Annexure 1

Site and Soils Investigation Report

SITE & SOILS INVESTIGATION REPORT

Darwin Beef Processing Facility

Prepared for

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1.0 INTRODUCTION

A reconnaissance level site and soil survey was carried out across the property where the Australian Agricultural Company Limited (AACo) is proposing to establish a beef processing facility.

The property is located approximately fifty (50) kms south of Darwin at the site of the disused World War Two Livingstone airstrip and alongside the Stuart Highway.

The survey focused on the land identified for the proposed effluent treatment ponds and effluent irrigation areas. The key objective was to identify the land resource characteristics of the site generally and examine the soil types and spatial variation across the subject land.

It is proposed that the effluent generated by the meat processing facility will be treated in a series of anaerobic and aerobic ponds and be stored in a large earthen dam prior to being spray irrigated onto fodder crops being grown for haymaking.

Importantly, the data generated by the Electro-Magnetic (EM) Survey undertaken by Precision Agronomics Australia was useful background information and helped in targeting areas for this soil survey.

Instruments used in this survey included a Duel EM–21S (reading at 0.5, 1.0, 1.5 & 3.0 metres depth), Gamma Radiometrics (measuring natural gamma ray emissions primarily from the top 40 cm of the surface) and an RTK GPS.

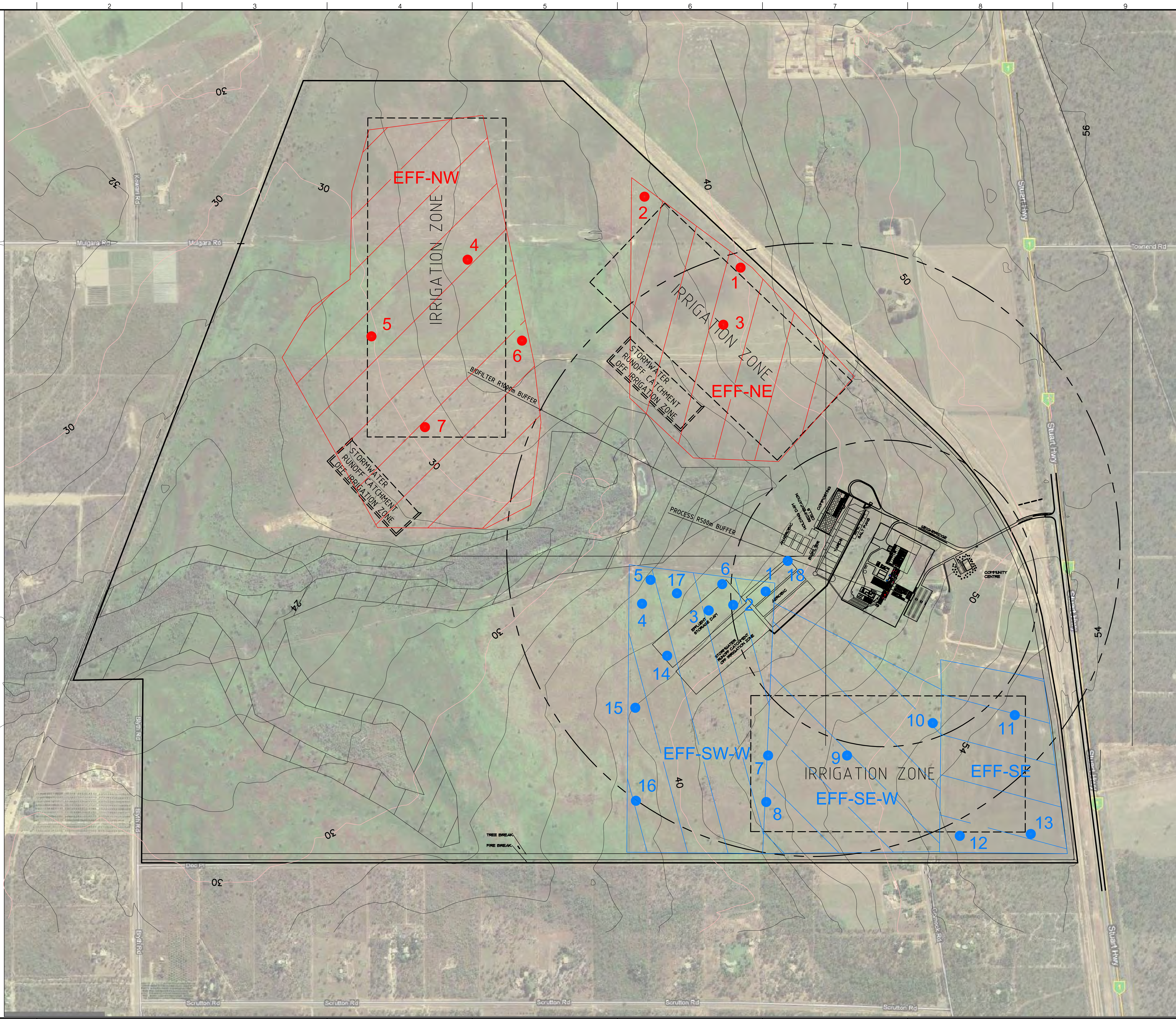
A slope : terrain analysis was undertaken including consideration of surface drainage characteristics and the likelihood of flooding.

The farm manager of twenty (20) or so years was consulted re cropping & pasture improvements, haymaking operations and local conditions regarding agricultural production in the wet and dry seasons.

Soil profiles were exposed for inspection, mainly by mechanical means using a backhoe. The location of soil pits was based upon map interpretation and consideration of landform, surface drainage and local knowledge.

Refer to the attached Photoplan which shows the locations of these inspection pits.

This soil survey involved making hypotheses about the soil distribution across the area and, as with all but the most comprehensive soil surveys, the decisions on soil types and distribution were extrapolated from a few strategically located soil profile observations (Charman and Murphy, 1991).



PROJECT NORTH

A1 SHEET	1:100	0 1000 2000
A3 SHEET	1:200	1:100
A1 SHEET	1:50	0 500 1000
A3 SHEET	1:100	1:50
A1 SHEET	1:25	0 250 5000
A3 SHEET	1:50	1:25
A1 SHEET	1:10	0 100 200
A3 SHEET	1:20	1:10

KEY PLAN

SOIL PITS

- NORTH EFFLUENT IRRIGATION AREA
- SOUTH EFFLUENT IRRIGATION AREA

DATE	REV.	AMENDMENT	DRAWN

ALL DIMENSIONS MUST BE VERIFIED ON SITE PRIOR TO COMMENCEMENT OF ANY WORKS. REFER TO DIMENSIONS. DO NOT SCALE

CLIENT :
NORTHERN AUSTRALIAN BEEF LIMITED

PROJECT :
DARWIN ABATTOIR

DRAWING :
SOIL SAMPLE PIT LOCATIONS

MEATENG

MEATENG PTY.LTD A.B.N. 41 286 569 547
8 MONTROSE STREET , HAWTHORN EAST ,
VICTORIA, AUSTRALIA, 3123
PHONE :(03) 9813 3444, FAX: (03) 9813 1208
EMAIL: info@meateng.com.au

DRAWN: DT	SCALE: 1:6000	SHEET SIZE: A1		
CHECKED: -	DATE: 19.09.2011			
JOB No: 463.02		DRG No: P039	REVISION A	

2.0 SITE CHARACTERISTICS

Following is a description of a number of key physical resource attributes ie. land use, landform, soil erosion and hydrogeology, assessed as part of site investigations.

2.1 Land Use

This cattle grazing property lies within the upper catchment areas of Berry Creek, a tributary to Blackmore River, and which locally drains to the west and then in a north westerly direction and ultimately into Darwin Harbour.

Land use on the property mainly comprises the management of improved pastures to support cattle grazing and dry season haymaking operations.

Figure 1. Extensive Haymaking Operations

The two main improved pastures that have been established on the arable areas across the property are the wet season grasses Humidicola (Tully grass) and Jarra (Digit grass). The lower and less well drained terrain is dominated by a range of water tolerant grass species with the taller Pandanus trees being prominent.

The proponent of the beef processing facility intends to irrigate the better drained pasture and fodder cropping paddocks with treated and nutrient rich effluent on an environmentally sustainable basis. The focus will be to balance the nutrients applied in the effluent with plant uptake and subsequently remove this nutrient from the soil-plant system by haymaking operations.

Effluent irrigation operations will be carefully managed to prevent adverse impacts on neighbouring properties and prevent off-site discharge of effluent.

Figure 2. Natural Revegetation & Prolific Grassy Regrowth

2.2 Landform

The property is located approximately eight (8) kilometres south of Noonamah on the Stuart Highway in the catchment of Berry Creek, upstream of Lake Deane and the perennially flowing Berry Springs.

The site of the proposed development and surrounding areas are characterised by flat and gently undulating terrain with slope gradients generally ranging from <1% to 2 %.

These gently sloping areas generally exhibit both a south westerly and north westerly aspect and drain to the centrally located and westerly falling drainage area that is a prominent feature of the property. Refer to the attached Photoplan.

The elevation of the property ranges from ~28 – 54 metres metres ASL.

Within the property the proposed development site has good separation from the property boundary and there is a good vegetative cover of mainly improved pastures in every direction.

The site proposed for the facilities including the rendering plant and associated works are on elevated land above flood prone areas.

2.3 Soil Erosion

The existing soil erosion across the property is generally assessed as only negligible to minor sheet erosion.

There is evidence at a very few isolated locations eg. towards the lower end of long gentle side slopes and through a few well used gateways, of minor sheet and rill or minor gully (< 0.5 metres deep) erosion.

Overall, the existing land use and management practices employed on the property are consistent with the inherent rural capability of the land.

It is relevant that the permanent improved pastures provide a good protective surface cover which helps in minimizing soil erosion across the property.

Note that these naturally infertile Yellow Podzolic Soils with their light sandy loam topsoil are susceptible to erosion and given the planned cropping program and the high intensity monsoon rainfall careful soil management practices are essential.

2.4 Hydrogeology

Local hydrogeological characteristics were assessed based on a search of existing bores in the vicinity of the proposed development from the NT Land Information System, NRETA Maps on the Department of Natural Resources, Environment, The Arts and Sport (NRETAS) website.

Refer to the Hydrogeological Report prepared to accompany the Development Application for a Beef Processing Facility to be submitted by AACo.

Key information from the NRETAS website search is outlined as follows :-

- The majority of the existing registered bores were drilled and constructed between 1995 and 2009 for domestic and agricultural production purposes
- Drilling generally ranging from 60 – 100 metres with standing water levels of 6 – 13 metres below ground level
- The main water bearing zones are recorded as being from approximately 27 – 95 metres in depth
- Yields were mostly sufficient for domestic and production bores ranging between 0.5 – 5 litres/second
- Those bores with records of water quality all indicated good quality water

Soil drill logs where recorded for the majority of these bores in the immediate vicinity of the proposed development and generally indicated the following information :-

- topsoil to 0.5 – 1.0 metre depth
- sandy surface soil is underlain by sandy clay and clay layers to ~20 - 30 metres in depth providing a barrier to the groundwater aquifer
- deeper layers generally included yellow and grey clay, red and grey shale and siltstone with gravelly seams

2.5 Topographical Limitations

In addition to the above description of physical resource attributes it is relevant to assess the topographic features and limitations of the land for effluent irrigation.

The topographic features and an indication of the limitation imposed by them on the proposed irrigation operation and comments are indicated in Table 1.

Table 1. Topographic Limitations

Feature	Result	Limitation	Comments
Slope Gradient	1 – 2.5 %	Nil – slight	Effluent to be applied at a rate allowing infiltration into the sandy surface soils
Terrain Element	Crests, mid-lower slopes	Nil - slight	Generally the area comprises broad even sloping land
Flooding	Nil	Nil – slight	Stormwater runoff will occur with extremely heavy rainfall events
Rockiness	<5%	Nil - slight	Area of “coffee rock” in southern mid sector not considered for irrigation
Groundwater	~ 27 – 35 metres	Slight	Seasonal waterlogging of soils occurs in the wet

Source :- Based on Hardie and Hird (1998)

3.0 SOILS INVESTIGATION

To gain an understanding of the soils in the area twenty five (25) soil pits were excavated across the property as well as inspection of soils at numerous other locations around the site during the week beginning the 8th August 2011.

Soil profile description

The methodology included describing the exposed soil profiles using the The Factual Key for the Recognition of Australian Soils (Northcote, 1979).

The Factual Key emphasizes observable soil features which allows definitive statements to be made about soils for practical purposes eg. construction of effluent treatment & storage dams, suitability for irrigation and manure applications, etc.

To aid in the interpretation of the soils data note that the nomenclature of the various soils sampled and tested is such that:

eg. P1 L1, refers to Pit 1 Layer 1, P3 L2, refers to Pit 3 Layer 2, etc.

Sampling Strategy

The soil sampling strategy included discrete sampling and stratified "composite" sampling.

The latter procedure involves collection of a number of samples from the identified soil strata of interest and mixing equivalent amounts of the soils to form a composite sample for laboratory testing. The results of the testing provide an estimate of the mean of the sites or strata from which the samples were collected.

Soil samples were collected during the week beginning 8th August 2011 at various locations assessed as typical of the areas of interest with samples taken from the topsoil layer and also subsoils at various depths.

This sampling methodology, including soil profile description, helps a skilled soil surveyor to verify hypotheses and predict the likely soil distribution at the site and to produce more accurate estimations of the particular soil parameters of interest.

4.0 FIELD DESCRIPTIONS

As indicated above soils have been classified using Northcote's Factual Key. However the soils are generally described below using the Australian Great Soil Groups (Charman and Murphy,1991).

Following is a description of the typical soil type across the relatively flat – low sloping landscape.

YELLOW PODZOLIC SOILS (Dy 5.11)

The soils across the majority of the study area are yellow duplex or texture contrast soils dominated by the mineral fraction ie. where there is a significant texture contrast between the A and B horizons.

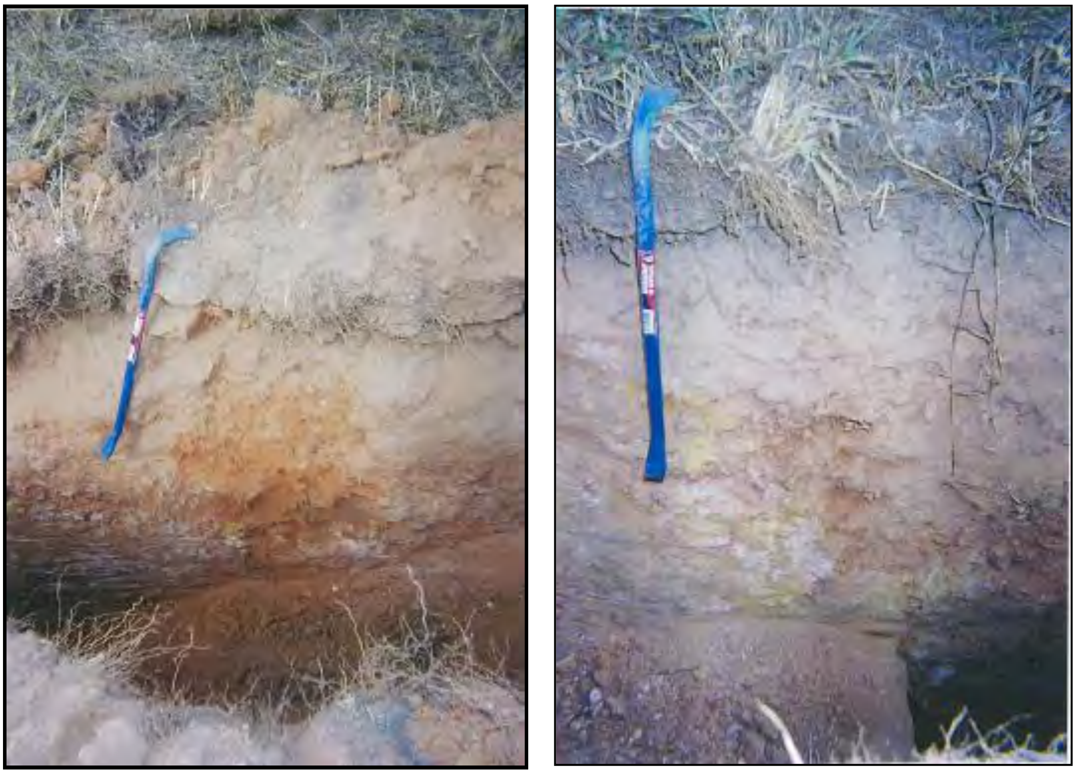
The surface soils of the area typically comprise dull yellowish loamy sands to approximately 20-30 cm depth with slightly higher clay content sandy loam soil to about 70-100 cm.

The subsoils are typically yellowish brown sandy clays with approximately 19-28 % clay content or light-medium clays with >30 % clay.

The typical soil type is described as a relatively deep, light coarse sandy soil overlaying sandy clay subsoils. Note that generally, the subsoils of the lower elevation and flatter terrain were comprised of high plasticity clay.

A prominent feature of most of the soil profiles inspected was the presence of a hard sesquioxidic layer ie. a hard lateritic or iron-rich layer often including ironstone gravels. They are associated with a deeply weathered soil profile including mottled clays (indicative of impeded drainage) below the laterite.

Figure 3. Typical Soil Profiles.



These lateritic layers were observed to be of varying thickness (~15- 50 cm) and are not considered as either A or B horizons. They occur between the sandy surface A horizon and the clayey B horizon.

These leached sandy soils are strongly acidic throughout ie. pH 4.9 - 5.7, and are relatively infertile soils.

The soil structure (pedality) ie. the size, shape and condition of the natural soil aggregates, is described as very weak in the topsoil with generally moderate pedality in the clayey subsoils.

Yellowish orange and reddish brown mottling ie, the presence of discoloured soil material often indicative of slow internal drainage, was generally observed and beginning at ~ 60-80 cm.

Significantly, fine plant roots (< ~1.0 mm) were generally observed to occur down through the lateritic layer to approximately 1.1 – 1.2 metres depth.

Figure 4. Exposed Lateritic Surface "Coffee Rock"

5.0 LABORATORY ANALYSIS

On completion of the detailed soil profile examinations discussed above, representative soil samples were collected for laboratory analysis. Chemical and physical testing was carried out on selected samples to determine the key chemical and engineering properties of the soils.

Testing was carried out as follows :-

***SWEP* Analytical Laboratories at Keysborough VIC**

Chemical testing:

- pH
- Electrical conductivity
- Cation exchange capacity and Cations
- Available Nitrogen and Total Nitrogen
- Available Phosphorus and Total Phosphorus
- Sulphate and Trace elements

Dept. of Lands, Research Service Centre Lab. at Scone NSW

Physical testing:

- Particle size analysis & Soil texture
- Unified Soil Classification System
- Emerson's Aggregate Test (EAT)
- Dispersion %
- Liquid Limit & Plastic Limit
- Volume Expansion % & Linear Shrinkage %
- Hydraulic conductivity
- Bulk density gms/cm^3
- Moisture content %
- pH, Electrical conductivity & Phosphorus sorption

6.0 LABORATORY RESULTS

The soils have been classified using the Unified Soil Classification System (USCS). It is based on the size of the particles, the amounts of the various sizes and the characteristics of the very fine particles (Charman and Murphy, 1991). The USCS classification and its interpretation are applicable in the design of dams and earthworks.

Useful information on the properties of soils eg. drainage characteristics, compaction characteristics, permeability, shear strength and cracking resistance when compacted, can be interpreted and inferred from USCS soil groups.

The soils at the site generally comprise sandy loam (10–15 % clay) surface soils overlying a lateritic layer containing ironstone gravel at approximately 80–100 cm depth over sandy light–medium clays to at least ~ 2.5 – 3.0 metres.

The near surface soil is classified as USCS class SM ie. silty sands with more than half the soil material coarse grained sand. These soils have relatively low proportion of clay (5-9 %) and silt (6-14 %) and the excessive hydraulic conductivity of these soils indicate their unsuitability for construction of effluent ponds.

The subsoil at ~ 1.1m and deeper is generally classed as USCS classes SC and CH ie. clayey sand and high plasticity clay, respectively. Although these soils have clay ranging from 19-37 % test results such as the low rate of clay dispersion (and high aggregation) indicate that construction of effluent ponds is problematic. Specialized treatment options ie. lining with more suitable clay material or plastic/poly liners should be further investigated.

Chemical treatment to induce dispersion (eg. using Sodium tripolyphosphate) combined with a high level of compaction is also an option requiring further investigation.

Laboratory test data is interpreted in the following sections.

6.1 Laboratory Results

Chemical Testing (Refer to Tables 2, 3 & 4.)

Soil pH is a measure of acidity, alkalinity or neutrality of soil. It also provides a guide to chemical processes and likely deficiencies and/or toxicities.

The results indicate that the topsoils are generally very strongly acid ie. pH 4.9 – 5.0, and the subsoils are generally strongly acid eg. pH 5.0 – 5.4, indicating the necessity to raise the soil pH by applications of fine lime.

Adjusted Cation Exchange Capacity (CEC) measures the ability of the soil to hold and exchange cations in the soil solution. It is also largely responsible for the stability of the soil structure, nutrient availability, pH and soil reaction to chemical additives.

The adjusted CEC is generally rated as low in both the topsoils and subsoils ie. 3.81 – 7.23 me/100g in the topsoils and 3.44 – 5.7 me/100g in the subsoils.

Overall soil productivity is dependant on a good soil balance of Calcium, Magnesium and Potassium with appropriate levels of Phosphorus and Sulphur. (Nitrogen is largely dependant on organic matter levels and applications of N should match plant requirements and potential yield).

Table 2. Laboratory Results

Sample ID **	Sample Depth (cm)	Adj. CEC (me/100g)	Cations % ECEC					Ca/Mg	pH (1:5 W)	EC 1:5 W (uS/cm)	Organic Matter %	Total P (mg/kg)	Total N %	N ppm	P ppm	K ppm	S ppm
			Ca	Mg	K	Na	H										
EFF - SE	0-15	6.18	8.3	2.4	1.1	4.1	84.1	3.31	5	28	1.8	242	0.107	2.7	30.2	27.3	0.9
	50-80	5.25	15.6	5.7	0.8	6.5	71.4	2.71	5.4	15	0.9	88	0.058	0.4	4.3	15.6	1.2
EFF - NE	0-15	3.2	13.4	4.1	1.9	7.2	73.4	3.29	4.9	22	1.7	103	0.094	2	14.5	23.4	0.5
	50-80	4.12	16.5	4.9	1.2	7	70.4	3.38	5	17	0.2	35	0.042	1.3	2.1	19.5	1
EFF - NW	0-15	4.76	12.4	3.4	1.7	4.8	77.7	3.65	5	25	2.6	129	0.175	1	13.3	31.2	0.5
	50-80	3.19	26	5.3	1.3	9.4	58	4.78	5.3	12	0.5	43	0.041	2.7	4.2	15.6	0.5
EFF-SE-W	0-15	5.93	9.1	3	1.3	3.9	82.6	2.95	5	28	2.6	224	0.123	3.7	24.7	31.2	0.7
	50-80	3.43	13.7	4.1	1.5	6.4	74.3	3.27	5.2	11	0.3	65	0.046	1.1	2.5	19.5	0.8
EFF-SW-W	0-15	3.41	14.1	3.8	1.8	7	73.3	3.64	4.9	20	0.8	65	0.078	3.6	9.3	23.4	0.4
	50-80	3.52	14.8	6.8	1.1	7.7	69.6	2.16	5	12	0.3	37	0.052	2	2.5	15.6	0.5

SWEP Analytical Laboratories, Keysborough Victoria. ** Refer to Photoplan for paddock location

Table 3. Laboratory Results - Trace Elements (ppm)

Paddock ID **	Copper	Zinc	Iron	Manganese	Cobalt	Molybdenum	Boron
EFF - SE TS	2.3	0.8	41	8	0.1	0.2	0.1
EFF - SE SS	2.3	0.5	12	3	0.1	0.1	0.1
EFF - NE TS	2.5	0.7	110	2	0.1	0.2	0.1
EFF - NE SS	1.8	0.5	18	2	0.1	0.2	0.1
EFF - NW TS	2.7	1.1	177	5	0.1	0.2	0.1
EFF - NW SS	2.6	0.4	31	4	0.1	0.1	0.1
EFF - SE-W TS	2.5	0.7	123	9	0.1	0.3	0.2
EFF - SE-W SS	1.8	0.3	12	4	0.1	0.3	0.1
EFF - SW-W TS	1.9	0.4	92	1	0.1	0.1	0.2
EFF - SW-W SS	2.6	0.4	48	1	0.1	0.2	0.1

SWEP Analytical Laboratories, Keysborough Victoria. TS – Topsoil SS – Subsoil ** Refer to Photoplan for paddock location

The lab results indicate that there is some variability in the concentrations of the key abundant cations ie. calcium, magnesium, potassium and sodium.

Calcium, Magnesium and Potassium are generally at a very low level in both the topsoil and the subsoil. Sodium is generally at elevated concentrations.

The relative proportions of the various cations is generally considered to be more important to plant nutrition and growth than actual cation concentrations. The proportion of these key cations is generally outside the desirable range.

Soil amelioration will help in addressing these soil fertility issues. Table 4. outlines the recommended applications of lime, gypsum and/or dolomite to bring more balance to these soils.

Sodicity in soil relates to the likely clay dispersion upon wetting of a soil which creates problems such as surface crusting and sealing, limiting infiltration of rainfall or irrigation water and poor soil permeability.

The laboratory results indicate that the topsoil are non-sodic to sodic ie. 3.9 – 7.2 % CEC, the subsoils are sodic ie. 6.4 – 9.4 % of CEC. Note that applications of gypsum will help in addressing the symptoms of sodicity in soils.

Salinity is indicative of the presence of soluble salts mainly sodium, calcium and magnesium and these can severely affect plant growth and productivity. These soils tested as non-saline.

Phosphorus is one of the major plant nutrients. Available phosphorus generally tested as significantly deficient in both the topsoils ie. 9.3 – 14.5 ppm, and subsoils (2.1 – 4.3 ppm). The exception is the two south eastern most paddocks where the lab data indicated available P in the topsoils are close to the desirable levels ie. 24.7 – 30.2 ppm.

The results for Total P (not necessarily available for plant growth) are similar in that the topsoils indicate a range of 65 – 242 ppm and are significantly higher than the subsoils with a range of 35 – 65 ppm.

The soils were tested for Phosphorus Sorption Capacity ie. the ability to adsorp or immobilise P, by the Scone laboratory. The results indicate that the clayey subsoils have a substantial capacity to immobilize P (355-583 mg/kg).

The nitrogen content in soil helps to indicate its fertility. Available Nitrogen ie. that N that is readily available to the plant, generally tested as very low ie. 0.4– 3.7 ppm. A plant response to applied nitrogen in the form of inorganic fertilizer or in treated effluent would be expected.

Table 4. Recommended Soil Amelioration

Paddock ID**	Gypsum Requirement (t/ha)	Lime Requirement (t/ha)	Dolomite Requirement (t/ha)	Magnesium Sulphate (kg/ha)
EFF – SW-W TS	0.2	0.8	0.6	0
EFF – SE-W TS	0	1.8	1.2	0
EFF – SE TS	0	1.8	1.3	0
EFF – NE TS	0.2	0.8	0.6	0
EFF – NW TS	0	1.3	0.9	0
EFF – SW-W SS	0.5	1.8	0.9	0
EFF – SE-W SS	0.3	1.7	1.2	0
EFF – SE SS	0.4	2.7	1.6	0
EFF – NE SS	0.4	1.9	1.4	0
EFF – NW SS	0.7	0.8	1.0	0

SWEP Analytical Laboratories, Keysborough Victoria. ** Refer to Photoplan for paddock locations

Total nitrogen measures the total amount of N, both organic and mineralized (available forms) in soil. As expected the levels of nitrogen are generally higher in the topsoils compared to the subsoils as this is where most of the organic matter and biological activity is found. Typically, the results indicate low – medium Total N in the topsoils and only very low – low levels in the subsoils.

Trace elements are those nutrients eg. Copper, Zinc, Iron, Manganese, Cobalt, Molybdenum and Boron, needed in relatively tiny proportions by growing plants. The results of testing for trace elements are provided in Table 3.

The results indicate trace elements are at varying levels eg. Copper and Molybdenum are generally satisfactory. Zinc, Manganese, Cobalt, and Boron appear to be deficient and test strips to trial different application rates will help in managing these apparent deficiencies.

The Results for Iron are variable ie. topsoil results are 41-177 ppm and subsoil results are 12-48 ppm. Generally it is desirable to have Iron > 30 ppm but where Iron is >100 ppm it may be reducing Phosphorus availability.

Initially, applications of the soil ameliorants outlined in Table 4. will help to address soil fertility issues and bring plant productivity closer to the optimum. Annual soil sampling and laboratory testing will detect changes resulting from application of the soil ameliorants and provide useful information for ongoing soil management.

Physical Testing **(Refer to Attachment 1. for Laboratory Results)**

Particle size analysis (PSA) indicates the percentage of particle size classes of the fine earth fraction ie. particles <2mm in size, by weight.

The near surface soils typically comprise loamy sands with clay content less than about 10% and a predominance of fine and coarse sand content ie. 57-79 %. They also exhibit relatively high gravel content of 10-29 %.

The subsoils are classed under the Unified Soil Classification System as sandy clays (SC) and high plasticity clays (CH).

The sandy clay subsoils have approximately 19-28 % clay, 5-14 % silt, 9-21 % fine sand, 18-38 % coarse sand and 12-48 % gravel.

The high plasticity clayey subsoils, generally seen at lower parts of the investigation area, exhibit greater clay content ie. 32-37 % clay. The proportions of silt range from 17-26 %, fine sand 12-15 %, coarse sand 20-29 % and gravel 5-10 %.

The Emerson Aggregate Test (EAT) is a simple test involving observing the coherence of a soil crumb or soil aggregate when placed in distilled water ie. it indicates soil dispersion or soil structural stability. Typically these soils are classed as EAT Classes 5-8.

Most samples were classed as EAT Class 5 and 6 ie. aggregates broke up or slaked but there was little or no clay dispersion indicating highly aggregated soils unlikely to hold water.

Special construction measures such as using a more suitable clay as a liner or installing flexible membranes/poly lining material, as well as special compactive effort and possibly the use of a clay dispersant, are indicated in constructing water retention structures. Further investigation is recommended.

Dispersion percentage is a measure of the degree of dispersion of the <0.005 mm (clay) soil fraction. The sandy surface soils tested as moderately to very highly dispersive ie. 36-86 % clay dispersion.

The clayey subsoils generally indicated only slight clay dispersion ie. 5-15 % dispersion. One subsoil sample ie. Profile 5 Layer 3, indicated a moderate dispersion rate of 40 % clay dispersion.

Volume Expansion measures the free swelling of a disturbed soil on wetting from air dry to saturated. All samples tested in the range from 0–6 % indicating a low rating for expansion on wetting, and shrinkage and cracking of the soil mass upon drying.

The Linear Shrinkage test indicates the potential shrinkage of the soil mass on drying. Normally the deeper subsoils are subject to this test. The results for the sandy clay subsoil samples ie. 2-7.5 %, indicate a low and non-critical expansion and shrinkage rating. The results for the high plasticity samples ie. 11-13 %, indicate a low to marginal rating.

The Liquid Atterberg Limit is the moisture content at which a soil passes from a liquid to plastic state. The results for the sandy clay subsoil samples ie. 28-41 %, indicate a low rating for degree of compressibility and shrink swell potential.

The results for the high plasticity samples ie. 51-65 %, generally indicate a medium to high rating for degree of compressibility and shrink swell potential.

The Plastic Atterberg Limit is used to calculate the Plasticity Index values which represent the range of water content through which a soil is in a plastic state. The results for the sandy clay subsoil samples ie. 5-20 %, indicate a low rating for degree of compressibility and shrink swell potential.

The results for the high plasticity samples ie. 25-36 %, indicate a medium to high rating for degree of compressibility and shrink swell potential.

The saturated hydraulic conductivity test results indicate the flow of water through soil per unit of energy gradient ie. it reflects the rate at which water moves into and through a structure, for example, a 60 cm thick clay liner installed as the surface layer of a water retention structure.

The results indicate that when a mixed soil sample from P1 L3 and P15 L3 was compacted in the laboratory to a bulk density of 1.86 g/cm^3 at a moisture content of 15.5 % the measured saturated hydraulic conductivity was 1.3 x 10^{-9} metres/sec or ~41 mm/year.

Similarly, the results indicate that when a mixed soil sample from P1 L4 and P6 L4 was compacted in the laboratory to a bulk density of 1.82 g/cm^3 at a moisture content of 16.6 % the measured saturated hydraulic conductivity was 3.1 x 10^{-10} metres/sec or ~10 mm/year.

The first result ie. from P1 L3 and P15 L3, indicates that the saturated hydraulic conductivity is marginally greater than that rate generally required by government agencies for clay linings on effluent treatment ponds.

The second of these saturated conductivity results ie. P1 L4 and P6 L4, indicates an extremely low rate of conductivity ie. a rate that generally complies with government design criteria for compacted clay linings on key structures such as effluent treatment ponds.

These results are for soil profiles located lower in the terrain. (Refer to Photoplan). Although they only relate to the preliminary investigations, they are encouraging in terms of achieving water retention in dams.

Importantly, these results have been achieved in controlled laboratory conditions where good compaction of relatively small quantities of soil material was achieved. It will take a considerable amount of compactive effort in the field if a clay lining was to comply with the requirements of government agencies.

The results of saturated hydraulic conductivity testing on the soils identified as Profile No.4, considered typical of the effluent irrigation areas, are also provided in the Scone Lab. report.

Note that these soils were subjected to a different test ie. the Constant Head Method, where the soil sample is prepared differently and only lightly compacted to be more representative of soils in the field. This test is used to provide information on the suitability of soils for irrigation.

It is important to note the much faster rate of flow of water through these soils. The results indicate well drained soils suitable for irrigation but, effluent will need to be carefully scheduled to supply the needs of the crop and to prevent leaching of applied nutrients below the root zone of the plants.

7.0 SOIL LIMITATIONS

The data gathered from the investigation and described above have been assessed and the limitations to the proposed effluent irrigation operation are identified in Table 5.

Table 5. Soil Limitations

	Results	Limitation	Comments
Exch. Sodium %	3.9 – 7.2	Moderate	Sodic – apply gypsum
Elec. Conductivity (ECe) dS/m	0.2 – 0.3	Slight	Non-saline
Root zone depth (metres)	~0.8 - 1.2	Moderate	Reasonable rooting zone above clayey subsoils
Depth to Hardpan/Lateritic layer	~0.8 – 1.2	Slight - Moderate	Root extension into and through hardpan observed in the field
Watertable depth (metres)	0.5 - 3	Slight - Moderate	Seasonally high watertable
Profile drainage	High	Moderate	Sandy loams have relatively large drainage capacity
Available water capacity (mm/m)	~80 - 100	Moderate	Plant available water limited & careful irrigation scheduling & management is essential
Soil pH	<5.5	Moderate	Optimum plant growth is reduced – apply ameliorants
Effective Cation Exch. Capacity (cmol (+)/kg)	3.4 – 7.2	Slight – Moderate	Achieving better soil fertility & balance will increase plant productivity
Emersion aggregate test	Class 5 - 8	Moderate	Well aggregated clayey subsoils
Phosphorus Sorption Capacity (mg/kg)	106 - 583	Slight – Moderate	Deeper subsoils have a good capacity to immobilize excess P

Source :- Based on Hardie and Hird (1998)

The soils limitations for effluent irrigation have been assessed as slight to moderate and can generally be addressed by good irrigation system design and soil management.

8.0 CONCLUSIONS

Effluent Treatment Ponds & Storage Dams

Regarding the suitability of the clayey subsoils for constructing effluent treatment and retention structures the findings of the on-site reconnaissance level investigation, including the laboratory test results, indicate that :-

> Although these subsoils are clayey sands or clays of high plasticity with significant proportions of clay (~19-37 % clay) the soil material is highly aggregated and has low dispersion percentages indicating high rates of hydraulic conductivity.

Therefore these soils appear unsuitable for water retention structures unless one of the following special construction treatments is applied:-

- Lined with more suitable clay material
- Installation of a flexible membrane/poly lining material
- Chemical treatment to induce clay dispersion eg. applying Sodium tripolyphosphate along with a high level of compaction

Note :-

The third treatment option may not be effective if the salinity of the treated effluent is too high so therefore further investigation of this treatment is essential to rule it in or out.

Naturally the construction of any major earthen water holding structure necessarily requires special compactive effort eg. placement of the clay lining in layers <15 cm, moisture content to be not more or less than 2% of optimum moisture content and compaction of each of the layers of the clay lining to 98 % of Proctor maximum dry density, ideally using a vibrating padfoot rolling machine.

Given that this site and soils investigation was at a reconnaissance level with the objective of providing guidance on the effluent treatment ponds and storage dam, and considering the above findings, it is warranted that further investigations including the proposed drilling program be undertaken.

Effluent Irrigation Areas

Regarding the suitability of these soils for cropping and irrigation with treated effluent the findings of the investigation, including the laboratory test results, indicate that :-

- The gently undulating irrigable areas ie. eliminating the lower elevated and waterlogged areas, have in general only nil to slight topographic limitations for properly scheduled and managed irrigation operations

- The relatively deep well drained sandy loam topsoils typical of these areas (underlain by clayey subsoils), have in general, slight to moderate limitations for effluent irrigation operations

It will be essential that good soil and irrigation management practices be undertaken for environmentally sustainable and beneficial effluent irrigation operations.

It would be logical to begin by implementing the recommendations regarding applications of lime, gypsum and/or dolomite to help achieve more optimal and balanced soil fertility.

Two significant management requirements are to balance the nutrients applied with those taken up and removed from the system by cropping and haymaking operations and to undertake careful irrigation scheduling.

Analysis of effluent prior to irrigating and annual soils analysis ie. environmental monitoring as outlined in the Environmental Management Plan completed as part of the AACo Development Application, will be useful in managing these farm operations in an environmentally sustainable manner and at the same time enhancing agricultural productivity.

9.0 REFERENCES

Abraham,S.M. & Abraham,N.A. Eds (1996): Site and Profile Information Handbook - Soil Data System

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Northcote, K.H. (1979): A Factual Key for the Recognition of Australian Soils, 4th Edn, Rellim Tech. Publications, Glenside, S.A.

Sweeten, J.M. (undated): Cattle Feedlot Waste Management Practices for Water and Air Pollution Control. Texas Agricultural Extension Service.

Zinga D.E. (1992) Soils and Site Assessment for Utilisation of Animal Effluent. Recycled Water Seminar. Wagga Wagga.

Attachment 1. Department of Lands Scone Research Centre Soil Test Report

Land & Property Management Authority
Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO11/278R3
REPORT TO:	Stewart Cruden AA Company Ltd Level 1, 299 Coronation Drive Milton Qld 4064
REPORT ON:	Twenty eight soil samples
PRELIMINARY RESULTS ISSUED:	7 September 2011
REPORT STATUS:	Final
DATE REPORTED:	19 September 2011
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

SR Young
(Laboratory Manager)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666 Fax: 02 6545 2520

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO11/278R3
Client Reference: Stewart Cruden
AA Company Ltd
Level 1, 299 Coronation Drive
Milton Qld 4064

Lab No	Method	C1A/4	C2A/3	P2B/2	P3A/1	P5A/1	P6A/1	P7B/2 Particle Size Analysis (%)					P8A/2	P9B/2	P13A/3
	Sample Id	EC (dS/m)	pH	LL (%)	PL (%)	VE (%)	LS (%)	clay	silt	f sand	c sand	gravel	D%	EAT	USCS
1	EFF P3L1	<0.01	5.1	nt	nt	nt	nt	4	7	48	31	10	nt	7	nt
2	EFF P3L2	<0.01	5.1	nt	nt	nt	nt	14	10	40	34	2	nt	5	nt
3	EFF P3L3	<0.01	5.0	nt	nt	nt	nt	18	8	19	34	21	nt	6	nt
4	EFF P3L4	<0.01	4.9	nt	nt	nt	nt	21	7	18	31	23	nt	6	nt
5	EFF P3L5	<0.01	4.9	nt	nt	nt	nt	22	50	11	5	12	nt	6	nt
6	EFF P4L1	<0.01	5.2	nt	nt	6	nt	3	4	29	27	37	86	8	SM
7	EFF P4L2	<0.01	5.4	nt	nt	4	nt	5	4	22	21	48	73	5	SM
8	EFF P4L3	<0.01	5.0	nt	nt	3	nt	25	5	10	21	39	10	6	SC
9	EFF P4L4	<0.01	5.5	nt	nt	2	nt	21	7	21	29	22	14	6	SC
10	EFF P7L3	<0.01	5.4	nt	nt	nt	nt	25	10	15	27	23	nt	6	nt
11	EFF P10L2	<0.01	5.5	nt	nt	nt	nt	22	3	29	38	8	nt	6	nt
12	EFF P10L3	<0.01	5.7	nt	nt	nt	nt	19	4	25	30	22	nt	6	nt
13	EFF P12L1	<0.01	5.2	nt	nt	nt	nt	9	5	24	33	29	nt	7	nt
14	EFF P12L2	<0.01	5.4	nt	nt	nt	nt	14	4	25	33	24	nt	5	nt
15	EFF P12L3	<0.01	5.3	nt	nt	nt	nt	32	5	15	38	10	nt	6	nt

nt – not tested

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Lab No	Method	C1A/4	C2A/3	P2B/2	P3A/1	P5A/1	P6A/1	P7B/2 Particle Size Analysis (%)					P8A/2	P9B/2	P13A/3
	Sample Id	EC (dS/m)	pH	LL (%)	PL (%)	VE (%)	LS (%)	clay	silt	f sand	c sand	gravel	D%	EAT	USCS
16	P1L1	<0.01	5.3	nt	nt	5	nt	5	7	28	39	21	36	5	SM
17	P1L2	<0.01	5.4	nt	nt	1	nt	6	6	21	33	34	50	3(1)	SM
18	P1L3	<0.01	5.4	32	19	nt	7.5	20	9	18	38	15	11	6	SC
19	P1L4	<0.01	5.1	41	21	nt	11.0	28	9	21	30	12	0	6	SC
20	P4L3	<0.01	5.6	nt	nt	0	nt	9	6	10	21	54	15	6	SM-SC
21	P4L4	<0.01	5.3	nt	nt	<1	nt	19	6	9	18	48	10	6	SC
22	P5L3	<0.01	5.7	28	23	nt	2.0	5	14	11	28	42	40	5	GC-SC
23	P6L4	<0.01	5.2	57	28	nt	13.0	32	26	15	22	5	9	6	CH
24	P15L3	<0.01	5.4	35	24	nt	7.0	26	11	21	27	15	6	6	SC-CL
25	P15L4	<0.01	5.2	51	26	nt	11.0	31	17	15	29	8	5	6	CH
26	P17L4	<0.01	5.1	65	29	nt	13.0	37	21	12	20	10	8	6	CH

nt = not tested

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Lab No	Method	C8B/1		
	Sample Id	P sorp (mg/kg)	P sorp index	Texture
1	EFF P3L1	106	1.1	loamy sand
2	EFF P3L2	269	2.3	sandy loam
3	EFF P3L3	583	3.9	loam
4	EFF P3L4	578	3.8	clay loam
5	EFF P3L5	493	3.4	silty loam
10	EFF P7L3	433	3.1	loam
11	EFF P10L2	362	2.8	sandy clay loam
12	EFF P10L3	355	2.7	loam
13	EFF P12L1	351	2.7	sandy loam
14	EFF P12L2	454	3.2	sandy loam
15	EFF P12L3	555	3.7	light clay

Report No: SCO11/278R3

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Lab No	Method	P17C/1	
	Sample Id	Saturated Hydraulic Conductivity (mm/hr)	BD (t/m^3)
6	EFF P4 L1	15	1.63
7	EFF P4 L2	14	1.58
8	EFF P4 L3	195	1.21
9	EFF P4 L4	165	1.32

Lab No	Method	P17D/1		
	Sample Id	Saturated Hydraulic Conductivity (m/s)	BD (t/m^3)	MC (%)
27	P1 L3 + P15 L3	1.3×10^{-9}	1.86	15.5
28	P1 L4 + P6 L4	3.1×10^{-10}	1.82	16.6

BD = bulk density at which hydraulic conductivity was determined using rainwater
MC = moisture content at which material was compacted

END OF TEST REPORT