2-A-M-S-1-5	254.35	190.02	25.29	1.33
B2-A-M-S-1-6	274.05	207.45	24.30	1.45
B2-A-M-S-1-7	260.70	199.35	23.53	1.39
B2-A-M-S-1-8	251.20	192.71	23.28	1.35
B2-A-M-S-2-0	244.09	174.78	28.40	1.22
B2-A-M-S-2-1	248.49	176.79	28.85	1.24
B2-A-M-S-2-2	256.59	186.30	27.39	1.30
B2-A-M-S-2-3	259.35	188.42	27.35	1.32
B2-A-M-S-2-4	268.92	197.51	26.55	1.38
B2-A-M-S-2-5	270.38	199.12	26.36	1.39
B2-A-M-S-2-6	272.77	200.64	26.44	1.40
B2-A-M-S-2-7	274.66	204.77	25.45	1.43
B2-A-M-S-2-8	255.87	194.79	23.87	1.36
B2-A-M-S-3-0	264.52	193.93	26.69	1.35

B2-A-M-S-3-1	271.14	197.87	27.02	1.38
B2-A-M-S-3-2	267.44	194.65	27.22	1.36
B2-A-M-S-3-3	262.53	193.35	26.35	1.35
B2-A-M-S-3-4	262.18	193.41	26.23	1.35
B2-A-M-S-3-5	274.50	204.29	25.58	1.43
B2-A-M-S-3-6	267.53	199.68	25.36	1.40
B2-A-M-S-3-7	271.00	202.56	25.26	1.42
B2-A-M-S-3-8	271.70	203.83	24.98	1.42
B2-A-M-S-4-0	250.81	183.33	26.91	1.28
B2-A-M-S-4-1	265.28	192.90	27.28	1.35
B2-A-M-S-4-2	275.21	201.76	26.69	1.41
B2-A-M-S-4-3	259.39	189.37	26.99	1.32
B2-A-M-S-4-4	263.48	193.92	26.40	1.35
B2-A-M-S-4-5	260.95	194.56	25.44	1.36
B2-A-M-S-4-6	246.38	186.78	24.19	1.30
B2-A-M-S-4-7	261.06	198.58	23.93	1.39
B2-A-M-S-4-8	258.58	196.09	24.17	1.37
B2-A-M-S-5-0	241.51	172.40	28.62	1.20
B2-A-M-S-5-1	254.36	179.52	29.42	1.25
B2-A-M-S-5-2	263.33	186.76	29.08	1.30
B2-A-M-S-5-3	250.05	178.03	28.80	1.24
B2-A-M-S-5-4	261.27	189.03	27.65	1.32
B2-A-M-S-5-5	265.77	193.52	27.19	1.35
B2-A-M-S-5-6	270.44	196.44	27.36	1.37
B2-A-M-S-5-7	279.88	207.56	25.84	1.45
B2-A-M-S-5-8	251.83	190.94	24.18	1.33
B2-A-M-S-6-0	247.16	181.02	26.76	1.26
B2-A-M-S-6-1	260.95	189.31	27.45	1.32
B2-A-M-S-6-2	283.43	208.77	26.34	1.46
B2-A-M-S-6-3	270.13	199.18	26.27	1.39
B2-A-M-S-6-4	261.85	194.48	25.73	1.36
B2-A-M-S-6-5	265.13	201.00	24.19	1.40
B2-A-M-S-6-6	246.70	188.33	23.66	1.32
B2-A-M-S-6-7	251.27	193.89	22.84	1.35
B2-A-M-S-6-8	257.75	198.65	22.93	1.39
B2-A-W-L-1-0	242.11	176.77	26.99	1.24
B2-A-W-L-10-0	252.45	184.21	27.03	1.29
B2-A-W-L-10-1	271.47	199.80	26.40	1.40
B2-A-W-L-10-2	277.26	204.03	26.41	1.43
B2-A-W-L-10-3	267.07	196.46	26.44	1.37
B2-A-W-L-10-4	265.40	194.51	26.71	1.36
B2-A-W-L-10-5	278.92	205.32	26.39	1.43

B2-A-W-L-10-6	278.91	208.10	25.39	1.45
B2-A-W-L-10-7	253.34	191.87	24.26	1.34
B2-A-W-L-10-8	267.91	205.56	23.27	1.44
B2-A-W-L-1-1	257.35	186.06	27.70	1.30
B2-A-W-L-11-0	254.14	179.17	29.50	1.25
B2-A-W-L-11-1	256.52	184.09	28.24	1.29
B2-A-W-L-11-2	258.30	186.86	27.66	1.31
B2-A-W-L-11-3	259.07	186.75	27.92	1.30
B2-A-W-L-11-4	258.83	189.70	26.71	1.33
B2-A-W-L-11-5	270.53	201.82	25.40	1.41
B2-A-W-L-11-6	256.89	196.65	23.45	1.37
B2-A-W-L-11-7	263.07	201.27	23.49	1.41
B2-A-W-L-11-8	233.16	177.88	23.71	1.24
B2-A-W-L-1-2	256.22	185.71	27.52	1.30
B2-A-W-L-12-0	246.70	173.83	29.54	1.21
B2-A-W-L-12-1	259.36	181.29	30.10	1.27
B2-A-W-L-12-2	265.56	185.59	30.11	1.30
B2-A-W-L-12-3	252.62	176.23	30.24	1.23
B2-A-W-L-12-4	266.70	189.27	29.03	1.32
B2-A-W-L-12-5	262.32	192.04	26.79	1.34
B2-A-W-L-12-6	253.00	188.08	25.66	1.31
B2-A-W-L-12-7	261.16	195.96	24.97	1.37
B2-A-W-L-1-3	274.96	198.41	27.84	1.39
B2-A-W-L-1-4	262.32	190.92	27.22	1.33
B2-A-W-L-1-5	264.78	191.76	27.58	1.34
B2-A-W-L-1-6	262.95	190.26	27.64	1.33
B2-A-W-L-1-7	274.65	203.54	25.89	1.42
B2-A-W-L-1-8	245.84	187.78	23.62	1.31
B2-A-W-L-2-0	235.48	169.44	28.05	1.18
B2-A-W-L-2-1	270.26	196.82	27.17	1.38
B2-A-W-L-2-2	265.51	193.32	27.19	1.35
B2-A-W-L-2-3	266.26	196.21	26.31	1.37
B2-A-W-L-2-4	268.61	199.39	25.77	1.39
B2-A-W-L-2-5	271.11	206.88	23.69	1.45
B2-A-W-L-2-6	259.12	198.66	23.33	1.39
B2-A-W-L-2-7	270.15	208.46	22.84	1.46
B2-A-W-L-2-8	247.42	189.34	23.47	1.32
B2-A-W-L-3-0	243.20	174.33	28.32	1.22
B2-A-W-L-3-1	257.35	187.50	27.14	1.31
B2-A-W-L-3-2	259.84	189.26	27.16	1.32
B2-A-W-L-3-3	260.54	190.80	26.77	1.33
B2-A-W-L-3-4	263.32	194.85	26.00	1.36

B2-A-W-L-3-5	272.92	200.96	26.37	1.40
B2-A-W-L-3-6	258.09	194.27	24.73	1.36
B2-A-W-L-3-7	265.19	203.25	23.36	1.42
B2-A-W-L-3-8	246.95	191.18	22.58	1.34
B2-A-W-L-4-0	241.60	174.96	27.58	1.22
B2-A-W-L-4-1	265.06	192.95	27.21	1.35
B2-A-W-L-4-2	258.55	188.02	27.28	1.31
B2-A-W-L-4-3	259.94	185.62	28.59	1.30
B2-A-W-L-4-4	295.88	215.15	27.29	1.50
B2-A-W-L-4-5	272.07	203.22	25.31	1.42
B2-A-W-L-4-6	235.77	178.59	24.25	1.25
B2-A-W-L-4-7	247.54	189.98	23.25	1.33
B2-A-W-L-4-8	250.75	191.52	23.62	1.34
B2-A-W-L-5-0	259.91	186.89	28.09	1.31
B2-A-W-L-5-1	253.95	183.39	27.79	1.28
B2-A-W-L-5-2	256.14	184.93	27.80	1.29
B2-A-W-L-5-3	249.42	181.27	27.32	1.27
B2-A-W-L-5-4	261.09	190.51	27.03	1.33
B2-A-W-L-5-5	259.23	192.27	25.83	1.34
B2-A-W-L-5-6	259.39	197.19	23.98	1.38
B2-A-W-L-5-7	254.09	194.25	23.55	1.36
B2-A-W-L-5-8	238.71	181.79	23.85	1.27
B2-A-W-L-6-0	250.40	181.77	27.41	1.27
B2-A-W-L-6-1	263.62	194.10	26.37	1.36
B2-A-W-L-6-2	273.28	202.02	26.08	1.41
B2-A-W-L-6-3	268.06	196.83	26.57	1.38
B2-A-W-L-6-4	261.93	195.80	25.25	1.37
B2-A-W-L-6-5	274.01	206.69	24.57	1.44
B2-A-W-L-6-6	267.09	202.38	24.23	1.41
B2-A-W-L-6-7	264.98	206.29	22.15	1.44
B2-A-W-L-6-8	265.93	202.65	23.80	1.42
B2-A-W-L-7-0	239.61	173.08	27.77	1.21
B2-A-W-L-7-1	253.37	179.52	29.15	1.25
B2-A-W-L-7-2	256.15	182.43	28.78	1.27
B2-A-W-L-7-3	249.88	176.38	29.41	1.23
B2-A-W-L-7-4	261.11	184.16	29.47	1.29
B2-A-W-L-7-5	260.09	186.44	28.32	1.30
B2-A-W-L-7-6	259.31	187.69	27.62	1.31
B2-A-W-L-7-7	263.77	197.81	25.01	1.38
B2-A-W-L-7-8	245.08	188.04	23.27	1.31
B2-A-W-L-8-0	251.08	183.88	26.76	1.28
B2-A-W-L-8-1	258.92	185.42	28.39	1.30

B2-A-W-L-8-2	255.04	182.14	28.58	1.27
B2-A-W-L-8-3	266.51	192.57	27.74	1.35
B2-A-W-L-8-4	260.32	190.65	26.76	1.33
B2-A-W-L-8-5	256.67	194.85	24.09	1.36
B2-A-W-L-8-6	247.18	189.39	23.38	1.32
B2-A-W-L-8-7	249.73	192.01	23.11	1.34
B2-A-W-L-8-8	241.39	185.58	23.12	1.30
B2-A-W-L-9-0	250.80	179.02	28.62	1.25
B2-A-W-L-9-1	250.92	181.74	27.57	1.27
B2-A-W-L-9-2	268.92	196.00	27.12	1.37
B2-A-W-L-9-3	254.54	184.68	27.45	1.29
B2-A-W-L-9-4	257.91	191.18	25.87	1.34
B2-A-W-L-9-5	261.64	196.31	24.97	1.37
B2-A-W-L-9-6	247.31	190.15	23.11	1.33
B2-A-W-L-9-7	261.62	202.28	22.68	1.41
B2-A-W-L-9-8	254.91	195.59	23.27	1.37
B2-A-W-S-1-0	241.05	175.26	27.29	1.22
B2-A-W-S-1-1	282.82	205.54	27.33	1.44
B2-A-W-S-1-2	274.76	201.12	26.80	1.41
B2-A-W-S-1-3	270.20	197.42	26.94	1.38
B2-A-W-S-1-4	258.82	200.31	22.61	1.40
B2-A-W-S-1-5	271.59	202.05	25.61	1.41
B2-A-W-S-1-6	245.86	188.05	23.51	1.31
B2-A-W-S-1-7	256.92	197.53	23.12	1.38
B2-A-W-S-1-8	234.17	180.08	23.10	1.26
B2-A-W-S-2-0	251.78	181.63	27.86	1.27
B2-A-W-S-2-1	256.87	183.62	28.52	1.28
B2-A-W-S-2-2	257.85	185.32	28.13	1.29
B2-A-W-S-2-3	254.03	180.21	29.06	1.26
B2-A-W-S-2-4	263.90	187.69	28.88	1.31
B2-A-W-S-2-5	269.97	197.55	26.83	1.38
B2-A-W-S-2-6	258.93	197.68	23.66	1.38
B2-A-W-S-2-7	235.87	181.51	23.05	1.27
B2-A-W-S-2-8	236.85	181.05	23.56	1.26
B2-A-W-S-3-0	254.56	186.63	26.69	1.30
B2-A-W-S-3-1	269.55	198.17	26.48	1.38
B2-A-W-S-3-2	273.60	202.76	25.89	1.42
B2-A-W-S-3-3	265.35	197.90	25.42	1.38
B2-A-W-S-3-4	273.87	206.67	24.54	1.44
B2-A-W-S-3-5	267.95	203.85	23.92	1.42
B2-A-W-S-3-6	239.01	183.87	23.07	1.28
B2-A-W-S-3-7	246.21	193.17	21.54	1.35

B2-A-W-S-3-8	241.74	188.57	22.00	1.32
B2-A-W-S-4-0	261.99	190.24	27.39	1.33
B2-A-W-S-4-1	271.39	198.75	26.77	1.39
B2-A-W-S-4-2	272.12	200.30	26.39	1.40
B2-A-W-S-4-3	262.33	192.09	26.78	1.34
B2-A-W-S-4-4	270.74	200.07	26.10	1.40
B2-A-W-S-4-5	265.40	198.74	25.12	1.39
B2-A-W-S-4-6	261.74	197.52	24.54	1.38
B2-A-W-S-4-7	255.92	194.35	24.06	1.36
B2-A-W-S-4-8	249.12	187.21	24.85	1.31
B2-A-W-S-5-0	247.88	177.86	28.25	1.24
B2-A-W-S-5-1	266.25	189.60	28.79	1.32
B2-A-W-S-5-2	251.04	178.92	28.73	1.25
B2-A-W-S-5-3	258.03	182.55	29.25	1.28
B2-A-W-S-5-4	262.79	186.60	28.99	1.30
B2-A-W-S-5-5	275.23	201.60	26.75	1.41
B2-A-W-S-5-6	260.28	197.70	24.04	1.38
B2-A-W-S-5-7	256.98	194.26	24.41	1.36
B2-A-W-S-5-8	242.02	182.17	24.73	1.27
B2-A-W-S-6-0	271.64	197.95	27.13	1.38
B2-A-W-S-6-1	258.24	185.60	28.13	1.30
B2-A-W-S-6-2	270.98	199.05	26.54	1.39
B2-A-W-S-6-3	265.81	193.69	27.13	1.35
B2-A-W-S-6-4	260.96	191.54	26.60	1.34
B2-A-W-S-6-5	269.36	200.85	25.43	1.40
B2-A-W-S-6-6	250.16	188.26	24.74	1.32
B2-A-W-S-6-7	269.68	203.87	24.40	1.42
B2-A-W-S-6-8	243.29	184.66	24.10	1.29

Notation meaning in order of character appearance (for both before and after data):

- B2: refers to field B2.
- I/A: refers to the 'initial' trip before picking, or the trip 'after' picking.
- E/M/W: refers to either the 'East', 'Middle' or 'West' plots.
- S/L: refers to the field sections picked by either the 'small' (2-row) picker, or the 'large' picker (CP690).
- First Number: refers to the sample number within a set.
- Second Number: refers to the top depth of each subsample in 10's of cm's.

8.7 Appendix F – Soil Constraint Data/Chemical Results

Constraint Data			
Sample Name	pH H20	pH CaCl2	EC (dS/cm)
LEC0	8.5	7.7	126.9
LEC1	8.7	8	135.1
LEC2	8.8	8	177.4
LEC3	9	7.9	224
LEC4	9.1	8	247.1
LEC5	9.2	8.2	263.2
LEC6	9.2	8.1	282.6
LEC7	9.2	8.1	396.7
LMC0	8.6	7.6	99
LMC1	8.7	7.7	106
LMC2	8.8	7.9	183.2
LMC3	8.9	8.1	211.9
LMC4	8.9	7.9	230.2
LMC5	9	8.2	259.3
LMC6	9.1	8	287.2
LMC7	9	8.2	520.6
LWC0	8.4	7.8	179
LWC1	8.6	7.8	103.8
LWC2	8.6	7.7	113.6
LWC3	8.8	7.8	154
LWC4	9	8.1	184.9
LWC5	9	7.8	185
LWC6	9	7.9	210.7
LWC7	9.1	8	231.8
SEC0	8.7	7.8	134.8
SEC1	8.9	7.9	166.7
SEC2	8.9	8	192
SEC3	9	*	224
SEC4	9.2	8	225.8
SEC5	9.2	8.1	228.8
SEC6	9.2	8.2	275.9
SEC7	9.2	8.3	315.7
SMC0	8.5	7.7	102.1
SMC1	8.6	7.9	105.7
SMC2	8.7	7.7	150.3
SMC3	8.9	8	175
SMC4	9	7.9	187.4
SMC5	9.1	8.1	196.3

SMC6	8.9	8	345.4
SMC7	8.8	7.9	411.6
SWC0	8.5	7.7	101.8
SWC1	8.5	7.7	111.1
SWC2	8.5	7.8	93.1
SWC3	8.7	7.8	130.2
SWC4	8.4	7.8	347.6
SWC5	9	7.9	158.7
SWC6	9	7.9	177.7
SWC7	9	7.9	206

Notation in order of character appearance:

- L/S: refers to the field sections picked by either the 'small' (2-row) picker, or the 'large' picker (CP690).
- E/M/W: refers to either the 'East', 'Middle' or 'West' plots.
- C: refers to these samples being the 'chemical' samples.
- Number: refers to the top depth of each subsample in 10's of cm's.

8.8 Appendix G – Sample Bag Weight Data

Bag Data	
Bag #	Wt (g)
1	6.75
2	6.7
3	6.65
4	6.76
5	6.66
6	6.74
7	6.67
8	6.73
9	6.69
10	6.77
11	6.72
12	6.81
13	6.8
14	6.68
15	6.64
16	6.75
17	6.64
18	6.74
19	6.63
20	6.7
Mean	6.71
Std Dev	0.054

Coef. Var.	0.802

8.9 Appendix H – Soil Corer Dimensions

Corer Diameter (cm)	4.27
Corer Area (cm2)	14.3
Sample Length (cm)	10
Sample Volume (cm3)	143.12

8.10 Appendix I – Risk Management Form

See next page.

Commented [AH2]: Put this in

University of Southern Queensland Offline Version

USQ Safety Risk Management System

Note: This is the offline version of the Safety Risk Management System (SRMS) Risk Management Plan (RMP) and is only to be used for planning and drafting sessions, and when working in remote areas or on field activities. It must be transferred to the online SRMS at the first opportunity.

Safety Risk Management Plan – Offline Version				
Assessment Title:	Research Project		Assessment Date:	20/10/2022
Workplace (Division/Faculty/Section):			Review Date:(5 Years Max)	Click here to enter a date
Context				
Description:				
What is the task/event/purchase/project/procedure?	Field Sampling of Cotton Field in NSW			
Why is it being conducted?	Completion of ENG4111 & ENG4112; Measuring compaction in field.			
Where is it being conducted?	Narrabi, NSW			
Course code (if applicable)	ENG4111, ENG4112	Chemical name (if applicable)	N/A	
What other nominal conditions?				
Personnel involved	Adam Henderson (Student - [redacted]), David West, Stirling Roberton			

Equipment	Oven, scales, centrifuge
Environment	Outdoors, in field. In P13, P4 labs
Other	
Briefly explain the procedure/process	Measure of soil pH, weighing and drying soil samples. Extracting soil from field with soil corer.
Assessment Team - who is conducting the assessment?	
Assessor(s)	
Others consulted:	

Probability	Consequence				
	Insignificant No Injury 0-$5K	**Minor** First Aid $5K-$50K	**Moderate** Med Treatment $50K-$100K	**Major** Serious Injuries $100K-$250K	**Catastrophic** Death More than $250K
Almost Certain 1 in 2	M	H	E	E	E
Likely 1 in 100	M	H	H	E	E
Possible 1 in 1000	L	M	H	H	H
Unlikely 1 in 10 000	L	L	M	M	M
Rare 1 in 1 000 000	L	L	L	L	L

Recommended Action Guide

E=Extreme Risk – Task ***MUST NOT*** proceed

H=High Risk – Special Procedures Required (See USQSafe)

M=Moderate Risk – Risk Management Plan/Work Method Statement Required

L=Low Risk – Use Routine Procedures

Eg 1. Enter Consequence

Eg 2. Enter Probability

Eg 3. Find Action

Step 1 (cont)	Step 2	Step 2a	Step 2b	Step 3			Step 4				
Hazards: From step 1 or more if identified	*The Risk:* What can happen if exposed to the hazard without existing controls in place?	*Consequence:* What is the harm that can be caused by the hazard without existing controls in place?	*Existing Controls:* What are the existing controls that are already in place?	*Risk Assessment:* Consequence x Probability = Risk Level			*Additional controls:* Enter additional controls if required to reduce the risk level	*Risk assessment with additional controls:*			
				Probability	Risk Level	ALARP? Yes/no		Consequence	Probability	Risk Level	ALARP? Yes/no
Example											
Working in temperatures over 35⁰ C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	catastrophic	Regular breaks, chilled water available, loose clothing, fatigue management policy	possible	high	No	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
Working in heat	Heat stress/heat stroke/exhaustion	Moderate	Regular breaks, cold water, appropriate clothin	Possible	High	No	Checking in on each other, scheduled breaks	Moderate	Unlikely	Low	Yes
Isolated work	Not hearing evacuation warnings	Moderate	Mobile phone contact, loudspeakers in field	Rare	Low	Yes		Select a consequence	Select a probability	Select a Risk Level	Yes or No
Physical labour	Potential for injury	Minor	Proper fitness for task, careful working	Possible	Low	Yes		Select a consequence	Select a probability	Select a Risk Level	Yes or No
Lifting heavy boxes of samples	Portential for back injury	Moderate	Proper lifting form, 2 person lifting	Unlikely	Moderate	Yes		Select a consequence	Select a probability	Select a Risk Level	Yes or No
Working in lab	Exposure to chemicals	Major	Not working with any strong chemical agents, avoid the storage areas	Rare	Low	Yes		Select a consequence	Select a probability	Select a Risk Level	Yes or No
Working with ovens	Potential burn	Moderate	Allow ovens to cool before taking out samples, use gloves	Rare	Low	Yes		Select a consequence	Select a probability	Select a Risk Level	Yes or No
		Select a consequence		Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
		Select a consequence		Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
		Select a consequence		Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
		Select a consequence		Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
		Select a consequence		Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
		Select a consequence		Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
		Select a consequence		Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No

Step 1 (cont)	Step 2	Step 2a	Step 2b	Step 3			Step 4				
Hazards: From step 1 or more if identified	*The Risk:* What can happen if exposed to the hazard without existing controls in place?	*Consequence:* What is the harm that can be caused by the hazard without existing controls in place?	*Existing Controls:* What are the existing controls that are already in place?	*Risk Assessment:* Consequence x Probability = Risk Level			*Additional controls:* Enter additional controls if required to reduce the risk level	*Risk assessment with additional controls:*			
				Probability	**Risk Level**	**ALARP? Yes/no**		**Consequence**	**Probability**	**Risk Level**	**ALARP? Yes/no**
Example											
Working in temperatures over 35^0 C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	catastrophic	Regular breaks, chilled water available, loose clothing, fatigue management policy	possible	high	No	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
				Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
				Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
				Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
				Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
				Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No

Step 5 - Action Plan (for controls not already in place)			
Additional controls	*Resources*	*Persons responsible*	*Proposed implementation date*
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.
			Click here to enter a date.

Step 6 - Approval			
Drafter's name:		Draft date:	Click here to enter a date.
Drafter's comments:			

Approver's name:		Approver's title/position:	
Approver's comments:			
I am satisfied that the risks are as low as reasonably practicable and that the resources required will be provided.			

Approver's signature:		Approval date:	Click here to enter a date.