Gloucester Stage 1A Irrigation Trial

Summary Report 1
(Soil and cropping activities to 31 August 2013)

Tiedman Irrigation Trial

Prepared by Fodder King Ltd
for AGL Upstream Investments Pty Ltd

4 December 2013

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1. Introduction

AGL Upstream Investments Pty Ltd (AGL) engaged Fodder King Ltd (FK) to provide technical advisory services with the site evaluation, design, set-up and operation of the Tiedmans irrigation trial for the Gloucester Gas Project (GGP). The irrigation trial involves two irrigation areas - the Stage 1A and Stage 1B areas. These are shown in Figure 1.

The Stage 1A area is the major focus of the trial and this summary report. This area is undergoing intensive monitoring of soil, water and crops, and irrigation (after blending) of most of the produced water stored on Tiedmans from previous pilot testing programs. A total of 52 soil and water monitoring points have been established to gather information relevant to the trial.

1.1. Purpose and scope of the trial

The primary purpose of the trial is to sustainably reuse produced water from AGL's exploration activities but at the same time use that water as a consumable for the trial to develop the knowledge and data for a viable beneficial-reuse strategy for the full-scale GGP.

A secondary purpose of this trial is to demonstrate AGL's commitment to leaving behind, on completion of the GGP, the legacy of an improved agricultural landscape with more productive soils than the original low quality parent soils. This should enable more productive use by subsequent owners or operators of the project land.

The Stage 1A Irrigation Trial involves the addition and mixing of ameliorants with the parent soils, the application of blended water (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, and analysis and reporting on the results.

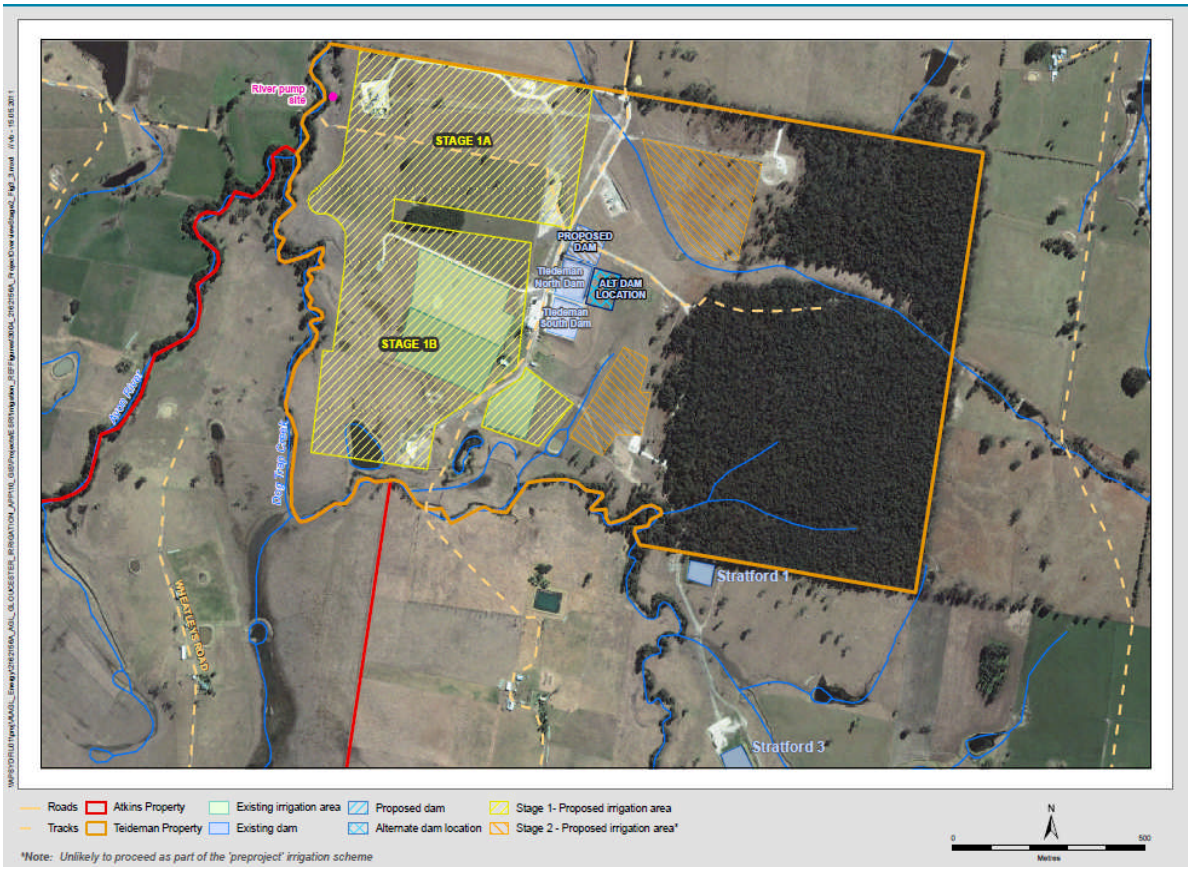

Figure 1: Gloucester Irrigation Areas for Exploration Produced Water

2. Soil monitoring

This report was prepared after the first batch of blended irrigation water was applied to the trial area and after the collection of Baseline 3 soil samples (ie the first samples collected after the irrigation of blended produced water).

2.1. Key soil quality findings - Baseline 3 (irrigated soils) vs Baseline 2 (pre-irrigated soil) vs Baseline 1 (parent soil)

Soil samples were taken at the same locations both prior to installation of the trial and during the trial.

When the soil test data is received, four analyses are carried out: Averages, Maxima, Minima and Standard Deviations. The following discussion deals with an analysis of the average values.

Salinity (as Electrical Conductivity)
As discussed in DRE Report 2 (FK 2013 *Soil quality monitoring and management, Report 2- Pre irrigation (Activities to 30 June 2013))* and, as expected, the salinity 'spike' - resulting from the use of compost and the mixing of sodic B-horizon of the parent soil - has subsided.

Soil Nitrate
The decrease in nitrate values reflects its high level of mobility in the soil when water (as irrigation or rainfall) is applied. The decrease can also be explained by the high level of uptake by the plants, facilitated by an optimum level of soil ECEC (effective cation exchange capacity).

Sodium and Exchangeable Sodium Percentage (ESP)
Exchangeable sodium has decreased over time and, coupled with increasing calcium from gypsum and lime application, the exchangeable sodium percentages (ESPs) have also decreased and currently sit at a desirable level of less than 6% to 80cm depth. This is in contrast to the parent soils (Baseline 1) and highlights how well the ameliorated soil is performing, compared to the parent soils.

Soil pH
Soil pH is within the optimal range, after the addition of the ameliorants. The soil pH values are tending to acidic at depth. The effect of higher pH (alkaline) water on the slightly acidic soil at depth may be beneficial and is the subject of ongoing monitoring.

Organic Carbon
Organic Carbon is within the optimal range, after addition of the ameliorants.

Effective Cation Exchange Capacity (ECEC)
ECEC is generally within the desired range.

Water holding capacity
The water holding capacity of the ameliorated soil has improved substantially in comparison to the parent soils. Experience gained from further irrigation will enable an estimate of water holding capacity to be made.

Saturated hydraulic conductivity
Saturated hydraulic conductivity (SHC) is a laboratory test carried out on soil samples to determine their relative ability to allow water to move through the soil. The parent soils had an SHC value of 0.11mm/hr which is very low but typical of the soil types of the area. Baseline 2 soil sampling included the measurement of SHC of the ameliorated soils which was determined to be 3.28mm/hr, which is a substantial improvement.

3. Crop Performance

3.1. Crops and harvesting

For the winter annual crop, the selection of triticale as an alternative to oats to suit this year's prevailing weather resulted in good crop establishment and a high round bale silage yield from the first harvest.

Being a winter-active crop, the triticale was harvested into round bale silage during July to enable new growth to occur in advance of a spring harvest. After the second harvest (late September) the triticale was sprayed and replaced with a fast growing summer grass (forage sorghum).

Lucerne is a winter dormant crop and did not begin to become active until after June when evapotranspiration values and warmer weather commenced.

3.2. Definition of nutritional measures

The nutritional test results for the Triticale and Lucerne harvest carried out in July are provided in Attachment 1. When testing crops for nutritional value there are a relatively small number of parameters in a typical feed analysis report to evaluate their animal-feeding-quality and they are briefly explained below.

Dry Matter (DM%)
DM is everything remaining after all the water in a feed sample has been removed. DM includes the energy, protein, vitamins and minerals required by animals for maintenance and production.

Dry Matter Digestibility (DMD %)
DMD is the percentage of the dry matter in a feed analysis that is able to be digested by animals. The higher the value the greater the uptake of feed by the animal.

Dry Organic Matter Digestibility (DOMD%)
DOMD is the percentage of the organic matter component that can be digested by the animal.

Metabolisable Energy (ME as mj/kg of Dry Matter)
ME is the feed energy available for animal production after accounting for losses from faeces, urine and gaseous products of digestion. The higher the value, the greater the amount of energy available to the animal.

Crude Protein (CP % of Dry Matter)
CP is the total nitrogen (N) in the diet, which includes not only true protein but also non-protein nitrogen which has the potential to be utilised for protein synthesis by organisms within an animal's stomach. N is measured and CP derived by multiplying N by a factor of 6.25. The higher the value, the greater the amount of protein available to the animal.

Neutral Detergent Fibre (NDF %)
NDF is a measure of the three structural carbohydrates in the feed – cellulose, hemi-cellulose and lignin. It is sometimes referred to as the cell wall constituent of the feed and represents the least digestible component of the feed. The lower the value, the greater the amount of feed that can be easily consumed by the animal.

Acid detergent Fibre (ADF%)
ADF is the result of deducting the hemi-cellulose component from NDF.

3.3. Comparison with national quality grading standards

The silage quality from the initial harvest (Cut 1) was good in spite of the lateness of harvesting of the Triticale. Late harvesting generally results in more yield but at the expense of nutritional quality. The nutritional test results have been compared with the Australian Fodder Industry Association (AFIA) national grading standards.

The Lucerne silage nutritional test result fell into the A1 category for Crude Protein, Metabolisable Energy and Dry Matter Digestibility and is shown on Table 3.1. This means that on the key nutritional measures the Lucerne was within the highest grading possible. Some 12 bales of silage were produced as a result of this first cut.

Table 3.1: Lucerne Silage Results

AFIA Grades for Legume and Pasture Hay & Silage					
Dry Matter Digestibility (%DM)	**Metabolisable Energy (Mj/kg DM)**	**Crude Protein (% DM)**			
		>19	**14-19**	**8-13**	**<8**
>66	**>9.5**	A1	A2	A3	A4
60-66	**8.7-9.5**	B1	B2	B3	B4
53-59	**7.4-8.4**	C1	C2	C3	C4
<53	**<7.4**	D1	D2	D3	D4

The Triticale silage result fell into the B1 grade under the Cereal Hay and Silage grading system and is shown on Table 3.2. This is also a good result, given the lateness of the harvest for this crop. Some 165 bales were produced from this winter crop.

Table 3.2: Triticale Silage Results

AFIA Grades for Cereal Hay & Silage					
Dry Matter Digestibility (%DM)	**Metabolisable Energy (Mj/kg DM)**	**Crude Protein (% DM)**			
		>10	**8-10**	**4-7**	**<4**
>66	**>9.5**	A1	A2	A3	A4
60-66	**8.7-9.5**	B1	B2	B3	B4
53-59	**7.4-8.4**	C1	C2	C3	C4
<53	**<7.4**	D1	D2	D3	D4

See *Attachment 1, Nutritional test results* for nutritional testing results for crops used in the trial.

3.4. Benchmarking analysis

There are no national aggregated statistical analyses for forage-based feeds that have been produced and tested in Australia. However, the laboratory selected to carry out the feed analysis has a relatively large database of test results for Australian-produced feeds. As there are no national aggregated statistics available, historical results from the laboratory for the past 8 years have been analysed.

Lucerne silage is classified under Legume silage and there were 894 samples in the Legume silage database. Generally this result compared favourably with the rest of the database with Crude Protein being greater than 60% of all samples (Decile 6), Dry Matter Digestibility being greater than 80% of all samples (Decile 8), Metabolisable Energy being greater than 70% of all samples (Decile 7) and Neutral Detergent Fibre being close to the mean (Decile 5). See Table 3.3.

Table 3.3: Lucerne Silage Comparisons

Tiedmans Lucerne silage Cut 1 vs all Legume silage				
Item	**Crude Protein (%DM)**	**Dry Matter Digestibility (%DM)**	**Metabolisable Energy (mj/kg DM)**	**Neutral Detergent Fibre (%DM)**
Database Mean (894 samples)	20.8	67.4	10.2	40.9
Tiedmans Cut 1 Sample Mean	19.3	73.4	11.0	42.1
Decile Ranking	6	8	7	5

While Triticale silage is not common, for the purpose of analysis it was classified as a Cereal silage and there were 1260 samples in the Cereal silage database. Generally this result was consistent with the very late growth stage of the Triticale when it was harvested. Crude Protein was greater than 40% of all samples (Decile 4), Dry Matter Digestibility was greater than 50% of all samples (Decile 5), Metabolisable Energy was greater than 50% of all samples (Decile 5) and Neutral Detergent Fibre was in the lowest 20% (Decile 8). See Table 3.4.

Table 3.4: Triticale Silage Comparisons

Tiedmans Triticale silage Cut 1 vs all Cereal silage				
Item	**Crude Protein (%DM)**	**Dry Matter Digestibility (%DM)**	**Metabolisable Energy (mj/kg DM)**	**Neutral Detergent Fibre (%DM)**
Database Mean (1260 samples)	11.9	66.8	10.1	52.9
Tiedmans Cut 1 Sample Mean	11.6	55.9	8.7	66.2
Decile Ranking	4	5	5	8

3.5. Salt and mineral take up

Two separate feed testing programmes are being undertaken for the trial. Firstly, fresh cut crop samples are being collected just prior to harvesting to form a snapshot of what the plants have taken up nutritionally as well as measuring a range of minerals and salts to aid in mass balance analysis.

The second set of samples is for nutritional analysis of the harvested product and to enable benchmarking against industry feed databases.

At this stage of the trial there is insufficient data to arrive at meaningful conclusions as to the uptake of salts and minerals and the likely impact on animal feeding performance.

The salt take-up, as measured by chlorides, currently ranges between 1% and 2% on a dry matter basis. For a high yielding crop system producing about 30 tonnes DM/ha/year this equates to between 300kg and 600kg of chlorides/ha/year being extracted from the water/soil. However, these are early results and further salt balance analysis will be undertaken during the trial.

4. Conclusions

AGL expects to leave behind an improved agricultural landscape with improved soils that can be used for cropping. Cropping activities have not been common previously in the district due to poor native soils.

The high average rainfall produces a green hue across the area that serves to disguise the infertile nature of the soils and their low water-holding capacity, which becomes apparent when the landscape dries out and pastures quickly brown off, even after relatively short periods without rain.

The primary soil and crop conclusions at this early stage of the irrigation trial are:

- The incorporation of ameliorant has produced a substantial improvement in soil quality in the trial area.
- The addition of soil improvements has facilitated deep drainage as well as promoted deep root development for maximum water take-up by plants and subsequent evapotranspiration.
- The soils have been substantially improved and are taking in water at approximately 30 times the rate of the parent soils.
- As a result of the improved soil quality, it has been possible to establish high water-using crops.
- As a result of healthy growth of crops, with high water demand, it has been possible to irrigate significant amounts of blended water (10.93 ML to 31 August).
- With a blended water quality of 1500Ec there is minimal effect on parent soils to date.

Attachments

Attachment 1 – Nutritional test results

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FEED ANALYSIS REPORT

AGL Upstream Investments Pty Ltd
22 Tate Street
Gloucester NSW 2422

ATTENTION Andrew Lenehan
FAX NUMBER

PURCHASE ORDER None
PROJECT NUMBER J1309-0742

DATE RECEIVED 23 September 2013
OUR SAMPLE NUMBER S2013-26214
YOUR REFERENCE Tiedmans/Silage/Lucerne/Cut 1
SAMPLE TYPE Silage
DESCRIPTION
DATE SAMPLE COLLECTED 20 September 2013

TEST	Result
NIR Package	
Dry Matter (%)	30.9
Moisture (%)	69.1
Crude Protein (% of dry matter)	19.3
Acid Detergent Fibre (% of dry matter)	18.7
Neutral Detergent Fibre (% of dry matter)	42.1
Digestibility (DMD) (% of dry matter)	73.4
Digestibility (DOMD) (Calculated) (% of dry matter)	69.0
Est. Metabolisable Energy (Calculated) (MJ/kg DM)	11.0

Note: **This report is not to be reproduced except in full.**

Final Report

Report Number: 92430

Comments:

Metabolisable Energy has been calculated using the following equation:
ME = 0.16 x DOMD%

AFIA Grade for legume and pasture hay + silage : A1

Please note: Dry Matter (DM%), Crude Protein (CP%) and Digestibility (DMD%) have been corrected in accordance with AFIA approved methods.

Karen Jackson

Team Leader, Food Safety Laboratory

30 September 2013

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FEED ANALYSIS REPORT

AGL Upstream Investments Pty Ltd
22 Tate Street
Gloucester NSW 2422

ATTENTION Andrew Lenehan
FAX NUMBER

PURCHASE ORDER None
PROJECT NUMBER J1309-0742

DATE RECEIVED 23 September 2013
OUR SAMPLE NUMBER S2013-26215
YOUR REFERENCE Tiedmans/Silage/Triticale Cut
SAMPLE TYPE Silage Cereal
DESCRIPTION
DATE SAMPLE COLLECTED 20 September 2013

TEST	Result
NIR Package	
Dry Matter (%)	44.2
Moisture (%)	55.8
Crude Protein (% of dry matter)	11.6
Acid Detergent Fibre (% of dry matter)	35.4
Neutral Detergent Fibre (% of dry matter)	66.2
Digestibility (DMD) (% of dry matter)	55.9
Digestibility (DOMD) (Calculated) (% of dry matter)	54.1
Est. Metabolisable Energy (Calculated) (MJ/kg DM)	8.7

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Final Report

Report Number: 92430

Comments:

Metabolisable Energy has been calculated using the following equation:
ME = 0.16 x DOMD%

AFIA Grade for cereal hay + silage : B1

Please note: Dry Matter (DM%), Crude Protein (CP%) and Digestibility (DMD%) have been corrected in accordance with AFIA approved methods.

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