Soil quality monitoring and management

Report 4 – Irrigation
(Activities from 1 January to 4 July 2014)

Tiedman Irrigation Program

Prepared by Fodder King Ltd
for AGL Upstream Investments Pty Ltd

August 2014

Table of Contents

Item	Contents	Page

Attachments

Executive Summary

This is Compliance Report 4 of a series of four (4) reports that have been undertaken during the Tiedman Irrigation Program (TIP) and covers the baseline soils analysis, subsequent soil improvement and re-testing of those soils, establishment of all data collection and monitoring equipment and establishment, irrigation then harvesting of irrigated fodder crops and grazing of improved pasture. This report covers the period from 1 January 2014 to 4 July 2014, which was the original expiry date for TIP REF approval issued on 4 July 2012 (PB, 2011). The irrigation program has recently been granted an additional approval to 30 April 2015.

This report provides further information on the effect of irrigating blended water on the natural and improved soils on AGL's Tiedman property over the period of the irrigation program. These reports are submitted in compliance with the approved Soil Quality Monitoring and Management Program (FK, 2012).

The TIP is being carried out across two areas within the AGL Tiedman property known as Stage 1A and Stage 1B. The Stage 1A area is generally referred to as the main irrigation area.

The Stage 1A area is the major focus of the approved Soil Quality Monitoring and Management Program. There has been extensive sampling and analysis of the quality of the parent and treated soils. This area is being intensively monitored for soil, water and crop performance.

The Stage 1A area is 12 hectares (ha) in size and is made up of 16 equal sized plots, 0.74 ha in size, where two crop systems (annuals and perennials) and four soil treatment types have been installed.

The Stage 1B irrigation area utilised in the reporting period is made up of 4 plots that total approximately 4 ha. The main pasture types grown include a mix of annual and perennial species.

This report sets out:

- the trial plot layout, crop selection and planting;
- the mass balance results for the reporting period;
- the performance of soils on the Stage 1A irrigation area;
- the performance of soils on the Stage 1B irrigation area;
- the performance of the sedimentation, runoff and erosion control measures; and
- the critical control points and any trigger responses.

Blended water with an average salinity of 1540 µS/cm was applied to Stage 1A (25.49 megalitres (ML) irrigated) and Stage 1B (7.48 ML irrigated) during the reporting period. During the same period some 36.38 ML of rain occurred across the Stage 1A area and 12.43 ML on the Stage 1B area.

In total, 59 % of the water received by the Stage 1A area fell as rain, while the balance (41 %) was applied by irrigation of blended water.

All crops have grown satisfactorily during the irrigation program.

For the main irrigation area (Stage 1A) none of the Critical Control Point trigger levels were reached during the reporting period.

Salinity and sodium concentrations have increased at depths greater than 20 cm across all soil sampling sites in the Stage 1A area but have had a limited effect on improved soil structure at this time. In the Stage 1B area, salinity and sodium concentrations have increased at a higher rate (in the near surface) than the Stage 1A area on the shallow improved soil.

The soil structure in Stage 1A plot areas remains significantly improved from the amendments and shows no indication of adverse effects (such as abnormal salinity or sodium levels, and clay particle dispersion) from the irrigation of blended water or periodic rainfall at this time.

In the Stage 1A area the net mass balance is close to zero, indicating that salts are accumulating in the soil profile but not at a level detrimental to soil structure or crop growth.

In the Stage 1B area there has been a larger increase in accumulated salts in relation to Stage 1A.

The monitoring and reporting period was a dry period with limited opportunities for the deep percolation and flushing of salts past the root zone in both the Stage 1A and Stage 1B areas.

1. Introduction

AGL Upstream Investments Pty Ltd (AGL) engaged Fodder King Ltd (FK) to provide technical advisory services (including soil investigations and the preparation of compliance reports) associated with the Tiedman irrigation program (TIP). The irrigation program involves two main irrigation areas (Stage 1A and Stage 1B). This report is the fourth compliance report for the irrigation program. It covers the assessment of soils after the soil treatments, establishment of crops within the Stage 1A area, improved pasture in Stage 1B and after the commencement of irrigation of blended water. The report covers the period from 1 January to 4 July 2014 (which was the expiry date for the TIP REF approval issued in July 2012). The two primary irrigation areas are shown in Figure 1.

Stage 1A is the major focus of the Soil Quality Monitoring and Management Program (SQMMP) (FK, 2012). This area is undergoing intensive monitoring of soil, water and crops, and application (after blending) of most of the produced water for irrigation. The Stage 1A area is about 22 hectares (ha) in total, of which 12 ha is being irrigated. Crop types are lucerne, forage sorghum, triticale and oats.

Stage 1B is where the lower salinity water, in the produced water storage dams, was irrigated in late 2012. Some additional irrigation, using blended water, has occurred on a 4.1 ha portion within the Stage 1B area. Approximately 10-20 ha of pasture in the Stage 1B area could be irrigated. The main pasture types grown include a mix of annual and perennial species.

There is an additional approved irrigation area (the Stage 2 area) which is approximately 15 ha. This area was not irrigated during the reporting period and is unlikely to be irrigated given the low volumes of produced water remaining in storage.

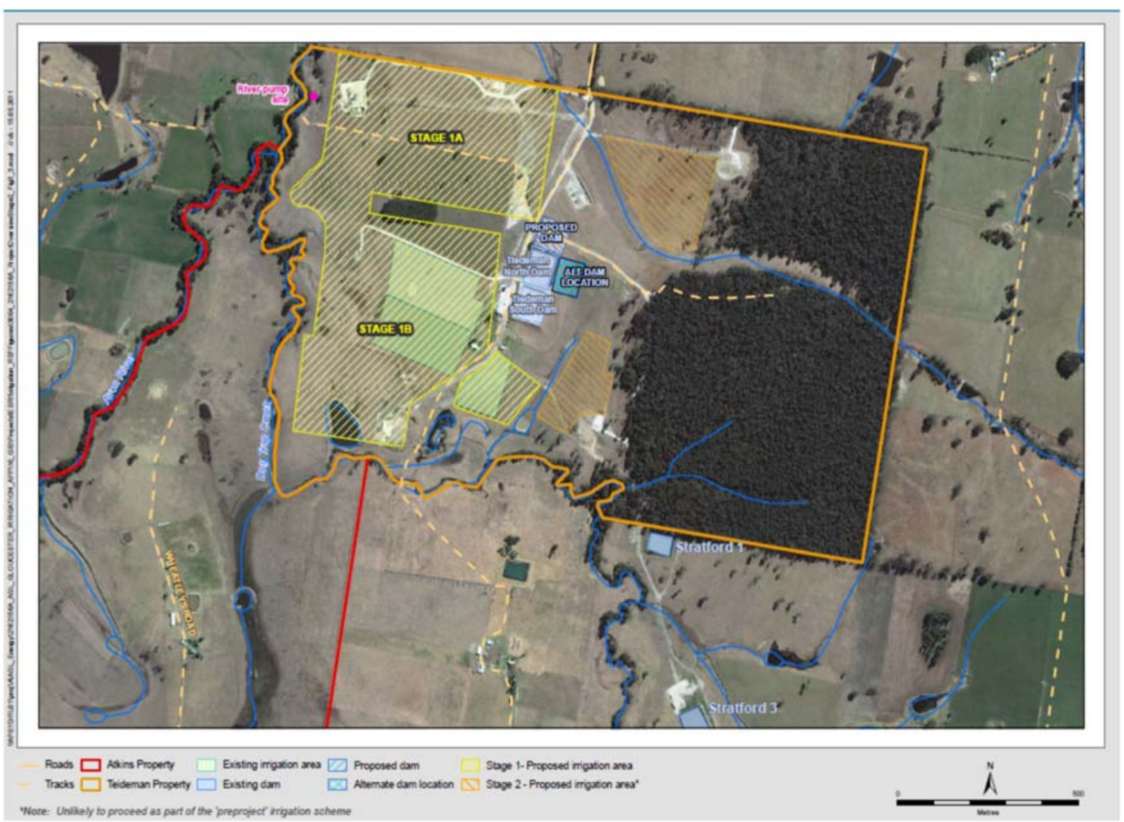


Figure 1: Gloucester Irrigation Areas for Exploration Produced Water

The Stage 1A, Stage 1B and Stage 2 irrigation areas are all located off the floodplain of the Avon River. The irrigation program was approved in July 2012 after the TIP REF (PB, 2011) and supplementary documents were submitted to NSW Trade and Investment (Division of Resources and Energy (DRE)) during 2011/12.

1.1. Requirements under the Soil Quality Monitoring and Management Program (FK, 2012).

The Soil Quality Monitoring and Management Program (SQMMP) was approved by DRE in October 2012 for the two irrigation areas and for the irrigation of up to 70 ML of produced water across an area of up to 40 ha.

Overall objectives

The overall objectives of the SQMMP are to:

- Develop and monitor the performance of soils on the irrigation area against baseline soil quality parameters;
- Develop, manage and monitor the water and salt balances; and
- Monitor, act and report on any adverse trends or impacts on soil structure and quality parameters.

Stage 1A objectives

The objectives of the Stage 1A irrigation area are to:

- Derive information about the use of blended water on improved soils in order to optimise the beneficial use of produced water;
- Provide information to optimise the design of a water treatment and storage system to match longer term beneficial re-use opportunities; and
- In order to minimise the overall 'footprint' of the project on the surrounding landscape, the irrigation program is aiming to achieve blended water application rates in the range of 3-5 megalitres/hectare/year.

Stage 1B objectives

The objectives of the Stage 1B area are to:

- Allow for the irrigation of the lowest salinity produced water stored in the holding dams to provide improved pasture for stock grazing across the property (which is the traditional land use);
- Provide freeboard in the holding dams for the blending of the more brackish produced water that is in storage;
- Derive information about the use of blended water on un-improved soils to assess the suitability of this approach for improved pasture.

1.2. Stage 1A Irrigation Trial description

In brief, the Stage 1A Irrigation Trial involves the addition and mixing of ameliorants with the parent soils, the application of blended water (CSG produced water and fresh water) to those soils with the aid of an accurate irrigation system, the regular sampling and testing of the soils, the regular analysis of mass and water balances, analysis of results, and reporting on the results.

The main activities are outlined as follows:

Baseline 1 soil study

A comprehensive baseline soil study to ascertain the characteristics of the parent soils across the Tiedman property but in particular the Stage 1A irrigation area. This data was collected and reported as part of the irrigation trial design during 2011 (FK, 2011).

Baseline 2 soil study

On completion of the soil amelioration, repeat the soil sampling and analysis to ascertain the baseline characteristics of the treated soil prior to irrigation.

Compliance Report 1 (FK (2013a) *Soil quality monitoring and management, Report 1- Pre irrigation (Activities to 31 March 2013),* covered the site soil investigations up to and including the Baseline 2 soil study and prior to the commencement of irrigation of the Stage 1A area.

Baseline 3 soil study

On completion of irrigation of blended water during the reporting period (1 April 2013 to 30 June 2013), repeat the soil sampling and analysis to ascertain the characteristics of the treated soil after initial irrigation and assess any trends.

Compliance Report 2, (FK (2013b) *Soil quality monitoring and management, Report 2 - Irrigation (Activities from 1 April to 30 June 2013),* covered the site soil investigation and results carried out at the end of this reporting period.

Baseline 4 soil study

On completion of irrigation of blended water during the reporting period (1 July 2013 to 31 December 2013), repeat the soil sampling and analysis to ascertain the characteristics of the treated soil after extended irrigation and assess any trends.

Compliance Report 3, (FK (2014a) *Soil quality monitoring and management, Report 3 - Irrigation (Activities from 1 July to 31 December 2013),* covers the site soil investigation and results carried out on the 7 and 8 November 2013.

Baseline 5 soil study

On completion of irrigation of blended water during the reporting period (1 January 2014 to 4 July 2014), repeat the soil sampling and analysis to ascertain the characteristics of the treated soil after extended irrigation and assess any trends.

Compliance Report 4, (this report) covers the site soil investigation and results carried out on the 19 May 2014.

Perched water piezometers

Paired piezometers to monitor the potential for the development of perched water zones in the shallow soil profile have been installed inside and immediately outside (i.e. down gradient) the area of each of the different soil treatment types. Construction details are provided in FK (2013a) *Soil quality monitoring and management, Report 1- Pre irrigation (Activities to 31 March 2013).*

Irrigation Program

The application of blended water to the Stage 1A trial area is subject to recommendations arising from daily water balance monitoring and anticipated weather conditions.

In the period from 1 January to 4 July 2014, approximately 25.49 ML of blended water was irrigated across the Stage 1A area to grow forage sorghum and lucerne. This water was taken from the Tiedman South dam (containing blended water for irrigation) and applied using an overhead linear move irrigator.

Carry out monitoring and data gathering

The requirement is to undertake all detailed monitoring and data gathering, including regular soil sampling and testing, and provide six monthly reports to NSW Trade and Investment (Division of Resources and Energy [DRE]) in accordance with REF approval conditions 3 and 6.

On completion of the Stage 1A irrigation program in mid-2014, soil sampling and testing (Baseline 5) was undertaken (similar to the extensive FK baseline study done in 2011) to establish the effect of irrigation on the ameliorated soil, prior to submission of this final report (Compliance Report 4) to DRE.

1.3. Soil quality monitoring and management program requirements

In order to manage the ameliorated soils during the Stage 1A irrigation trial, a number of soil quality attributes are being monitored. These include water balance, salt balance, nutrient balance, carbon balance, and soil structure. Crop yield, crop persistence and crop health are also being monitored.

Water balance

The water balance provides the framework for tracking inputs to calculate salt, nutrient and carbon balances in the receiving soil and for determining trigger points to prevent adverse impacts on soil quality. The water balance is based on the *Environmental Guidelines: Use of Effluent by Irrigation (DECC, 2004).*

The aim of irrigation management during the irrigation program is to maintain a soil moisture deficit, within the optimal soil moisture range for crop growth, which is between wilting point and field capacity. Soil moisture is continually monitored to track soil moisture patterns (surplus or deficit) due to both rainfall and irrigation. Irrigation is only applied when there is both a daily irrigation deficit and a soil moisture deficit (with respect to soil field capacity). The AGL on-site weather station data and available rainfall forecasts are used to guide the applied irrigation water and to monitor the water balance.

Salt, nutrient and carbon balances

The salt, sodium, nutrient (nitrogen and phosphorus) and soil carbon (Total C) balances are determined during the Stage 1A irrigation program. Monitoring and analysis of blended CSG water applied, soil chemistry and soil-water allow the determination of inputs and outputs, and sources and sinks, to interpret mass balance processes and the management implications for short and long-term irrigation.

Soil structure

Apart from the physical causes of soil erosion, such as loss of ground cover, key soil chemistry parameters such as soil pH, Cation Exchange Capacity (CEC) and the soil Exchangeable Sodium Percentage (ESP) indicate the potential for loss of soil structure when irrigated with waters of a given electrolyte concentration. The relationship between ESP, the Sodium Adsorption Ratio (SAR) of permeating soil water, and the potential impact on soil structure as summarised in the *Environmental Guidelines: Use of Effluent by Irrigation* (DECC, 2004), is detailed in Lucas (2009) and discussed further in *Section 4. Performance of soils on the Stage 1A irrigation area* of this report.

Crop growth, persistence and health

Crop growth is determined from measuring dry matter yield after harvest over successive cropping cycles. An important aspect of the trial was to establish ground cover as quickly as possible after installation to minimise the risk of erosion of bare ameliorated soil. During the previous reporting period the annual summer crop (forage sorghum) was established, having replaced the winter cereal (triticale). During autumn, the forage sorghum was replaced by the next triticale crop for the winter of 2014.

Crop persistence is measured by plant counts and monitored at regular intervals. Crop health is measured by pasture sample analysis, leaf tissue analysis, harvested fodder analysis and monitored at regular intervals by an agronomist.

1.4. Stage 1B irrigation program description

The principal use of the Stage 1B area is to:

i. Initially directly irrigate existing pasture with the lower salinity produced water in the Tiedman South dam so as to create capacity in the dam for blending of the larger volumes of produced water.

ii. Establish some shallow rooted pasture species on a 4.1 ha area to evaluate irrigation application rates and irrigability of these traditional pastures in comparison with the more salt tolerant and deeper rooted crops that are established in the Stage 1A area. Blended irrigation water was used for this part of the program.

In the period from 1 January to 4 July 2014, approximately 7.48 ML of blended water was irrigated across the Stage 1B area to grow improved pasture. This water was taken from the same dam (Tiedman South) as the blended water applied to Stage 1A and applied using a small travelling irrigator.

The Stage 1B improved pasture/grazing area is currently being managed by a lessee. The lessee is using rotational grazing as a method to finish EU-accredited cattle prior to slaughter. There are 12-14 head of cattle on this area at any one time.

2. Irrigation program layout, crop selection and planting

2.1. Stage 1A irrigation area

2.1.1. Trial layout

The Stage 1A irrigation layout was designed to ensure minimum buffer distances from the Avon River (40 m), boundaries (10 m), power lines (15 m) and a copse of trees (10 m).

This created an irrigable area of 587 m (oriented east-west) by 322 m (oriented north-south). From within this area the final trial irrigation area was selected to satisfy the following requirements:

- Four soil treatments;
- Two crop systems (annuals and perennial);
- An individual plot size that could accommodate the typical range of agricultural operations;
- Irrigated by a low pressure overhead spray linear irrigator, creating a rectangular shaped irrigation zone with a central road for the linear cart to traverse; and
- The need to have a trial area as close as possible to final scale.

This resulted in a trial plot area measuring approximately 395 m from east to west by 313 m from north to south. See Attachment 1.

There are 16 equal-sized trial plots. Each individual trial plot is approximately 0.75 hectares in size, measuring 47.85 m by 156.62 m. This size enables most agricultural equipment to operate within the plot.

Factoring in non-productive crop areas taken up by bund walls the 'green' crop area is 0.73 hectares (46.85 m x 155.62 m).

Due to the selection of a centre feed linear move irrigator as the method for applying irrigation water, each treatment and crop combination was split evenly on either side of the centreline of the linear irrigator, resulting in eight plots (Plots 1-8) under the northern leg of the irrigator and eight plots (Plots 9-16) under the southern leg of the irrigator.

This accommodated the need for two crop types and four treatment depths on either side of the cart track.

2.1.2. Crop selection

Due to the expected year-round flow characteristics of produced water, perennials and annuals are being trialled to develop crop combinations that will maximise the utilisation of water.

The crop types being irrigated for the 18 month program are:

- Perennials (lucerne) – eight plots x four treatment depths
- Annuals - eight plots x four treatment depths
  - winter forage cereals (triticale), planted in April 2013 and harvested/removed in September 2013
  - followed by a summer forage (forage sorghum), established in September 2013 and harvested/removed in April 2014
  - followed by a second triticale crop planted in May 2014.

2.1.3. Planting

The Stage 1A crops and varieties established and planted during the period were as follows:

- Forage sorghum
  - Planted – 25/09/2013
  - Variety – "BMR Octane"

- Seeding rate – 25 kg/ha
    - Removed and replaced by Triticale
    - ha
- Lucerne
    - Planted - 12/04/2013
    - Variety – "L91"
    - Seeding rate – 20 kg/ha.
- Triticale
    - Planted - 5/05/2014
    - Variety – "Monstress"
    - Seeding rate – 120 kg/

2.1.4.Crop performance since planting

Table 2.1 provides a summary of crop production for the reporting period. The triticale (winter annual) was replaced in September 2013 by forage sorghum (summer annual) and harvested over the summer/autumn period before being replaced by triticale in May 2014.

All crops have performed satisfactorily. More information is provided in *Summary Report 2 (Soil and cropping activities from 1st September 2013 to 31st March 2014).*

Table 2.1: Crop production summary for the reporting period

Crop	Number of bales		Bale weights		Total dry matter yield (tonnes)	Total dry matter yield (tonnes/ hectare)
	Silage bales	Hay bales	Silage bales (kg)	Hay bales (kg)		
Forage Sorghum						
Harvest 1 (17/01/2014)		29		493	8.92	1.49
Harvest 2 (26/02/2014)	29		440	0	4.65	0.78
Harvest 3 (1/05/2014)	115		550	0	17.41	2.92
Total for forage sorghum					**30.98**	
Lucerne						
Harvest 1 (17/01/2014)		16		616	7.84	1.31
Harvest 2 (26/02/2014)	15		586		6.04	1.01
Harvest 3 (3/04/2014)	24		550		7.14	1.20
Harvest 4 (1/05/2014)	24		594		5.83	0.98
Harvest 5 (20/06/2014)	10		580		3.19	0.53
Total for lucerne					**30.04**	
Total for the period (1/01/2014 – 4/07/2014)					**61.02**	**10.22**

During the period the production volumes were:

- Forage sorghum – harvested in January, February and May (30.986 dry matter (DM) tonnes)
- Lucerne – harvested in January, February, April, May and June (30.04 DM tonnes)

The total production of 61.02 DM tonnes (see Table 2.1) is consistent with the accumulated yield expected for the summer/autumn period.

Total production since the program commenced is as follows:

- Gross yield (tonnes) – 314.10
- Dry Matter Yield (tonnes) – 140.4
- Dry matter yield per hectare (tonnes/ha) – 11.76

Typical forage sorghum plot showing post-harvest regrowth

Typical lucerne plot showing post-harvest regrowth

2.2. Stage 1B irrigation area

The four Stage 1B irrigation plots are located just to the south of the Stage 1A trial plots and are sized and named as follows:

- AL1 – 0.97 hectares
- AL2 – 0.89 hectares
- AL3 – 1.13 hectares
- AL4 – 1.10 hectares

The total area is 4.1 ha and the layout of this area is provided in Attachment 2.

2.2.1. Pasture selection

The pasture type initially chosen for this area was a pasture mix (71 % Ryegrass, 20 % Clover, and 9 % Chicory) which was the same for all four plots. There was no deep soil treatment across any of these four plots. A second pasture mix was established in autumn 2014.

2.2.2. Planting

Autumn 2013

The pasture mix varieties below were planted on 28/03/2013 at a combined rate of 35 kg/ha:

- Ryegrass
  - Variety – "Knight"
  - Seeding rate – 25 kg/ha
- Clover
  - Variety – "USA Red Clover"
  - Seeding rate – 7 kg/ha
- Chicory
  - Variety – "Punter"
  - Seeding rate – 3 kg/ha

Autumn 2014

The pasture mix varieties below were planted on Plots 1 and 2 on 26/03/2014 at a combined rate of 38 kg/ha:

- Ryegrass
  - Variety – "Knight"
  - Seeding rate – 12.5 kg/ha
- Ryegrass
  - Variety – "Asset AR37"
  - Seeding rate – 12.5 kg/ha
- Clover
  - Variety – "USA Red Clover"
  - Seeding rate – 6 kg/ha
- Chicory
  - Variety – "Punter"
  - Seeding rate – 3 kg/ha
- Kikuyu
  - Variety – N/A
  - Seeding rate – 4 kg/ha

The pasture mix varieties below were planted on Plots 3 and 4 on 26/03/2014 at a combined rate of 46.5 kg/ha:

- Ryegrass
    - Variety – “Knight”
    - Seeding rate – 30 kg/ha
    - Seeding rate – 12.5 kg/ha
- Chicory
    - Variety – “Punter”
    - Seeding rate – 4 kg/ha

2.2.3. Pasture performance since planting

A satisfactory pasture density has been maintained for cattle grazing during the reporting period.

3. Mass balance results for the period

3.1. Average rainfall patterns

The irrigation site lies within a relatively high rainfall zone, with a mean rainfall of approximately 983 millimetres (mm) per annum. The rainfall pattern is slightly summer-dominant with 56 % occurring between November and March and 44 % occurring between April and October. As a result the consideration of rainfall is a significant factor in determining the timing of when irrigation will be undertaken.

3.2. Rainfall and Evapotranspiration

Figure 3.1 summarises rainfall and evapotranspiration (ETo) between the 1 January – 4 July 2014 where 303 mm of rain occurred during the period. Most rainfall fell in February (58 mm), March (126 mm) and April (77 mm). Rainfall across the total Stage 1A plot area of 12 ha was 36.4 ML. The equivalent volume across the Stage 1B area of 4.1 ha was 12.4 ML.

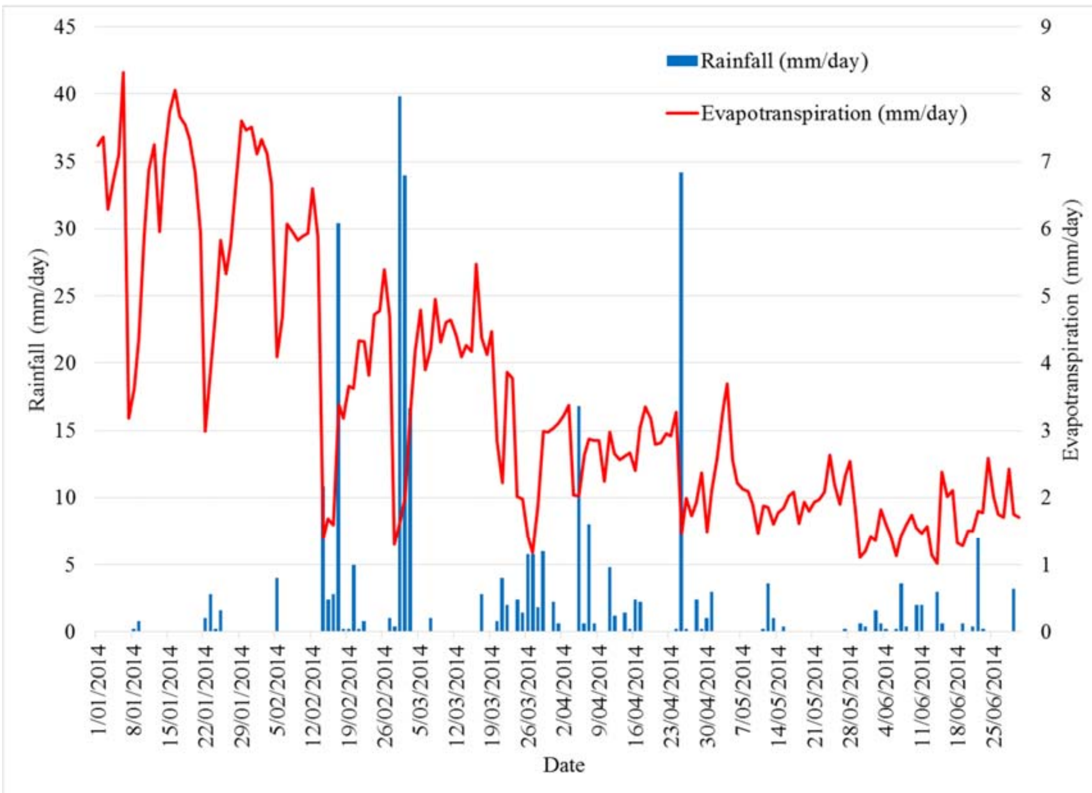


Figure 3.1: Rainfall and Evapotranspiration for the Period (1st January – 4th July 2014)

There are no ETo data specific to the site (see explanation in FK, 2011), however ETo was interpolated from regionally available data through the *iWater* service.

During the reporting period 41 % of the total water received across the Stage 1A area came from blended water while 59 % came from rainfall (refer Table 3.1).

Table 3.1 Rainfall and irrigation for the period – Stage 1A

Units	Rainfall for the period	Irrigation for the period	Total
mm	303.4	212.4	515.8
ML	36.4	25.49	61.89
%	59	41	100

3.3. Irrigation scheduling and water balance

3.3.1. Stage 1A

The water balance was based on *Environmental Guidelines: Use of Effluent for Irrigation (DECC, 2004)*:

Applied CSG water (Qcsg) + Rainfall (Qr) ≤ Evapotranspiration (ETo) + Percolation (P) + Runoff (R) + Interception Loss (IL), where R is designed to be zero, therefore the daily water balance is:

- Qcsg ≤ ETo + P + IL – Qr
- Daily Irrigation Deficit (DID) = ETo + P + IL – (Qr + Qcsg)

Negative values mean irrigation should not be applied.

The cumulative DID (over 6 day periods) was used in conjunction with real-time soil moisture to determine if irrigation was possible at a given time. For example, a 25 mm rainfall event may offset 6 days (or more) of low ETo, and if the rainfall event saturates the soil, then irrigation does not occur.

Figure 3.2 summarises the Daily Irrigation Deficit (DID), cumulative DID (7-day) and applied irrigation of blended CSG water (1st January – 4th July 2014).

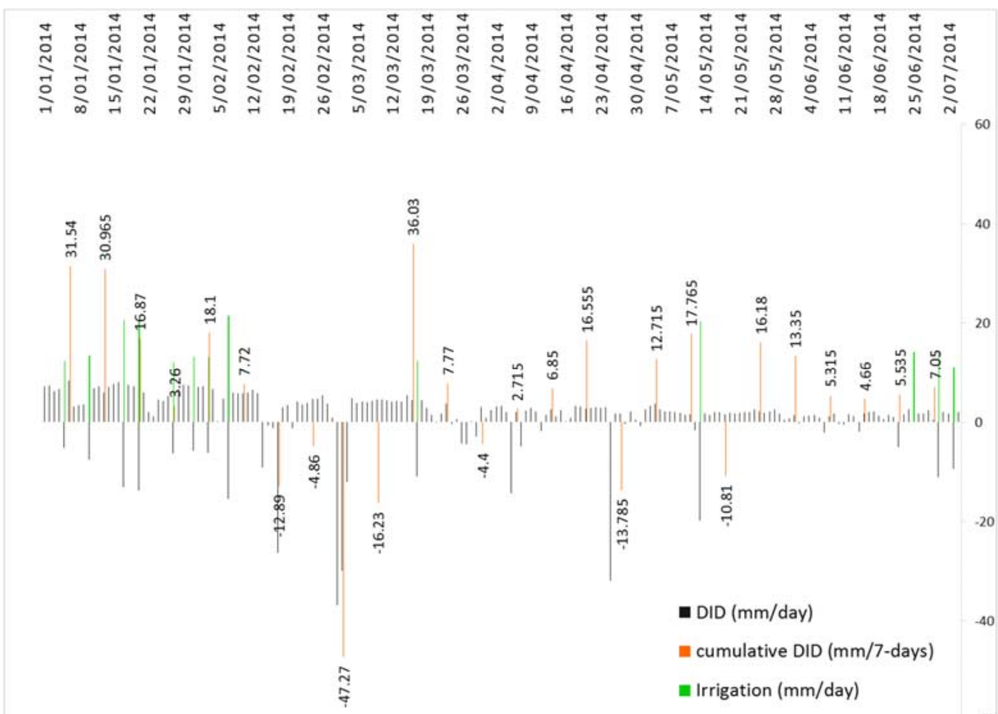


Figure 3.2: Stage 1A - Daily Irrigation Deficit (DID), 7-day cumulative DID and Irrigation applied for the Period (1st January – 4th July 2014)

In addition to the water balance, real-time soil moisture monitoring ensured that irrigation was only applied when there was available "space" in the soil profile. Figures 3.3a and 3.3b show the wetting and drying patterns of MS1 (control area outside the irrigation area) and MS5 (in the deepest treatment zone within the irrigation area).

The general similarity between irrigated and non-irrigated soils and their wetting and drying periods indicates that the structure of the receiving soil is being maintained and water is passing to the deeper parent soil. For example, comparison of Figure 3.3a to 3.3b shows that water movement through the soil has not been significantly altered by irrigation. That is, the general wetting and drying periods in MS1 (due to rainfall shown by blue columns) are generally observed in MS5 trends. Water is either moving to deeper groundwater or being used by plants to create these similar patterns. However, irrigation (black columns) was applied to MS5 and, while the irrigation "spikes" increased the presence of soil water during this period, this allowed considerable water uptake by plants in the trial area. Further discussion on soil water dynamics will be provided in *Section 4.3 Key Findings – Baseline 5(irrigated soils) vs Baseline 4(irrigated soils)*.

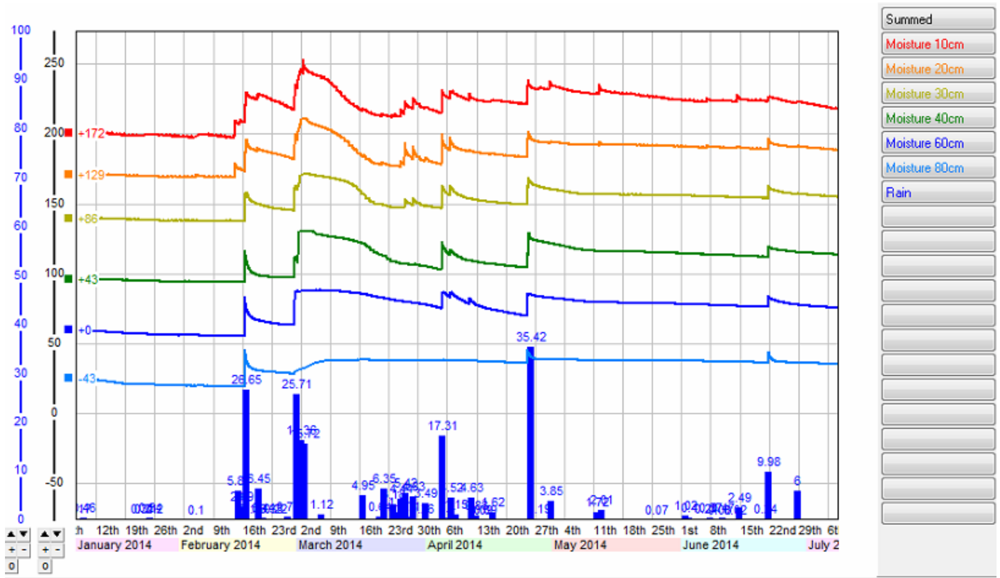


Figure 3.3a: Soil moisture monitoring showing wetting and drying periods for MS1 (control, outside irrigation area) from 1st January 2014 – 4th July 2014

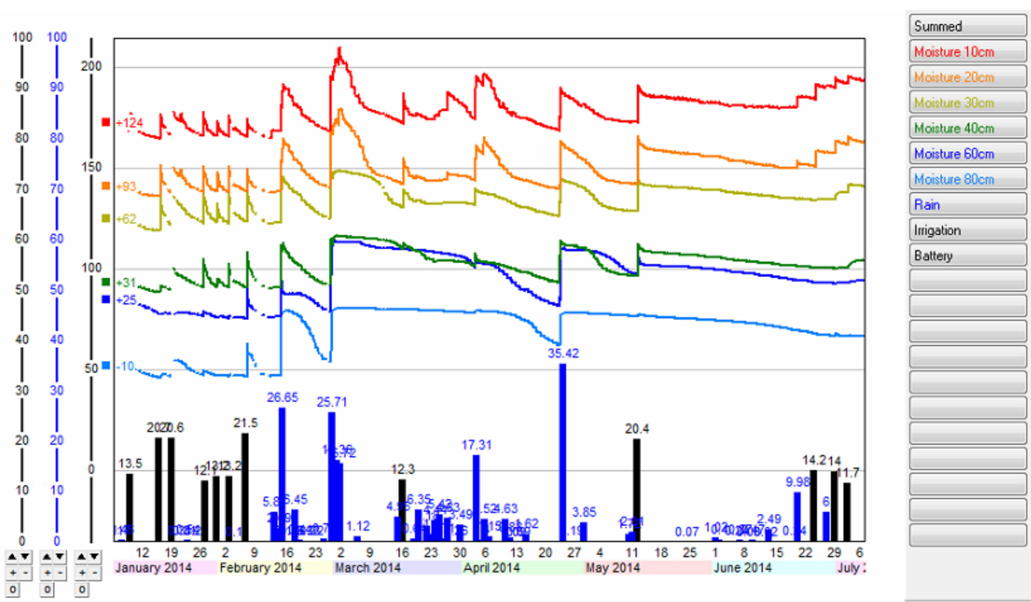


Figure 3.3b: Soil moisture monitoring showing wetting and drying periods for MS5 (deepest treatment zone inside irrigation area) from 1st January 2014 – 4th July 2014

Irrigation of blended CSG water occurred intermittently from 1 January – 4 July 2014 as indicated by the water balance previously described in the Section 3.3.1. Approximately 25.49 ML of blended CSG water was applied to the Stage 1A area during the period compared to 32.45 ML in the previous reporting period. The DID, cumulative DID and soil moisture indicated that these were optimum irrigation opportunities that would result in zero runoff while maintaining soil moisture levels suitable for crop growth.

3.3.2. Stage 1B

The water balance used for Stage 1A was also used for Stage 1B and is shown in Figure 3.4. Approximately 7.48 ML (~ 182 mm) of blended CSG water was applied to the 4 ha in Stage 1B from 1st January to 4th July 2014.

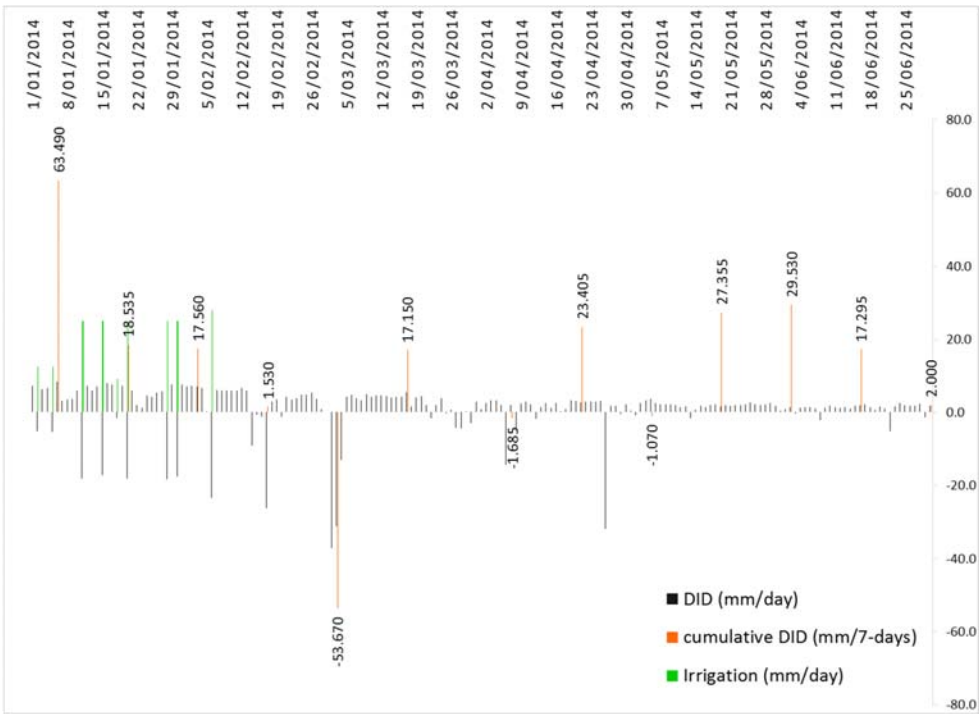


Figure 3.4: Stage 1B - Daily Irrigation Deficit (DID), 6-day cumulative DID and Irrigation applied for the Period (1st January – 4th July 2014)

3.4. Irrigation water quality

Table 3.2 summarises water quality of the blended water used to irrigate Stages 1A and 1B from 1 January to 4 July 2014 (from Parsons Brinckerhoff, 2014c). The water quality results are from the February 2014 quarterly sampling event and are from the Tiedman South dam.

The blended water (February 2014) had an average EC of 1540 µS/cm which was close to the mixing-model design objective for water quality prior to irrigation (≈ 1500 µS/cm). The elevated lab pH (9.66) is of minor concern to site soils at these EC values as the pH can be attributed to carbonate interactions in the blended water and there is substantial buffering capacity in the amended soils. The field pH of 8.39 is considered more representative. The water monitoring compliance reports (Parsons Brinckerhoff, 2013 and Parsons Brinckerhoff, 2014c) assess blended water quality for irrigation against the ANZECC irrigation guidelines. The ANZECC irrigation guideline pH range is between 6 and 9.

The blended irrigation water has elevated pH and this may cause some nutrient uptake problems. The blended irrigation water was generally low in nutrients (nitrate and ortho-phosphate) however at a pH of 9.66 all phosphorus is in the bound form and is not available to plants. Adjustment of the pH to around 7.5 would release phosphorus for crop assimilation.

Sodium, nutrients and Total Organic Carbon (TOC) values are discussed further in section 3.5 with respect to mass balance results and potential impacts on site soils.

Table 3.2: Water quality of the blended CSG water prior to irrigation (from TSD)

Parameter	Units	Value
Electrical Conductivity (EC) (lab)	µS/m	1540
pH (lab)	no units	9.66
Chloride (Cl)	mg/L	207
Sodium (Na)	mg/L	262
Sodium Adsorption Ratio (SAR)	-	12.9
Total Alkalinity	mg $CaCO_3$/L	369
Bicarbonate Alkalinity (HCO_3)	mg $CaCO_3$/L	165
Carbonate Alkalinity (CO_3^-)	mg $CaCO_3$/L	204
Hardness	mg $CaCO_3$/L	27
Aluminium (Al)	mg/L	9.42
Boron (B)	mg/L	0.25
Calcium (Ca)	mg/L	6
Copper (Cu)	mg/L	0.014
Fluoride (F)	mg/L	0.8
Iron (Fe)	mg/L	5.38
Magnesium (Mg)	mg/L	3
Manganese (Mn)	mg/L	0.049
Nitrate nitrogen (NO_3)	mg/L	<0.01
Total Kjeldahl Nitrogen (TKN)	mg/L	3.1
Total Phosphorus (P)	mg/L	1.61
Orthophosphate (PO_4^{3-})	mg/L	0.63
Potassium (K)	mg/L	92
Sulfate (SO_4^{2-})	mg/L	26
Zinc (Zn)	mg/L	0.043
Total Dissolved Solids (TDS)	mg/L	1000
Total Organic Carbon (TOC)	mg/L	35

Note – Water quality analysis is from Parsons Brinckerhoff 2014c, laboratory results are from the Tiedman South dam and are from the February 2014 sampling event

3.5. Sodium, nutrient and carbon balance

The aim of using mass balances was to determine how the sodium, nutrient and carbon load in the applied water was accumulating in the receiving soil over time. Mass balance results are presented as mg/kg applied during the reporting period and are compared to soil data to determine changes over time.

3.5.1. Stage 1A

The mass of soil in Stage 1A was calculated as:

11.94 ha = 119,400 m^2 x 0.333 m (average treatment depth) x 1200 kg/m^3 (soil bulk density) = 47,712,240 kg of soil in Stage 1A.

Table 3.3 provides a summary of mass balances for sodium, nitrate nitrogen, total phosphorus and total organic carbon

Table 3.3: Stage 1A mass balance summary for sodium, nitrate nitrogen, total phosphorus and total organic carbon (for 6 months and in total)

	Dam WQ mg/L	Irrigation applied this period ML	Irrigation applied since 1/4/2013 ML	Total Applied this period mg	Total Applied since 1/4/2013 mg	Site soil mass kg	Total Applied this period mg/kg	Total Applied since 1/4/2013 mg/kg
Sodium (Na)	262	25.49	63.06	6,678,380,000	16,521,720,000	47,712,240	139.97	346.28
Total Nitrogen (TN)	3.1	25.49	63.06	79,019,000	195,486,000	47,712,240	1.66	4.10
Total Phosphorus (P)	1.61	25.49	63.06	41,038,900	101,526,600	47,712,240	0.86	2.13
Total Organic Carbon (TOC)	35	25.49	63.06	892,150,000	2,207,100,000	47,712,240	18.70	46.26

Approximately 140 mg/kg of sodium has been applied during the reporting period. Soil analysis over this period (discussed in Section 4) indicated that sodium ranged from approximately 407 mg/kg to 1014 mg/kg (to 1200 mm soil depth) with an average of 528 mg/kg (323 mm soil depth). The 140 mg/kg of sodium applied during this period increased soil sodium concentration compared to Baseline 4; however FK has assessed that this increase in sodium concentration is likely to have only a minor impact on soil structure and water movement through the soil at this time. The impact of sodium on soil structure is discussed in *Section 4.3 Key Findings – Baseline 5 (irrigated soils) vs Baseline 4 (irrigated soils)*.

Nitrate nitrogen, total phosphorus and total organic carbon have been applied in negligible quantities through irrigation during the both the reporting period and the whole of the irrigation period.

3.5.2. Stage 1B

The mass of soil in Stage 1B was calculated as:

4ha = 40,000 m^2 x 0.15 m (average treatment depth) x 1200 kg/m^3 (soil bulk density)
= 7,200,000 kg of soil in Stage 1B

Table 3.4 provides a summary of mass balances for sodium, nitrate nitrogen, total phosphorus and total organic carbon.

Table 3.4: Stage 1B mass balances summary for sodium, nitrate nitrogen, total phosphorus and total organic carbon (for 6 months and in total)

	Dam WQ mg/L	Irrigation applied this period ML	Irrigation applied since 1/4/2013 ML	Total Applied this period mg	Total Applied since 1/4/2013 mg	Site soil mass kg	Total Applied this period mg/kg	Total Applied since 1/4/2013 mg/kg
Sodium (Na)	262	7.48	20.64	1,959,760,000	5,407,680,000	7,200,000	272.2	751.07
Total Nitrogen (TN)	3.1	7.48	20.64	23,188,000	63,984,000	7,200,000	3.2	8.89
Total Phosphorus (P)	1.61	7.48	20.64	12,042,800	33,230,400	7,200,000	1.7	4.62
Total Organic Carbon (TOC)	35	7.48	20.64	261,800,000	722,400,000	7,200,000	36.4	100.33

Approximately 272 mg/kg of sodium has been applied during the period. Soil analysis over this period (discussed in Section 4) indicated that sodium increased from 898 mg/kg to 1056 mg/kg (0-20 cm depth) since soil sampling in Baseline 4. The 272.2 mg/kg of sodium applied during this latest period increased sodium in the soil profile increasing soil Sodium and Exchangeable Sodium Percentage (ESP) from ~ 15 to ~ 17.

Nitrate nitrogen, total phosphorus and total organic carbon have been applied in minimal quantities through irrigation at this time and pose no threat to soil or crop health.

3.6. Perched water piezometer results

Shallow piezometers in the soil profile installed around and within the respective irrigation areas also provided data to assist irrigation scheduling. These sites have no relevance for environmental monitoring. Table 3.5 shows the dual piezometer sites and the monitored water level depths during 2013 and 2014. Piezometer locations are shown in Attachments 1 and 2.

Table 3.5: Piezometer sites and water level depths in 2013 and 2014

Piezometer ID	Piezometer Depth below surface (mm)	Water level in Piezometer (mm) on sampling date									
		6/02/2013	7/03/2013	11/04/2013	21/05/2013	13/06/2013	1/10/2013	8/11/2013	30/01/2014	11/03/2014	20/05/2014
SP1A	600	600	570	60	210	600	0	0	160	300	0
SP1B	1200	0	0	0	0	0	0	0	0	200	0
SP2A	600	530	550	0	0	510	0	90	60	0	20
SP2B	1200	1200	950	140	0	1000	200	0	0	140	0
SP3A	900	540	0	0	0	680	70	0	0	60	40
SP3B	1200	0	0	0	0	0	0	0	0	0	0
SP4A	1200	400	0	0	0	730	0	290	0	120	30
SP4B	1200	0	0	0	0	0	0	0	0	0	0
SP5A	400	0	0	0	0	270	0	10	0	0	30
SP5B	1200	0	420	0	0	1090	320	220	0	700	800
SP6A *	1200	580	0	160	0	1200	390	0	0	700	800
SP6B *	1200	0	0	0	0	0	0	110	0	660	0
SP7A	400	270	0	90	160	280	0	140	100	130	30
SP7B	1200	0	0	0	0	0	0	0	0	80	0
SP8A	400	380	0	0	100	400	0	110	120	120	0
SP8B	1200	0	925	0	0	210	0	0	0	240	0
SP9A ^	500	Not installed until May 2013				0	0	0	0	0	0
SP9B ^	700	Not installed until May 2013				0	0	0	0	0	0
SP10A ^	500	Not installed until May 2013				0	80	80	80	0	0
SP10B ^	700	Not installed until May 2013				0	0	0	0	0	0
Rainfall between periods (mm)		*82*	*101*	*28*	*34*	*98*	*54*	*9*	*192*	*150*	*120*
Irrigation between periods (mm) (Stage 1B in brackets)		*0 (0)*	*0 (0)*	*0 (0)*	*29 (0)*	*10 (75)*	*108 (88)*	*131 (59)*	*159 (0)*	*48 (0)*	*33 (0)*
Total water applied between periods (mm) (Stage 1B in brackets)		*82 (82)*	*101 (101)*	*28 (28)*	*63 (34)*	*108 (173)*	*162 (142)*	*140 (68)*	*351 (0)*	*198(0)*	*153 (0)*

Key * - dual piezometers located upstream and downstream of catch dam 2 (CDW) outside the irrigation area
^ - Stage 1B piezometers

The piezometers within the trial area (those denominated by the letter "A") were installed to depths that matched the depth of treatment for each location. The paired piezometers outside of the trial area (those denominated by the letter "B") were all installed to the same depth of 1.2 metres.

The piezometers within the Stage 1A irrigation area generally contained more water than the outside piezometers. This is due to the substantially improved infiltration rate of the ameliorated soils inside the trial area, resulting in the promotion of downward movement of water into the soil (to treatment depth), rather than surface runoff which would occur in the parent soils. Also, most piezometers accumulated water during high rainfall however piezometer water level trends indicate that this water either permeated into the surrounding soil over time and/or was transpired by plants.

Paired piezometers (SP9a, SP9b, SP10a, and SP10b) were installed in the Stage 1B area (see Attachment 2) to monitor the potential for perched water to develop inside and immediately outside (i.e. down gradient) of the irrigated pasture area. The piezometers were installed to a depth of 500 mm inside the area to be irrigated and 700 mm outside the area to be irrigated.

Piezometer water quality was also monitored - based on pH and EC (µS/cm). Table 3.6 shows all samples that were field tested since the irrigation program commenced in April 2013. The table does not include laboratory water samples submitted by Parsons Brinckerhoff (PB, 2014a and c). Note that not all piezometers contained water during sampling periods and only those tested are provided in Table 3.6.

Table 3.6: pH and EC of piezometer waters

Date	Piezometer ID	WL in pipe (mm)	pH	EC µS/cm
7/03/2013	SP1A	510	7.24	3150
7/03/2013	SP5B	740	7.29	4010
11/04/2013	SP1A	1020	6.87	3560
11/04/2013	SP2B	1080	6.75	3270
8/11/2013	SP2A	610	7.62	2830
8/11/2013	SP5A	480	7.27	2140
8/11/2013	SP6B	1310	6.54	1850
30/01/2014	SP1A	160	7.42	2030
30/01/2014	SP2A	60	6.98	3000
30/01/2014	SP7A	100	7.25	1580
30/01/2014	SP8A	120	7.31	1710
20/05/2014	SP5B	800	7.66	4890
20/05/2014	SP6A	800	7.74	5030
maximum		1310	7.74	5030
minimum		60	6.54	1580
standard deviation		408	0.36	1149

Salinities reflect the natural salinity in the soil profile. Fluctuations in pH and EC are a function of rainfall, irrigation and crop water use however results provide a basis for estimating water quality that may leach below the root zone to the regional water table in the bedrock.

3.7. Overall salt balance

3.7.1. Avon catchment perspective – Response to rainfall

To understand the impact of irrigation to the Stage 1A area with respect to the EC of off-site discharge it is important to understand how the surrounding Avon River catchment responds to rainfall. Figure 3.5 provides water level and EC data extracted from the NSW Office of Water (NOW) real-time monitoring program for the Avon River (ID 208028 - Waukivory) for the whole irrigation period (April 2013 to July 2014).

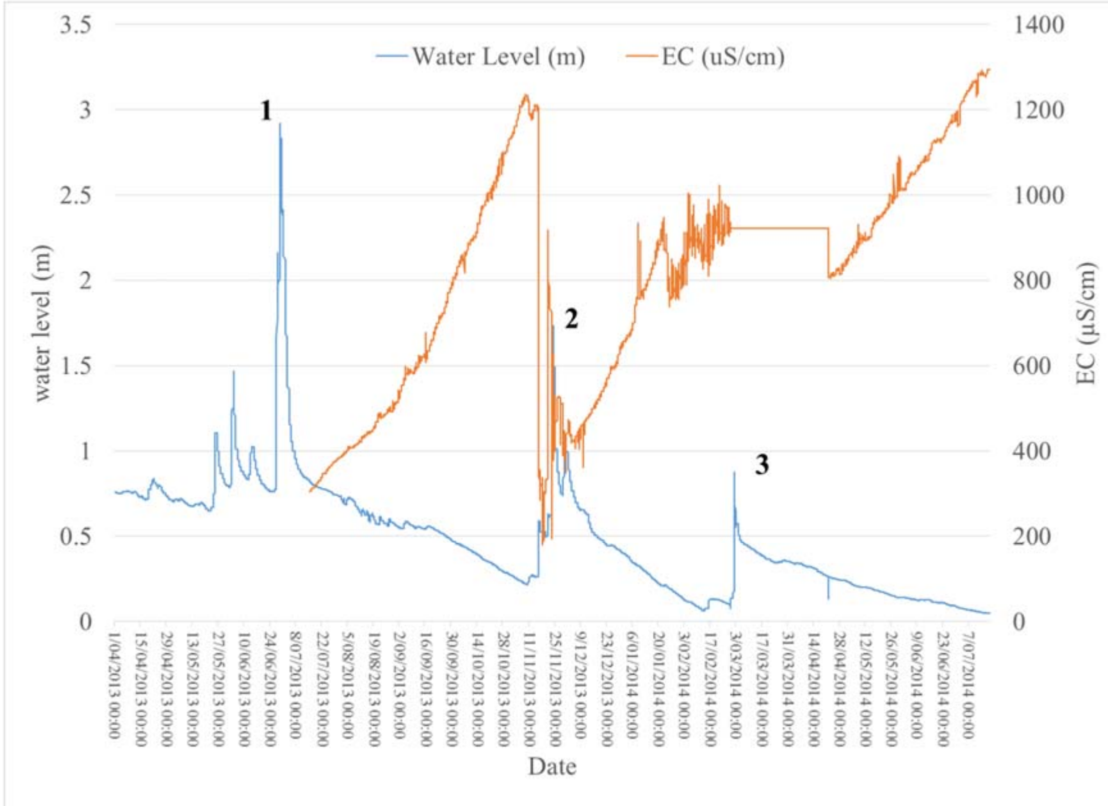


Figure 3.5: Water level and EC data for the Avon River

Three major increases in water level can be observed between the 13/5/2013 and 7/7/2014 (highlighted as 1, 2 and 3). In general, there is an inverse relationship between water level and EC. Using "2" as an example, the trend is a salinity spike (due to salts in the general landscape running off in the first flush) then a reduction to low salinity water as overland flow dominates then a gradual increase again as groundwater base flows contribute. This is followed by a steady increase over (up to) several months in conjunction with decreasing water levels.

The rapid decrease in EC and increase in water level during rainfall indicates that the undulating catchment, with poorly drained soils on the slopes, promotes rapid surface runoff to the Avon River. The steady increase in EC in the days, weeks and months after rainfall is attributable to shallow groundwater baseflow as the alluvial groundwater system drains after being recharged after each high rainfall event. These dynamics were also recognised in the Parsons Brinckerhoff Water Compliance Report (PB, 2014a).

3.7.2. Leaching fraction estimates

To estimate the EC of soil water and leached salts during the Stage 1A irrigation trial it was necessary to determine a leaching fraction. The major inputs and assumptions are outlined below and are based on the methodology prescribed in Ayers & Westcott, Water quality for agriculture, FAO, 1994:

- Applied average water salinity (EC_w) = **1.54 dS/m**
- Crop water demand (ET) = **1761 mm** (1/4/2013 – 4/7/2014).
- The crop water use pattern is 40-30-20-10. This means the crop will get 40 percent of its ET demand from the upper quarter of the root zone, 30 percent from the next quarter, 20 percent from the next, and 10 percent from the lowest quarter. Crop water use will increase the concentration of the soil-water which drains into the next quarter (EC_{sw}) of the root zone (see Figure 3.6).
- Estimated leaching fraction (LF) = 0.15. The estimated leaching fraction of 0.15 means that 15 percent of the applied irrigation water entering the surface percolates below the

root zone and 85 percent replaces water used by the crop to meet its ET demand and water lost by surface evaporation.

- Repeat calculations based on irrigation + rainfall and weighted EC (1/4/2013 – 4/7/2014).

In Figure 3.6, five points in the root zone are used to determine the average root zone salinity. These five points are soil-water salinity at (1) the soil surface, (EC_{sw0}); (2) bottom of the upper quarter of the root zone, (EC_{swl}); (3) bottom of the second quarter depth, (EC_{sw2}); (4) bottom of the third quarter, (EC_{sw3}) and (5) bottom of the fourth quarter or the soil-water draining from the root zone (EC_{sw4}) which is equivalent to the salinity of the drainage water (EC_w).

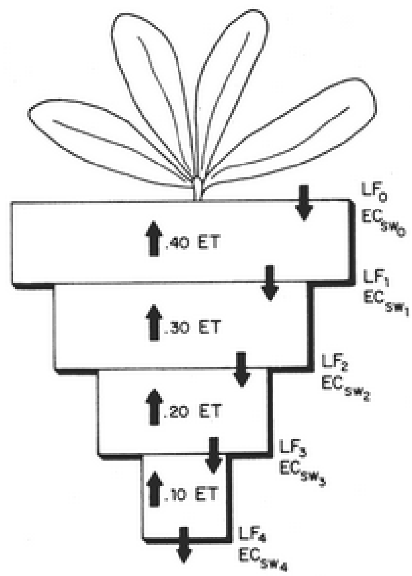


Figure 3.6: Leaching dynamics in the root zone (FAO, 1994)

With a LF of 0.15, the applied water (AW) needed to meet both the crop ET and the LF is determined from the following equation:

$$AW = \frac{ET}{1-LF} = \frac{1761}{1-0.15} = 2072\ mm \qquad \text{Equation 1}$$

Since essentially all the applied water enters and leaches through the soil surface, effectively removing any accumulated salts, the salinity of the soil water at the surface (EC_{sw0}) must be very close to the salinity of the applied water as shown using equation (2) and assuming LF0 = 1.0.

$$ECw = ECsw0 = \frac{ECw}{LF0} = \frac{1.54}{1} = 1.54\ dS/m \qquad \text{Equation 2}$$

The salinity of the soil-water draining from the bottom of each root zone quarter is found by determining the leaching fraction for that quarter using equation (3) and then determining the soil-water salinity using equation (4).

$$LF = \frac{Water\ leached}{Water\ applied} \qquad \text{Equation 3}$$

$$ECsw0 = \frac{ECw}{LF} \qquad \text{Equation 4}$$

For the bottom of the first quarter:

$$LF1 = \frac{2072-(0.4\ x\ 1761)}{2072} = 0.66 \qquad ECsw1 = \frac{ECw}{LF1} = 2.33\ dS/m$$

At the bottom of the second quarter:

$$LF2 = \frac{2072-(0.4\ x\ 1761)-(0.3\ x\ 1761)}{2072} = 0.41 \qquad ECsw2 = \frac{ECw}{LF2} = 3.76\ dS/m$$

At the bottom of the third quarter:

$$LF3 = \frac{2072-(0.4\ x\ 1761)-(0.3\ x\ 1761)-(0.2\ x\ 1761)}{2072} = 0.24 \qquad ECsw3 = \frac{ECw}{LF3} = 6.42\ dS/m$$

At the bottom of the root zone (fourth quarter):

$$LF4 = \frac{2072 - (0.4\ x\ 1761) - (0.3\ x\ 1761) - (0.2\ x\ 1761) - (0.1\ x\ 1761)}{2072} = 0.15$$

$$ECsw4 = \frac{ECw}{LF4} = 10.27\ dS/m$$

The average soil-water salinity of the root zone is found by taking the average of the five root zone salinities found above:

$$Average\ ECsw = \frac{1.54 + 2.33 + 3.76 + 6.42 + 10.27}{5} = 4.86\ dS/m$$

The same approach shown above was used but rainfall was incorporated using a volume-weighted EC_w. Approximately 689 mm of rainfall occurred (EC < 0.02 dS/m) in conjunction with 527 mm of irrigation (EC = 1.54 dS/m). Since rainfall has minimal "salts", the EC_w used in the new calculation was determined by a simple dilution method resulting in a new EC_w of 0.80 dS/m (527mm/1216mm x 1.54 dS/m = 0.67 dS/m).

For the bottom of the first quarter:

$$LF1 = \frac{2072-(0.4\ x\ 1761)}{2072} = 0.66 \qquad ECsw1 = \frac{ECw}{LF1} = 1.02\ dS/m$$

At the bottom of the second quarter:

$$LF2 = \frac{2072-(0.4\ x\ 1761)-(0.3\ x\ 1761)}{2072} = 0.41 \qquad ECsw2 = \frac{ECw}{LF2} = 1.63\ dS/m$$

At the bottom of the third quarter:

$$LF3 = \frac{2072-(0.4\ x\ 1761)-(0.3\ x\ 1761)-(0.2\ x\ 1761)}{2072} = 0.24 \qquad ECsw3 = \frac{ECw}{LF3} = 2.79\ dS/m$$

At the bottom of the root zone (fourth quarter):

$$LF4 = \frac{2072 - (0.4\ x\ 1761) - (0.3\ x\ 1761) - (0.2\ x\ 1761) - (0.1\ x\ 1761)}{2072} = 0.15$$

$$ECsw4 = \frac{ECw}{LF4} = 4.47\ dS/m$$

The average soil-water salinity of the root zone is found by taking the average of the five root zone salinities found above:

$$Average\ ECsw = \frac{0.67 + 1.02 + 1.63 + 2.79 + 4.47}{5} = 2.15\ dS/m$$

Using the LF calculations above and also considering rainfall EC, the (estimated) average soil-water salinity of the root zone ranges from 2.15 – 4.86 dS/m.

3.7.3. Piezometer water quality

The range in average soil-water salinity of the root zone as calculated above is very similar to piezometer water EC recorded in the field (~ 1.58 – 5.03 dS/m). Table 3.6 shows piezometer water pH and EC which was sampled/analysed when water was present.

Table 3.6: pH and EC of piezometer waters

Date	Piezometer ID	WL in pipe (mm)	pH	EC uS/cm
7/03/2013	SP1A	510	7.24	3150
7/03/2013	SP5B	740	7.29	4010
11/04/2013	SP1A	1020	6.87	3560
11/04/2013	SP2B	1080	6.75	3270
8/11/2013	SP2A	610	7.62	2830
8/11/2013	SP5A	480	7.27	2140
8/11/2013	SP6B	1310	6.54	1850
30/01/2014	SP1A	160	7.42	2030
30/01/2014	SP2A	60	6.98	3000
30/01/2014	SP7A	100	7.25	1580
30/01/2014	SP8A	120	7.31	1710
20/05/2014	SP5B	800	7.66	4890
20/05/2014	SP6A	800	7.74	5030
maximum		1310	7.74	5030
minimum		60	6.54	1580
standard deviation		408	0.36	1149

Fluctuations in pH and EC will be a function of rainfall, irrigation and crop water use however results provide a basis for estimating any significant change in soil-water salinity over time. For example, piezometer water sampled (SP1A and SP5B) on the 7/3/2013, after ~ 100 mm rainfall in the previous week, can be considered as background values of soil water EC prior to irrigation. The majority of EC values recorded in various piezometers over the irrigation period rarely exceeded these background values. Note that the presence of soil water in these very shallow piezometers did not occur after any irrigation event and only filled after significant rainfall.

3.7.4. Salt mass balance

Table 3.7 summarises the salt balance for the Stage 1A area and Figures 3.7 and 3.8 conceptually show salt dynamics in the parent soil and irrigated soil respectively.

Table 3.7: Salt balance summary

		Parent soil (tonnes of salt)	Amended soil (tonnes of salt)	Difference (tonnes of salt)
Input	**Rain**	2.68	2.68	0
Input	**Irrigation**	0	78.51	78.51
Input	**Soil**	91.99	176.20	84.21
Output	**Salts flushed out***	0.40	11.78	11.38
Output	**Salts leached***	13.80	26.43	12.63
Output	**Crop**	0	4.9	4.9

*estimated values based on required leaching fraction and site observations

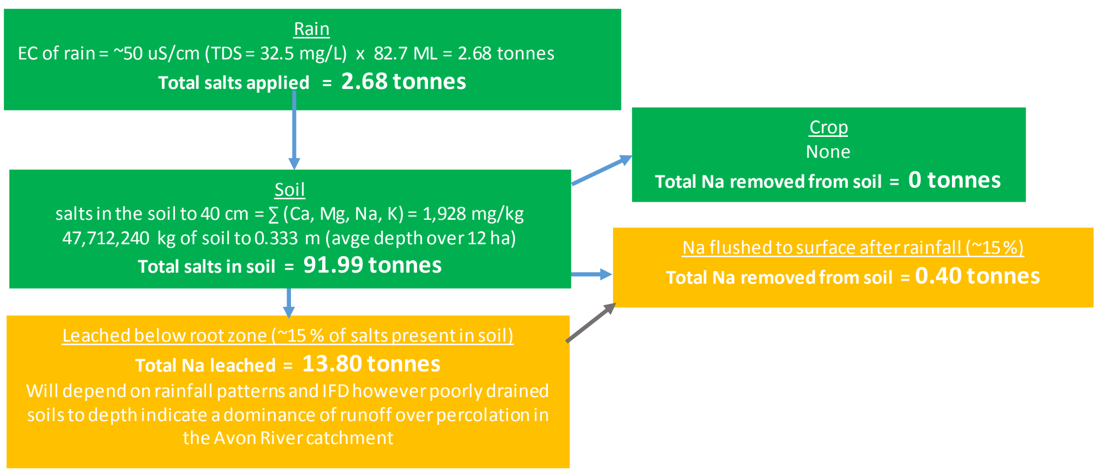


Figure 3.7: Salt mass balance for the parent soil prior to irrigation (gold boxes are assumptions)

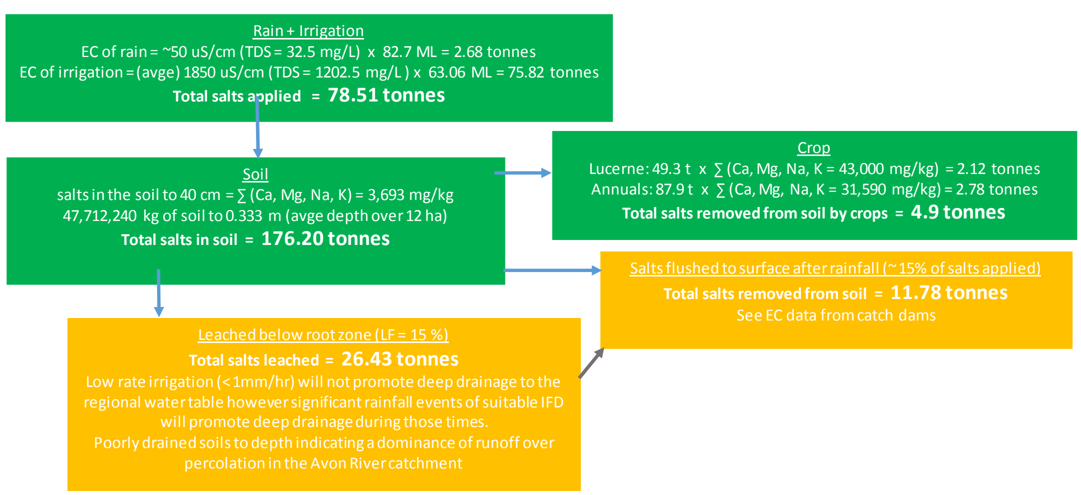


Figure 3.8: Salt mass balance for the amended soil after irrigation (1/4/2013 – 4/7/2014) (gold boxes are assumptions)

The gold boxes in Figures 3.7 and 3.8 represent assumptions based on site observations and typical irrigation principles. The green boxes are inputs and outputs based on measured data where the sum of the average Ca, Mg, Na and K (in mg/kg, 0 - 40 cm depth) were defined as the "salt load".

Where have the salts gone? The comparison between the parent soil (Figure 3.7) and the irrigated soil (Figure 3.8) indicate that salt is most likely accumulating in the poorly drained soils. For example, approximately 92 tonnes of salt were present in the parent soil, and after 15 months of irrigation adding 78.51 tonnes of salt from blended water, we would expect a total salt mass of approximately 170 tonnes. Recent soil results indicate approximately 176 tonnes of salt is present however if the salts removed by the crops (4.9 tonnes) is subtracted from the soil salt mass, the value (~172 tonnes) suggests little movement of salts from the site (net mass balance of near zero). Therefore, it is likely that the LF has been over-estimated considering the poorly drained soils as indicated by low saturated hydraulic conductivity (K_{sat}).

Have salts been flushed from the soil during rain events? It is uncertain whether the rapid runoff attributes of the catchment has flushed some salts from the upper 40 cm of soil profile after rainfall and affected flows in surface runoff to the catch dams. Figure 3.9 shows the Catch Dam West (CDW) EC profile in conjunction with rainfall/runoff and timing of antecedent irrigation events (salt load – shown in gold shaded area). There are several trends within the EC data collected from the catch dams. The salinity trend for CDW is shown in Figure 3.9 and trends are also similar for Catch Dam East (CDE); and both catch dams are detailed in Parsons Brinckerhoff (refer Figure 4.3 in PB, 2014c).

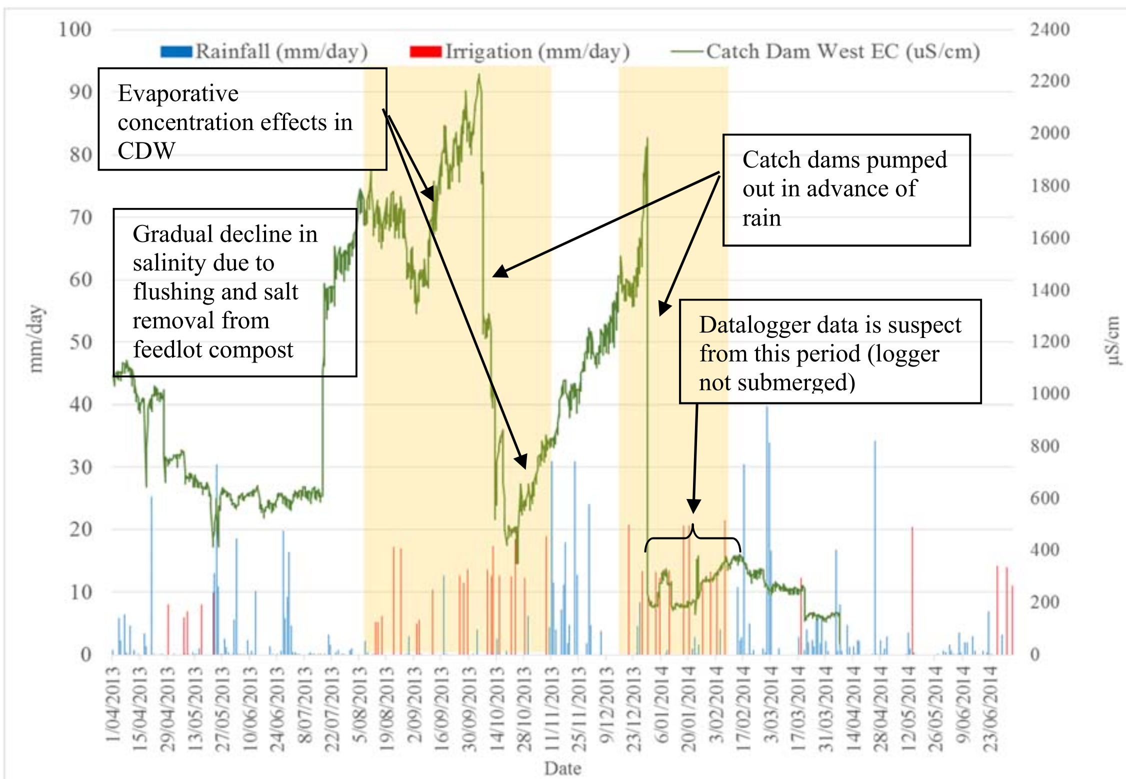


Figure 3.9: Catch dam EC profile in conjunction with rainfall/runoff and timing of antecedent irrigation events (salt load)

The main observations from Figure 3.9 show:

- EC maximum is only just above the EC of the blended water applied to the 12 ha;
- The shaded area (gold) shows periods of relatively higher intensity irrigation and the fact that we apply 25 mm over 25-30 hours would mean that very little moisture would reach lower depths (application rate < 1 mm/hr);
- Rainfall 'pushes' salts down the profile until the salt 'backs up' (in the upper 40 cm) resulting in surface runoff to catch dams after significant rainfall events;
- There is a strong evaporation effect (i.e. increase in EC) evident in the residual dam water during spring and summer (periods of no runoff); and
- There is a gradual decline in salinity in CDW over the monitoring period due to flushing and the salt removal resulting from the application of composted feedlot manure before irrigation began.

3.7.5. Summary

In summary, the key findings of section 3.7 are:

1. The Avon River catchment responds rapidly to significant rainfall due to poorly drained soils on cleared slopes, resulting in low EC runoff (after initial salinity spike);
2. Piezometer EC (soil-water measured in the field) and leaching fraction (based on both rainfall and irrigation) estimates (calculation) were found to reside in a similar range (~1.5 – 5.0 dS/m);
3. Salinity in CDW has been generally decreasing since the commencement of the irrigation program. The application of composted feedlot manure prior to the irrigation trial resulted in a salt loading of ~1000 µS/cm at the commencement of the program. In addition, several salinity spikes in CDW have been recorded during the irrigation period due to minimal water being kept in the catch dams. During drier periods this residual water evaporates and higher salinity water stagnates in base of the dams.
4. The net mass balance for the period is near zero which suggests that salts are accumulating in the soil profile however they are not at a level detrimental to soil structure or crop growth at this time.

4. Performance of soils on the Stage 1A irrigation area

This report (Report 4) was prepared after blended irrigation water was applied to the trial area and after the collection of Baseline 5 soil samples in May 2014.

4.1. Soil analysis parameters

The Stage 1A soil analysis program covers measurement of the parameters shown in Table 4.1

Table 4.1 – Soil analysis parameters

Parameter	Measurement Units
Chlorides	mg/kg
Electrical Conductivity - Soil:water (1:5)	dS/m
pH (1:5 water)	-
pH (1:5 $CaCl_2$)	-
Organic Carbon (OC)	%
Nitrate Nitrogen (NO_3)	mg/kg
Phosphorus (Colwell)	mg/kg
Phosphorus Buffer Index (PBI-Col)	-
Sulphur	mg/kg
Copper	mg/kg
Zinc	mg/kg
Manganese	mg/kg
Iron	mg/kg
Boron	mg/kg
Potassium	mg/kg, meq/100g
Calcium	mg/kg, meq/100g
Magnesium	mg/kg, meq/100g
Sodium	mg/kg, meq/100g
Aluminium	mg/kg, meq/100g
Potassium %	%
Calcium %	%
Magnesium %	%
Sodium %	%
Aluminium %	%
Effective Cation Exchange Capacity (ECEC)	meq/100g
Calcium/Magnesium Ratio	-
Soil texture	-
Soil colour	-
Physical analysis: (bulk density, porosity, and infiltration rate)	-

The 16 soil sampling locations were chosen to sample representative soils in each of the 16 plots that comprise the Stage 1A area. At each location soils are sampled at 20 cm depth intervals to a depth of 1.2m or until refusal on weathered rock. The sampling locations within those plots that have been slotted to different depths are all located within the constructed slots.

The reason for sampling within the slots is to assess where the salinity is migrating to in the profile. It is known that most of the irrigation and moisture is concentrated in the slots so the soil sampling to assess salinity trends is also within the slots.

4.2. Baseline 5 – Amended soil sampling and test results

The 16 soil sampling locations (CS1-CS16) were re-sampled on the 19 May 2014 and subsequently analysed. The location of these 16 sampling sites is shown in Attachment 1. These 16 vertical soil locations have been at the same location since the baseline sampling program in early 2013. Soil sampling is within each of the slots where slots are present within the plot. Soil samples were taken manually using a hand auger to the depths dictated by the different treatments in order to minimise disturbance. The full suite of desired samples was extracted (a sample is taken at 20 cm intervals at every location to a maximum depth of 120 cm). At some locations there is refusal on shallow weathered rock hence there is not full coverage to 120 cm.

The summarised soil test results are shown in Attachment 3 together with the full sample results from each of these 16 sampling locations.

4.3. Key findings – Baseline 5 (irrigated soils) vs Baseline 4 (irrigated soils)

The changes in average values between Baseline 5 and Baseline 4 (November 2013) are shown in Attachment 4. In addition, Baseline 5 is also compared against Baseline 1 (parent soil) values.

Salinity (as EC)

As discussed in Report 2, the salinity 'spike' resulting from the use of compost and the mixing of layer 3 of the parent soil has subsided. However average Baseline 5 data indicates an increase in EC at all depths greater than 20 cm compared to Baseline 4 results (refer Figure 4.1 and Figure 4.2).

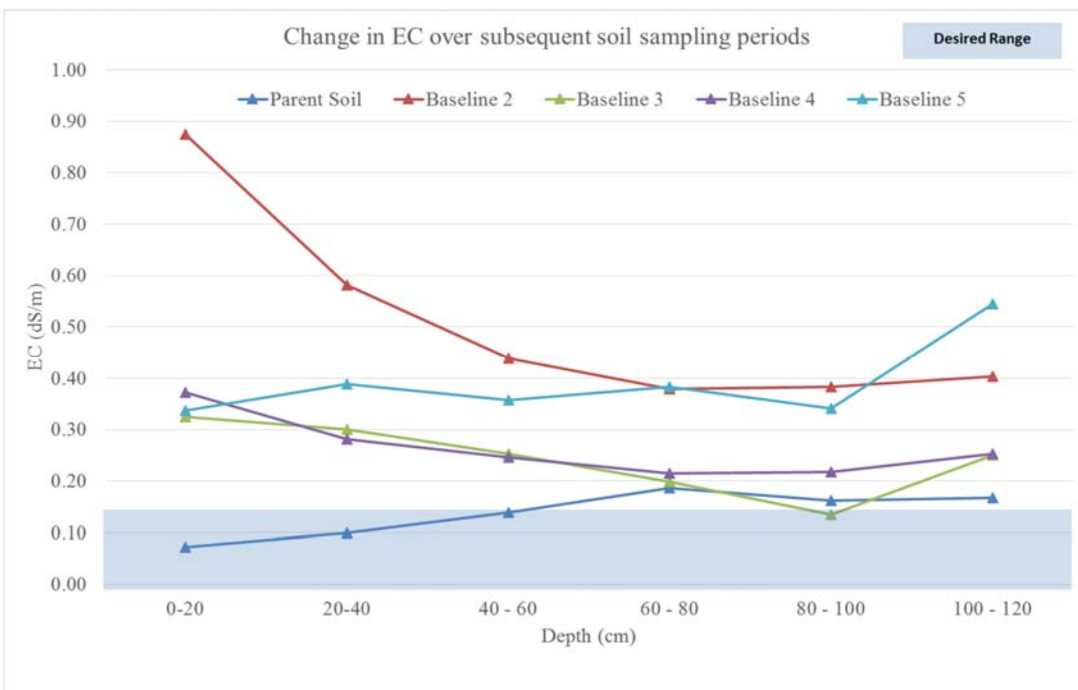


Figure 4.1: Change in (average) EC for all sites over subsequent sampling periods

Figure 4.2 shows change in EC over subsequent sampling periods for a single site (CS3 with a treatment depth of 1200 mm). Salinity has increased at depths greater than 60 cm since the Baseline 4 sampling event in November 2013.

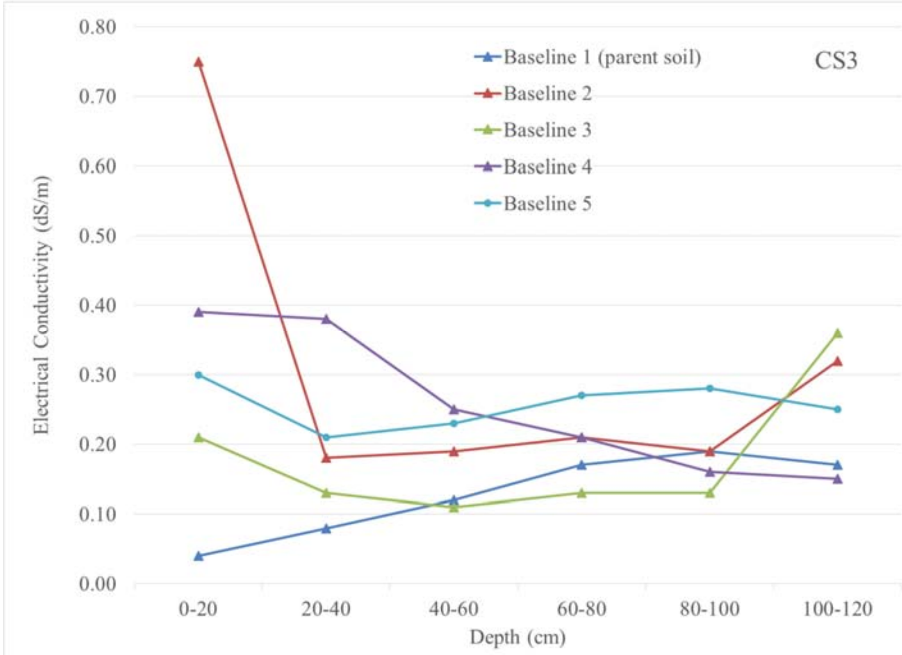


Figure 4.2: Change in EC for site CS3 (treatment depth = 1200 mm) over subsequent sampling periods

Sodium and Exchangeable Sodium Percentage (ESP)

The average sodium values have slightly increased at all depths and as a result the exchangeable sodium percentages have also increased. These percentages were above the desirable level of < 6 % to 80 cm depth (refer to the composite changes shown in Figure 4.3). Soil ESP increased from Baseline 4 results at all depths however is still below Baseline 1 values (Parent soil). Additional soil monitoring after a series of large rainfall events will clarify the effectiveness of deep leaching due to rainfall.

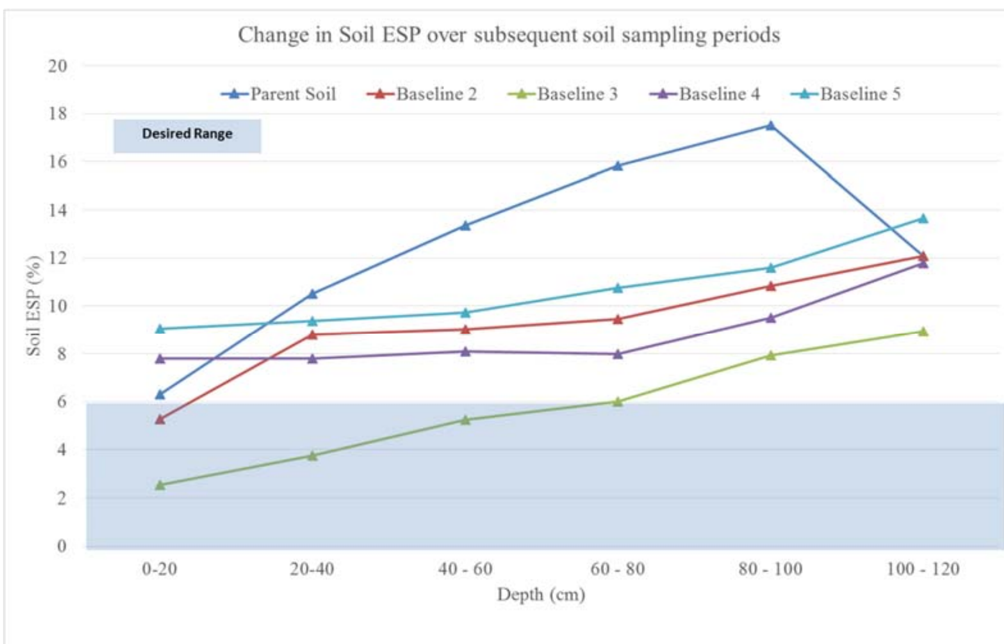


Figure 4.3. Change in Exchangeable Sodium Percentage (ESP)

Nitrate

Nitrate levels at all sites are very low due to crop uptake.

Calcium

Calcium levels remained stable and have contributed to minimising soil ESP increases.

Calcium/Magnesium Ratio

A Calcium/Magnesium ratio of around 2 is considered to represent an optimum balance for plant growth. The calcium/magnesium ratio has increased to the optimum balance at depth.

Effective Cation Exchange Capacity (ECEC)

The cation exchange capacities have stabilised near the surface at all sites due to the addition of lime after Baseline 2 (refer Figure 4.4). This favours healthy plant growth, as discussed in *2.1.4 Crop performance since planting.*

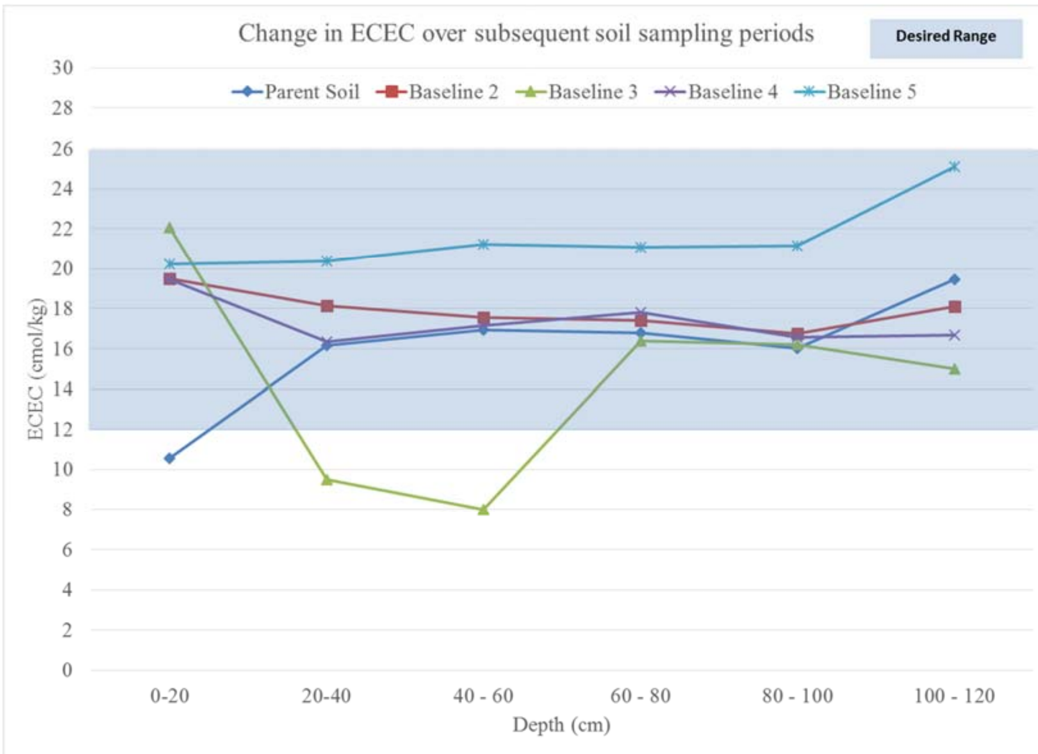


Figure 4.4: Change in (average) ECEC for all sites over subsequent sampling periods

Soil structure

Soil amendment and application of blended water has the potential to impact on soil structure. The Tiedman irrigation program has closely monitored soil structure, changes in soil chemistry, and the water quality of applied waters (irrigation and rainfall).

Maintenance of soil structure can be interpreted from the leaching dynamics between Baseline soil sampling campaigns. For example, the first 5 columns (in blue) in Table 4.2 show average results for Baseline 1 (B1), Baseline 2 (B2), Baseline 3 (B3), Baseline 4 (B4) and Baseline 5 (B5). The 5 middle columns (in yellow) show the relative difference between each Baseline. The last 5 columns (in grey) show the relative difference between each Baseline compared to Baseline 1 (Parent soil).

Table 4.2 – Leaching dynamics between Baseline soil surveys

Changes in Na (mg/kg)													
cm	B1	B2	B3	B4	B5	B2-B1	B3-B2	B4-B3	B5-B4	B2-B1	B3-B1	B4-B1	B5-B1
0-20	135	239	128	342	407	104	-111	213	66	104	-7	207	272
20-40	381	356	153	273	423	-25	-203	121	150	-25	-228	-108	42
40 - 60	527	361	181	306	464	-166	-180	125	158	-166	-346	-221	-63
60 - 80	606	383	220	331	524	-223	-163	112	193	-223	-387	-275	-82
80 - 100	643	426	298	367	567	-217	-129	69	201	-217	-345	-276	-76
100 - 120	624	501	308	456	784	-123	-193	148	328	-123	-316	-168	160
Changes in ESP (%)													
cm	B1	B2	B3	B4	B5	B2-B1	B3-B2	B4-B3	B5-B4	B2-B1	B3-B1	B4-B1	B5-B1
0-20	6.2	5.3	2.5	7.8	9.0	-0.9	-2.8	5.2	1.3	-0.9	-3.7	1.6	2.8
20-40	10.5	8.6	3.8	7.8	9.4	-1.9	-4.8	4.0	1.6	-1.9	-6.7	-2.7	-1.1
40 - 60	13.5	8.9	5.2	8.1	9.7	-4.6	-3.7	2.9	1.6	-4.6	-8.3	-5.4	-3.8
60 - 80	15.7	9.6	6.0	8.0	10.8	-6.1	-3.5	2.0	2.8	-6.1	-9.7	-7.7	-5.0
80 - 100	17.4	11.1	7.9	9.5	11.6	-6.4	-3.1	1.6	2.1	-6.4	-9.5	-7.9	-5.8
100 - 120	13.9	12.0	8.9	11.8	13.7	-1.9	-3.1	2.9	1.9	-1.9	-5.0	-2.2	-0.3
Changes in Ca (mg/kg)													
cm	B1	B2	B3	B4	B5	B2-B1	B3-B2	B4-B3	B5-B4	B2-B1	B3-B1	B4-B1	B5-B1
0-20	570	2364	2981	2351	2439	1794	617	-630	88	1794	2411	1781	1869
20-40	360	1456	2094	1586	1783	1096	638	-508	197	1096	1734	1226	1423
40 - 60	259	1243	1385	1361	1421	984	142	-25	60	984	1126	1102	1161
60 - 80	292	1088	1075	1219	1420	796	-14	144	201	796	783	927	1128
80 - 100	165	943	443	1106	1249	779	-500	663	143	779	278	941	1084
100 - 120	147	903	370	897	1773	756	-533	527	876	756	223	750	1626
Changes in Mg (mg/kg)													
cm	B1	B2	B3	B4	B5	B2-B1	B3-B2	B4-B3	B5-B4	B2-B1	B3-B1	B4-B1	B5-B1
0-20	625	1135	688	655	664	510	-447	-33	8	1135	687	655	39
20-40	1360	1337	801	797	1077	-23	-536	-4	280	1337	801	797	-283
40 - 60	1520	1507	884	982	1281	-12	-623	98	299	1507	884	982	-239
60 - 80	1449	1519	1033	1087	1262	71	-487	54	176	1519	1032	1087	-186
80 - 100	1420	1446	1279	1089	1369	26	-168	-190	280	1446	1279	1089	-51
100 - 120	1360	1434	1183	1195	1491	74	-252	13	296	1434	1183	1195	131
Changes in Ca/Mg													
cm	B1	B2	B3	B4	B5	B2-B1	B3-B2	B4-B3	B5-B4	B2-B1	B3-B1	B4-B1	B5-B1
0-20	0.7	2.1	2.8	2.3	2.3	1.5	0.7	-0.6	0.1	1.5	2.2	1.6	1.7
20-40	0.2	0.9	1.8	1.4	1.1	0.8	0.9	-0.4	-0.3	0.8	1.6	1.3	0.9
40 - 60	0.1	0.8	1.0	0.9	0.7	0.7	0.2	-0.1	-0.3	0.7	0.9	0.8	0.6
60 - 80	0.1	0.7	0.7	0.8	0.7	0.6	0.0	0.1	-0.1	0.6	0.6	0.7	0.5
80 - 100	0.1	0.6	0.2	0.8	0.5	0.5	-0.4	0.6	-0.2	0.5	0.2	0.7	0.5
100 - 120	0.1	0.4	0.2	0.5	0.7	0.4	-0.2	0.3	0.2	0.4	0.1	0.4	0.6
Rainfall (mm)	528	82	113	273	213	82	113	273	213	82	113	273	213
Irrigation (mm)	0	0	39	276	187	0	39	276	187	0	39	276	187

Key: B1 = Baseline 1 soil sampling, B2 = Baseline 2 soil sampling, B3 = Baseline 3 soil sampling, B4 = Baseline 4 soil sampling, B5 = Baseline 5 soil sampling

Table 4.2 indicates that, when compared to B1, sodium (Na^+) generally decreased for B2 and B3 then increased in B4 and again in B5. Similar trends can be observed in the soil ESP results which are a result of the balance between Na^+ and Calcium (Ca^{2+}) and Magnesium (Mg^{2+}). Importantly, both Ca^{2+} and Mg^{2+} remained relatively stable throughout the profile and their presence maintains soil ESP. Even though soil Na^+ increased from B3 to B4 to B5, the B5 results still remain less than B1 results (parent soil) at this time. Also, the Ca/Mg ratio has generally increased due to the previous addition of ameliorants and significantly, both cations have minimised Na^+ accumulation by preferentially occupying exchange sites in the soil.

Another key to maintaining soil structure is the sodium adsorption ratio (SAR) of applied waters (irrigation and rainfall) and the subsequent impact on clay dispersion or flocculation. Clay dispersion is one end of diffuse double layer (DDL) theory where clay particles separate into single platelets; clay particle flocculation is where many platelets align together to form clusters. Both depend on the electrolyte concentration of the applied waters and the antecedent ESP of the receiving soil (refer Chapter 2 in Lucas, 2009).

The degree of clay dispersion that may occur has a direct effect on permeability and, as a result, downward soil water movement. Therefore maintaining clay (micro-aggregate) stability will promote suitable infiltration rates. Lucas (2009) describes the soil ESP/effluent SAR continuum for micro-aggregate/soil pore stability which predicts clay particle behaviour in a soil of known ESP and irrigated with a water of known SAR.

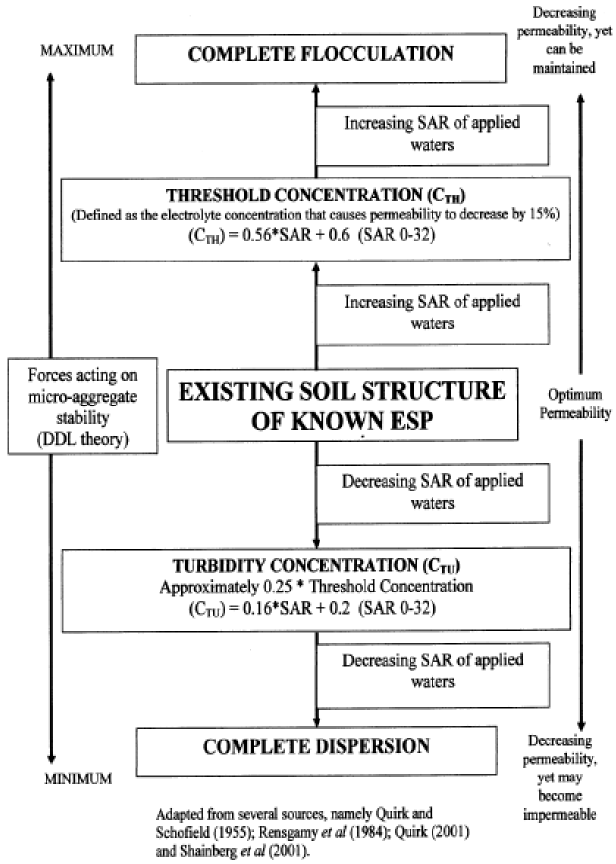


Figure 4.2 Soil ESP/effluent SAR continuum for micro-aggregate/soil pore stability (from Lucas, 2009)

Different electrolyte concentrations from blended irrigation water and from rainfall will initiate changes in clay particle behaviour (flocculation to dispersion) in the receiving soil over time. For example, the average soil ESP in the upper 40 cm of the soil profile was 9.2 in Baseline 5. The SAR of irrigation waters was approximately 12.9 during the same period. Based on the equation in Figure 4.2, the threshold concentration (C_{TH}) that maintains micro-aggregate stability would be:

$C_{TH} = (0.56 \times 9.2) + (0.6) = 5.8$

Note that the ESP = SAR between 0-32 and soil ESP is used in the equations in Figure 4.2. The applied blended water with a SAR of 12.9 exceeds the C_{TH} indicating that while soil structure would be maintained there would be a small (expected) decrease in infiltration rate.

Since the beginning of the irrigation program and in view of (recent) increasing soil ESP at the Gloucester site, has soil structure been significantly altered? Figure 4.3 conceptually shows the predicted susceptibility of clay dispersion (loss of soil structure) over time from irrigation with blended water and rainfall. The columns represent soil ESP at 0 – 40 cm depth and is an average of all soil sites (CS1 – CS16). The C_{TU} (red solid line) and C_{TH} (green solid line) are based on soil ESP and equations in Figure 4.2 and, similar to soil ESP, also fluctuate over time. The purple dotted line represents the SAR of blended water applied to the site (variable SAR) and the light blue dotted line represents the SAR of rainfall (relatively constant SAR).

How to read Figure. 4.3:

1. Both the C_{TU} and C_{TH} lines will move up or down dependent on soil ESP, but the C_{TH} will always be the same distance above the C_{TU} and provides a "zone" of optimum permeability and stable soil structure;

2. Blended water SAR is highly variable while rainfall SAR remains relatively constant. Note: Rainfall will cause the most damage to a high ESP soil (> 18 in this case as the C_{TU} and rainfall SAR would then be the same and dispersion will follow);

3. At current soil ESP values the soil structure is being maintained but towards the C_{TH} end of the continuum. Further increases in soil ESP will trend towards poorer soil structure under the existing irrigation/rainfall regime.

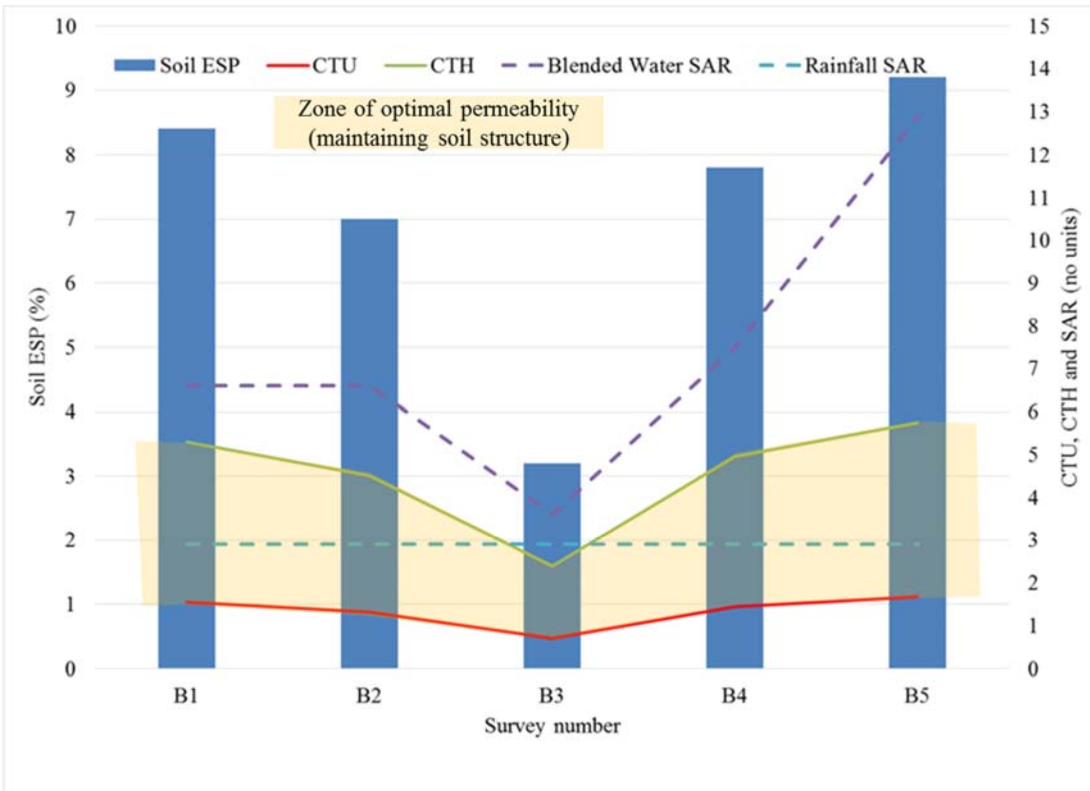


Figure 4.3: Conceptualisation of predicted susceptibility of clay dispersion from irrigation with blended CSG water and rainfall

Problems may occur if Na^+ is allowed to accumulate over time as the soil ESP would gradually rise and micro-aggregate/soil pore stability would be reflected in the changing C_{TH} and C_{TU}. For example, if soil ESP increased to 20 % in the upper 40 cm of the soil profile then the corresponding C_{TH} and C_{TU} would be 12.6 and 4.2. This means that rainfall would cause complete dispersion of surface micro-aggregates that would block soil pore spaces and severely reduce infiltration in the upper 10 cm of the soil profile.

It is important to note that as ESP increases, the electrolyte concentration of the applied solution must also increase to maintain optimum permeability. For example, Davidson and Quirk (1961) demonstrate the impact of changing the electrolyte concentration of irrigation waters, using Riverina clay (60% clay, pH=7.4, ESP=23) near Deniliquin, NSW. The soil was irrigated with waters that had an electrolyte concentration slightly higher than the C_{TH} (point A in Figure 4.3) and with Murrumbidgee River water, which was approximately half the C_{TU} (point B in Figure 4.3). In the first case, the 7.5 cm of water applied was observed to have permeated completely into the soil after 16 hours (Quirk, 2001). In contrast, large volumes of the Murrumbidgee water remained pooled on the surface after a similar time period.

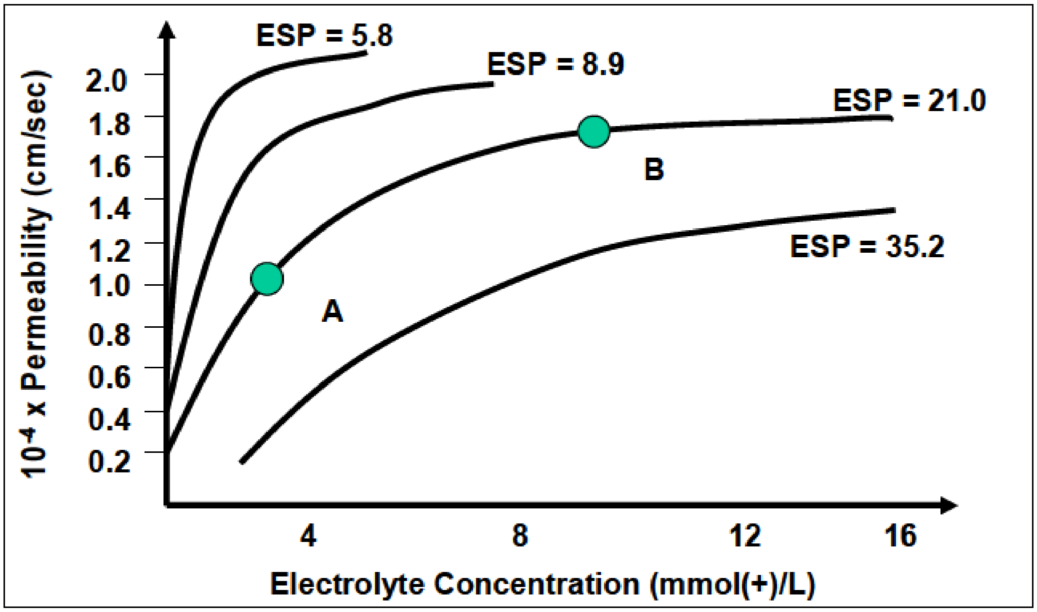


Figure 4.3: Permeability as a function of electrolyte concentration and soil ESP (Lucas, 2009)

Quirk (2001) states that when the irrigation water electrolyte concentration exceeds the C_{TH}, the soil appears granular and dries to a friable state (flocculated). Conversely, when irrigation water electrolyte concentration is less than the C_{TU}, the surface soil appears white (dispersed clay particles) and water remains pooled on the surface for extended periods (Quirk, 2001). Figure 4.3 shows permeability of a soil (same soil but with ESP's of 5.8, 8.9, 21 and 35 %) as a function of electrolyte concentration and soil ESP.

From the graph it can be seen that at low electrolyte concentrations (< 2 mmol(+)/L) all soils (of varying soil ESP) decrease in permeability. This is due to the electrolyte concentration being less than the C_{TU} and clay dispersion occurs. Dispersed clay particles translocate downwards through the soil profile and block soil pores in the upper 10 cm, resulting in a significant decrease in permeability.

At higher electrolyte concentrations (> 4 mmol(+)/L) greater permeability can be maintained. This is due to the electrolyte concentration being greater than the C_{TH} and a shift to clay flocculation occurs. Flocculated clay particles, while creating smaller pore spaces, can facilitate downward water movement through the soil profile to promote a leaching regime. Figure 4.3 also shows how soil permeability decreases with increasing soil ESP.

Note: therefore, the aim of managing soil structure is about creating a leaching regime that allows the removal of excess Na^+ from the soil profile. Table 4.2 highlighted the dynamic leaching of Na^+ and the relatively stable presence of Ca^{2+} and Mg^{2+} and is mainly due to the seasonal rainfall patterns at Gloucester and optimising irrigation application at appropriate times (by water balance calculation).

The soil structure in Stage 1A has significantly improved from the amendments (Baseline 2) however there are increasing soil EC and soil ESP trends after 14 months of irrigation that need to be addressed through a leaching management strategy.

Consulting agronomist to AGL, MNC Agronomy, observed that:

"Soil structure has continued to improve, with heavier soil type areas (high clay %) becoming less noticeable in the top of the soil profile." MNC Agronomy, March/April 2014 Monthly Agronomy Report

4.4. Natural soil characteristics

Independently of Fodder King, Parsons Brinckerhoff completed a survey of the mineral content of shallow soils across the whole of the Tiedman property in April 2014 (Parsons Brinckerhoff, 2014b). This report indicated that aluminium and iron were the highest metal concentrations in the natural soils across the property. Of the major cations, sodium was the most abundant and the highest concentrations observed were within the Stage 1A and Stage 1B irrigation areas.

For the trace metals the concentrations were low with the different trace metals varying in concentration from site to site.

4.5. Soil profile descriptions

In March 2014 a series of inspection pits were excavated and examined to monitor soil and crop performance in the Stage 1A area. Eight inspection pits were completed and detailed soil profile descriptions, along with high resolution photographs, are provided in Attachment 6.

As part of the new TIP REF approval conditions, this 6-monthly compliance report needs to include:

- Detailed soil profile descriptions, including high resolution photos of soil profiles; and
- Description of soil structure, soil colour and mottles

These aspects are all included in the Stage 1A soil profile descriptions that is included as Attachment 6.

4.6. Electromagnetic Survey Results

The results of the second electromagnetic (EM) survey will be issued as an addendum to this report. The first EM31 survey was completed in June 2011 and the results are presented in Fodder King, 2011.

5. Performance of soils on the Stage 1B irrigation area

5.1. Irrigation area

The area selected for the Stage 1B area has no previous history of cropping or substantial soil improvement, although improved pasture was briefly irrigated in 2009 when small amounts of produced water were irrigated under an earlier REF approval (details provided in AGL, 2010). Some soil sampling and monitoring was completed as part of this earlier irrigation program.

The Stage 1B area is approximately 4.1 hectares in area and is located to the south of the Stage 1A trial area. The Stage 1B irrigation area is shown in Attachment 2. A single composite soil sample was prepared from a series of samples collected along diagonal transects across plots AL1/2 and AL3/4 respectively. The same transect has been used each sampling round to assess salinity changes in the shallow soil profile. Soil samples were taken manually using a hand auger to a depth of 200mm in order to minimise disturbance.

5.2. Baseline 4 – amended soil sampling and test results

A soil composite sample was taken on the 19 May 2014 and subsequently analysed. Soil samples were taken (transect approach) manually using a hand auger (to 200 mm soil depth) in order to minimise disturbance. The full suite of desired samples was extracted. The summarised soil test results are shown in Attachment 5 together with the full sample results from each of the sampling locations.

5.3. Key findings – Baseline 4 (irrigated soils) vs Baseline 3 (irrigated soils)

Baseline 4 (irrigated soil) vs Baseline 3 (irrigated soil) key findings include (to 200 mm):

- Decrease in soil EC (0.26 to 0.24 dS/cm)
- Increase in soil pH ($CaCl_2$) (4.98 to 5.4)
- Increase in soil ESP (15 % to 16.7 %) because Na^+ increased and Ca^{2+} and Mg^{2+} remained stable
- Organic carbon remained similar to Baseline 3 at around 2.9 %
- Ca^{2+} slightly increased from 898 to 1056 mg/kg
- ECEC slightly increased from 10 to 11.4 meq/100g

These increases in shallow soil attributes are due to the application of blended irrigation waters with relatively high sodium concentrations and relatively high pH. There was no deep leaching and limited rainfall during the monitoring period to reduce these salt increases in the shallow profile.

5.4. Key findings – Baseline 4 (irrigated soils) vs Baseline 1 (parent soil)

Baseline 4 (irrigated soil) vs Baseline 1 (parent soil) key findings include (to 200 mm):

- Increase in soil EC (0.21 to 0.24 dS/cm)
- Increase in soil pH ($CaCl_2$) (4.63 to 5.4)
- Decrease in soil ESP (17 % to 16.7 %)
- Organic carbon remained similar to Baseline 1 at around 2.9 %
- Ca^{2+} increased from 431 to 1056 mg/kg due to lime addition
- ECEC increased from 6.3 to 11.4 meq/100g

6. Sedimentation, runoff and erosion control

A number of environmental protection measures were installed across the Stage 1A irrigation area to ensure that bare soils were not eroded during rainfall events and to ensure that soil and sediment was retained within the irrigation plot areas.

6.1. Protection measures

The following sedimentation, runoff and erosion control protection measures were installed for the Stage 1A trial irrigation area.

- Trial plot bunding and drainage to catch dams;
- Diversion banks to catch all runoff from the trial plots and divert it to the catch dams;
- Two catch dams with pumps and recycling pipework to collect any runoff from the trial area and recycle it back to the storage dam;
- Modern overhead spray irrigation system;
- Diversion drains to prevent the possibility of any overland runoff entering the trial area; and
- Spray-grassing of all structures.

The environmental protection measures were supplemented by the following monitoring locations which are in place to minimise sediment runoff and subsurface water migration:

- 10 soil moisture monitoring positions;
- Seven paired sets of piezometers to monitor for soil water (ephemeral and permanent)
- One pair of piezometers to monitor for sub-surface leakage from the western catch dam;
- Six rain gauges; and
- An automatic weather station.

6.2. Summary of weather and irrigation applied

The key information relevant to the performance of the sedimentation, runoff and erosion control measures during the reporting period is shown in Table 6.1.

6.2.1. Rainfall

Rainfall for the reporting period totalled 303.4 mm, as recorded by the AGL weather station on Tiedmans. This compares with a total of 299.2 mm recorded at the Bureau of Meteorology (BOM) site at Gloucester Post Office (site no 60015). January rainfall was 92 % less than the mean, February rainfall was 58% less than the mean, March rainfall was 14 % above the mean, April was 26 % less than the mean, May was 84 % below the mean and June (including to 4th July) was 64 % less than the mean. Total rainfall for the period (303.4 mm) was 47 % less than the mean (577.4 mm) for the period.

6.2.2. Rain days

Out of the 181 days in the reporting period, 73 days (40 %) were wet. A wet day occurred when 0.2 mm (or more) of rainfall was registered in the Tiedmans weather station rain gauge.

6.2.3. Rainfall intensity

All of the rain events that occurred during the period were below the threshold level of 24.9 mm/hour which defines a 1 in 1 year rainfall event at Tiedmans. See FK (2012) *Soil Quality Monitoring and Management Program – Tiedman irrigation trial*. The highest hourly rainfall intensity rate was 21.2 mm/hour, which occurred on the 16/02/2014.

6.2.4. Blended water irrigation

Blended water irrigation occurred in all months except April when no water was irrigated.

Table 6.1 - Key weather and irrigation information

Key information	January	February	March	April	May	June-July4th	Total for period
Rainfall							
AGL weather station (mm)	6.6	58.2	126.4	77.0	9.4	25.6	**303.4 mm**
Bureau of Meteorology Gloucester Post Office (mm)	9.2	51.8	146.4	56.8	10.4	24.6	**299.2mm**
Mean monthly rainfall at Gloucester Post Office (mm)	114.0	122.8	127.8	77.1	67.5	68.2	**577.4 mm**
Number of rain days (≥ 0.2mm recorded)	6	12	15	17	8	15	**73**
Percentage rain days	19 %	43 %	48 %	57 %	26 %	50 %	**40 %**
Highest rainfall days	2.8 mm (23/01/14)	30.4 mm (17/02/14)	39.8 mm (1/03/14)	34.2 mm (25/04/14)	3.6 mm (12/05/14)	7.0 mm (22/06/14)	**39.8 mm (1/03/14)**
Highest hourly rainfall rate (mm/hr)	1.6mm/hr (23/01/14)	21.2mm/hr (17/02/14)	5.4mm/hr (2/03/14)	10.6mm/hr (4/04/14)	2.2mm/hr (12/05/14)	2.6mm/hr (28/06/14)	**21.2mm/hr (16/02/14)**
Blended water irrigation application	105.7 mm	34.7 mm	12.3 mm	0mm	20.4 mm	39.3 mm	**212.4 mm**
Total applied water (rainfall plus blended water)	112.3 mm	92.9 mm	138.7 mm	77.0 mm	29.8 mm	65.1 mm	**515.8 mm**
Blended water salinity	1540 µS/cm	1540 µS/cm	1540 µS/cm	1540 µS/cm	1540 µS/cm	1540 µS/cm	**1540 µS/cm**

6.3. Performance under rainfall and irrigation

The combined application of rainfall and blended water irrigation totalled 515.8 mm, which is approximately 11% lower than the mean rainfall for Gloucester (refer Table 6.1).

6.3.1. Trial plot bunding and drainage to catch dams

All plot bunds performed to design requirement during the period. Some small non-draining low lying areas occurred at the inside corners of some of the northern plots but the area affected was not considered to be significant enough to warrant any remedial measures.

6.3.2. Diversion banks to catch runoff from the trial plots and divert it to the catch dams.

All diversion banks performed satisfactorily during the monitoring period.

6.3.3. Two catch dams with pumps and recycling pipework

Both Catch Dam 1 (CDE) and Catch Dam 2 (CDW) operated to design requirements. Water collected in the catch dams was pumped back to the blended water dam (TSD) on the Tiedman property.

6.3.4. Overhead spray system

The irrigation system was managed in accordance with the operating procedures and blended water was applied when there was sufficient deficit available in the soil profile.

6.3.5. Diversion drains

All diversion drains operated satisfactorily during the period and erosion had not occurred due to grassing of the drains and installation of silt traps at regular intervals.

6.3.6. Spray-grassing of all structures

All bund walls, diversion banks and diversion drains have a well-established grass cover and are mowed to ensure that there are no flow blockages.

The grassed aprons in front of the catch dams, in conjunction with geo-fabric netting, have prevented any erosion from occurring as well as preventing any siltation of the dams.

7. Stage 1A critical control point monitoring and response plan

7.1. Critical Control Points

The following critical control points were nominated in the soil quality monitoring and management plan. Full details are provided in Fodder King (2012) *Soil Quality Monitoring and Management Program – Tiedman irrigation trial*.

Table 7.1: Stage 1A Irrigation Area Critical control points

Critical Control Point	Hazard	Trigger	Response	Mitigation	Risk
CSG Dam and Mixing Dam	Brackish overflow to landscape	Excessive rainfall	Record and report lost volume from storages	Continual monitoring of dam depth and salinity with maintenance of adequate freeboard	Low
Catch Dams	Brackish overflow to landscape	Excessive rainfall or irrigation	Keep dams empty at all times. Record and report lost volume from storages + halt irrigation	Continual monitoring of dam depth and salinity	Low
Soil moisture monitoring system	System failure	Sensor fault	Halt irrigation	Replace defective sensors	Low
Shallow piezometer water level	Perched water tables	Excessive rainfall and/or over-irrigation	Adjust irrigation rates	Review irrigation schedule	Low
Ameliorated soil in the irrigation area (1)	Increasing salinity	Soil salinity increase of more than 50% above the average value of the new baseline for the ameliorated soils	Review with agencies and if necessary: • Increase dilution of CSG water. • Adjust irrigation rates. • Install collection and recycling system.	6 monthly soil sampling	Low
Non - ameliorated parent soil (2)	Increasing salinity	Soil salinity increase of more than 50% above the average value of 0.12 dS/m (1:5) in the root zone to 1m depth	Review with agencies and if necessary: • Compare against external control site • Increase dilution of CSG water. • Adjust irrigation rates.	6 monthly soil sampling	Very Low

Key (1) – across the 16 ameliorated soil sampling sites.
(2) – across 5 proposed parent soil locations (four internal sites within each of the 4 soil treatment types plus one external control site

Approximately 25.49 ML of blended irrigation water was applied across the Stage 1A area during this reporting period compared to the previous reporting period where 32.45 ML was applied.

There were no events that triggered an operational response. Each of the Critical Control Points in Table 7.1 are discussed below.

7.2. CSG water dam and mixing dam

During the reporting period there were no trigger events and consequently there was no brackish water overflow to the landscape from the Tiedman storage dams.

7.3. Catch Dams

During the reporting period water levels in the two catch dams were kept low in order to collect any first flush run-off from the Stage 1A irrigation area. As a result of the ongoing monitoring of the daily water balance a soil water buffer storage volume was maintained at all times to minimise the risk of run-off occurring. When run-off was collected in the catch dams, float-activated pumps recycled this water back to the blended water dam (Tiedman South dam).

There was one overflow event in March 2014 after a period of heavy rain. The water that discharged as overland flow was low salinity (Parsons Brinckerhoff, 2014c). Consequently there was no overflow of brackish water to the landscape.

7.4. Soil moisture monitoring system

There were no system failures to the soil moisture monitoring system. One of the moisture probes will need to be repaired to solve a problem with intermittent readings but this is considered to be a minor maintenance issue.

7.5. Shallow piezometer water level

The soil piezometers within the Stage 1A irrigation area generally contained more water than the corresponding piezometers in the non-ameliorated and non-irrigated parent soil. This is due to the substantially improved infiltration rate of the ameliorated soils inside the trial area, resulting in the promotion of downward movement of water into the soil (to treatment depth), rather than surface runoff which would occur in the parent soils. Most piezometers accumulated water during high rainfall however piezometer water level trends indicate that this water either percolated to a lower depth in the soil over time and/or was taken up and transpired by plants.

7.6. Ameliorated soil in the irrigation area

Following on from Report 3, there has been a general increase in average soil EC (see Table 7.2).

Table 7.2 – Percentage change in average soil salinity between Baselines

			Percentage change between Baselines
	Baseline 2 EC	**Baseline 3 EC**	
Weighted average salinity (dS/m)	0.58	0.26	**-55%**
	Baseline 3 EC	**Baseline 4 EC**	
Weighted average salinity (dS/m)	0.26	0.28	**8%**
	Baseline 4 EC	**Baseline 5 EC**	
Weighted average salinity (dS/m)	0.28	0.37	**32%**
	Baseline 2 EC	**Baseline 4 EC**	
Weighted average salinity (dS/m)	0.58	0.28	**-52%**
	Baseline 2 EC	**Baseline 5 EC**	
Weighted average salinity (dS/m)	0.58	0.37	**-36%**

Note: Weighted average salinity is calculated by taking the EC value at each depth interval and assigning a weighting based on the number of samples taken at that interval, repeated for all intervals and totalled.

However, as shown in Table 7.2, the percentage changes in the weighted average EC values between Baselines 2, 3, 4 and 5 have not exceeded the trigger point of a 50 % increase in EC over Baseline 2 (ameliorated soil).

The weighted average Baseline 5 EC was still 36 % below the Baseline 2 (ameliorated soil) EC.

7.7. Non-ameliorated parent soil

Two parent soil sampling points (PS1 and PS2) located downhill and outside of the western end of the irrigation area were selected and sampled as part of Baseline 5.

An A horizon (0-200 mm) and B horizon sample (600-800 mm) was extracted and tested for EC as shown in Table 7.3.

Table 7.3 – Parent soil salinity outside irrigation area

Soil sample location	A Horizon (0-200 mm) (dS/m)	B Horizon (600-800 mm) (dS/m)
PS1	0.06	0.08
PS2	0.07	0.18
Average	0.065	0.13

The trigger point of 50% above the average value of 0.12 dS/m has not been exceeded.

8. Conclusions

A summary of conclusions, focussing on the Stage 1A area (the main focus of the Tiedmans Irrigation Trial) is provided below:

8.1. Stage 1A area

- A volume of 25.49 ML of blended water was irrigated across this area in the 6 months from 1 January to 4 July 2014
- Water balance management in conjunction with a number of environmental protective measures resulted in all blended water being consumed within the irrigation area.
- Salinity and sodium concentrations have increased at depths greater than 20 cm across all soil sampling sites in the Stage 1A area but have had a limited effect on improved soil structure at this time.
- Soil salinity for Baseline 5 is still below the ameliorated soil levels that were measured in Baseline 2.
- Soil piezometer behaviour indicates that there is no permanent soil water accumulating in the shallow soil profile due to irrigation activities.
- The Exchangeable Sodium Percentages (ESP) for Baseline 5 are generally lower than the parent soil but slightly above the ameliorated soil, indicating that, while sodium is being mobilised downwards through the ameliorated soil, its further movement may be limited by the lower infiltration rate characteristics of the deeper parent soils.
- Calcium and Magnesium levels have remained stable while the Sodium has been mobilised downwards, resulting in generally better soil quality for supporting crops, as measured by Effective Cation Exchange Capacity (ECEC).
- Soil structure has been significantly improved by amelioration and shows no indication of adverse effects, such as abnormal salinity or sodium accumulation, or clay particle dispersion, being caused by irrigation water.
- The net mass balance is close to zero, indicating that salts are accumulating in the soil profile but not at a level detrimental to soil structure or crop growth.
- The crops demonstrated healthy growth and yields under the application of blended water.

8.2. Stage 1B area

- A volume of 7.48 ML of blended water was irrigated across this area in the 6 months from 1 January to 4 July 2014.
- Crop usage has been carried out by grazing of the area with an acceptable stocking rate.
- Salinity (as EC) and sodium concentrations have increased at a higher rate (in the near surface) than in the Stage 1A area.
- Soil piezometer behaviour indicates that there is no permanent soil water accumulating due to irrigation.
- The Exchangeable Sodium Percentages (ESP) for Baseline 4 are now similar to the parent soil.
- Calcium and magnesium levels have remained stable, resulting in generally better soil quality for supporting crops, as measured by Effective Cation Exchange Capacity (ECEC).
- There has been a larger increase in salt accumulation in Stage 1B compared to Stage 1A.

References

AGL (2010) *Irrigation monitoring report for Stratford Pilot – Tiedman Property 2009.* AGL Upstream Gas.

AGL (2012) *Water Management Plan for the Tiedman Irrigation Program – Gloucester,* AGL Upstream Gas.

ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality Volumes 3 and 4.* Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra

Ayers, R.S & Westcot, D.W (1994) *Water quality for agriculture*. FAO Irrigation and Drainage Paper No 29, Rev 1. (FAO, Rome).

DECC (2004) *Environmental Guidelines: Use of Effluent by Irrigation*, NSW Department of Environment and Conservation, ISBN 1 74137 076 0.

Fodder King (2010) *Technical Assessment of land in the Gloucester Basin for irrigation of CSG water,* Report for AGL Upstream Investments Pty Ltd.

Fodder King (2011) *Preliminary Investigations and Design of an Irrigation Trial on land in the Gloucester Basin for irrigation of CSG water*, Report for AGL Upstream Investments Pty Ltd.

Fodder King (2012) *Soil Quality Monitoring and Management Program – Tiedman irrigation trial*, Report for AGL Upstream Investments Pty Ltd.

Fodder King (2013a) *Soil quality monitoring and management, Report 1- Pre irrigation (Activities to 31 March 2013),* Report for AGL Upstream Investments Pty Ltd.

Fodder King (2013b) *Soil quality monitoring and management, Report 2- Irrigation (Activities from 1 April to 30 June 2013),* Report for AGL Upstream Investments Pty Ltd

Fodder King (2014a) *Soil quality monitoring and management, Report 3- Irrigation (Activities from 1 July to 31st December 2013),* Report for AGL Upstream Investments Pty Ltd

Fodder King (2014b) *Summary Report 2 (Soil and cropping activities from 1st September 2013 to 31st March 2014),* Report for AGL Upstream Investments Pty Ltd

Lucas S.A (2009) Sodium flux in Woodlot Soils Irrigated with Treated Effluent: The Implications for Sustainable Irrigation and Soil Management, Lambert Academic Publishing, Saarbrucken, p195

Henderson L (2000) Soil Landscapes of the Dungog 1:100000 Sheet. Map and Report. Department of Land and Water Conservation

Parsons Brinckerhoff (2011) *Gloucester Exploration Program - Irrigation Proposal Review of Environmental Factors*, Report PR_5506 for AGL Energy Limited.

Parsons Brinckerhoff (2013) *Tiedman Irrigation Trial – August 2013 Water Compliance Report Gloucester Gas Project.* Report RPT 7408 Rev C to AGL Upstream Investments

Parsons Brinckerhoff (2014a) *Tiedman Irrigation Program - Water Compliance Report for the Period 1 July to 31 December 2013,* Report Rpt 7674 RevB to AGL Upstream Investments.

Parsons Brinckerhoff (2014b) *Tiedman Property Gloucester – Analysis of trace metals in soils and general soil chemistry*. 11 July 2014. AGL Upstream Investments.

Parsons Brinckerhoff (2014c) *Tiedman Irrigation Program - Water Compliance Report for the Period 1 January to 4 July 2014,* Report 2162406F-WAT-RPT-001 RevC to AGL Upstream Investments

Davidson, J. L. and Quirk, J. P. (1961). The influence of dissolved gypsum on pasture establishment on irrigated sodic clays. *Australian Journal of Agricultural Research.* **12**: 100-110.

Quirk, J. P. (2001). The significance of the threshold and turbidity concentrations in relation to sodicity and microstructure. *Australian Journal of Soil Research.* **39**: 1185-1217.

Attachments

Attachment 1 – Stage 1A area plot layout

Attachment 2 – Stage 1B area plot layout

Attachment 3 – Stage 1A Baseline 5 summary tables and soil test results

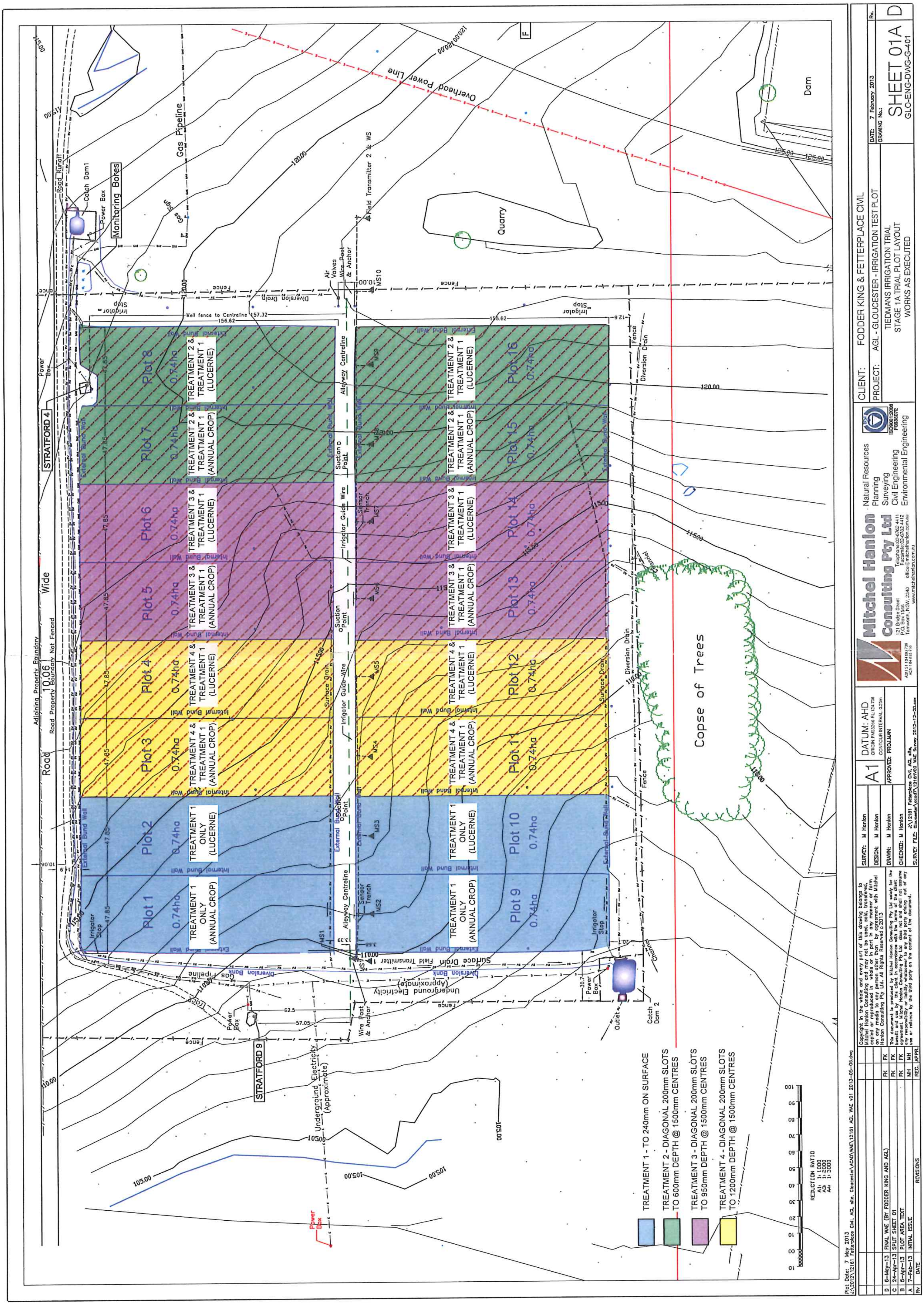
Attachment 4 – Stage 1A – Baseline 5 vs Baseline 4 comparisons

Attachment 5 – Stage 1B soil test summary tables and results

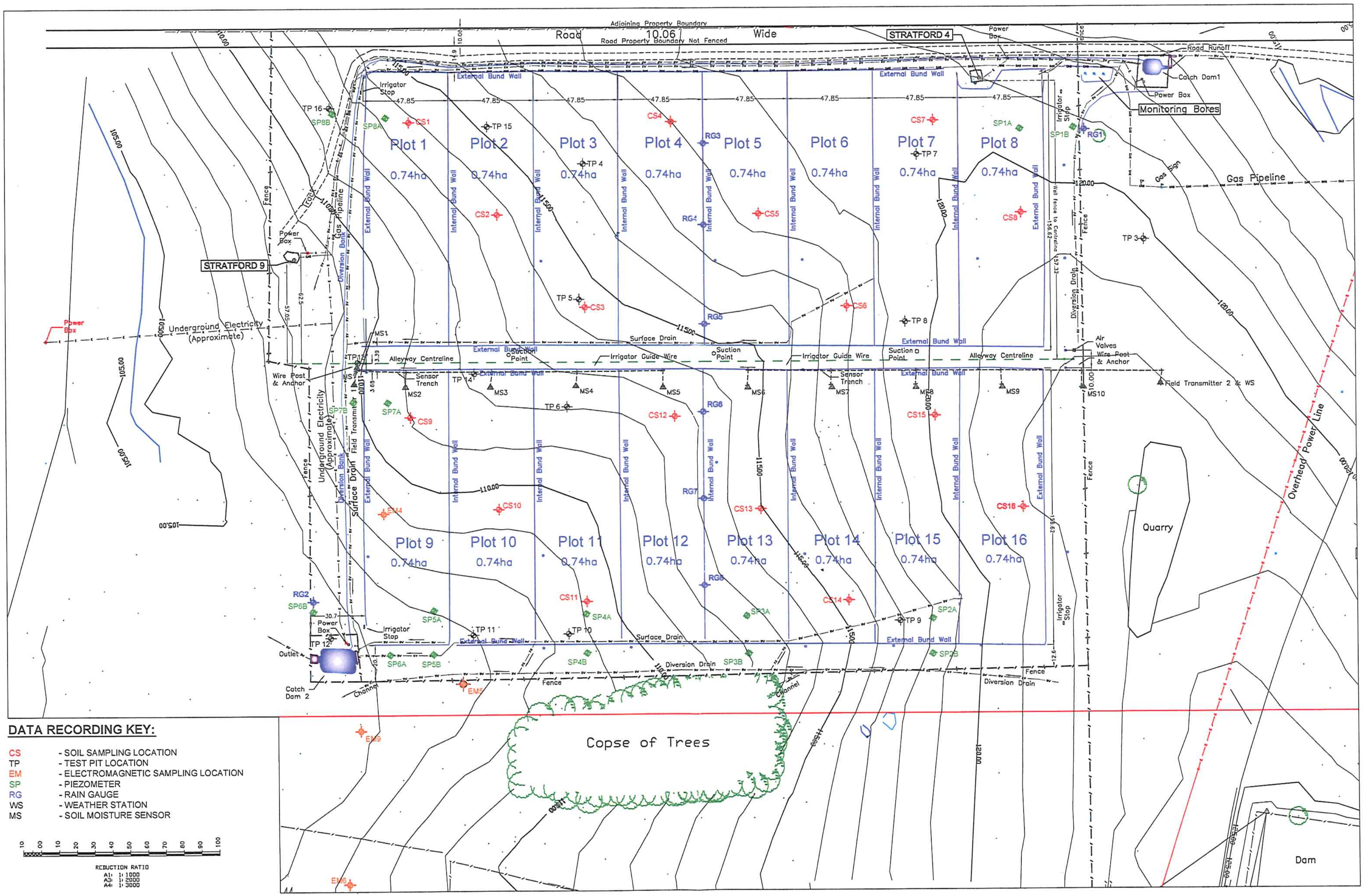
Attachment 6 – Soil profile descriptions

Attachment 1.

Stage 1A area plot layout



TREATMENT 1 - TO 240mm ON SURFACE
TREATMENT 2 - DIAGONAL 200mm SLOTS TO 600mm DEPTH @ 1500mm CENTRES
TREATMENT 3 - DIAGONAL 200mm SLOTS TO 950mm DEPTH @ 1500mm CENTRES
TREATMENT 4 - DIAGONAL 200mm SLOTS TO 1200mm DEPTH @ 1500mm CENTRES
Plot 1 0.74ha TREATMENT 1 ONLY (ANNUAL CROP)
Plot 2 0.74ha TREATMENT 1 ONLY (LUCERNE)
Plot 3 0.74ha TREATMENT 4 & TREATMENT 1 (ANNUAL CROP)
Plot 4 0.74ha TREATMENT 4 & TREATMENT 1 (LUCERNE)
Plot 5 0.74ha TREATMENT 3 & TREATMENT 1 (ANNUAL CROP)
Plot 6 0.74ha TREATMENT 3 & TREATMENT 1 (LUCERNE)
Plot 7 0.74ha TREATMENT 2 & TREATMENT 1 (ANNUAL CROP)
Plot 8 0.74ha TREATMENT 2 & TREATMENT 1 (LUCERNE)
Plot 9 0.74ha TREATMENT 1 ONLY (ANNUAL CROP)
Plot 10 0.74ha TREATMENT 1 ONLY (LUCERNE)
Plot 11 0.74ha TREATMENT 4 & TREATMENT 1 (ANNUAL CROP)
Plot 12 0.74ha TREATMENT 4 & TREATMENT 1 (LUCERNE)
Plot 13 0.74ha TREATMENT 3 & TREATMENT 1 (ANNUAL CROP)
Plot 14 0.74ha TREATMENT 3 & TREATMENT 1 (LUCERNE)
Plot 15 0.74ha TREATMENT 2 & TREATMENT 1 (ANNUAL CROP)
Plot 16 0.74ha TREATMENT 2 & TREATMENT 1 (LUCERNE)
Road 10.06 Wide
Adjoining Property Boundary
Road Property Boundary Not Fenced
STRATFORD 4
STRATFORD 9
Monitoring Bores
Catch Dam1
Catch Dam 2
Power Box
Gas Pipeline
Overhead Power Line
Quarry
Dam
Copse of Trees
Alleyway Centreline
Irrigator Guide Wire
Suction Point
Sensor Trench
External Bund Wall
Internal Bund Wall
Surface Drain
Diversion Drain
Diversion Bank
Field Transmitter
Underground Electricity (Approximate)
Wire Post & Anchor
Air Valves
Irrigator Stop
Fence
CLIENT: FODDER KING & FETTERPLACE CIVIL
PROJECT: AGL - GLOUCESTER - IRRIGATION TEST PLOT
TIEDMANS IRRIGATION TRIAL
STAGE 1A TRIAL PLOT LAYOUT
WORKS AS EXECUTED
DATE: 7 February 2013
SHEET 01A
GLO-ENG-DWG-G-401
D
Mitchel Hanlon Consulting Pty Ltd
Natural Resources
Planning
Surveying
Civil Engineering
Environmental Engineering
A1
DATUM: AHD
SURVEY: M Hanlon
DESIGN: M Hanlon
DRAWN: M Hanlon
CHECKED: M Hanlon
D 6-May-13 FINAL WAE (BY FODDER KING AND AGL)
C 24-Apr-13 SPLIT SHEET 01
B 5-Apr-13 PLOT AREA TEXT
A 7-Feb-13 INITIAL ISSUE
REDUCTION RATIO A1: 1:1000 A3: 1:2000 A4: 1:3000
Plot Date: 7 May 2013



DATA RECORDING KEY:

CS	- SOIL SAMPLING LOCATION
TP	- TEST PIT LOCATION
EM	- ELECTROMAGNETIC SAMPLING LOCATION
SP	- PIEZOMETER
RG	- RAIN GAUGE
WS	- WEATHER STATION
MS	- SOIL MOISTURE SENSOR

REDUCTION RATIO
A1: 1:1000
A3: 1:2000
A4: 1:3000

Plot Date: 7 May 2013
J:\2012\12161 Fetterplace Civil, AGL, site, Gloucester\ACAD\WAE\12161 AGL WAE v01 2013-05-06.dwg

Rv	DATE	REVISIONS	REC.	APPR.
D	6-May-13	FINAL WAE (BY FODDER KING AND AGL)	FK	FK
C	24-Apr-13	SPLIT SHEET 01	FK	FK
B	5-Apr-13	PLOT AREA TEXT	FK	FK
A	7-Feb-13	INITIAL ISSUE	MH	MH

This document is produced by Mitchel Hanlon Consulting Pty Ltd solely for the benefit and use by the client in accordance with the terms of the client agreement. Mitchel Hanlon Consulting Pty Ltd does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by the third party on the content of the document.

SURVEY: M Hanlon
DESIGN: M Hanlon
DRAWN: M Hanlon
CHECKED: M Hanlon
J:\12161 Fetterplace Civil, AGL, site,
SURVEY FILE: Gloucester\acad\12161V02 WAE Survey 2012-12-20.xxx

A1
DATUM: AHD
ORIGIN PM55266 RL:124.736
CONTOUR INTERVAL: 0.25m
APPROVED: PROJ.MAN

Mitchel Hanlon Consulting Pty Ltd
ABN 51 104 693 736
ACN 104 693 736
121 Bridge Street
P.O. Box 1568
Tamworth, NSW, 2340
Telephone: 02-6762 4411
Facsimile: 02-6762 4412
office@mitchelhanlon.com.au
www.mitchelhanlon.com.au

Natural Resources
Planning
Surveying
Civil Engineering
Environmental Engineering

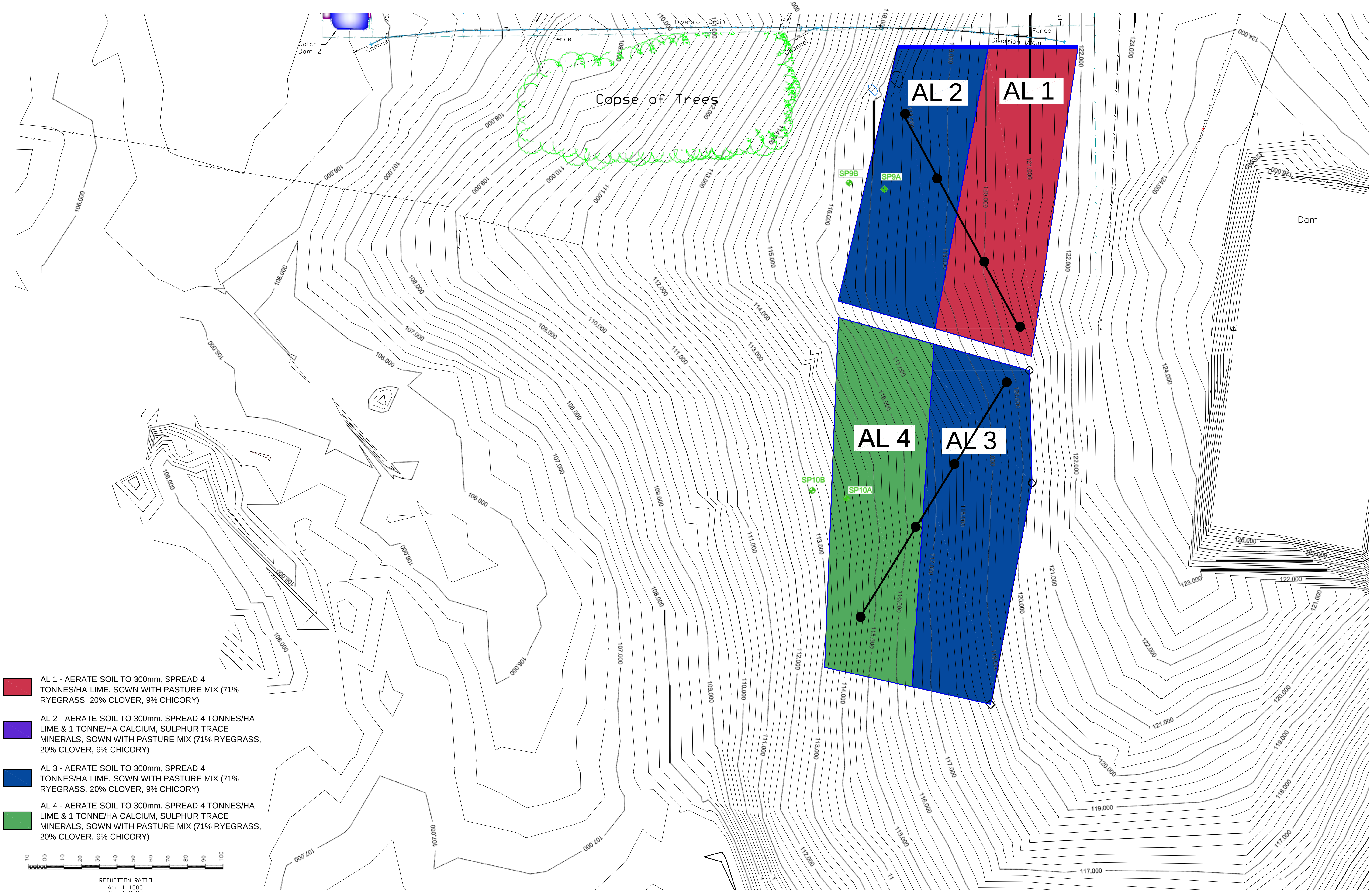
ISO9001:2008 FS556072

CLIENT: FODDER KING & FETTERPLACE CIVIL
PROJECT: AGL - GLOUCESTER - IRRIGATION TEST PLOT
TIEDMANS IRRIGATION TRIAL
STAGE 1A DATA RECORDING LOCATIONS
WORKS AS EXECUTED

DATE: 7 February 2013
DRAWING No.:
SHEET 01B
GLO-ENG-DWG-G-402
Rv. D

Attachment 2.

Stage 1 B area plot layout



AL 1 - AERATE SOIL TO 300mm, SPREAD 4 TONNES/HA LIME, SOWN WITH PASTURE MIX (71% RYEGRASS, 20% CLOVER, 9% CHICORY)

AL 2 - AERATE SOIL TO 300mm, SPREAD 4 TONNES/HA LIME & 1 TONNE/HA CALCIUM, SULPHUR TRACE MINERALS, SOWN WITH PASTURE MIX (71% RYEGRASS, 20% CLOVER, 9% CHICORY)

AL 3 - AERATE SOIL TO 300mm, SPREAD 4 TONNES/HA LIME, SOWN WITH PASTURE MIX (71% RYEGRASS, 20% CLOVER, 9% CHICORY)

AL 4 - AERATE SOIL TO 300mm, SPREAD 4 TONNES/HA LIME & 1 TONNE/HA CALCIUM, SULPHUR TRACE MINERALS, SOWN WITH PASTURE MIX (71% RYEGRASS, 20% CLOVER, 9% CHICORY)

REDUCTION RATIO
A1: 1:1000
A3: 1:2000
A4: 1:3000

Plot Date: 27 June 2013
J:\2012\12161 Fetterplace Civil, AGL site, Gloucester\ACAD\WAE\12161 AGL WAE v01 2013-06-27.dwg

Rv	DATE	REVISIONS	REC.	APPR.
B	27-Jun-13	AMENDMENTS AS PER EMAIL RECEIVED ON 27/6/13		
A	26-Jun-13	ADDITIONAL SHEETS AS PER EMAIL RECEIVED ON 24/6/13		

SURVEY: M Hanlon
DESIGN: M Hanlon
DRAWN: M Hanlon
CHECKED: M Hanlon
SURVEY FILE: J:\12161 Fetterplace Civil, AGL site, Gloucester\ccad7\12161V02 WAE Survey 2012-12-20.ccx

A1

DATUM: AHD
ORIGIN: PM55266 RL:124.736
CONTOUR INTERVAL: 0.25m
APPROVED: PROJ.MAN

Mitchel Hanlon Consulting Pty Ltd
Natural Resources
Planning Surveying
Civil Engineering
Environmental Engineering
121 Bridge Street
P.O. Box 1568
Telephone: 02-6762 4411
Facsimile: 02-6762 4412
ABN 51 104 693 736
ISO9001:2008 FS555072

CLIENT: FODDER KING
PROJECT: AGL - GLOUCESTER - IRRIGATION TEST PLOT
TIEDMANS IRRIGATION TRIAL
STAGE 1B TRIAL PLOT LAYOUT

DATE: 7 February 2013
DRAWING No.: SHEET 05
Rv. B

Attachment 3.

Stage 1A Baseline 5 summary tables and soil test results

STAGE 1A BASELINE 5 SOIL TEST RESULTS

AVERAGE N =	Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g	Al meq/100g	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Al mg/kg	K %	Ca %	Mg %	Na %	Al %	ECEC meq/100g	Ca/Mg ratio	ESP %
16	0-20	0.34	6.58	28	2.5	0.80	12.17	5.46	1.771	0.02	315	2439	664	407	2	4.0	58.8	28.0	9.0	0.1	20.2	2.3	9.0
12	20-40	0.39	5.80	9	1.3	0.72	8.90	8.86	1.842	0.05	280	1783	1077	423	5	3.4	42.5	44.4	9.4	0.3	20.4	1.1	9.4
11	40 - 60	0.36	5.44	9	0.8	0.55	7.09	10.54	2.020	1.01	215	1421	1281	464	91	2.5	31.4	50.8	9.7	5.6	21.2	0.7	9.7
8	60 - 80	0.38	5.98	7	0.8	0.50	7.09	10.39	2.281	0.81	195	1420	1262	524	73	2.4	31.4	50.4	10.8	5.1	21.1	0.7	10.8
8	80 - 100	0.34	5.93	6	0.7	0.49	6.23	11.26	2.468	0.68	192	1249	1369	567	61	2.3	26.7	54.9	11.6	4.5	21.1	0.5	11.6
4	100 - 120	0.55	6.92	12	0.8	0.57	8.85	12.27	3.410	0.00	222	1773	1491	784	0	2.2	32.9	51.3	13.7	0.0	25.1	0.7	13.7

Maximum N =	Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g	Al meq/100g	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Al mg/kg	K %	Ca %	Mg %	Na %	Al %	ECEC meq/100g	Ca/Mg ratio	ESP %
16	0-20	1.03	7.42	57	3.72	1.30	18.30	7.66	2.50	0.10	508	3667	931	575	9	8	69	56	13	1	29.2	4.09	12.8
12	20-40	1.39	7.22	15	2.54	2.30	19.50	11.60	2.64	0.31	899	3908	1410	607	28	7	59	58	13	2	33.3	2.20	13.2
11	40 - 60	1.05	7.33	37	1.34	1.37	17.30	14.50	3.11	5.44	536	3467	1762	715	489	4	51	65	13	31	34.1	1.41	13.0
8	60 - 80	0.88	7.41	13	1.54	0.79	17.00	13.40	3.90	4.82	309	3407	1629	897	433	3	48	62	12	31	35.1	1.27	12.4
8	80 - 100	0.81	7.28	11	1.46	0.90	14.60	14.20	4.34	4.17	352	2926	1726	998	375	3	43	69	14	28	34.0	1.03	13.9
4	100 - 120	0.90	7.68	32	1.06	0.81	13.60	14.00	4.41	0.01	317	2725	1702	1014	1	3	45	63	14	0	32.2	1.15	14.4

Minimum N =	Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g	Al meq/100g	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Al mg/kg	K %	Ca %	Mg %	Na %	Al %	ECEC meq/100g	Ca/Mg ratio	ESP %
16	0-20	0.19	5.73	11	1.4	0.28	3.01	3.51	1.28	0	109	603	427	294	0	2	27	17	5	0	11.1	0.48	5.5
12	20-40	0.20	4.48	4.2	0.65	0.38	5.16	3.74	1.53	0	149	1034	455	352	0	2	28	27	6	0	13.6	0.50	6.2
11	40 - 60	0.22	4.03	1.7	0.41	0.33	1.76	6.36	1.47	0	129	353	773	338	0	2	11	36	8	0	15.7	0.16	7.7
8	60 - 80	0.17	4.01	3.1	0.44	0.35	2.73	6.04	1.28	0	137	547	734	294	0	2	15	38	8	0	14.3	0.24	8.3
8	80 - 100	0.10	4.08	0.5	0.28	0.26	1.77	5.78	1.27	0	102	355	703	292	0	2	11	38	8	8	15.0	0.16	8.5
4	100 - 120	0.25	5.77	3.1	0.48	0.35	3.49	10.90	2.49	0	137	699	1325	572	0	2	20	39	13	7	17.3	0.32	13.2

Standard Deviation N =	Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g	Al meq/100g	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Al mg/kg	K %	Ca %	Mg %	Na %	Al %	ECEC meq/100g	Ca/Mg ratio	ESP %
16	0-20	0.20	0.50	11.4	0.61	0.30	3.93	1.29	0.39	0.03	117	787	157	90	3	1	10	9	2	0	4.70	0.84	2.2
12	20-40	0.32	0.99	3.2	0.59	0.52	4.23	2.10	0.32	0.10	203	847	255	74	9	1	10	10	2	1	5.28	0.56	2.0
11	40 - 60	0.22	1.21	9.4	0.28	0.29	4.47	2.17	0.42	1.71	114	897	264	97	154	1	13	10	2	9	5.40	0.37	1.6
8	60 - 80	0.23	1.24	3.5	0.35	0.17	4.69	2.63	0.84	1.72	65	940	319	193	155	1	11	9	1	11	6.76	0.31	1.5
8	80 - 100	0.25	1.19	3.2	0.45	0.22	4.35	2.65	0.95	1.48	85	872	323	219	133	1	11	11	2	10	6.70	0.28	2.1
4	100 - 120	0.31	0.82	13.6	0.29	0.23	5.20	1.31	0.93	0.01	91	1042	159	213	0	0	12	12	1	0	7.19	0.40	0.6

82 Plain Street Tamworth NSW 2340
P 02 6762 1733 **F** 02 6765 910 9
admin@eastwestonline.com.au
www.eastwestonline.com.au
ABN 82 125 442 382

eastwest GEO•AG•ENVIRO

ANALYSIS REPORT SOIL

Project No:	**EW140391**	**Date of Issue:**	**18/6/2014**
Customer:	Fodder King	Report No:	1
Address:	PO Box 148 Dulwich Hill NSW 2203	Date Received:	20/05/2014
Attention:	Paul McCardell	Matrix:	Soil
Phone:	02 9569 7400	Location:	AGL Gloucester
Fax:	-	Sampler ID:	Client Supplied
email:	fodder@fodderking.com.au	Date of Sampling:	20/05/2014
		Sample Condition:	Acceptable

Results apply to the samples submitted. All pages of this report have been checked and approved for release. This report supersedes any previous report.

Signed: ____________________

Stephanie Cameron
Operations Manager

ASPAC
PROFICIENT LAB
Visit www.aspac-australasia.com to view our certification details.

East West is certified by the Australian-Asian Soil & Plant Analysis Council to perform various soil and plant tissue analysis. The tests reported herein have been performed in accordance with our terms of accreditation.
This report must not be reproduced except in full and EWEA takes no responsibility of the end use of the results within this report.
This analysis relates to the sample submitted and it is the client's responsibility to make certain the sample is representative of the matrix to be tested.
Samples will be discarded one month after the date of this report. Please advise if you wish to have your sample/s returned.

Results you can rely on.

ANALYSIS REPORT

Project No: EW140391

Analyte	Method		Units	LOR	CS1 (0-20) 140391-1	CS2 (0-20) 140391-2	CS3 (0-20) 140391-3	CS3 (20-40) 140391-4
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	92.8	68.4	70.8	87.6
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.29	0.20	0.30	0.21
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	7.77	7.16	7.59	6.95
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	7.42	6.84	7.11	6.17
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	28.1	16.6	56.8	12.0
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	76.6	148	241	55.8
PBI	PBI (Col)	*R&L 9I2a*	*mg/kg*	*10*	81.8	89.1	89.1	83.6
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	75.6	24.9	46.8	50.2
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	2.56	1.79	2.27	0.95
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	2.57	1.94	2.28	1.09
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.15	1.31	1.24	1.36
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.86	2.27	3.10	1.02
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	7.40	3.16	1.07	<1.0
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	112	179	70.8	159
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.66	0.57	0.81	0.31

Analyte	Method		Units	LOR	CS1 *mg/kg*	CS1 *meq/100g*	CS2 *mg/kg*	CS2 *meq/100g*	CS3 (0-20) *mg/kg*	CS3 (0-20) *meq/100g*	CS3 (20-40) *mg/kg*	CS3 (20-40) *meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	259	0.66	237	0.61	351	0.90	169	0.43
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	2213	11.1	2025	10.1	2857	14.3	1297	6.49
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	421	3.51	615	5.13	659	5.49	838	6.98
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	452	1.97	304	1.32	412	1.79	364	1.58
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	0.4	0.00	0.3	0.00	0.4	0.00	0.3	0.00

Analyte	Method		Units	LOR	CS1 (0-20) 140391-1	CS2 (0-20) 140391-2	CS3 (0-20) 140391-3	CS3 (20-40) 140391-4
Ex Potassium %	Calc	-	*%*	*na*	3.86	3.54	4.00	2.80
Ex Calcium %	Calc	-	*%*	*na*	64.3	58.9	63.6	41.9
Ex Magnesium %	Calc	-	*%*	*na*	20.4	29.8	24.4	45.1
Ex Sodium %	Calc	-	*%*	*na*	11.4	7.69	7.97	10.2
Ex Aluminium %	Calc	-	*%*	*na*	0.03	0.02	0.02	0.02
ECEC	Calc	-	*meq/100g*	*na*	17.2	17.2	22.5	15.5
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	328	261	462	175
Texture	McDonald *et al*	-	*Class*	*na*	CL	CL	CL	LMC
Colour	Munsell	-	*Class*	*na*	10YR 2/2	10YR 4/3	10YR 3/2	10YR 3/3

eastwest GEO•AG•ENVIRO

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	140391-5	140391-6	140391-7	140391-8
				Sample ID	CS3	CS3	CS3	CS3
				Depth (cm)	40-60	60-80	80-100	100-120
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	138	158	142	121
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.23	0.27	0.28	0.25
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	6.01	6.41	6.60	6.52
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	4.79	5.79	5.85	5.77
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	7.8	6.9	6.9	5.4
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	29.9	35.9	27.5	18.4
PBI	PBI $_{(Col)}$	*R&L 9I2a*	*mg/kg*	*10*	112	67.1	74.5	73.8
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	61.7	71.8	74.3	70.4
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	0.54	0.56	0.48	0.56
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	0.57	0.68	0.51	0.56
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.12	1.51	1.56	1.55
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	0.73	0.99	0.98	0.85
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	<1	<1	<1	<1
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	95.4	85.3	172	224
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	<0.25	<0.25	<0.25	<0.25

Analyte	Method	Method Reference	Units	LOR	140391-5 *mg/kg*	140391-5 *meq/100g*	140391-6 *mg/kg*	140391-6 *meq/100g*	140391-7 *mg/kg*	140391-7 *meq/100g*	140391-8 *mg/kg*	140391-8 *meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	134	0.34	153	0.39	159	0.41	153	0.39
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	745	3.73	851	4.26	887	4.44	698	3.49
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	1272	10.6	1222	10.2	1258	10.5	1310	10.9
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	411	1.79	484	2.10	559	2.43	573	2.49
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	41.2	0.46	1.2	0.01	0.3	0.00	0.2	0.00
Ex Potassium %	Calc	-	*%*	*na*	2.03		2.31		2.30		2.27	
Ex Calcium %	Calc	-	*%*	*na*	22.0		25.1		25.0		20.2	
Ex Magnesium %	Calc	-	*%*	*na*	62.7		60.1		59.0		63.1	
Ex Sodium %	Calc	-	*%*	*na*	10.6		12.4		13.7		14.4	
Ex Aluminium %	Calc	-	*%*	*na*	2.71		0.08		0.02		0.01	
ECEC	Calc	-	*meq/100g*	*na*	16.9		16.9		17.8		17.3	
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	159		156		182		187	
Texture	McDonald *et al*	-	*Class*	*na*	MC		MC		MC		MC	
Colour	Munsell	-		*na*	10YR 5/4		10YR 4/3		10YR 4/2		10YR 4/3	

ANALYSIS REPORT

Project No: EW140391

				Sample ID	CS4		CS4		CS4		CS4	
				Depth (cm)	0-20		20-40		40-60		60-80	
Analyte	**Method**	**Method Reference**	**Units**	**LOR**	**140391-9**		**140391-10**		**140391-11**		**140391-12**	
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	53.8		94.4		158		294	
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.21		0.28		0.40		0.57	
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	7.37		7.45		7.36		7.24	
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	6.75		6.92		6.85		6.78	
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	20.8		11.7		9.5		7.6	
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	259		239		116		58.3	
PBI	PBI (Col)	*R&L 9I2a*	*mg/kg*	*10*	110		106		94.8		91.1	
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	33.4		65.8		140		190	
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	2.42		1.14		1.00		0.77	
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	2.52		1.63		1.00		0.79	
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.62		1.27		1.06		1.87	
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	5.84		3.44		1.58		1.20	
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	1.1		<1		<1		<1	
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	72.1		54.5		51.1		83.2	
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.7		0.41		0.33		<0.25	
					mg/kg	*meq/100g*	*mg/kg*	*meq/100g*	*mg/kg*	*meq/100g*	*mg/kg*	*meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	408	1.05	360	0.92	302	0.77	282	0.72
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	3175	15.9	2977	14.9	2672	13.4	1914	9.6
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	857	7.14	1117	9.31	1305	10.9	1421	11.8
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	320	1.39	381	1.66	491	2.13	698	3.03
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	0.2	0.00	0.3	0.00	0.2	0.00	0.6	0.01
Ex Potassium %	Calc	-	*%*	*na*	4.11		3.45		2.85		2.87	
Ex Calcium %	Calc	-	*%*	*na*	62.4		55.6		49.2		38.0	
Ex Magnesium %	Calc	-	*%*	*na*	28.1		34.8		40.1		47.0	
Ex Sodium %	Calc	-	*%*	*na*	5.47		6.19		7.86		12.05	
Ex Aluminium %	Calc	-	*%*	*na*	0.01		0.01		0.01		0.03	
ECEC	Calc	-	*meq/100g*	*na*	25.5		26.8		27.1		25.2	
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	630		451		343		292	
Texture	McDonald *et al*	-	*Class*	*na*	LMC		MC		MC		MC	
Colour	Munsell	-	*Class*	*na*	10YR 3/3		10YR 4/3		10YR 4/3		10YR 5/3	

eastwest GEO•AG•ENVIRO

ANALYSIS REPORT

Project No: EW140391

				Sample ID	CS4		CS4		CS5		CS5	
				Depth (cm)	80-100		100-120		0-20		20-40	
Analyte	**Method**	**Method Reference**	**Units**	**LOR**	**140391-13**		**140391-14**		**140391-15**		**140391-16**	
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	331		460		148		201	
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.61		0.90		0.34		0.35	
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	7.15		7.27		7.24		6.91	
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	6.73		6.95		6.87		6.52	
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	2.5		3.1		30.7		9.6	
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	72.0		73.5		109		85.5	
PBI	PBI (Col)	*R&L 9I2a*	*mg/kg*	*10*	108		121		87.8		77.7	
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	204		377		93.9		93.6	
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	0.85		0.99		1.40		0.87	
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	1.06		1.06		1.55		1.43	
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.77		1.83		1.31		1.56	
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.90		1.84		2.06		1.88	
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	<1		<1		4.8		2.3	
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	149		156		124		129	
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	<0.25		0.26		0.55		0.29	
					mg/kg	*meq/100g*	*mg/kg*	*meq/100g*	*mg/kg*	*meq/100g*	*mg/kg*	*meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	*-*	*10*	292	0.75	282	0.72	263	0.67	232	0.59
Calcium Ex	ICP-OES	*R&L 15D3*	*-*	*10*	1995	9.98	2716	13.6	1803	9.02	1537	7.69
Magnesium Ex	ICP-OES	*R&L 15D3*	*-*	*10*	1496	12.5	1413	11.78	698	5.82	1096	9.13
Sodium Ex	ICP-OES	*R&L 15D3*	*-*	*10*	730	3.17	913	3.97	485	2.11	432	1.88
Aluminium Ex	ICP-OES	*R&L 15G1*	*-*	*0.5*	0.2	0.00	0.5	0.01	0.2	0.00	0.2	0.00
Ex Potassium %	Calc	*-*	*%*	*na*	2.84		2.41		3.83		3.08	
Ex Calcium %	Calc	*-*	*%*	*na*	37.8		45.2		51.2		39.8	
Ex Magnesium %	Calc	*-*	*%*	*na*	47.3		39.2		33.0		47.3	
Ex Sodium %	Calc	*-*	*%*	*na*	12.0		13.2		12.0		9.74	
Ex Aluminium %	Calc	*-*	*%*	*na*	0.01		0.02		0.01		0.01	
ECEC	Calc	*-*	*meq/100g*	*na*	26.4		30.1		17.6		19.3	
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	324		339		293		271	
Texture	McDonald *et al*	*-*	*Class*	*na*	HC		HC		CL		LMC	
Colour	Munsell	*-*	*Class*	*na*	10YR 4/3		10YR 4/4		10YR 3/2		10YR 4/2	

eastwest GEO•AG•ENVIRO

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	140391-17	140391-18	140391-19	140391-20
				Sample ID	CS5	CS5	CS5	CS6
				Depth (cm)	40-60	60-80	80-100	0-20
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	138	126	97.2	74.8
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.31	0.25	0.18	0.23
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	7.02	7.08	6.66	7.51
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	6.58	6.57	5.98	6.53
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	37.3	12.6	4.7	37.8
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	57.4	34.7	18.4	278
PBI	PBI $_{(Col)}$	*R&L 9I2a*	*mg/kg*	*10*	82.3	65.1	53.0	107
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	74.9	73.1	40.5	21.4
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	0.78	0.44	0.32	2.70
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	0.84	0.49	0.40	2.97
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.48	1.26	1.25	1.45
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.83	0.99	0.80	7.25
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	6.5	3.7	<1	3.7
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	234	160	106	78.7
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.27	<0.25	<0.25	1.11

Analyte	Method	Method Reference	Units	LOR	140391-17 *mg/kg*	140391-17 *meq/100g*	140391-18 *mg/kg*	140391-18 *meq/100g*	140391-19 *mg/kg*	140391-19 *meq/100g*	140391-20 *mg/kg*	140391-20 *meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	216	0.55	180	0.46	151	0.39	475	1.22
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	1403	7.02	1028	5.14	463	2.32	3063	15.3
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	908	7.57	857	7.14	1225	10.2	586	4.88
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	375	1.63	355	1.54	481	2.09	347	1.51
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	0.1	0.00	0.1	0.00	0.7	0.01	0.5	0.01

Analyte	Method	Method Reference	Units	LOR	140391-17	140391-18	140391-19	140391-20
Ex Potassium %	Calc	-	*%*	*na*	3.30	3.23	2.58	5.31
Ex Calcium %	Calc	-	*%*	*na*	41.8	36.0	15.4	66.8
Ex Magnesium %	Calc	-	*%*	*na*	45.1	50.0	68.0	21.3
Ex Sodium %	Calc	-	*%*	*na*	9.72	10.8	13.9	6.58
Ex Aluminium %	Calc	-	*%*	*na*	0.01	0.01	0.05	0.02
ECEC	Calc	-	*meq/100g*	*na*	16.8	14.3	15.0	22.9
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	267	213	195	627
Texture	McDonald *et al*	-	*Class*	*na*	LMC	SC	SC	CL
Colour	Munsell	-	*Class*	*na*	10YR 4/4	10YR 4/1	10YR 6/6	10YR 2/2

eastwest GEO•AG•ENVIRO

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	CS6 20-40 140391-21	CS6 40-60 140391-22	CS6 60-80 140391-23	CS6 80-100 140391-24
Chlorides	.	*R&L 5A1*	*mg/kg*	*5*	156	189	218	141
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.28	0.30	0.33	0.23
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	6.84	6.30	6.18	6.42
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	6.22	5.52	5.69	5.96
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	4.2	1.7	3.4	<0.5
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	46.3	37.2	28.0	9.8
PBI	PBI (Col)	*R&L 9I2a*	*mg/kg*	*10*	80.4	78.7	80.7	55.3
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	83.2	97.3	108	65.5
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	0.88	0.98	0.86	0.28
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	0.99	1.21	1.13	0.28
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.71	1.27	1.72	1.98
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.28	1.33	1.32	0.68
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	2.5	3.9	8.9	<1
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	93.2	113	146	51.5
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.31	0.33	<0.25	<0.25

Analyte	Method	Method Reference	Units	LOR	140391-21 *mg/kg*	140391-21 *meq/100g*	140391-22 *mg/kg*	140391-22 *meq/100g*	140391-23 *mg/kg*	140391-23 *meq/100g*	140391-24 *mg/kg*	140391-24 *meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	213	0.55	226	0.58	178	0.46	160	0.41
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	1850	9.25	1766	8.83	1582	7.91	1501	7.51
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	1197	9.98	1348	11.2	1224	10.2	1660	13.83
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	379	1.65	395	1.72	432	1.88	479	2.08
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	0.3	0.00	0.4	0.00	0.2	0.00	0.3	0.00
Ex Potassium %	Calc	-	*%*	*na*	2.55		2.59		2.23		1.72	
Ex Calcium %	Calc	-	*%*	*na*	43.2		39.5		38.7		31.5	
Ex Magnesium %	Calc	-	*%*	*na*	46.6		50.2		49.9		58.0	
Ex Sodium %	Calc	-	*%*	*na*	7.69		7.68		9.19		8.74	
Ex Aluminium %	Calc	-	*%*	*na*	0.02		0.02		0.01		0.01	
ECEC	Calc	-	*meq/100g*	*na*	21.4		22.4		20.4		23.8	
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	261		214		223		194	
Texture	McDonald *et al*	-	*Class*	*na*	MC		MC		MC		HC	
Colour	Munsell	-	*Class*	*na*	10YR 4/3		10YR 5/3		10YR 4/3		10YR 5/4	

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	140391-25	140391-26	140391-27	140391-28
				Sample ID	CS7	CS7	CS7	CS8
				Depth (cm)	0-20	20-40	40-60	0-20
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	136	182	211	86.8
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.36	0.31	0.32	0.21
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	7.29	6.16	5.51	6.62
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	6.80	5.25	4.82	6.29
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	35.2	8.7	3.6	11.0
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	253	62.6	44.3	89.2
PBI	PBI (Col)	*R&L 9I2a*	*mg/kg*	*10*	132	109	99.1	112
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	60.5	203	95.9	24.8
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	2.23	1.34	0.65	2.26
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	2.25	1.49	0.69	2.29
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.34	1.30	1.20	1.01
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	5.49	2.07	1.45	2.44
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	4.9	7.0	2.5	4.8
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	150	287	164	169
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.57	0.29	<0.25	0.36

Analyte	Method	Method Reference	Units	LOR	140391-25 *mg/kg*	140391-25 *meq/100g*	140391-26 *mg/kg*	140391-26 *meq/100g*	140391-27 *mg/kg*	140391-27 *meq/100g*	140391-28 *mg/kg*	140391-28 *meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	445	1.14	223	0.57	157	0.40	108	0.28
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	3663	18.3	1281	6.41	1249	6.2	1917	9.59
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	919	7.66	965	8.04	1292	10.8	491	4.09
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	490	2.13	360	1.57	438	1.90	421	1.83
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	1.0	0.01	3.3	0.04	13.0	0.14	0.5	0.01

Analyte	Method	Method Reference	Units	LOR	140391-25	140391-26	140391-27	140391-28
Ex Potassium %	Calc	-	*%*	*na*	3.90	3.44	2.07	1.75
Ex Calcium %	Calc	-	*%*	*na*	62.6	38.5	32.1	60.7
Ex Magnesium %	Calc	-	*%*	*na*	26.2	48.4	55.3	25.9
Ex Sodium %	Calc	-	*%*	*na*	7.28	9.42	9.78	11.6
Ex Aluminium %	Calc	-	*%*	*na*	0.04	0.22	0.74	0.04
ECEC	Calc	-	*meq/100g*	*na*	29.3	16.6	19.5	15.8
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	640	291	222	157
Texture	McDonald *et al*	-	*Class*	*na*	LC	LMC	LMC	CL
Colour	Munsell	-	*Class*	*na*	10YR 2/2	10YR 4/3	10YR 5/4	10YR 2/2

.

eastwest GEO•AG•ENVIRO

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	140391-29	140391-30	140391-31	140391-32
				Sample ID	CS8	CS8	CS9	CS10
				Depth (cm)	20-40	40-60	0-20	0-20
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	166	146	162	66.8
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.25	0.22	0.31	0.19
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	5.30	5.04	6.49	7.24
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	4.48	4.22	5.96	6.47
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	5.1	2.3	25.4	28.7
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	19.7	7.9	103	290
PBI	PBI $_{(Col)}$	*R&L 9I2a*	*mg/kg*	*10*	188	173	123	109
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	55.3	43.5	59.5	14.7
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	0.65	0.41	3.50	2.83
Total Carbon	LECO	*R&L 6B2*	*0.2*	*0.2*	0.89	0.39	3.50	3.09
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	0.93	1.32	1.19	1.98
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	0.67	<0.5	3.08	10.6
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	1.1	<1	7.1	3.1
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	150	87.0	316	235
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.30	<0.25	0.59	1.02
					mg/kg / *meq/100g*	*mg/kg* / *meq/100g*	*mg/kg* / *meq/100g*	*mg/kg* / *meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	264 / 0.68	142 / 0.36	183 / 0.47	245 / 0.63
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	1213 / 6.07	352 / 1.76	2763 / 13.8	2377 / 11.9
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	1129 / 9.41	1299 / 10.8	607 / 5.06	453 / 3.78
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	488 / 2.12	450 / 1.96	417 / 1.81	359 / 1.56
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	13.7 / 0.15	154 / 1.71	5.0 / 0.06	0.6 / 0.01
Ex Potassium %	Calc	-	*%*	*na*	3.67	2.19	2.21	3.52
Ex Calcium %	Calc	-	*%*	*na*	32.9	10.6	65.1	66.6
Ex Magnesium %	Calc	-	*%*	*na*	51.1	65.1	23.8	21.1
Ex Sodium %	Calc	-	*%*	*na*	11.5	11.8	8.55	8.74
Ex Aluminium %	Calc	-	*%*	*na*	0.83	10.3	0.26	0.04
ECEC	Calc	-	*meq/100g*	*na*	18.4	16.6	21.2	17.9
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	263	193	207	313
Texture	McDonald *et al*	-	*Class*	*na*	MC	MC	CL	CL
Colour	Munsell	-	*Class*	*na*	10YR 4/3	10YR 5/6	10YR 2/2	10YR 4/3

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	140391-33	140391-34	140391-35	140391-36
				Sample ID	CS11	CS11	CS11	CS11
				Depth (cm)	0-20	20-40	40-60	60-80
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	67.0	71.2	158	181
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.26	0.23	0.31	0.32
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	7.76	7.81	7.83	7.86
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	6.90	6.96	7.07	7.15
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	38.5	6.8	4.9	4.9
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	263	48.6	42.4	39.9
PBI	PBI $_{(Col)}$	*R&L 9I2a*	*mg/kg*	*10*	110	72.4	70.1	72.0
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	38.9	49.9	74.9	105
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	2.05	0.77	0.61	0.52
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	2.05	0.77	0.62	0.52
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.30	0.92	1.21	1.91
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	4.72	0.99	0.84	1.05
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	2.6	1.0	1.1	1.0
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	106	80.9	92.7	103
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.83	0.27	<0.25	<0.25

Analyte	Method	Method Reference	Units	LOR	140391-33 *mg/kg*	140391-33 *meq/100g*	140391-34 *mg/kg*	140391-34 *meq/100g*	140391-35 *mg/kg*	140391-35 *meq/100g*	140391-36 *mg/kg*	140391-36 *meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	417	1.07	150	0.38	129	0.33	136	0.35
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	3002	15.0	1719	8.60	1613	8.07	1440	7.20
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	919	7.66	1328	11.1	1387	11.6	1559	13.0
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	447	1.94	394	1.71	454	1.97	525	2.28
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	0.2	0.00	0.2	0.00	0.1	0.00	0.1	0.00

Analyte	Method	Method Reference	Units	LOR	140391-33	140391-34	140391-35	140391-36
Ex Potassium %	Calc	-	*%*	*na*	4.16	1.77	1.51	1.53
Ex Calcium %	Calc	-	*%*	*na*	58.4	39.5	36.8	31.5
Ex Magnesium %	Calc	-	*%*	*na*	29.8	50.9	52.7	56.9
Ex Sodium %	Calc	-	*%*	*na*	7.57	7.87	9.00	10.0
Ex Aluminium %	Calc	-	*%*	*na*	0.01	0.01	0.01	0.00
ECEC	Calc	-	*meq/100g*	*na*	25.7	21.8	21.9	22.8
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	708	215	211	206
Texture	McDonald *et al*	-	*Class*	*na*	CL	MC	MC	MC
Colour	Munsell	-	*Class*	*na*	10YR 3/2	10YR 5/4	10YR 6/3	10YR 5/2

eastwest GEO•AG•ENVIRO

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	CS11 80-100 140391-37	CS11 0-120 140391-38	CS12 0-20 140391-39	CS12 20-40 140391-40
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	226	234	212	242
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.36	0.33	1.03	1.39
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	7.95	8.08	7.55	7.44
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	7.20	7.28	7.23	7.22
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	5.4	32.4	32.5	14.7
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	27.5	23.4	522	376
PBI	PBI $_{(Col)}$	*R&L 9I2a*	*mg/kg*	*10*	106	108	152	126
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	84.2	65.1	707	890
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	0.53	0.48	2.83	2.54
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	0.53	0.54	2.83	2.54
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.50	1.96	1.50	1.71
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.23	0.96	10.3	8.10
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	1.5	1.4	1.4	3.7
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	58.0	163	86.3	161
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	<0.25	<0.25	1.48	0.99

Analyte	Method	Method Reference	Units	LOR	140391-37 *mg/kg*	140391-37 *meq/100g*	140391-38 *mg/kg*	140391-38 *meq/100g*	140391-39 *mg/kg*	140391-39 *meq/100g*	140391-40 *mg/kg*	140391-40 *meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	133	0.34	135	0.35	507	1.30	897	2.30
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	1179	5.90	1050	5.3	1899	9.5	3905	19.5
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	1456	12.1	1493	12.4	577	4.81	1066	8.88
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	610	2.65	637	2.77	326	1.42	608	2.64
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	0.1	0.00	0.1	0.00	0.4	0.00	0.2	0.00

Analyte	Method	Method Reference	Units	LOR	140391-37	140391-38	140391-39	140391-40
Ex Potassium %	Calc	-	*%*	*na*	1.62	1.66	7.64	6.90
Ex Calcium %	Calc	-	*%*	*na*	28.0	25.2	55.8	58.5
Ex Magnesium %	Calc	-	*%*	*na*	57.7	59.8	28.2	26.6
Ex Sodium %	Calc	-	*%*	*na*	12.6	13.3	8.33	7.93
Ex Aluminium %	Calc	-	*%*	*na*	0.01	0.01	0.03	0.01
ECEC	Calc	-	*meq/100g*	*na*	21.0	20.8	17.0	33.4
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	218	216	1113	1269
Texture	McDonald *et al*	-	*Class*	*na*	MC	MC	CL	CL
Colour	Munsell	-	*Class*	*na*	10YR 5/1	10YR 5/3	10YR 3/1	10YR 4/1

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	CS12 40-60 140391-41		CS12 60-80 140391-42		CS12 80-100 140391-43		CS12 100-120 140391-44	
Chlorides	Probe	R&L 5A1	mg/kg	5	291		452		548		556	
Electrical Conductivity	Soil:Water (1:5)	R&L 3A1	dS/m	0.01	1.05		0.88		0.81		0.70	
pH (H2O)	Electrode	R&L 4A1	pH units	na	7.65		7.81		7.86		8.29	
pH ($CaCl_2$)	Electrode	R&L 4B1	pH units	na	7.33		7.41		7.28		7.68	
NO_3-Nitrogen Ex	Aqueous Buffer	In House	mg/kg	2	10.3		11.7		10.9		7.7	
Phosphorus Colwell	UV-Vis	R&L 9B1	mg/kg	2	253		250		265		213	
PBI	PBI $_{(Col)}$	R&L 9I2a	mg/kg	10	121		124		174		206	
Sulphur	ICP-OES	R&L 10D1	mg/kg	1	671		518		417		264	
Organic Carbon	LECO	R&L 6B3	%	0.2	1.22		1.54		1.46		1.06	
Total Carbon	LECO	R&L 6B2	%	0.2	1.59		1.64		1.47		2.24	
Copper Ex	ICP-OES	R&L 12A1	mg/kg	0.5	1.80		2.13		2.96		2.42	
Zinc Ex	ICP-OES	R&L 12A1	mg/kg	0.5	4.95		6.02		4.45		2.47	
Manganese Ex	ICP-OES	R&L 12A1	mg/kg	1	4.9		15.7		23.8		16.0	
Iron Ex	ICP-OES	R&L 12A1	mg/kg	1	187		205		271		299	
Boron Ex	ICP-OES	R&L 12C2	mg/kg	0.25	0.47		0.50		0.58		0.44	
					mg/kg	meq/100g	mg/kg	meq/100g	mg/kg	meq/100g	mg/kg	meq/100g
Potassium Ex	ICP-OES	R&L 15D3	-	10	534	1.37	310	0.79	352	0.90	315	0.81
Calcium Ex	ICP-OES	R&L 15D3	-	10	3464	17.3	3406	17.0	2912	14.6	2601	13.0
Magnesium Ex	ICP-OES	R&L 15D3	-	10	1472	12.3	1608	13.4	1698	14.2	1678	14.0
Sodium Ex	ICP-OES	R&L 15D3	-	10	715	3.11	896	3.90	998	4.34	1015	4.41
Aluminium Ex	ICP-OES	R&L 15G1	-	0.5	0.3	0.00	0.5	0.01	0.4	0.00	0.3	0.00
Ex Potassium %	Calc	-	%	na	4.02		2.26		2.66		2.51	
Ex Calcium %	Calc	-	%	na	50.8		48.5		42.9		40.4	
Ex Magnesium %	Calc	-	%	na	36.0		38.1		41.7		43.4	
Ex Sodium %	Calc	-	%	na	9.12		11.1		12.8		13.7	
Ex Aluminium %	Calc	-	%	na	0.01		0.02		0.01		0.01	
ECEC	Calc	-	meq/100g	na	34.1		35.1		34.0		32.2	
Colwell Potassium	AAS	R&L 18A1	mg/kg	10	1000		503		575		545	
Texture	McDonald *et al*	-	Class	na	MC		MC		MC		MC	
Colour	Munsell	-	Class	na	10YR 3/3		10YR 4/4		10YR 3/1		10YR 5/4	

eastwest GEO•AG•ENVIRO

ANALYSIS REPORT

Project No: EW140391

				Sample ID	CS13		CS13		CS13		CS13	
				Depth (cm)	0-20		20-40		40-60		60-80	
Analyte	**Method**	**Method Reference**	**Units**	**LOR**	**140391-45**		**140391-46**		**140391-47**		**140391-48**	
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	128		208		151		100	
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.30		0.34		0.29		0.28	
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	6.89		5.21		5.09		5.27	
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	6.45		4.51		4.32		4.46	
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	23.7		5.6		5.3		3.1	
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	64.0		41.7		18.4		20.9	
PBI	PBI $_{(Col)}$	*R&L 9I2a*	*mg/kg*	*10*	187		359		381		276	
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	64.1		127		76.0		29.4	
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	1.63		1.11		0.97		0.90	
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	1.75		1.11		1.03		0.90	
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.15		1.20		0.91		1.37	
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.90		1.40		0.63		0.79	
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	18.3		11.6		3.3		8.0	
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	277		325		169		411	
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.81		0.43		0.34		0.31	
					mg/kg	*meq/100g*	*mg/kg*	*meq/100g*	*mg/kg*	*meq/100g*	*mg/kg*	*meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	265	0.68	168	0.43	162	0.42	146	0.37
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	1862	9.31	1031	5.16	781	3.91	545	2.73
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	778	6.48	1253	10.4	1366	11.4	1357	11.3
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	562	2.44	493	2.14	505	2.20	516	2.24
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	0.6	0.01	0.4	0.00	292	3.24	149	1.66
Ex Potassium %	Calc	-	*%*	*na*	3.59		2.37		1.96		2.04	
Ex Calcium %	Calc	-	*%*	*na*	49.2		28.4		18.5		14.9	
Ex Magnesium %	Calc	-	*%*	*na*	34.3		57.4		53.8		61.8	
Ex Sodium %	Calc	-	*%*	*na*	12.9		11.8		10.4		12.3	
Ex Aluminium %	Calc	-	*%*	*na*	0.04		0.02		15.34		9.04	
ECEC	Calc	-	*meq/100g*	*na*	18.9		18.2		21.1		18.3	
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	423		217		185		203	
Texture	McDonald *et al*	-	*Class*	*na*	CL		LMC		MC		MC	
Colour	Munsell	-	*Class*	*na*	7.5YR 3/2		10YR 3/2		10YR 3/3		10YR 4/2	

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	140391-49		140391-50		140391-51		140391-52	
				Sample ID	CS13		CS14		CS14		CS14	
				Depth (cm)	80-100		0-20		20-40		40-60	
Chlorides	Probe	R&L 5A1	mg/kg	5	48.4		218		266		224	
Electrical Conductivity	Soil:Water (1:5)	R&L 3A1	dS/m	0.01	0.10		0.47		0.41		0.28	
pH (H2O)	Electrode	R&L 4A1	pH units	na	5.56		6.62		5.48		4.62	
pH ($CaCl_2$)	Electrode	R&L 4B1	pH units	na	4.36		5.96		4.97		4.03	
NO_3-Nitrogen Ex	Aqueous Buffer	In House	mg/kg	2	5.6		15.5		10.2		7.1	
Phosphorus Colwell	UV-Vis	R&L 9B1	mg/kg	2	14.5		252		49.7		10.0	
PBI	PBI $_{(Col)}$	R&L 9I2a	mg/kg	10	89.6		168		203		352	
Sulphur	ICP-OES	R&L 10D1	mg/kg	1	21.2		127		123		48.8	
Organic Carbon	LECO	R&L 6B3	%	0.2	0.28		3.72		1.64		0.60	
Total Carbon	LECO	R&L 6B2	%	0.2	0.28		3.72		1.64		0.63	
Copper Ex	ICP-OES	R&L 12A1	mg/kg	0.5	1.07		1.61		1.33		1.00	
Zinc Ex	ICP-OES	R&L 12A1	mg/kg	0.5	0.98		8.16		2.14		0.56	
Manganese Ex	ICP-OES	R&L 12A1	mg/kg	1	2.7		13.7		6.5		2.5	
Iron Ex	ICP-OES	R&L 12A1	mg/kg	1	167		247		173		84.7	
Boron Ex	ICP-OES	R&L 12C2	mg/kg	0.25	<0.25		0.84		0.40		0.38	
					mg/kg	meq/100g	mg/kg	meq/100g	mg/kg	meq/100g	mg/kg	meq/100g
Potassium Ex	ICP-OES	R&L 15D3	-	10	102	0.26	383	0.98	259	0.66	208	0.53
Calcium Ex	ICP-OES	R&L 15D3	-	10	353	1.77	3560	17.8	1448	7.24	786	3.93
Magnesium Ex	ICP-OES	R&L 15D3	-	10	1317	11.0	522	4.35	449	3.74	763	6.36
Sodium Ex	ICP-OES	R&L 15D3	-	10	394	1.71	574	2.50	411	1.79	338	1.47
Aluminium Ex	ICP-OES	R&L 15G1	-	0.5	114	1.27	2.2	0.02	10.4	0.12	490	5.44
Ex Potassium %	Calc	-	%	na	1.64		3.83		4.90		3.01	
Ex Calcium %	Calc	-	%	na	11.0		69.4		53.4		22.2	
Ex Magnesium %	Calc	-	%	na	68.7		17.0		27.6		35.9	
Ex Sodium %	Calc	-	%	na	10.7		9.73		13.19		8.29	
Ex Aluminium %	Calc	-	%	na	7.93		0.10		0.85		30.7	
ECEC	Calc	-	meq/100g	na	16.0		25.7		13.5		17.7	
Colwell Potassium	AAS	R&L 18A1	mg/kg	10	146		474		330		279	
Texture	McDonald *et al*	-	Class	na	SC		CL		LMC		MC	
Colour	Munsell	-	Class	na	10YR 5/6		10YR 3/2		10YR 5/3		10YR 4/2	

ANALYSIS REPORT

Project No: EW140391

				Sample ID	CS14		CS14		CS15		CS15	
				Depth (cm)	60-80		80-100		0-20		20-40	
Analyte	**Method**	**Method Reference**	**Units**	**LOR**	**140391-53**		**140391-54**		**140391-55**		**140391-56**	
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	118		114		222		243	
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.17		0.16		0.44		0.42	
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	4.82		4.88		6.85		5.93	
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	4.01		4.08		5.94		5.49	
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	6.9		8.1		16.2		9.9	
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	20.5		33.7		241		64.0	
PBI	PBI (Col)	*R&L 9I2a*	*mg/kg*	*10*	295		296		176		142	
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	26.5		26.5		108		137	
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	0.65		1.18		2.50		1.46	
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	0.75		1.41		2.50		1.46	
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.22		1.16		1.38		1.42	
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	0.68		0.93		5.39		1.77	
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	1.5		2.6		9.9		8.9	
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	90.7		121		177		216	
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.32		0.43		0.52		0.26	
					mg/kg	*meq/100g*	*mg/kg*	*meq/100g*	*mg/kg*	*meq/100g*	*mg/kg*	*meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	*-*	*10*	170	0.44	182	0.47	176	0.45	186	0.48
Calcium Ex	ICP-OES	*R&L 15D3*	*-*	*10*	571	2.86	665	3.33	601	3.01	1918	9.59
Magnesium Ex	ICP-OES	*R&L 15D3*	*-*	*10*	725	6.04	693	5.78	748	6.23	928	7.73
Sodium Ex	ICP-OES	*R&L 15D3*	*-*	*10*	294	1.28	293	1.27	306	1.33	421	1.83
Aluminium Ex	ICP-OES	*R&L 15G1*	*-*	*0.5*	434	4.82	375	4.17	6.5	0.07	0.7	0.01
Ex Potassium %	Calc	-	*%*	*na*	2.82		3.11		4.07		2.43	
Ex Calcium %	Calc	-	*%*	*na*	18.5		22.2		27.1		48.8	
Ex Magnesium %	Calc	-	*%*	*na*	39.1		38.5		56.2		39.4	
Ex Sodium %	Calc	-	*%*	*na*	8.28		8.49		12.0		9.32	
Ex Aluminium %	Calc	-	*%*	*na*	31.2		27.8		0.65		0.04	
ECEC	Calc	-	*meq/100g*	*na*	15.4		15.0		11.1		19.6	
Colwell Potassium	AAS	*R&L18A1*	*mg/kg*	*10*	248		332		483		250	
Texture	McDonald *et al*	-	*Class*	*na*	MC		MC		LMC		CL	
Colour	Munsell	-	*Class*	*na*	10YR 5/6		10YR 5/6		10YR 2/2		10YR 4/3	

eastwest GEO•AG•ENVIRO

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	CS15 40-60 140391-57		CS16 0-20 140391-58		CS16 20-40 140391-59		CS16 40-60 140391-60	
Chlorides	Probe	R&L 5A1	mg/kg	5	217		94.8		95.6		144	
Electrical Conductivity	Soil:Water (1:5)	R&L 3A1	dS/m	0.01	0.29		0.26		0.20		0.29	
pH (H2O)	Electrode	R&L 4A1	pH units	na	5.20		6.29		5.62		5.87	
pH ($CaCl_2$)	Electrode	R&L 4B1	pH units	na	4.43		5.73		4.86		5.30	
NO_3-Nitrogen Ex	Aqueous Buffer	In House	mg/kg	2	6.8		34.2		12.1		7.5	
Phosphorus Colwell	UV-Vis	R&L 9B1	mg/kg	2	25.6		133		44.2		59.2	
PBI	PBI (Col)	R&L 9I2a	mg/kg	10	240		118		210		178	
Sulphur	ICP-OES	R&L 10D1	mg/kg	1	57.4		32.8		41.5		62.9	
Organic Carbon	LECO	R&L 6B3	%	0.2	1.34		2.64		1.11		0.91	
Total Carbon	LECO	R&L 6B2	%	0.2	1.37		2.68		1.11		0.96	
Copper Ex	ICP-OES	R&L 12A1	mg/kg	0.5	1.27		1.33		1.12		1.54	
Zinc Ex	ICP-OES	R&L 12A1	mg/kg	0.5	1.29		4.81		1.73		1.57	
Manganese Ex	ICP-OES	R&L 12A1	mg/kg	1	9.4		9.3		2.8		<1	
Iron Ex	ICP-OES	R&L 12A1	mg/kg	1	422		300		159		95.7	
Boron Ex	ICP-OES	R&L 12C2	mg/kg	0.25	<0.25		0.57		0.35		0.31	
					mg/kg	meq/100g	mg/kg	meq/100g	mg/kg	meq/100g	mg/kg	meq/100g
Potassium Ex	ICP-OES	R&L 15D3	-	10	141	0.36	298	0.76	238	0.61	228	0.58
Calcium Ex	ICP-OES	R&L 15D3	-	10	740	3.70	2165	10.8	1167	5.84	1442	7.21
Magnesium Ex	ICP-OES	R&L 15D3	-	10	1014	8.45	631	5.26	1389	11.6	1742	14.5
Sodium Ex	ICP-OES	R&L 15D3	-	10	469	2.04	294	1.28	353	1.53	533	2.32
Aluminium Ex	ICP-OES	R&L 15G1	-	0.5	101	1.12	4.5	0.05	27.5	0.31	4.0	0.04
Ex Potassium %	Calc	-	%	na	2.31		4.20		3.07		2.37	
Ex Calcium %	Calc	-	%	na	23.6		59.6		29.4		29.2	
Ex Magnesium %	Calc	-	%	na	53.9		28.9		58.3		58.8	
Ex Sodium %	Calc	-	%	na	13.0		7.03		7.73		9.39	
Ex Aluminium %	Calc	-	%	na	7.16		0.28		1.54		0.18	
ECEC	Calc	-	meq/100g	na	15.7		18.2		19.9		24.7	
Colwell Potassium	AAS	R&L18A1	mg/kg	10	157		469		370		300	
Texture	McDonald *et al*	-	Class	na	LMC		CL		MC		MC	
Colour	Munsell	-	Class	na	10YR 3/3		10YR 5/4		10YR 5/6		10YR 5/4	

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	PS1 A	PS1 B	PS2 A	PS2 B
				Sample ID	PS1 A	PS1 B	PS2 A	PS2 B
				Depth (cm)	40-60	0-20	20-40	40-60
					140391-61	140391-62	140391-63	140391-64
Chlorides	Probe	*R&L 5A1*	*mg/kg*	*5*	14.4	25.0	22.2	140
Electrical Conductivity	Soil:Water (1:5)	*R&L 3A1*	*dS/m*	*0.01*	0.06	0.08	0.07	0.18
pH (H2O)	Electrode	*R&L 4A1*	*pH units*	*na*	5.48	5.50	5.45	6.15
pH ($CaCl_2$)	Electrode	*R&L 4B1*	*pH units*	*na*	4.80	4.18	4.80	5.09
NO_3-Nitrogen Ex	Aqueous Buffer	*In House*	*mg/kg*	*2*	12.2	4.7	11.6	5.3
Phosphorus Colwell	UV-Vis	*R&L 9B1*	*mg/kg*	*2*	23.1	8.1	20.2	9.9
PBI	PBI (Col)	*R&L 9I2a*	*mg/kg*	*10*	96.0	199	90.7	72.7
Sulphur	ICP-OES	*R&L 10D1*	*mg/kg*	*1*	10.3	7.0	9.4	8.3
Organic Carbon	LECO	*R&L 6B3*	*%*	*0.2*	2.21	0.35	2.35	0.74
Total Carbon	LECO	*R&L 6B2*	*%*	*0.2*	2.28	0.35	2.35	0.79
Copper Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	1.31	1.36	1.43	1.26
Zinc Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*0.5*	3.09	<0.5	1.90	0.39
Manganese Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	27.0	<1	41.6	<1
Iron Ex	ICP-OES	*R&L 12A1*	*mg/kg*	*1*	562	110	338	94.3
Boron Ex	ICP-OES	*R&L 12C2*	*mg/kg*	*0.25*	0.28	<0.25	0.40	0.67

Analyte	Method	Method Reference	Units	LOR	PS1 A *mg/kg*	PS1 A *meq/100g*	PS1 B *mg/kg*	PS1 B *meq/100g*	PS2 A *mg/kg*	PS2 A *meq/100g*	PS2 B *mg/kg*	PS2 B *meq/100g*
Potassium Ex	ICP-OES	*R&L 15D3*	-	*10*	120	0.31	107	0.27	82.0	0.21	95.0	0.24
Calcium Ex	ICP-OES	*R&L 15D3*	-	*10*	761	3.81	222	1.11	860	4.30	1002	5.01
Magnesium Ex	ICP-OES	*R&L 15D3*	-	*10*	344	2.87	1098	9.15	503	4.19	1532	12.8
Sodium Ex	ICP-OES	*R&L 15D3*	-	*10*	87.5	0.38	339	1.47	164	0.71	743	3.23
Aluminium Ex	ICP-OES	*R&L 15G1*	-	*0.5*	10.2	0.11	292	3.24	16.3	0.18	2.3	0.03

Analyte	Method	Method Reference	Units	LOR	PS1 A	PS1 B	PS2 A	PS2 B
Ex Potassium %	Calc	-	*%*	*na*	4.12	1.80	2.19	1.14
Ex Calcium %	Calc	-	*%*	*na*	50.9	7.28	44.8	23.5
Ex Magnesium %	Calc	-	*%*	*na*	38.4	60.0	43.7	60.0
Ex Sodium %	Calc	-	*%*	*na*	5.09	9.66	7.43	15.2
Ex Aluminium %	Calc	-	*%*	*na*	1.52	21.3	1.89	0.12
ECEC	Calc	-	*meq/100g*	*na*	7.47	15.3	9.60	21.3
Colwell Potassium	AAS	*R&L 18A1*	*mg/kg*	*10*	185	136	101	116
Texture	McDonald *et al*	-	*Class*	*na*	FSCL	LMC	CL	MC
Colour	Munsell	-	*Class*	*na*	7.5YR 4/6	10YR 5/3	10YR 4/4	10YR 5/4

Attachment 4.

Stage 1A – Baseline 5 vs Baseline 4 comparisons

Differences in average values between Baseline 5 (irrigated) and Baseline 4 (irrigated)

Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 Mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g	Al meq/100g	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Al mg/kg	K %	Ca %	Mg %	Na %	Al %	ECEC meq/100g	ESP %
0-20	-0.04	0.10	6.07	0.02	-0.06	0.44	0.07	0.29	0.02	-25	88	8	66	2	-0.4	-1.3	0.3	1.3	0.1	0.75	1.26
20-40	0.11	0.06	-6.33	-0.21	0.15	0.98	2.30	0.65	-0.09	58	197	280	150	-8	-0.2	-3.9	3.3	1.6	-0.9	4.00	1.59
40-60	0.11	0.05	-5.51	-0.65	0.04	0.30	2.46	0.69	0.58	14	60	299	158	52	-0.5	-7.1	2.8	1.6	3.2	4.06	1.62
60-80	0.17	0.43	2.00	-0.15	0.03	1.01	1.45	0.84	-0.05	10	201	176	193	-4	-0.3	-3.6	0.1	2.8	1.1	3.27	2.76
80-100	0.12	0.44	-1.44	-0.22	0.05	0.71	2.30	0.87	0.61	18	143	280	201	55	-0.5	-7.2	1.5	2.1	4.1	4.55	2.10
100-120	0.29	0.92	8.73	0.11	0.20	2.89	2.58	1.49	-0.01	76	876	296	328	-1	0.0	6.0	-7.8	1.9	-0.1	8.42	1.87

Differences in average values between Baseline 4 (irrigated) and Baseline 3 (irrigated)

Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g	Al meq/100g	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Al mg/kg	K %	Ca %	Mg %	Na %	Al %	ECEC meq/100g	ESP %
0-20	0.05	-0.16	-21.34	-0.70	-0.09	-3.14	-0.27	0.93	0.00	-36	-630	-33	213	0.0	0.3	-7.4	2.0	5.2	0.0	-2.58	5.25
20-40	-0.02	-0.27	-13.94	-0.61	-0.12	-2.54	-0.03	0.52	0.04	-46	-508	-4	121	4.0	-0.1	-9.2	4.7	4.0	0.6	-2.12	4.03
40 - 60	-0.01	0.08	-9.74	-0.20	-0.04	-0.12	0.81	0.54	0.05	-14	-25	98	125	5.0	-0.4	-3.2	1.4	2.9	-0.7	1.24	2.86
60 - 80	0.02	0.75	-12.46	-0.25	0.04	0.72	0.45	0.49	-0.29	15	144	54	112	-26.0	0.2	4.1	-2.0	2.0	-4.1	1.40	1.97
80 - 100	0.08	1.25	-0.49	0.29	0.18	3.31	-1.56	0.30	-1.84	68	663	-190	69	-165.0	1.1	20.1	-11.0	1.6	-11.8	0.39	1.56
100 - 120	0.00	1.71	-3.03	0.24	0.14	4.11	-0.04	0.58	-1.83	54	527	13	148	-164.0	0.7	14.6	-5.3	2.9	-12.8	1.70	2.86

Differences in average values between Baseline 3 (irrigated) and Baseline 2 (ameliorated)

Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g	Al meq/100g	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Al mg/kg	K %	Ca %	Mg %	Na %	Al %	ECEC meq/100g	ESP %
0-20	-0.55	0.51	-117	0.40	-0.05	3.08	0.00	-0.48	0.00	-20	617	0	-111	-0.2	-1.0	7.5	-3.7	-2.7	0.0	2.55	2.54
20-40	-0.28	0.69	-23	0.62	0.06	3.19	-1.86	-0.89	-0.14	23	638	-226	-203	-12.3	0.4	17.5	-11.9	-5.0	-0.9	0.36	3.76
40 - 60	-0.19	0.01	-21	0.36	0.04	0.71	-1.66	-0.78	0.03	17	142	-201	-180	2.5	0.5	6.8	-4.1	-3.8	0.6	-1.66	5.24
60 - 80	-0.18	-0.46	-12	0.08	0.00	-0.07	-0.94	-0.71	0.70	0	-14	-114	-163	62.7	0.2	-0.7	-1.2	-3.4	5.1	-1.02	6.02
80 - 100	-0.25	-0.95	-26	-0.32	-0.14	-2.50	1.31	-0.56	1.35	-55	-500	159	-129	121.6	-0.9	-13.7	9.9	-2.9	7.6	-0.54	7.95
100 - 120	-0.15	-1.28	-5	-0.34	-0.14	-2.66	-1.18	-0.84	1.70	-54	-533	-143	-193	152.7	-0.5	-11.8	3.3	-3.2	12.1	-3.12	8.93

Differences in average values between Baseline 3 (irrigated) and Baseline 1 (parent soil)

Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g	Al meq/100g	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Al mg/kg	K %	Ca %	Mg %	Na %	Al %	ECEC meq/100g	ESP %
0-20	0.25	2.18	41.30	1.87	0.64	12.33	-0.99	-0.22	-0.26	250	2471	-121	-51	-23	1	43	-36	-5	-3	11.50	2.5
20-40	0.20	1.62	27.40	1.62	0.27	8.90	-5.32	-1.16	-0.36	105	1784	-647	-266	-33	1	46	-36	-8	-3	2.33	3.8
40 - 60	0.11	0.69	21.05	1.30	0.18	5.62	-5.23	-1.50	-0.09	70	1126	-635	-346	-8	1	34	-27	-8	0	-1.02	5.2
60 - 80	0.01	0.00	15.46	0.90	0.07	3.91	-3.42	-1.68	0.74	26	783	-416	-387	67	0	23	-19	-10	5	-0.39	6.0
80 - 100	-0.03	-0.66	5.14	0.35	-0.07	1.39	-1.17	-1.50	1.51	-26	278	-142	-345	136	0	9	-8	-10	9	0.17	7.9
100 - 120	0.08	-0.80	4.41	0.17	-0.05	1.11	-1.46	-1.37	-2.71	-21	223	-178	-316	-243	0	7	-4	-8	5	-4.48	8.9

Denotes an increase in Baseline soil test values compared to previous Baseline soil test values

Attachment 5.

Stage 1B soil test summary tables and results

STAGE 1 B – SOIL TEST RESULTS

Nutrient	Units	Result- Baseline 1	Result – Baseline 2	Result – Baseline 3	Result – Baseline 4
Chlorides	mg/kg	140	65	247	142
Electrical Conductivity	dS/m	0.21	0.11	0.26	0.24
pH ($CaCl_2$)	pH units	4.63	4.80	4.98	5.4
NO_3- Nitrogen extract	mg/kg	53.1	15.5	11.5	16.5
Phosphorous Colwell	mg/kg	82.8	40.9	37.9	42.2
Sulphur	mg/kg	10.0	14.4	46.0	41.1
Organic Carbon	%	2.82	2.98	3.13	2.87
Copper ex	mg/kg	0.49	<0.5	0.9	1.78
Zinc ex	mg/kg	4.27	3.3	3.1	2.97
Manganese ex	mg/kg	32.9	22.0	28.0	18.2
Boron ex	mg kg	0.62	0.51	0.5	0.47
Potassium ex	mg/kg	145	224	267	271
Potassium ex	meq/100g	0.37	0.57	0.68	0.69
Calcium ex	mg/kg	429	820	895	1054
Calcium ex	meq/100g	2.15	4.10	4.48	5.27
Magnesium ex	mg/kg	305	384	397	421
Magnesium ex	meq/100g	2.54	3.20	3.31	3.51
Sodium ex	mg/kg	245	163	345	439
Sodium ex	meq/100g	1.07	0.71	1.5	1.91
Aluminium ex	mg/kg	16.5	6.30	2.06	3.5
Aluminium ex	meq/100g	0.18	0.07	0.02	0.04
Ex Potassium	%	5.89	6.69	6.85	6.08
Ex Calcium	%	34.0	47.8	44.8	46.1
Ex Magnesium	%	40.3	37.3	33.1	30.7
Ex Sodium	%	16.9	8.26	15.0	16.7
Ex Aluminium	%	2.91	0.82	0.23	0.34
ECEC	Meq/100g	6.3	8.58	10.0	11.4

ANALYSIS REPORT

Project No: EW140391

Analyte	Method	Method Reference	Units	LOR	Sample ID: 1 B Comp Depth cm: 0-20 140391-65	
Chlorides	Probe	R&L 5A1	mg/kg	5	142	
Electrical Conductivity	Soil:Water (1:5)	R&L 3A1	dS/m	0.01	0.24	
pH (H2O)	Electrode	R&L 4A1	pH units	na	5.91	
pH ($CaCl_2$)	Electrode	R&L 4B1	pH units	na	5.40	
NO_3-Nitrogen Ex	Aqueous Buffer	In House	mg/kg	2	16.5	
Phosphorus Colwell	UV-Vis	R&L 9B1	mg/kg	2	42.2	
PBI	PBI (Col)	R&L 9I2a	mg/kg	10	128	
Sulphur	ICP-OES	R&L 10D1	mg/kg	1	41.1	
Organic Carbon	LECO	R&L 6B3	%	0.2	2.87	
Total Carbon	LECO	R&L 6B2	%	0.2	3.14	
Copper Ex	ICP-OES	R&L 12A1	mg/kg	0.5	1.78	
Zinc Ex	ICP-OES	R&L 12A1	mg/kg	0.5	2.97	
Manganese Ex	ICP-OES	R&L 12A1	mg/kg	1	18.2	
Iron Ex	ICP-OES	R&L 12A1	mg/kg	1	180	
Boron Ex	ICP-OES	R&L 12C2	mg/kg	0.25	0.47	
					mg/kg	*meq/100g*
Potassium Ex	ICP-OES	R&L 15D3	-	10	271	0.69
Calcium Ex	ICP-OES	R&L 15D3	-	10	1054	5.27
Magnesium Ex	ICP-OES	R&L 15D3	-	10	421	3.51
Sodium Ex	ICP-OES	R&L 15D3	-	10	439	1.91
Aluminium Ex	ICP-OES	R&L 15G1	-	0.5	3.5	0.04
Ex Potassium %	Calc	-	%	na	6.08	
Ex Calcium %	Calc	-	%	na	46.1	
Ex Magnesium %	Calc	-	%	na	30.7	
Ex Sodium %	Calc	-	%	na	16.7	
Ex Aluminium %	Calc	-	%	na	0.34	
ECEC	Calc	-	meq/100g	na	11.4	
Colwell Potassium	AAS	R&L 18A1	mg/kg	10	359	
Texture	McDonald *et al*	-	Class	na	L	
Colour	Munsell	-	Class	na	10YR 3/2	

DOCUMENT END

Attachment 6.

Stage 1A Soil profile descriptions

1. Introduction

Soil test pits were inspected in March 2014 to determine the performance of ameliorated soils in the Stage 1A irrigation area at the Tiedmans site. Observations and soil descriptions were recorded on the day and an A and B horizon sample from each test pit were collected for analysis. Soil classification was determined based on soil description and analysis results. This report summarises test pit observations and soil analysis, description and classification.

2. Method

Eight test pits were excavated using a backhoe to reveal the soil profile including at least one "slot" in each treatment. The location of the test pits in the Stage 1A irrigation area are shown in Figure A. Treatment characteristics of each test pit site are summarised in Table 1.

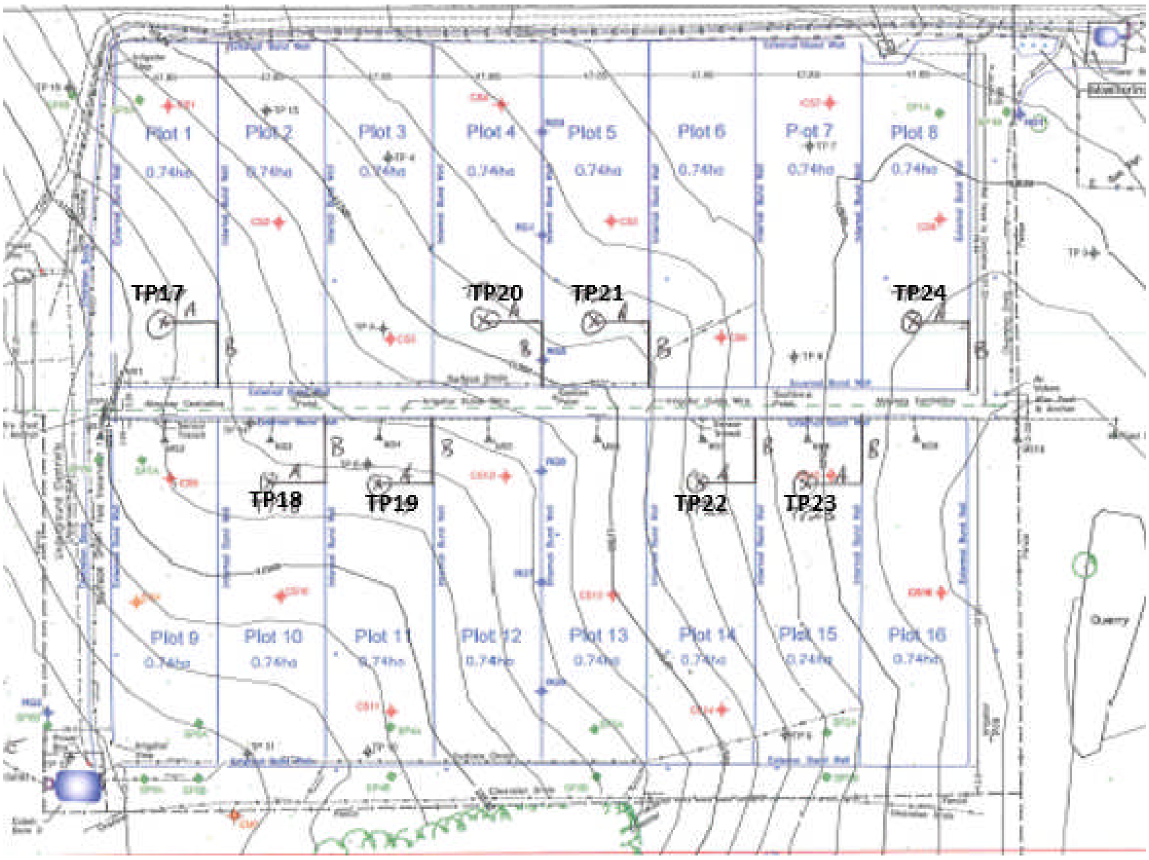


Figure 1: Test pit locations in the Stage 1A irrigation area at Tiedmans

Table 1: Test pit summary of slotting depth, treatment depth and crop type

	Slotting depth (m)	Treatment ID	Crop type
TP17	0	T1	Annual
TP18	0	T1	Lucerne
TP19	1200	T1 + T4	Annual
TP20	1200	T1 + T4	Lucerne
TP21	950	T1 + T3	Annual
TP22	950	T1 + T3	Lucerne
TP23	650	T1 + T2	Annual
TP24	650	T1 + T2	Lucerne

Site observations and soil descriptions were undertaken on the day, including a photographic record. Soil samples were taken from the excavated A and B horizons and bagged/sealed/stored for transport to the soil laboratory. Soil analysis included pH (H_20 and $CaCl_2$), electrical conductivity (EC, dS/m), total nitrogen (TN, mg/L), nitrate (NO_3^-, mg/L), total carbon (TC, %), organic carbon (Org-C, %), chlorides (Cl^-, mg/L) and exchangeable cations (Ca, Mg, Na, K in meq/100g and mg/kg). Effective Cation Exchange Capacity (ECEC, meq/100g), calcium/magnesium ratio (Ca/Mg) and exchangeable sodium percentage (ESP) were calculated from soil laboratory analysis data.

The Australian Soil Classification (ASC) system devised by Isbell (2002) was used to classify soils observed in the test pits.

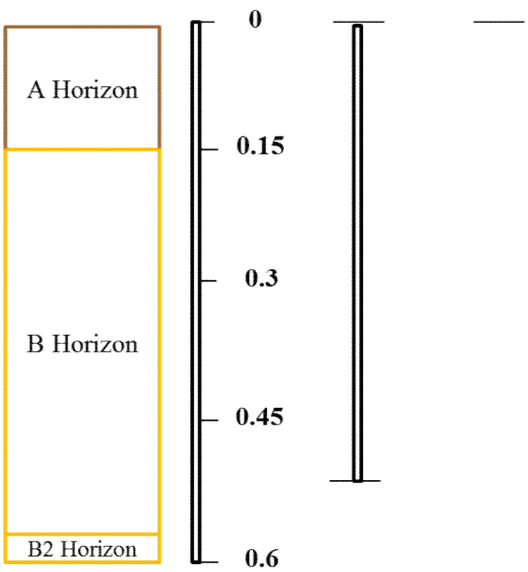
3. Results & Discussion

All Test Pits displayed strong texture contrast between A horizons and B horizons. Seven of the eight Test Pits had strongly acid B horizons (pH < 5.5) and some unusual subsoil chemical features (high magnesium, sodium and aluminium) which indicate a Kurosol. One Test Pit (TP19) was classified as a Sodosol as the B horizon was not strongly acid.

Comments on Kurosols from the Australian Soil Classification:
http://www.clw.csiro.au/aclep/asc_re_on_line/ku/kurosols.htm
"The relevance of sodicity in strongly acid soils is open to question as in theory the presence of aluminium in such soils should counterbalance the usual deleterious effect of sodium (via dispersion) on soil physical properties. Unpublished data from many localities in Australia imply that for B horizons the critical limits of pH 5.5 and ESP of 6 to distinguish dispersive and non-dispersive soils seems to generally work in practice, although as might be expected, some soils do not behave as predicted. For this reason, sodicity is also used in Kurosols, but at a lower hierarchical level, to cater for those soils which have an ESP > 6 and may disperse in spite of having a pH less than 5.5. The role of the high exchangeable magnesium in many Kurosols is largely unknown."

3.1 Soil Description and Classification

TP18: Treatment 1 only, 240 mm – Lucerne (no slots)



A Horizon: Dry, brown clay loam to 0.15 m, fine roots and worms present, diffuse boundary to B horizon

B Horizon: Dry, yellow/light brown medium to heavy clay, fine/medium roots observed to 0.5 m, worms present to 0.3 m, diffuse boundary to dry crumbly pale yellow/white B2 horizon

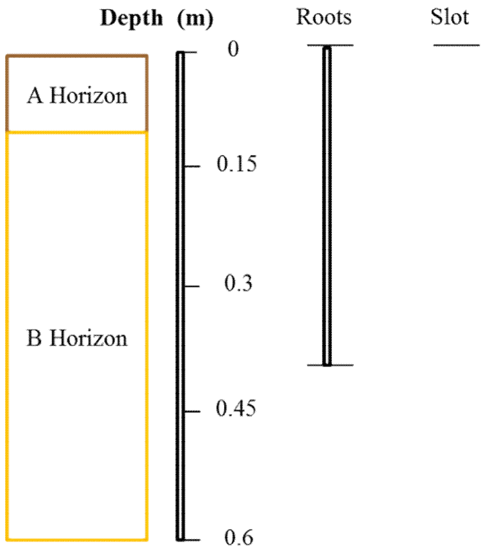
Figure 2: Soil description for TP18

Table 2: Soil classification for TP18

TP18
Abrupt texture contrast between A and B horizons
Strongly acid B horizon (pH = 5.52)
Ca/Mg ratio < 0.1 in B horizon
High magnesium in B horizon and ESP > 6

Order	Kurosol [KU]
Suborder	Yellow [AC]
Great Group	Magnesic-Natric [GP]
Subgroup	Sodic [EO]
Family: A horizon thickness	Medium [B] 0.1 - < 0.3 m
Family: Gravel on surface or A horizon	Non-gravelly [E] < 2 %
Family: A horizon texture	Loamy [L] 10 - 20 % clay
Family: B horizon texture	Clayey [O] > 35 % clay
Family: Soil depth	Moderate [V] 0.5 - < 1 m
Soil Classification	**[KU] [AC] [GP] [EO] [B] [E] [L] [O] [V]**

TP17: Treatment 1 only, 240 mm – Forage Sorghum (no slots)



A Horizon: Moist, brown clay loam to 0.1 m, fine roots and worms present, diffuse boundary to B horizon

B Horizon: Moist, yellow medium to heavy clay, fine roots observed to 0.4 m

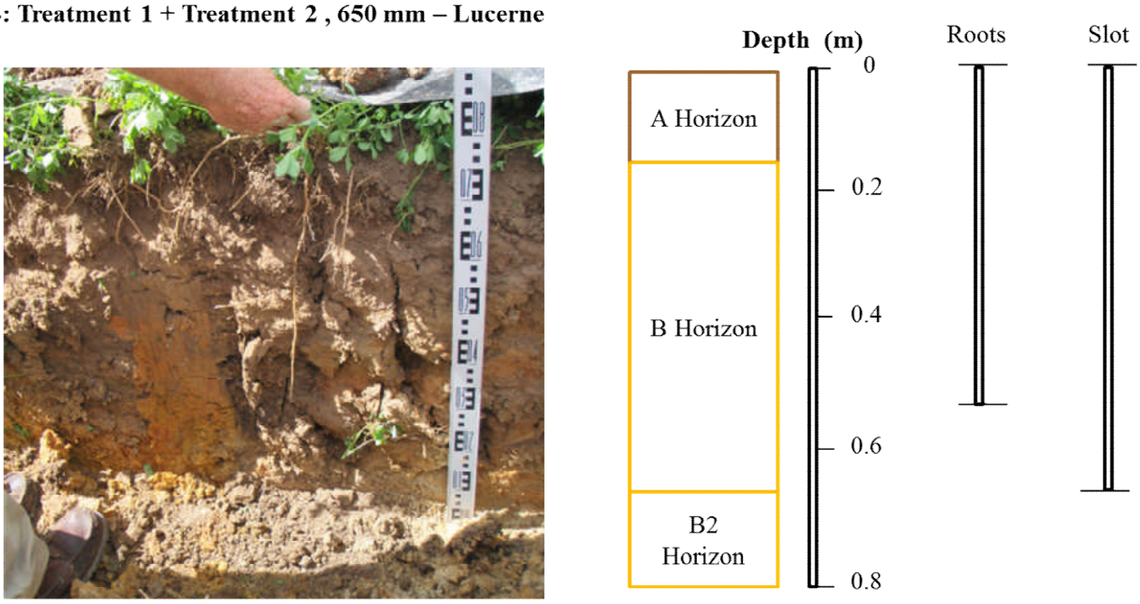
Figure 3: Soil description for TP17

Table 3: Soil classification for TP17

TP17
Abrupt texture contrast between A and B horizons
Strongly acid B horizon (pH = 4.89)
High magnesium in B horizon and ESP > 6

Order	Kurosol [KU]
Suborder	Yellow [AC]
Great Group	Eutrophic [AH] ECEC > 15 meq/100g
Subgroup	Sodic [EO]
Family: A horizon thickness	Medium [B] 0.1 - < 0.3 m
Family: Gravel on surface or A horizon	Non-gravelly [E] < 2 %
Family: A horizon texture	Loamy [L] 10 - 20 % clay
Family: B horizon texture	Clayey [O] > 35 % clay
Family: Soil depth	Moderate [V] 0.5 - < 1 m
Soil Classification	**[KU] [AC] [AH] [EO] [B] [E] [L] [O] [V]**

TP24: Treatment 1 + Treatment 2 , 650 mm – Lucerne



A Horizon: Dry, light brown clay loam to 0.15 m, fine to medium roots and worms present, diffuse boundary to B horizon

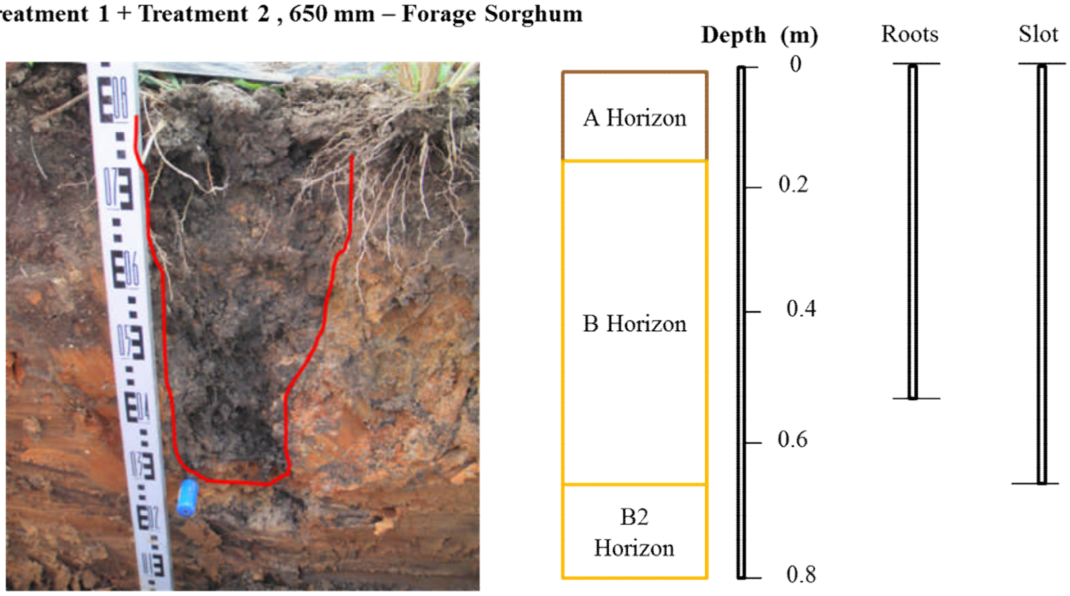
B Horizon: Dry to moist, brown/yellow heavy clay, medium roots observed to 0.5 m in slot, worms present to 0.4 m in slot, diffuse boundary to dry crumbly pale yellow/white B2 horizon

Figure 4: Soil description for TP24

Table 4: Soil classification for TP24

TP24 Abrupt texture contrast between A and B horizons Strongly acid B horizon (pH = 5.36) High magnesium in B horizon and ESP > 6	Order	Kurosol [KU]
	Suborder	Brown [AB]
	Great Group	Eutrophic [AH] ECEC > 15 meq/100g
	Subgroup	Sodic [EO]
	Family: A horizon thickness	Medium [B] 0.1 - < 0.3 m
	Family: Gravel on surface or A horizon	Non-gravelly [E] < 2 %
	Family: A horizon texture	Loamy [L] 10 - 20 % clay
	Family: B horizon texture	Clayey [O] > 35 % clay
	Family: Soil depth	Moderate [V] 0.5 - < 1 m
	Soil Classification	**[KU] [AB] [AH] [EO] [B] [E] [L] [O] [V]**

TP23: Treatment 1 + Treatment 2 , 650 mm – Forage Sorghum



A Horizon: Dry, light brown clay loam to 0.15 m, fine roots and worms present, diffuse boundary to B horizon

B Horizon: Moist, yellow/red heavy clay, fine roots observed to 0.5 m (in slot, highlighted by red line in figure), worms present to 0.4 m in slot, diffuse boundary to wet yellow/red B2 horizon

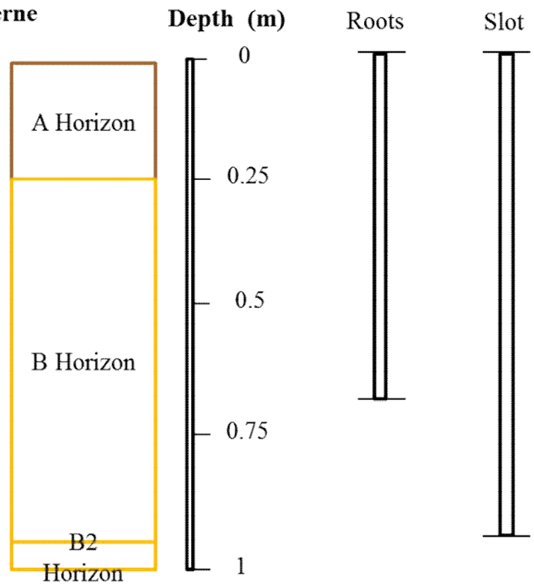
Figure 5: Soil description for TP23

Table 5: Soil classification for TP23

TP23
Abrupt texture contrast between A and B horizons
Strongly acid B horizon (pH = 4.71)
High magnesium in B horizon and ESP > 6

Order	Kurosol [KU]
Suborder	Yellow [AC]
Great Group	Eutrophic [AH] ECEC > 15 meq/100g
Subgroup	Sodic [EO]
Family: A horizon thickness	Medium [B] 0.1 - < 0.3 m
Family: Gravel on surface or A horizon	Non-gravelly [E] < 2 %
Family: A horizon texture	Loamy [L] 10 - 20 % clay
Family: B horizon texture	Clayey [O] > 35 % clay
Family: Soil depth	Moderate [V] 0.5 - < 1 m
Soil Classification	**[KU] [AC] [AH] [EO] [B] [E] [L] [O] [V]**

TP22: Treatment 1 + Treatment 3 , 950 mm – Lucerne



A Horizon: Dry, light brown clay loam to 0.25 m, fine to medium roots and worms present, diffuse boundary to B horizon

B Horizon: Moist, brown/yellow medium to heavy clay with red lenses and some mottling, fine/medium roots observed to 0.7 m, worms present to 0.4 m, diffuse boundary to wet pale yellow/white B2 horizon

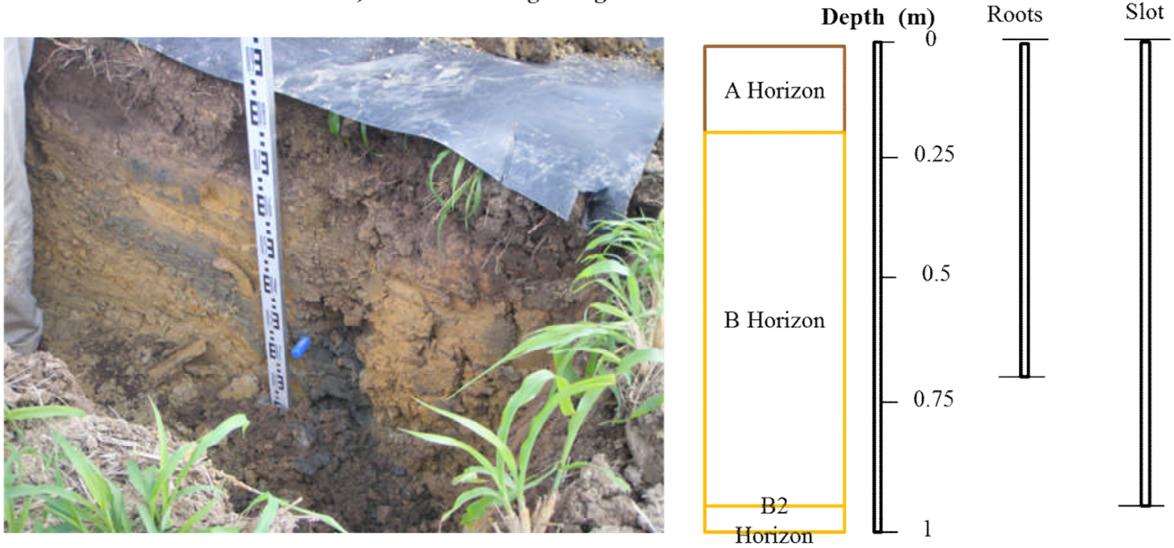
Figure 6: Soil description for TP22

Table 6: Soil classification for TP22

TP22
Abrupt texture contrast between A and B horizons
Strongly acid B horizon (pH = 4.97)
Ca/Mg ratio < 0.1 in B horizon
High magnesium in B horizon and ESP > 6

Order	Kurosol [KU]
Suborder	Yellow [AC]
Great Group	Magnesic-Natric [GP]
Subgroup	Sodic [EO]
Family: A horizon thickness	Medium [B] 0.1 - < 0.3 m
Family: Gravel on surface or A horizon	Non-gravelly [E] < 2 %
Family: A horizon texture	Loamy [L] 10 - 20 % clay
Family: B horizon texture	Clayey [O] > 35 % clay
Family: Soil depth	Moderate [V] 0.5 - < 1 m
Soil Classification	**[KU] [AC] [GP] [EO] [B] [E] [L] [O] [V]**

TP21: Treatment 1 + Treatment 3 , 950 mm – Forage Sorghum



A Horizon: Dry to moist, light brown clay loam to 0.2 m, fine roots and worms present, diffuse boundary to B horizon

B Horizon: Moist, brown/yellow medium to heavy clay, fine roots observed to 0.7 m, worms present to 0.4 m, diffuse boundary to wet pale yellow/white B2 horizon

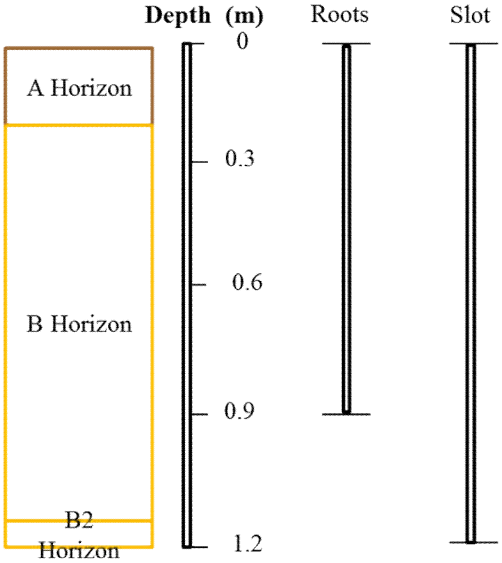
Figure 7: Soil description for TP21

Table 7: Soil classification for TP21

TP21
Abrupt texture contrast between A and B horizons
Strongly acid B horizon (pH = 5.32)
Ca/Mg ratio < 0.1 in B horizon
High magnesium in B horizon and ESP > 6

Order	Kurosol [KU]
Suborder	Brown [AB]
Great Group	Magnesic-Natric [GP]
Subgroup	Sodic [EO]
Family: A horizon thickness	Medium [B] 0.1 - < 0.3 m
Family: Gravel on surface or A horizon	Non-gravelly [E] < 2 %
Family: A horizon texture	Loamy [L] 10 - 20 % clay
Family: B horizon texture	Clayey [O] > 35 % clay
Family: Soil depth	Moderate [V] 0.5 - < 1 m
Soil Classification	**[KU] [AB] [GP] [EO] [B] [E] [L] [O] [V]**

TP20: Treatment 1 + Treatment 4 , 1200 mm – Lucerne



A Horizon: Dry light brown clay loam to 0.2 m, fine to medium roots and worms present, diffuse boundary to B horizon

B Horizon: Dry, brown/yellow medium to heavy clay, fine/medium roots observed to 0.9 m, worms present to 0.3 m, diffuse boundary to wet yellow/white B2 horizon

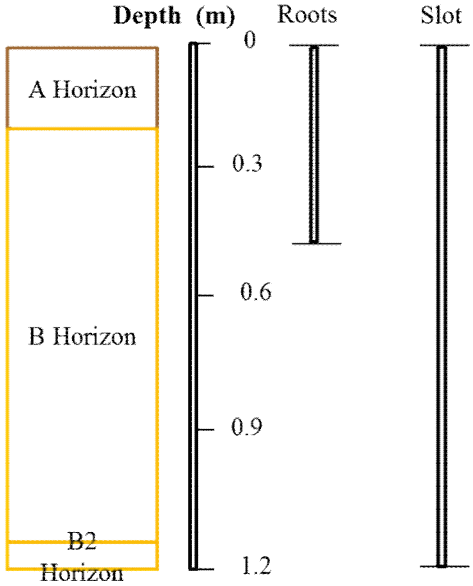
Figure 8: Soil description for TP20

Table 8: Soil classification for TP20

TP20
Abrupt texture contrast between A and B horizons
Moderately acid B horizon (pH = 5.77)
High magnesium in B horizon and ESP > 6

Order	Kurosol [KU]
Suborder	Brown [AB]
Great Group	Magnesic-Natric [GP]
Subgroup	Sodic [EO]
Family: A horizon thickness	Medium [B] 0.1 - < 0.3 m
Family: Gravel on surface or A horizon	Non-gravelly [E] < 2 %
Family: A horizon texture	Loamy [L] 10 - 20 % clay
Family: B horizon texture	Clayey [O] > 35 % clay
Family: Soil depth	Moderate [V] 0.5 - < 1 m
Soil Classification	**[KU] [AB] [GP] [EO] [B] [E] [L] [O] [V]**

TP19: Treatment 1 + Treatment 4 , 1200 mm – Forage Sorghum



A Horizon: Moist, dark brown clay loam to 0.2 m, fine to medium roots and worms present, diffuse boundary to B horizon

B Horizon: Moist, brown/yellow medium to heavy clay, fine/medium roots observed to 0.4 m, worms present to 0.3 m, diffuse boundary to wet pale yellow/white B2 horizon

Figure 9: Soil description for TP19

Table 9: Soil classification for TP19

TP19
Abrupt texture contrast between A and B horizons
B horizon NOT strongly acid (pH = 6.64, therefore not a Kurosol)
Ca/Mg ratio < 0.1 in B horizon
High magnesium in B horizon and ESP > 6

Order	Sodosol [SO]
Suborder	Brown [AB]
Great Group	Mesonatric [DP] ESP = 15 - < 25 %
Subgroup	Magnesic [DB]
Family: A horizon thickness	Medium [B] 0.1 - < 0.3 m
Family: Gravel on surface or A horizon	Non-gravelly [E] < 2 %
Family: A horizon texture	Loamy [L] 10 - 20 % clay
Family: B horizon texture	Clayey [O] > 35 % clay
Family: Soil depth	Moderate [V] 0.5 - < 1 m
Soil Classification	**[SO] [AB] [DP] [DB] [B] [E] [L] [O] [V]**

4. Soil analysis

Table 10 summarises soil analysis data taken at the time of pit inspections. Pit soils were sampled as A and B horizons only.

Table 10: Test pit analysis data

ID	Horizon	EC (1:5) dS/m	pH H20	pH $CaCl_2$	TN mg/kg	NO_3 mg/kg	TC %	Org-C %	Cl^- mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Al mg/kg	K %	Ca %	Mg %	Na %	Al %	ECEC meq/100g	Ca/Mg ratio	ESP %
TP17	A	0.25	6.97	6.46	2526	19.9	3.01	2.49	64.8	246	2285	405	338	9	3.7	67.3	19.7	8.7	0.6	16.9	3.4	8.7
TP17	B	0.31	4.89	4.24	977	6.1	1.21	0.95	120	199	1238	1079	430	99	2.8	33.3	47.9	10.1	5.9	18.5	0.7	10.1
TP18	A	0.19	5.99	5.23	1066	7.3	1.46	1.1	88	149	832	605	322	9	3.5	37.7	45.2	12.7	0.9	11.0	0.8	12.7
TP18	B	0.23	5.52	4.61	5767	4.9	0.3	0.2	245	180	110	1969	678	54	2.2	2.6	78.0	14.2	2.9	20.8	0.0	14.2
TP19	A	0.45	7.26	6.74	3256	23	3.5	2.6	81.2	547	3607	538	361	1	5.5	70.8	17.4	6.2	0.0	25.4	4.1	6.2
TP19	B	0.23	6.64	5.52	568	6	0.16	0.12	107	137	158	1580	598	4	2.1	4.7	77.5	15.5	0.2	16.8	0.1	15.5
TP20	A	0.18	6.48	5.85	1046	7.9	1.24	1.04	76	133	954	370	241	0	3.7	51.8	33.1	11.4	0.0	9.2	1.6	11.4
TP20	B	0.22	5.77	4.79	558	5.5	0.36	0.28	132	160	343	1276	559	16	2.7	11.2	68.9	16.0	1.2	15.2	0.2	16.0
TP21	A	0.22	6.06	5.4	1352	7.7	1.78	1.51	105	164	962	387	276	1	4.4	49.9	33.1	12.5	0.1	9.6	1.5	12.5
TP21	B	0.19	5.32	4.26	605	5.1	0.24	0.17	82.4	176	138	1374	575	236	2.6	3.9	64.4	14.2	14.9	17.6	0.1	14.2
TP22	A	0.21	6.58	6.05	2954	19.9	3.73	2.93	77.8	297	1675	490	340	1	5.2	57.1	27.5	10.1	0.1	14.6	2.1	10.1
TP22	B	0.28	4.97	4.02	426	5.9	0.26	0.22	174	149	72	1459	699	305	2.0	1.9	62.6	15.9	17.7	19.2	0.0	15.9
TP23	A	0.31	6.21	5.73	1829	7.7	2.67	2.12	119	246	1952	445	308	1	4.1	63.3	23.8	8.7	0.1	15.38	2.7	8.7
TP23	B	0.31	4.71	4.05	9.37	5.1	1.01	0.76	166	176	643	839	366	280	2.9	21.0	45.2	10.4	20.4	15.26	0.5	10.4
TP24	A	0.28	6.38	6.16	2053	11.4	2.7	0.5	95.2	309	2585	551	283	1	4.1	66.3	23.3	6.3	0.1	19.46	2.8	6.3
TP24	B	0.34	5.36	4.52	906	5.1	0.82	0.5	224	223	717	1617	713	246	2.4	15.4	57.1	13.3	11.8	23.29	0.3	13.3

Seven of the eight Test Pits had strongly acid B horizons (pH < 5.5) and some unusual subsoil chemical features (high magnesium, sodium and aluminium) which indicate a Kurosol. One Test Pit (TP19) was classified as a Sodosol as the B horizon was not strongly acid. In general, parameters increasing with depth included EC, Cl^-, Na, Mg and Al. The presence of Mg and Al (low pH) at depth is likely to buffer against loss of soil structure by Na in all test pits.

Parameters decreasing with depth included pH, TN, NO_3^-, TC, Org-C and Ca. Reduced TC and Org-C in the B horizons is likely to reflect some leaching from the A horizon. Reduced NO_3^- at depth is likely to reflect water movement into the root zone and assimilation by plants. TN levels remain adequate for providing a source of NO_3^- after nitrification processes occur (no fertilizer required). Parameters such as ECEC and Ca/Mg ratio are within desired ranges in the A horizon.

5. Summary

5.1 Soil classification and analysis

- Kurosols are the dominant soil classification (sharp textural contrast between A and B horizons with pH < 5.5 in B horizon).
- B horizons have low pH (< 5.5) due to the presence of Mg and Al.
- Soil ESP in A horizon ranged between 6.2 – 12.7 %, slightly higher than the desired range of < 6.
- Soil ESP in B horizon ranged between 10.1 – 16 %, however this is typical of B horizons in many Australian soils.
- Presence of Mg and Al (low pH) at depth buffers against loss of soil structure by Na.
- TN levels remain adequate for providing a source of NO_3^- after nitrification processes occur (no fertilizer required).
- ECEC and Ca/Mg ratio are within desired ranges in the A horizon.

6. References

Isbell, R. (2002) *The Australian Soil Classification,* Revised Edition, Australian Soil and Land Survey Handbooks Series 4, CSIRO Publishing, pp152.
http://www.clw.csiro.au/aclep/asc_re_on_line/soilhome.htm