

HLA



moira station cattle feedlot

Moira Station Cattle Feedlot Environmental Assessment

Volume 2

December 2005

Prepared for:
Agricultural Equity Investments Pty Ltd

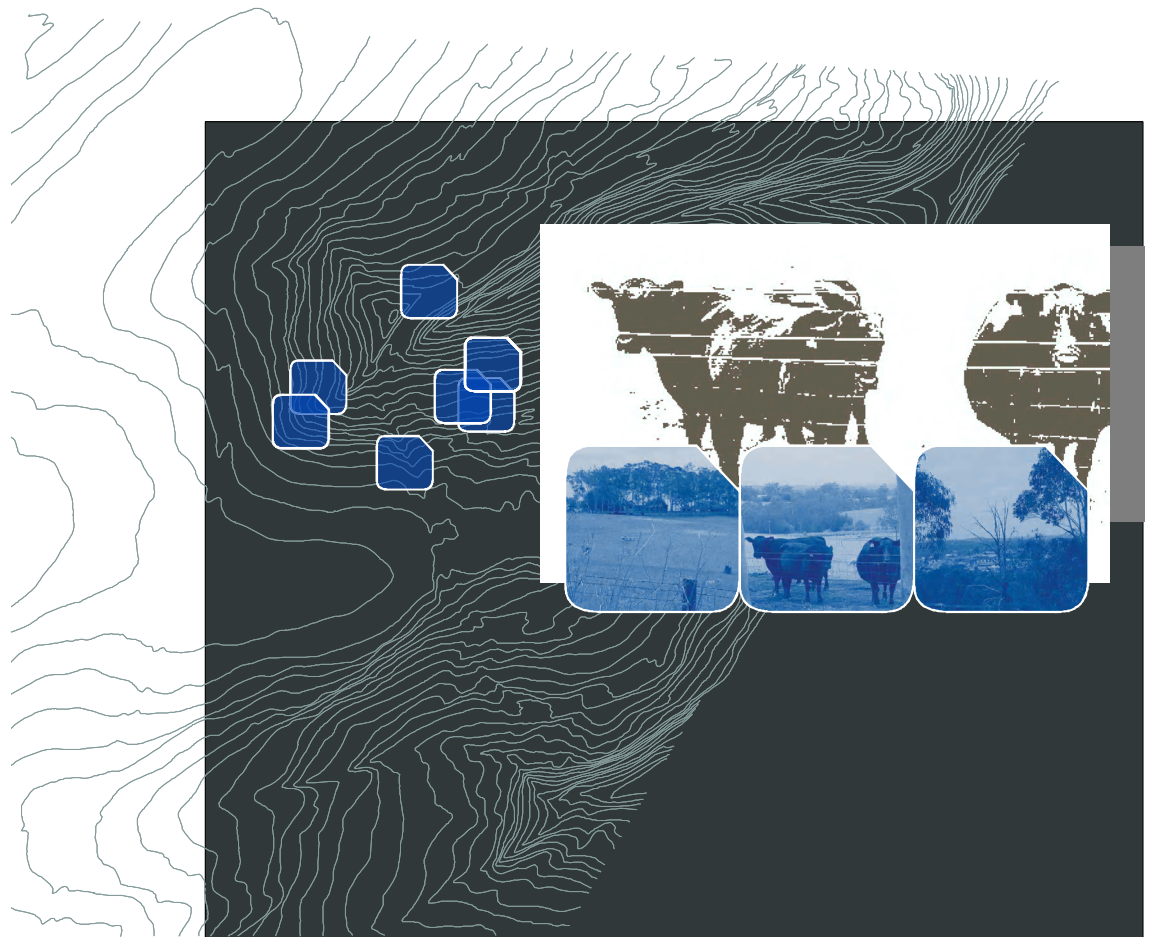
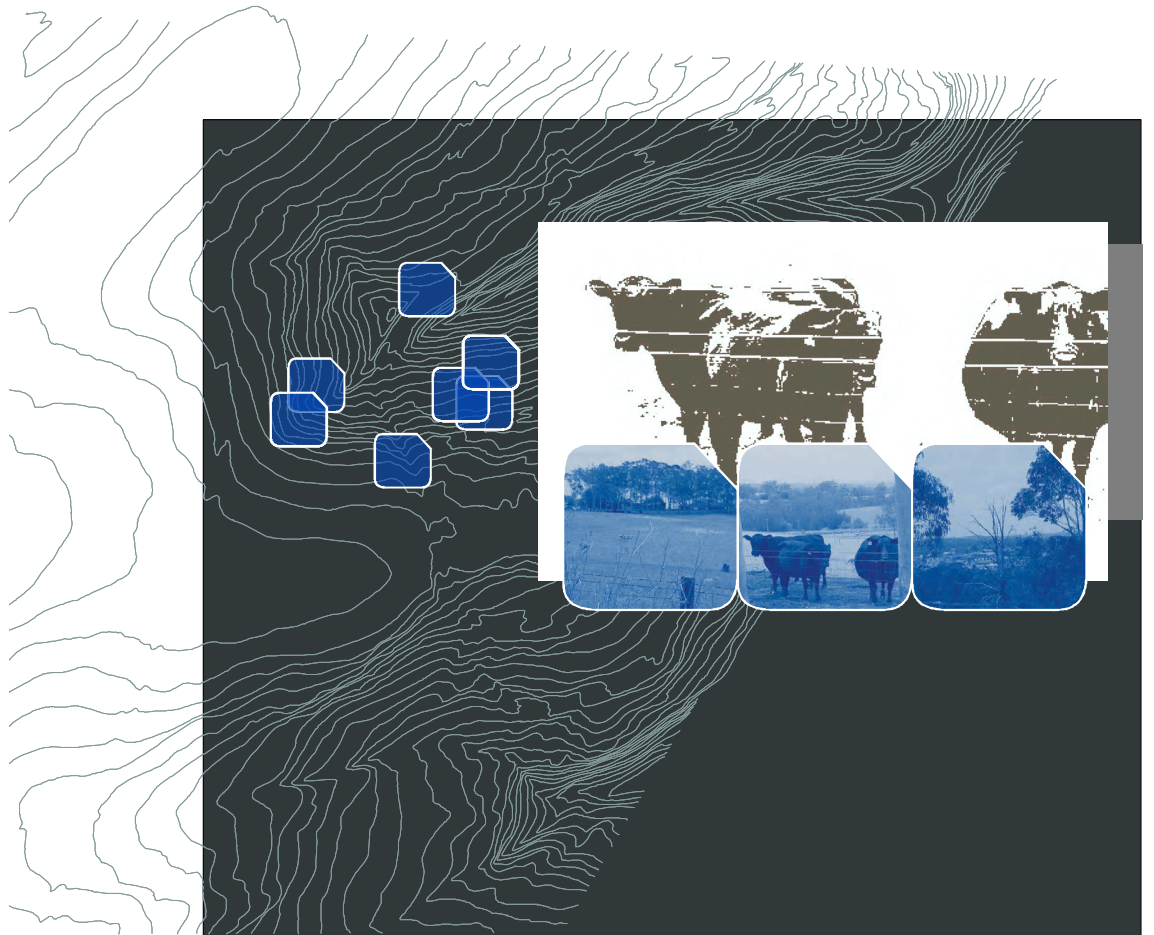


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appendix a

director general's requirements



Department of
Infrastructure, Planning and Natural Resources

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Major Development Assessment
Telephone: 02 9762 8164
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Ms Fiona Kennedy
HLA-Envirosciences Pty Ltd
PO Box 1943
MILTON QLD 4064

JOB NO
REG NO <i>IN-02313</i>
1 SEP 2004
PERSON RESPONSIBLE
CIRCULATE TO <i>Fiona Kennedy</i>

Our Ref: S04/01177
Your Ref:

Dear Ms Kennedy

Proposed Moira Cattle Feedlot, Moira Station, Mathoura – Murray LGA

I refer to the Planning Focus Meeting held on 17 June 2004 and subsequent request for the requirements for the preparation of an Environmental Impact Statement (EIS) for the above proposal. Attachment No. 1 outlines the statutory matters that must be included in any EIS under clauses 71 and 72 of the *Environmental Planning and Assessment Regulation 2000* (the Regulation).

You should note that if the Development Application (DA) to which these requirements relate is not made within two years of the date of this letter, clause 73(6) of the Regulation requires you to consult further with the Director-General prior to lodging the application.

Specific Requirements

Through discussions at the Planning Focus Meeting for this proposal and subsequent consultation with relevant agencies, a number of key issues have been identified as being of particular relevance for discussion in the EIS. Pursuant to clause 73(1) of the Regulation, the Director-General requires that the issues summarised below, and provided in detail in the Attachments, be addressed in the EIS. The issues have been ranked to generally indicate those matters the Department considers to be of greatest significance. Ranking is aimed at assisting the preparation of the EIS, and is not necessarily indicative of the actual magnitude of any of the impacts listed.

Issues of Key Environmental Planning Importance for EIS Preparation:

- Air quality impacts, particularly with regard to the emission of air pollutants, including odour and particulates;
- Waste management, particularly the identification and proposed management of solid and liquid waste;
- Soil management, particularly with regards to existing soil conditions and the suitability and sustainability of any proposed activities, such as wastewater irrigation;
- Water cycle management, including water supply and water consumption;

Issues of Environmental Planning Importance for EIS Preparation:

- Transport impacts, particularly site access and traffic generation;
- Noise impacts, particularly with regards to impacts on any nearby sensitive noise receptors;
- Visual impacts should be taken into consideration;

Other Important Issues:

- Animal welfare, disease management and vector controls and details of contingency measures for the mass disposal of livestock in the event of disease outbreak should be considered;
- Impacts on flora and fauna, on, in or adjacent to the proposed development should be considered;
- Aboriginal cultural heritage should be taken into consideration;
- Provisions of relevant environmental planning instruments should be considered;
- Socio-economic impacts on the locality and the broader region should be considered; and
- Effective consultation with the public and Government bodies should be undertaken.

State Significant Development

The Director-General also requires the following for all State Significant Development Applications:

- The Applicant shall nominate a contact person (and telephone number) who will be made available to answer public enquiries about the proposal;
- The Applicant shall consult with the community that is likely to be affected by the proposal. A report on who was consulted must be submitted with the DA, describing how the affected community was identified, consultation methods, and key issues raised by the community;
- The Applicant shall provide a disk containing an electronic copy of the Executive Summary to the EIS, in pdf format or another format that can be easily converted to pdf format (preferably no larger than 1MB); and
- Electronic copies of the EIS shall be provided on CD in an appropriate format.

Requirements of Integrated Approval Bodies

Under Section 91 of the *Environmental Planning and Assessment Act 1979*, development is "integrated development" if it requires certain approvals from other bodies in addition to the consent authority before it may be carried out.

In your Form A, you indicated that the proposal would require additional approvals from the Roads and Traffic Authority under section 138 of the *Roads Act 1993*, the Department of Environment and Conservation (DEC) under the *Protection of the Environment Operations Act 1997* and the Department under the *Water Management Act 2000*. These agencies have provided their requirements (see Attachment No. 3) and you must address these as part of the preparation of your EIS. The DEC's letter also identifies other issues of interest to the DEC such as flora and fauna impacts and Aboriginal cultural heritage and you should consider these during the preparation of your EIS.

If further integrated approvals are identified before the Development Application is lodged, you must conduct your own consultation with the relevant agencies and address their requirements in your EIS, and when lodging your Development Application, you must include:

- At least one copy of the Development Application and supporting documentation for each of the integrated approval bodies; and
- Cheques for \$250, made payable to each of the integrated approval bodies.

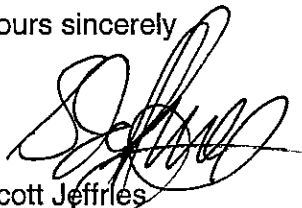
Commonwealth Approvals

If your proposal contains any actions that may have significant impact on matters of National Environmental Significance, then it may require additional approvals under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These approvals are in addition to any approvals required under NSW legislation. Correspondence was received from the Department of Environment and Heritage (Attachment No. 4) in relation to the proposal and you should contact this Department if you have any questions about the application of the EPBC Act to this proposal.

Further Information

Please contact Joanna Bakopanos on (02) 9762 8164 if you require any further information regarding the Director-General's requirements for the EIS.

Yours sincerely



25/08/04

Scott Jeffries
A/ Manager, Manufacturing and Rural Industries
Major Development Assessment
as delegate for the Director-General

Note: Matters of National Environmental Significance under the EPBC Act are:

- i) World Heritage properties;
- ii) RAMSAR wetlands;
- iii) threatened species or ecological communities listed in the EPBC Act;
- iv) migratory species listed in the EPBC Act;
- v) the environment in a Commonwealth marine area; and
- vi) nuclear actions.

Attachment No. 1

**STATUTORY REQUIREMENTS FOR THE PREPARATION OF AN ENVIRONMENTAL IMPACT STATEMENT
UNDER PART 4 OF THE ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979**

In accordance with the *Environmental Planning and Assessment Act 1979* (the Act), an environmental impact statement (EIS) must meet the following requirements.

Content of EIS

Pursuant to Schedule 2 and clause 72 of the *Environmental Planning and Assessment Regulation 2000* (the Regulation), an EIS must include:

1. A summary of the environmental impact statement.
2. A statement of the objectives of the development or activity.
3. An analysis of any feasible alternatives to the carrying out of the development or activity, having regard to its objectives, including the consequences of not carrying out the development or activity.
4. An analysis of the development or activity, including:
 - (a) a full description of the development or activity; and
 - (b) a general description of the environment likely to be affected by the development or activity, together with a detailed description of those aspects of the environment that are likely to be significantly affected; and
 - (c) the likely impact on the environment of the development or activity, and
 - (d) a full description of the measures proposed to mitigate any adverse effects of the development or activity on the environment, and
 - (e) a list of any approvals that must be obtained under any Act or law before the development or activity may be lawfully carried out.
5. A compilation, (in a single section of the environmental impact statement) of the measures referred to in item 4(d).
6. The reasons justifying the carrying out of the development or activity in the manner proposed, having regard to biophysical, economic and social considerations, including the following principles of ecologically sustainable development:
 - (a) The precautionary principle - namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.In the application of the precautionary principle, public and private decisions should be guided by:
 - (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and
 - (ii) an assessment of the risk-weighted consequences of various options,

- (b) Inter-generational equity - namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations,
- (c) Conservation of biological diversity and ecological integrity, namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration,
- (d) Improved valuation, pricing and incentive mechanisms, namely, that environmental factors should be included in the valuation of assets and services, such as:
 - (i) polluter pays, that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,
 - (ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,
 - (iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

An environmental impact statement referred to in Section 78A(8) of the Act shall be prepared in written form. The prescribed form to accompany the environmental impact statement must comply with the requirements of clause 71 of the Regulation and be signed by the person who has prepared it.

Procedures for public exhibition of the EIS are set down in clauses 77 to 81 of the Regulation.

Attention is also drawn to clause 283 of the Regulation regarding false or misleading statements in EISs.

Note

If the development application to which the EIS relates is not made within 2 years from the date of issue of the Director-General's requirements, under clause 73(6) of the Regulation the proponent is required to reconsult with the Director-General.

Attachment No. 2

SPECIFIC REQUIREMENTS FOR THE PREPARATION OF AN ENVIRONMENTAL IMPACT STATEMENT

Environmental Planning Instruments

- Statutory Planning instruments, the EIS must assess the proposal against the provisions and objectives of all relevant planning instruments, including: *State Environmental Planning Policy No 30 – Intensive Agriculture*; *State Environmental Planning Policy No 33 – Hazardous and Offensive Development*; and the *Murray Local Environmental Plan 1989*;
- The Department's Guideline *Cattle Feedlots* should be consulted during preparation of the EIS. As the proposal includes the irrigation of effluent material, you should also take into consideration the Department's Guidelines *Irrigation and Sewage Effluent*. These Guidelines can be purchased from the Department's Information Centre, 20 Lee Street, Sydney (02 9762 8044); and
- The Department of Primary Industries (former NSW Agriculture) *Policy for Sustainable Agriculture in NSW 1998* should be considered.

Description of the Development and Environment

- The zoning of the land affected by the proposed development and the permissibility of these works within these zones must be identified. An indication of surrounding land uses and any potential land use constraints should also be provided in the EIS;
- The EIS must clearly outline the general scope of the project, including the site layout, methods of operation including the production process and schedule, the type of machinery and equipment to be used, associated facilities and construction methods and environmental control safeguards;
- Details on capital investment, hours of operation, employment numbers any staging of the proposal and expected life of the operation should be discussed; and
- Details of any new or modified utilities required by the proposed development must be outlined, including the results of any consultations with relevant utility providers in relation to the provision of those utilities.

Air Quality

- Impacts of construction activities on air quality, particularly dust emissions, should be detailed with appropriate mitigation measures identified;
- A full air quality assessment must be included in the EIS, particularly with regard to particulates and odour. The assessment must identify all fugitive and point source emissions during operation and must assess these parameters from a project-specific perspective in accordance with the Department of Environment and Conservation's (DEC) *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW (2000)* and draft policy *Assessment and Management of Odour from Stationary Sources in NSW (2000)*. The air quality assessment must consider any potential air quality and amenity impacts on any nearby private residences;
- Details of any air pollution control measures must be provided; and
- An outline of any air quality monitoring for the proposed development, including pollutants and parameters that should be monitored, monitoring locations, methods and frequencies.

Land and Soil Management

- The EIS must provide an assessment on the soil types present on site. In particular, the soil assessment should consider the capacity of the soil to receive effluent/ manure in terms of its cation exchange capacity, phosphorous sorption etc. and other engineering attributes such as permeability, plasticity, soil profile, salinity and sodicity;

- The EIS must also detail the proposed irrigation and solid waste application practices at the site, including nutrient loading rates, cropping regime, wet weather contingency arrangements, irrigation methods and monitoring programs;
- Details of past land uses on the site should be considered, particularly with respect to the potential presence of contaminated soil/ material on the site and any implications for the proposed future use. Appropriate mitigation, management and/ or relevant remediation measures must be outlined for any activity that may affect those areas of the site;
- The EIS must also detail measures to be employed to ensure that operation of the proposed development does not lead to any contamination of the site; and
- The EIS must provide details of any soil excavations/ filling on the site, particularly whether any fill needs to be brought on site. The origin, quantities and suitability of the fill needs to be considered.

Waste Management

- Construction wastes, including quantities and qualities of waste, management, minimisation and treatment/ disposal methods must be considered;
- The EIS must identify the types and likely annual rates of production of all waste streams from the proposed development, including domestic waste products. Proposed methods of treatment, re-use and/ or disposal of these waste streams should be clearly indicated;
- Wastes that are not be reused or recycled should be classified in accordance with the DEC's *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes*; and
- Details of waste management at the proposed development should clearly reflect the principles of "reduce, reuse and recycle".

Water Management

- Full details of the proposal's water cycle and its management should be provided, including a description of water supply and the need for any licences, water consumption requirements and measures to reuse water within the process;
- The EIS must identify all potential surface water and groundwater impacts associated with the proposal, and describe what measures would be implemented to minimise/ manage any impacts;
- Full details of stormwater management systems should be provided in the EIS with a demonstration that those systems can accommodate likely storm events (justification should be provided for the design capacity of those systems). Particular note should be made of any proposed measures to segregate stormwater run-off of varying qualities and proposed stormwater infrastructure (eg major drainage, first flush systems, sedimentation devices etc); and
- Details of the proposed erosion and sedimentation control measures to be utilised throughout the life of the development must be provided.

Transport Impacts

- A Traffic Impact Study (TIS), prepared in accordance with the RTA's publication *Guide to Traffic Generating Developments*, must be included as part of the EIS. The TIS should include details of expected traffic movements to and from the proposed development site with specific consideration of:
 - traffic generation during construction (volume and frequency), site access points, hours of traffic movement and proposed traffic routes;
 - traffic generation during operation (volume and frequency), site access points, hours of traffic movement (particularly in regard to shift times) and proposed traffic routes;
 - the design of the internal roadways and parking;

- the types of road transport to be employed;
- the capability of proposed routes (including road and intersection capacity) to handle predicted traffic movements associated with the proposal. Any road upgrades that may be required should be noted with a summary of consultations with the RTA and Council, where relevant, in relation to those upgrades; and
- the cumulative impacts of traffic generated by the proposed development.

Noise Impacts

- The EIS must assess the predicted noise impact resulting from all noise sources during construction and operation, including road traffic noise. The noise assessment must be undertaken in accordance with the DEC's *Industrial Noise Policy (2000)* and *Environmental Criteria for Road Traffic Noise*;
- In relation to construction noise, the noise assessment must be undertaken in accordance with the *Construction Site Noise* guidelines from the DEC's *Environmental Noise Control Manual*. A copy of these guidelines may be obtained from the DEC's Noise Control Policy section on (02) 9995 5785; and
- Consideration of potential impacts resulting from vibration generated during any drilling activities.

Visual Impacts

- The EIS must consider the visibility of the proposed development with reference to the height and scale of the development and materials used, particularly with regards to the potential for any visual amenity impacts on any nearby residential areas, adjacent development and publicly accessible places, including public roads. The EIS must also detail any proposed screening of the development to mitigate or minimise any visual impacts.

Animal Welfare and Disease Management

- The EIS must demonstrate adherence to relevant codes of practice and completion of an Animal Care Statement;
- The EIS must include disease control measures and provide consideration of contingency measures for the mass disposal of livestock in the event of a disease outbreak; and
- Consideration must be given to the control of vermin and other pest species.

Flora and Fauna

- The EIS must consider potential impacts of the proposed development on flora and fauna, particularly the need for any clearing of native vegetation (including grassland species) and subsequent management measures to offset these losses; and
- The EIS must identify potentially impacted critical habitats; threatened species, populations or ecological communities, or their habitats, and apply the test of significance under Part 5A of the *Environmental Planning and Assessment Act 1979*.

European and Aboriginal Cultural Heritage

- The EIS must consider the impact of the development with respect to the indigenous and non-indigenous heritage significance, particularly in areas that are proposed to be disturbed. Details should be provided of consultation with relevant Local Aboriginal Land Councils.

Socio-Economic Impacts

- The EIS must address the impact of the proposed development on agriculture in the regions, particularly with the grain industry;

- Consideration should be given to the potential impacts of the development on accommodation in the Murray area;
- Details should be provided as to the intended source of employment for the proposal; and
- Consideration of the value-adding potential of the development to other industries in the region should be provided.

Hazard and Risk Management

- The EIS must detail the transport, handling, storage and use of any dangerous goods at the site.

Environmental Monitoring and Management

- The EIS must indicate how the environmental performance of the proposal would be monitored and managed during construction and operation. This should include the provision of a comprehensive list of table that details all commitments made by the Applicant in relation to environmental impact mitigation, management and monitoring (such as for water quality, flora and fauna, navigation and visual issues). A clear statement must be made indicating:
 - What measures will be implemented/applied;
 - The scope of these measures; and
 - The timing of implementation/application of these measures.

Consultation

- You should address those issues raised by government agencies at the Planning Focus Meeting held for the proposal on 17 June 2004; and
 - Consultation with the parties listed below may be useful in the preparation of the EIS. It is noted that consultation requirements may vary significantly between the parties listed. It is the Applicant's responsibility to justify the extent and scope of all consultations.
 - Department of Environment and Conservation;
 - Murray Shire Council;
 - NSW Agriculture (now part of the Department of Primary Industries);
 - Roads and Traffic Authority;
 - Department of Housing;
 - Relevant utility providers;
 - Local Aboriginal Land Council; and
 - Relevant local community groups.
-

Attachment No. 3



Subject: DG Requirements for EIS for proposed Beef Cattle Feedlot on Moira Station on behalf of Agricultural Equity Investments Pty Ltd.

The EIS should address the following:

- Any potential impacts from the development on water quality both **surface water** (via run off or other overland flow)
- 1. Detail any mitigation against possible erosion and movements of sediment into any watercourses around the development site or offsite, both during and post construction. This includes any borrow areas.
- 2. Detail how all catchment runoff is to be redirected around the feedlot site and natural flows allowed to pass around the development area.
- 3. Detail on how feedlot run off is to be controlled with regard to the feedlot development site, how all water up to the 1 in 20 year, 24-hour storm event is to be contained on site. How the feedlot site is to be protected from run on and drained appropriately to suitable treatment works. Detail as to how nutrient laden run off is to be captured and used on site to avoid the movement of nutrient to any watercourses around the development site.
- 4. If manure/solids will be stockpiled at this site detail on the location of such and how run on to this stockpile area is to be minimised by appropriate works and runoff directed to settling ponds or other appropriate works.
- 5. Whilst from the information provided to date it appears that the site is not located on a designated floodplain, the EIS must show due consideration to the impacts of any works associated with the proposed feedlot on flood flows. If the proposed development affects the flow of water to or from a river or lake, approval may be required under Part VIII of the *Water Act 1912*.
- 6. The capture of surface water is governed by rules pertaining to harvestable rights. The applicant will need to show that any storage's proposed for this development are either within the harvestable right for the property or that the storage's can be licensed appropriately and water transferred in if needed.
- **And ground water.**
- 1. Detail any mitigation against possible movement of water through the soil profile to groundwater in any areas where new water storage or water movement is to occur. For example earthen drains or effluent holding basins. With respect to drains for the redirection of surface flows from the feedlot area, due to the potential for groundwater contamination, detail how the drain floors are to meet the requirement for no movement of contaminated water to groundwater. Detail also how feedlot floors are to achieve this requirement.

2. Detail any mitigation where possible movement of water to the water table in any areas where storage of wet materials is to occur. For example if manure/solids will be stockpiled at this site the base of the stockpile must also be impermeable to the same requirements as the pens. Detail how wet materials storage areas are to achieve this requirement.
 3. Carcass Disposal. With respect to any pits for on site carcass disposal, due to the potential for groundwater contamination, detail how the pits are to meet the requirement for no potential movement of contaminated water to groundwater.
 4. Groundwater Levels and Sampling. There is a need for testing to ensure contamination does not occur. Detail how this testing and monitoring is to be undertaken, eg. How often and for what parameters will groundwater testing be undertaken and who is to interpret the information? Any groundwater testing piezometers require a licence under the *Water Act 1912*.
- Effects of the development on **flora and fauna** both terrestrial and aquatic if relevant.
 - 1. Solid reuse. Where solid wastes are to be spread on site, detail as to the quantities and as to how harm is to be mitigated with respect to native vegetation to prevent potential harm via increase in nutrient loads.
 - 2. The EIS must provide information that fully considers the effects of the development on native flora, fauna and threatened species and how are the impacts on native flora, fauna and threatened species to be managed to acceptable levels?
 - Detail how the proponent intends to ensure **adequate permanent water supply** to this development. Detail how any proposed water supply meets the requirements of NSW legislation with regard to the *Water Act 1912* or other relevant legislation.

The less important issues (only as DIPNR do not administer the relevant legislation) are:

- The need for an appropriate archaeological survey to be conducted.
- Carcass Disposal. Detail how provision is to be made for on site disposal of carcasses in the event that offsite options are not available.
- Soil properties. Detail how any changes to soil properties are to be monitored (both physical and chemical properties). Detail as to how often monitoring will occur, what the parameters will be, where it will occur and who is to interpret the information.

Craig McIntyre
Natural Resource Officer
Resource Access Unit
Albury Office
Murray/Murrumbidgee Region.



299DA003
087492 / 087491
S Lyons

Department of Infrastructure, Planning and Natural Resources
Senior Environmental Planning Officer
Major Development Assessment
GPO Box 3927
SYDNEY NSW 2001

Attention: Chris Ritchie

Proposed Moira Cattle Feedlot, Moira Station Murray Shire.

Dear Sir,

I refer to your correspondence dated 3 and 8 June 2004 regarding the subject proposed development and the RTA's EIS requirements.

The EIS should include a Traffic Impact Study in accordance with section 2 of the RTA's Guide to Traffic Generating Developments. The Traffic Impact Study should include (but not be limited to) the following points:

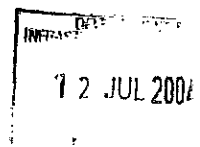
- Types and volumes of vehicles to be used.
- The direction of travel of all vehicles entering and exiting the site.
- AADT (annual average daily traffic) on key streets.
- Peak period traffic volumes and congestion levels at key adjacent intersections.
- Hours and days of operation.
- Safety and efficiency of the internal road layout.
- Impact of generated traffic on key adjacent intersections, the environment and other major traffic generating developments in close proximity.
- Accident history of road network in the area.
- Access location and width.
- Sight distance at access location.
- Safety and efficiency of access to site from adjacent road network.
- Assessment of traffic noise and dust effects.

For any further enquiries please contact Mrs Suzie Lyons on (02) 6938 1146 or 0407 935 083.

Yours faithfully

for
C E Blomfield
Regional Manager

8 July 2004



EIS Requirements

Notice No: 1039773



NSW EPA
NEW SOUTH WALES
ENVIRONMENT PROTECTION AUTHORITY

Protection of the Environment Operations Act 1997

Notice No: 1039773

Our ref: 241086A1-ALF5033

FAXED
1535 13/8/04

Ms Joanna Bakopanos

A/Senior Environmental Planning Officer

Major Development Assessment

Department of Infrastructure, Planning and Natural Resources

GPO Box 3927

SYDNEY NSW 2001

Dear Ms Bakopanos

**RE: PROPOSED LIVESTOCK INTENSIVE INDUSTRY – FEEDLOT “MOIRA STATION”
MURRAY LOCAL GOVERNMENT AREA**

I refer to your request for Department of Environment and Conservation (DEC) requirements for the Environmental Impact Statement (EIS) in regard to the above proposal, received by the DEC on 27 July 2004.

As you are aware the DEC is a new State Government department bringing together the Environment Protection Authority, the National Parks and Wildlife Service (NPWS), Resource NSW and the Royal Botanic Gardens and Domain Trust, and also linking with the work of the Sydney Catchment Authority. The Environment Protection Authority will continue to be the legal entity through which the DEC exercises its statutory functions under environment protection legislation. The following comments relate to statutory departmental responsibilities under the *National Parks and Wildlife Act, 1974*, the *Environment Planning and Assessment Act, 1979* the *Threatened Species Conservation Act 1995* and the *Protection of the Environment Operations Act 1997* (POEO Act).

The DEC has considered the details of the proposal as provided by the Department of Infrastructure, Planning and Natural Resources (DIPNR) and has identified the information it requires to consider whether to issue its general terms of approval. These requirements are detailed in Attachments 'A', 'B' and 'C'. In summary, the DEC's key information requirements for the proposal are:

1. air quality including odour and dust;
2. noise;
3. water;
4. general waste management;
5. emergency waste management in the event of disease outbreak;

6. flora and fauna;
7. Aboriginal cultural heritage.

To assist the DEC in assessing the EIS, it is requested that the EIS follows the format of DIPNR's EIS guidelines and addresses DEC's specific information requirements as outlined in the attachments. If the necessary information is not adequately provided in the EIS then delays in the development application process may occur.

A major issue at feedlot facilities is the generation of odour. The DEC's experience is that odours from feedlot facilities can significantly impact on the amenity of adjacent neighbours. For this reason the DEC requires a detailed and thorough investigation and assessment of odour in the EIS.

While the design and management of a facility can minimise the generation of odour, the close proximity of sensitive receptors may necessitate a level of design and management that is difficult to achieve in terms of technology and economic viability. Given the close proximity of the proposed "Moirra Station" feedlot to sensitive receptors and potential difficulties in meeting odour performance requirements under the *POEO Act*, we suggest that it may be in the applicant's best interest to undertake the required odour impact assessment in the early stages to confirm the feasibility of the proposal prior to undertaking other studies. You will recall the DEC recommended this course of action at the Planning Focus Meeting on 17 June 2004.

It is essential that the DEC is able to validate the odour impact assessment as part of the decision making process. To do this the DEC needs to be able to reproduce any odour dispersion modelling and the results presented. To facilitate this the proponent must provide all dispersion model input, output and meteorological data files used in the dispersion modelling (Microsoft Windows compatible format) on a diskette with the EIS report.

In addition, potential waste will need to be assessed and classified in accordance with the EPA's *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes* to determine the need for waste issues to be covered in an environment protection licence. In some cases a separate licence is required for the transport of certain waste. A copy of the guideline can be obtained from Pollution Line on 131 555 or down loaded from the EPA's Web site at <http://www.epa.nsw.gov.au/waste/guidelines.htm>.

Statutory Requirements

The proposed development is scheduled under the *POEO Act* and requires a licence under that Act. The applicant will need to make a separate application to obtain the Environment Protection Licences. General information on licence requirements can be obtained from Pollution Line on 131 555 or be found at the DEC Web site at <http://www.epa.nsw.gov.au/licensing/>.

The environmental assessment should also assess the development in relation to the requirements of Section 5A ('Significant effect on threatened species, populations or ecological communities or their habitats') of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

EIS Requirements

Notice No: 1039773



Protection of the Environment Operations Act 1997

The assessment should also determine whether a permit to disturb Aboriginal objects under Part 6 s87, or whether a licence to destroy, deface or damage Aboriginal objects may be required under Part 6 s90, of the *National Parks and Wildlife Act 1974*. Appendices B and C contain the Environmental Assessment Guidelines of the former NPWS. These guidelines address requirements under the EP&A Act and the DEC's areas of responsibility relating to flora, fauna, cultural heritage and threatened species, populations and ecological communities and their habitats. If you have any questions regarding flora, fauna, threatened species or Aboriginal cultural heritage, please contact Erica Baigent, Conservation Planning Officer, on (02) 6883 5311.

The DEC will require 4 copies of the EIS when the application is submitted. These documents should be lodged with the DEC's Albury office - Postal address PO Box 544 Albury NSW 2640 and marked to the attention of the Regional Manager, South West.

If you have any enquiries regarding the above matters please contact Brian Wild or Frank Robinson at our Albury office on 02 6022 0600.

Yours sincerely

Rob Monteith 13/8/04

ROB MONTEITH

Regional Manager South West

Department of Environment and Conservation

ATTACHMENT A

**Proposed Intensive Agricultural Development – FEEDLOT –
“Moira Station”, Cobb Highway , Mathoura**

Environment Protection Authority Information Requirements

A EXECUTIVE SUMMARY

- An executive summary should be provided in the EIS. It should provide a short overview, in non-technical language, of the proposal and the potential environmental impacts.

B THE LOCATION

1. General

- Provide an overview of the affected environment to place the proposal in its local and regional environmental context including:
 - i. meteorological data (eg rainfall, temperature and evaporation, wind speed and direction);
 - ii. topography (eg landform element, slope type, gradient and length);
 - iii. surrounding land uses (eg potential synergies and conflicts);
 - iv. soil types and properties (including erodibility, engineering and structural properties, dispersibility, permeability and any soil issues such as salinity and sodicity);
 - v. ecological information (eg water system habitat, vegetation, fauna);
 - vi. availability of services and the accessibility of the site for passenger and freight transport;
 - vii. surrounding land uses and planning zonings.

C THE PROPOSAL

1. Objectives of the proposal

- The objectives of the proposal should be clearly stated and refer to:
 - i. the size and type of the operation, the nature of the processes and the products, by-products and wastes produced;
 - ii. a life cycle approach to the production, use or disposal of products;
 - iii. the anticipated level of performance in meeting required environmental standards and cleaner production principles;
 - iv. the staging and timing of the proposal and any plans for future expansion;
 - v. the proposal's relationship to any other industry or facility.

2. Description of the proposal

- Outline the production process including:
 - i. the environmental “mass balance” for the process – quantify in-flow and out-flow of materials, any points of discharge to the environment and their respective destinations (land, stormwater, atmosphere, recycling, landfill etc);
- Outline cleaner production actions, including:
 - i. measures to minimise waste (typically through addressing source reduction);
 - ii. proposals for use or recycling of by-products;
 - iii. proposed disposal methods for solid and liquid waste (e.g. application to land on and/or off the premises);
 - iv. all potential sources and nature of any air emissions;
 - v. water management system including all potential sources of water pollution (point and diffuse sources), proposals for re-use, treatment etc, emission levels of any wastewater discharged, discharge points;
 - vi. soil contamination treatment and prevention systems.
- Outline construction works including:
 - i. actions to address any existing soil contamination;
 - ii. any earthworks or site clearing; re-use and disposal of cleared material (including use of spoil on-site);
 - iii. construction timetable and staging; hours of construction; proposed construction methods;
 - iv. environment protection measures, including noise mitigation measures, dust control measures and erosion and sediment control measures.

D IDENTIFICATION AND PRIORITISATION OF ISSUES

- Provide an overview of the methodology used to identify and prioritise environmental issues. The methodology should take into account:
 - i. relevant NSW government guidelines;
 - ii. industry guidelines;
 - iii. relevant research and reference material;
 - iv. relevant preliminary studies or reports for the proposal;
 - v. consultation with stakeholders.

E ENVIRONMENTAL ISSUES

1. Cumulative Impacts

The EIS must assess the following issues in regard to cumulative impacts.

- Identify the extent that the receiving environment is already stressed by existing development/s and background levels of emissions to which this proposal will contribute.
- Assess the impact of the proposal against the long-term air, noise and water quality objectives for the area or region.
- Identify infrastructure requirements flowing from the proposal (eg water and sewerage services, transport infrastructure upgrades).
- Assess likely impacts from such additional infrastructure and measures reasonably available to the proponent to contain such requirements or mitigate their impacts.

2. Air

The EIS must identify and discuss the following points relating to air quality resulting from the development.

- Provide details of the project that are essential for predicting and assessing air impacts including:
 - i. the quantities and physico-chemical parameters (eg concentration, moisture content, bulk density, particle sizes etc) of materials to be used, transported, produced or stored;
 - ii. an outline of procedures for handling, transport, production and storage;
 - iii. the management of any solid, liquid and gaseous waste streams with potential for significant air impacts.
- Provide a baseline description of existing air quality and meteorology, using existing information and site representative ambient monitoring data.
- Identify all sources of air emissions from the development.
- Identify all pollutants of concern (including odour) and assess emissions by quantity, source, discharge point, time of discharge and dispersion/control method.
- Incorporate a full assessment/modelling by a suitably qualified and experienced person of air quality impacts (including odour and dust) resulting from all activities on the premises and include recommendations and strategies for controlling all pollutants of concern (including odours) to ensure all relevant requirements of the Protection of the Environment Operations Act 1997 (POEO) and the Clean Air (Plant and Equipment) Regulation 1997 will be complied with. The assessment must be transparent, be fully reproducible and use meteorological data representative of the site.
- Outline specifications of any pollution control equipment (including manufacturer's performance guarantees where available) and management protocols for both point and fugitive emissions. Where possible, this should include cleaner production processes.

- Outline and discuss any management strategies that can be implemented to minimise the impacts of the development on local air quality.

A detailed and thorough investigation and assessment of odour must be provided in the EIS. The EPA Draft policy: *Assessment and Management of Odour from Stationary Sources in NSW* (January 2001) sets out considerations in relation to odour assessment and management in NSW. While this document is only a draft at this stage, it may assist in the assessment of offensive odour impacts, if the methodologies outlined in this document are adopted.

Technical analysis and information provided must follow EPA guidelines including "Approved methods for the sampling and analysis of air pollutants in New South Wales" and "Approved methods and guidance for the modelling and assessment of air pollutants in NSW". These publications are available from the EPA's Web site <http://www.epa.nsw.gov.au>. If, in the analysis, assumptions are made or reference is made to other work or information/data is transposed from other sources then fully detailed explanations, background and detail must be provided to support and justify the assumptions etc. Copies and details of all data and reports referenced must be provided.

3. Noise

The EIS must provide the methods and results of a detailed noise assessment of the site in relation to the development. A suitably qualified and experienced person should carry out the noise assessment. The noise assessment must at least identify and discuss the following points relating to noise resulting from the development benchmarked against background levels.

- A baseline description of existing noise environment, using existing information and site representative ambient monitoring data.
- Identify any noise sensitive locations likely to be affected by the activity.
- Identify and assess all noise sources from the development (including both construction and operation phases). Detail all potentially noisy activities including ancillary activities such as transport of goods and raw materials to and from the site.
- Specify the times of operations for all phases of the development and for all noise producing activities.
- Determine the expected noise level and noise character (eg tonality, impulsiveness, vibration etc) likely to be generated from noise sources during site establishment, construction, operational phase, transport including traffic noise generated by the proposal and other services.
- Determine the noise levels likely to be received at the most sensitive locations.
- Determine the most appropriate noise mitigation measures including both noise controls and management of impacts for both construction and operational noise. This will include selecting quiet equipment and construction methods, noise barriers or acoustic screens, location of stockpiles, temporary offices, compounds and vehicle routes, scheduling of activities, etc.
- For traffic noise impacts, provide a description of the ameliorative measures considered (if required), reasons for inclusion or exclusion, and procedures for calculation of noise levels

including ameliorative measures. Also include, where necessary, a discussion of any potential problems associated with the proposed ameliorative measures.

The noise assessment should include noise contours if there is to be a significant level of noise impact with particular attention to any potential impulsive noise characteristics that may occur during some site activities. Consideration should also be given to existing meteorological conditions and specify the times of operation for all phases of the development and for all noise producing activities.

Assessments must follow procedures outlined in the EPA's "New South Wales Industrial Noise Policy" (available from the EPA's Web site <http://www.epa.nsw.gov.au>).

4. Water

The potential for water pollution from a feedlot is significant. Storage and stockpiling of a number of products around the feedlot, along with use of cleaning and disinfecting chemicals during cleaning may lead to contaminated runoff. Stockpiling of feedlot manure is of particular concern. This material is generally highly concentrated in nutrients and likely to have significant environmental impact if leachate reaches surface or ground water.

The EIS must include a full analysis of the following issues regarding the development.

- Describe the catchment and groundwaters including proximity of the development to any waterways and groundwaters and provide an assessment of their sensitivity/significance from a public health, ecological and/or economic perspective. Groundwater information should include, but not restricted to, depth to watertable, depth to other groundwater (eg fractured rock), flow direction and gradient, groundwater quality, reliance on groundwater by surrounding users and environment.
- Outline the site layout, demonstrating efforts to avoid proximity to water resources (surface and groundwaters) and showing potential areas of modification of contours, drainage etc.
- Full details of water management on the site including full details of the controlled catchments, clear water by-passes, stormwater management, discharge points, likely range of flow rates and pollutant concentrations that may be released into the environment including residual impacts after mitigation measures are implemented, for example from waste storage and treatment areas, chemical storage, handling and transport areas.
- Outline how total water cycle considerations are to be addressed showing total water balances for the development (with the objective of minimising demands and impacts on water resources). Include water requirements (quantity, quality and source(s)) and proposed storm and waste water disposal, including type, volumes, proposed treatment and management methods and re-use options.
- Provide details and assessments of the project relevant to any water impacts (both surface and groundwater) of the development such as drainage works and associated infrastructure; land forming and excavations; working capacity of structures and water resource requirements of the proposal.

- Describe the effects and significance of any pollutant loads on the receiving environment.
- Outline pollution control measures including,
 - i. Stormwater management at the source to contain pollutants on site,
 - ii. Sediment and erosion control measures,
 - iii. Waste water management appropriate to the type and volume of waste water based on hierarchy of avoiding generation, capturing contaminated water including stormwater, reuse/recycling and treating any unavoidable discharge,
 - iv. Relating to storage of materials, possible accidental spills, appropriate disposal methods and generation of leachate.
- Identify and address any potential impacts on quality or quantity of groundwater describing their source and significance.

5. Waste

A full assessment of the waste stream at this development should be undertaken to determine possible environmental impacts. The disposal of this waste material must also be fully assessed.

The EIS must identify and discuss the following points relating to waste resulting from the development:

- The quantity and type of both liquid waste and non-liquid waste generated, handled, processed or disposed of at the premises or off site. Waste must be assessed and classified in accordance with the EPA's "Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes".
- Liquid waste and non-liquid waste management at the facility, including:
 - i) the transportation, assessment and handling of the waste arriving at or generated at the site;
 - ii) any stockpiling of wastes or recovered materials at the site;
 - iii) any waste processing related to the facility, including reuse, recycling, reprocessing (including composting) or treatment both on- and off-site;
 - iv) the method for disposing of all wastes or recovered materials at the facility;
 - v) the method of treating all wastes from the facility prior to disposal/reuse to ensure that the system is sustainable and does not pollute surface or groundwaters;
 - vi) the emissions arising from the handling, storage, processing and reprocessing of waste at the facility;
 - vii) the proposed controls for managing the environmental impacts of these activities;
 - viii) quantifying all wastes to be removed from the premises and outlining where each will be treated or disposed of;
 - ix) provide contingencies for waste disposal should on-site treatment facilities not be available or fail to perform to the required standards of environmental protection.

- Assess the adequacy of proposed measures to minimise natural resource consumption and minimise impacts from the handling, transporting, storage, processing and reprocessing of waste and/or chemicals.

The EIS must present a suitable contingency plan and disposal strategy to address mass carcass disposal. The plan needs to be consistent with guidelines from NSW Agriculture/DPI to ensure it meets its quarantine requirements under any relevant legislation e.g. Exotic Diseases Act. If the plan includes area(s) for disposal, these should be sufficient to accept all stock on site, be dedicated for the purpose and be reserved from future development. Suitable procedures for such an eventuality should be detailed in the plan.

6. Dangerous Goods and Chemical Transport, Handling and Storage

The EIS must outline all details regarding the transport, handling, storage and use of dangerous goods, chemicals and product both on the site and with ancillary activities.

7. Soil and Soil Contamination Issues

The EIS must provide details of site history. If earthworks are proposed, this needs to be considered with regard to possible soil contamination.

The EIS should provide considerations of site maintenance, and proposed plans for the final condition of the site (ensuring its suitability for future uses).

8. Environmental Management Plan and Monitoring

A large development of this nature usually requires an Environmental Management and Monitoring Plan. The plan should include timeframes for reporting on achievement against the objectives of the plan, along with monitoring results. The EIS should outline what is intended in this regard for this development.

The EIS must outline how the proposal and its environmental protection measures would be implemented and managed in an integrated manner so as to demonstrate that the proposal is capable of complying with statutory obligations under EPA licences or approvals.

The mitigation strategies should include the environmental management and cleaner production principles which would be followed when planning, designing, establishing and operating the proposal. It should include two sections: one setting out the program for managing the proposal and the other outlining the monitoring program with a feedback loop to the management program.

F ADMINISTRATIVE ISSUES

1. List of approvals and licences

The EIS must outline and identify all licences required under Protection of the Environment Operations Act.

The Protection of the Environment Operations Act (1997) (POEO Act), Scheduled 1 lists activities and facilities that require an environment protection licence from the EPA.

A feedlot of this capacity will require an environment protection licence from the EPA. Any storage, production and/or transport of waste may also require a licence. Waste will need to be assessed and classified in accordance with the EPA's *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes* to determine the need for a licence. A copy of the guidelines can be obtained from Pollution Line on 131 555 or down loaded from the EPA's Web site at <http://www.epa.nsw.gov.au/waste/guidelines.htm>.

General information on license requirements can also be obtained from Pollution Line or be found at the EPA Web site at <http://www.epa.nsw.gov.au/legal/>

ATTACHMENT B

**Proposed Intensive Agricultural Development – FEEDLOT –
“Moirra Station”, Cobb Highway , Mathoura**

FLORA, FAUNA AND ABORIGINAL CULTURAL HERITAGE

INTRODUCTION

The *Environmental Planning and Assessment Act (1979) (EP&A Act)* requires that proponents of a development/activity and the Consent/Determining Authorities adequately assess the impact of a development or activity in any Environmental Impact Assessment (EIA) documents. These EIA documents include:

- Statement of Environmental Effects (SoEE), or
- Review of Environmental Factors (REF), or
- Environmental Impact Statement (EIS).

These are introductory, generic specifications of the Department of Environment and Conservation (DEC) for an adequate assessment of the impacts of a development proposal on native flora and fauna (ie including protected and threatened species). However, the DEC recognises that the scale and complexity of the project will to some extent, dictate the level of information that is required to address the questions posed below. Consequently, flora and fauna assessments need to be tailored to suit the proposal. For example, a development which is proposed on land which has already been totally (or substantially) cleared should address the issues raised below but the amount of work required to address these issues may be substantially less than if the area comprised undisturbed bushland and, therefore, of more significant wildlife habitat value. A preliminary assessment, including a desktop investigation and a preliminary site inspection, may indicate the need for a detailed survey of the site.

Aboriginal cultural heritage and archaeological sites may still be present on substantially disturbed areas and appropriate assessment of these is required. (Please refer to separate Cultural Heritage Assessment Guidelines included.)

It is up to the proponent (and later the consent and/or determining authorities after appropriate consultation) to determine the detail and comprehensiveness of assessment required to form legally defensible conclusions regarding the impact of the proposal. The scale and intensity of the proposed development should dictate the detail of investigation.

It is important that all conclusions are supported by adequate data and that these data are clearly presented in EIA documentation.

The DEC will consider the following issues when reviewing an EIA document:

1. **Concerns** - What are the DEC's concerns regarding the conservation of natural and cultural heritage in accordance with the relevant legislation? Is the proposal likely to affect natural and cultural heritage? How?
2. **Provision of Information** - Is adequate information provided for a valid assessment of the impacts?
3. **Validity of Conclusions** - Has the proponent arrived at valid conclusions as a result of the assessment of impacts?
4. **Recommended Conditions to Consent** - Should Consent or Approval be granted, what conditions (if any) are required to ensure that the project is developed, and thereafter managed in accordance with natural and cultural heritage conservation and the provisions of legislation administered by the DEC?

Thus the EIA document should fully describe the existing environment including flora and fauna, so that future impacts can be properly assessed and then reviewed (eg during the public participation phase).

FLORA

Background

The Australian flora comprises many endemic taxa and is therefore unique in the world.

The DEC is concerned at the extent to which vegetation has been cleared and otherwise modified in Western NSW. This high level of modification has been highlighted in the National State of the Environment Reports (1996 and 2001). Evidence strongly suggests that many plant species and communities are threatened with extinction.

Although the proposed site may be disturbed by various landuses, any remnants of native vegetation are of significant natural heritage value, including riparian and wetland areas. The area of vegetation and habitat at the proposed site may provide an area of high biological diversity, high conservation value or may not be well represented or protected elsewhere. It may also act as a corridor or migratory route for wildlife, drought refuge habitat or have other important values.

The NSW community places a high value on those areas of native vegetation that remain. The DEC is committed to the protection, appropriate management, and where necessary, rehabilitation of native vegetation. For these reasons, the DEC considers that careful planning

should precede any development that involves further vegetation clearance or other significant impact within areas of remnant vegetation.

Report Requirements

The EIA documentation should include a report on the flora that includes the following:

- detailed location map and identification of the area surveyed (including the location of photographs, transects, areas of significance etc),
- at least one of the following: a land satellite image, vegetation communities map, aerial photograph, or a remnant vegetation map,
- a complete plant list (including scientific names of those plants) of all tree, shrub, ground cover and aquatic species, categorised according to country of origin (ie., native vs exotic),
- a detailed description of vegetation structure (in terms of a scientifically accepted classification system) and spatial distribution (i.e. plant densities and patterning) on the site, including a vegetation map,
- describe the condition and integrity of the vegetation including a description of any past disturbance,
- an account of the likely original vegetation communities (pre-, or at early settlement), and an assessment of the likely regional distribution of the original communities,
- an assessment of whether the plant communities are adequately represented in conservation reserves or otherwise protected,
- an account of the hydrology of the area and how this relates to the dynamics of the vegetation communities,
- a list of **known** and **likely** threatened species as listed under Schedules 1 & 2 (*Threatened Species Conservation Act 1995*) which might occur at the site. The DEC database needs to be accessed and the likelihood of occurrence of threatened flora species determined,
- an assessment of the impacts of the proposal on flora, on-site and off-site (eg siltation, water availability or drainage changes) and measures to mitigate these impacts,
- an assessment of the significance of the impact of the development at both the site and at the regional scale,
- a detailed rehabilitation/management plan including a list of the plant species to be used during rehabilitation (if required),
- detail methodologies used and a list of the reference literature cited, and
- any other issues that may be considered relevant.

The above guidelines will provide some of the information necessary to conduct an 'Eight Part Test of Significance' required for threatened flora and fauna under Section 5a of the *EP&A Act*, should threatened species be likely or known to occur in the locality of the subject development proposal. Similarly, it will provide some of the information required if an application is found to be necessary under the *Native Vegetation Conservation Act (1997)*. However the above relates

mostly to the specific environmental assessment processes under the *EP&A Act* and does not constitute an 'Eight Part Test of Significance'.

Native Vegetation Conservation Act (1997)

The DEC wishes to stress that the proponents will need to consider the provisions of the *Native Vegetation Conservation Act (1997) (NVC Act)*. If the proposal involves the clearing of native vegetation it may require the consent of the Director General of Land and Water Conservation.

The *NVC Act* also allows for Regional Vegetation Committees to create Regional Vegetation Management Plans that will set guidelines for vegetation management in each region. Please contact the Department of Land and Water Conservation if the proposed development is in one of these Regions or if you have any other queries regarding the *NVC Act*.

FAUNA

Background

Evidence suggests that Western NSW has suffered the highest extinction rate for indigenous mammals of any region in the world. Many other vertebrate species are currently threatened. One of the major reasons for such a high level of extinction has been the destruction of habitat. Native vegetation including wetland, riparian and remnant environments, are very significant areas of fauna habitat. Therefore any development in such areas should fully consider the impact on fauna and its habitat.

Report Requirements

The EIA document should include a report on the fauna (including protected and threatened species), that includes the following:

- detailed location map and identification of the area surveyed (including the location of photographs, transects, areas of significance etc),
- at least one of the following: a land satellite image, vegetation communities map, aerial photograph, or a remnant vegetation map,
- a complete list of all **known** and **likely** terrestrial and aquatic species (eg birds, mammals, reptiles and amphibians including scientific names). It is suggested that invertebrates also be considered as they form part of the food chain for many fauna species,
- those species which are protected, threatened or listed under any international agreements, as well as introduced species,
- those species known or likely to breed in the area,
- any species which have specific habitat requirements found within the project area,

- those species or populations which may be near the limit of their geographic range or are a disjunct/isolated population,
- assessment of the importance or otherwise of the location as a corridor, migratory route or drought refuge, in relation to other remnant vegetation, riparian and wetland areas or habitat in the region,
- assessment of the impacts of the proposal on all fauna and its habitat, at both the site and at the regional scale,
- identification of any mitigation measures proposed to limit or ameliorate the impact of the proposal,
- detailed methodologies used and a list of the reference literature cited, and,
- any other issues that may be considered relevant.

SEPP No. 44 - Koala Habitat Protection

The Shire may be listed in Schedule 1 of SEPP No. 44 - Koala Habitat Protection. If so, the requirements of the SEPP regarding Koala habitat protection should be considered by the proponents.

THREATENED SPECIES OF FAUNA AND FLORA

BACKGROUND

Apart from the need to consider the impact on protected species, the proponent will need to address the requirements of legislation that currently governs threatened species protection and impact assessment in NSW.

The *Threatened Species Conservation Act (1995) (TSC Act)* protects all threatened flora and fauna native to NSW (excluding fish and marine plants). The proponent will need to consider the provisions of this Act.

The *TSC Act* contains lists of threatened species, which are divided into 5 categories – those presumed extinct, endangered species, endangered populations, endangered ecological communities and vulnerable species. This Act also allows for the declaration of critical habitat, key threatening processes and the preparation of both Recovery Plans and Threat Abatement Plans. These listings and plans must be considered as part of the EIA process.

If an activity or development is proposed in a locality likely or known to be occupied by a threatened species, population, ecological community or critical habitat, any potential impact to that threatened species must be taken into account during the development assessment process. However under the *EP&A Act*, some types of development are not required to go through approval processes. Please note that a licence may still be required under the *TSC Act* if such a development/activity is likely to harm a threatened species, population or ecological community.

An information circular ('*Threatened Species Conservation Act 1995*') is available from the Western Directorate for detailed information about the *TSC Act*.

EIGHT PART TEST & SPECIES IMPACT STATEMENTS

If during the flora or fauna assessment or survey, threatened species are **found** or are **likely** to occur in the area, the proponents must undertake an 'Eight Part Test of Significance' as outlined in section 5A of the *EP&A Act* to determine whether or not the development would be likely to have a significant impact upon threatened species.

The '8 Part Test' is a statutory mechanism which allows decision makers to assess whether a proposed development or activity is likely to have a significant effect on threatened species, populations or ecological communities, or their habitats.

The '8 Part Test' is contained within section 5A of the *EP&A Act* and consists of eight factors which need to be addressed for informed decisions to be made regarding the effect of a proposed development or activity on threatened species, populations or ecological communities, or their habitats. An information circular ('Threatened Species Assessment under the EP&A Act: The 8 Part Test of Significance') is available from the Western Directorate for detailed information about the '8 Part Test'.

Following threatened species assessment via the '8 Part Test', it may be necessary to prepare a Species Impact Statement (SIS). The proponent will need to prepare a SIS in the following circumstances:

- If (after having addressed Section 5A) the flora/fauna assessment concludes that there is likely to be a significant impact to threatened species, or
- The proposed development is likely to affect critical habitat declared under the *TSC Act*.

If a SIS is required, the proponent (not the consultant) must write to the Director-General of DEC for any formal requirements for the SIS that he might deem appropriate. The SIS must then be prepared in accordance with these requirements and provided to the Director-General. In some instances the Minister for the Environment will also need to be consulted for approval. An information circular ('Species Impact Statements') is available from the Western Directorate for detailed information about this assessment.

Methods to reduce the impact on the protected and threatened species should be considered fully, and are considered an integral requirement within any SIS document.

The DEC advises that conducting an '8 Part Test' or a SIS according to the provisions of the *EP&A Act* and the *TSC Act* is a complex task and should be undertaken by suitably qualified person(s).

AVAILABLE DATA

The DEC can supply, at the standard cost, fauna prediction data and recorded fauna sightings data (Wildlife Atlas of NSW) to help in the investigation.

The following information on site recordings of Flora and Fauna is available from DEC:

- **Atlas of NSW Wildlife (1995).** A DEC database containing records of fauna and flora, including threatened species. Computer print-outs for all records on a 1:100,000 mapsheet are available (at cost) from the Data Exchange Officer on (02) 9585 6684.
- **Threatened Species of Western NSW (Dec. 1996).** Species profiles including likely distribution, habitat and threats. Ringbound folders are available at \$82.50 (incl. GST) (plus \$5.50 postage) from the Western Directorate Office, Dubbo (02) 6883 5330.

Other reference literature may be available for the subject locality/region. The proponent should explore this possibility thoroughly.

ENVIRONMENTAL ASSESSMENT GUIDELINES

CULTURAL HERITAGE

Aboriginal sites are widespread throughout New South Wales. There is considerable regional variation in the types of sites, their age, their contents and how they are situated on the landscape. It is important that these sites are conserved as fragile and irreplaceable Aboriginal heritage. In some cases there is Aboriginal oral tradition concerning specially significant sites or landscape features

The Department of Environment and Conservation (DEC) has a statutory role in the protection and preservation of Aboriginal sites. This includes reviewing and assessing the Aboriginal cultural and archaeological aspects of environmental studies, as well as a regulatory role in their impact or destruction.

The EIS or other environmental assessment should consider Aboriginal cultural heritage, even if the area is disturbed in some way. The EIS should consider:

- Accessing the DEC's Aboriginal Heritage Information Management System (AHIMS) in the initial planning stage. This is to determine if there are any already known sites which will require protection, or if there is a need for a Section 87 Permit or Section 90 Consent (see below). The AHIMS database is not a conclusive indicator that sites may exist in the development area. Information from the AHIMS database may be made available by the AHIMS Registrar. For contact details and general information about the Aboriginal Heritage Information Management System please refer to Attachment 1.
- The Aboriginal community (which may include Local Aboriginal Land Councils, Native Title Groups and Elders Groups) needs to be consulted so that they can be advised that there may be impact to sites relevant to their heritage. There also may be knowledge in the community about sites in the development area, particularly those related to oral tradition. This process of Aboriginal consultation should be maintained throughout the entire EIS procedure.
- An assessment of the need for an archaeological survey, and if so, to what level of detail. This should be defined by a study plan or research design. In most cases, an on-the-ground systematic archaeological investigation will be needed. If there is a likelihood of buried sites not visible on the surface, a Section 87 Permit from the DEC may be needed for sub-surface testing.
- The outcome of the survey is to determine what sites can be avoided, and what ones cannot. Another objective is to assess the significance of the sites. It maybe that damage or destruction of some sites is unacceptable, or that special safe-guards are needed for others.

A broad overview of the Aboriginal Heritage Assessment process is contained in Attachment 2.

If Aboriginal objects/places are known to be directly or indirectly adversely affected, the Proponents will need to apply for, and be issued, a Section 87 Permit or a Section 90 Consent by the Director-General of the DEC to comply with the National Parks and Wildlife Act (1974). A necessary part of this is a written statement detailing the concerns and opinion of the proposed impact from the Aboriginal community.

Normally, Special Conditions are attached. These may include provisions for impact minimisation and salvage. Salvage is a form of mitigation by documenting in detail what is to be lost by the impact. Frequently it involves archaeological excavation and analysis, or other types of recovery and study.

Alternatively the development might be redesigned by the Proponent to accommodate and protect the site(s). The archaeological survey, analysis and reporting, as well as the negotiation with the Aboriginal community, can be a lengthy process. If a Permit for salvage is needed, then this can add on more time. It is important to begin the study for Aboriginal site impacts in the very earliest stages to avoid delays in the developments' timeline.

The DEC has produced detailed guidelines for consultants and these are available from the Cultural Heritage Manager.

Further information should be sought from the Cultural Heritage Manager at the NPWS office at Dubbo.

Cultural Heritage Manager
Western Aboriginal Heritage Unit
Department of Environment and Conservation
52 Wingewarra St
PO Box 2111

DUBBO NSW 2830

PH (02) 6883 5345

FAX (02) 6834 9382

ATTACHMENT 1

THE ABORIGINAL SITES REGISTER OF NSW
GENERAL INFORMATION

The National Parks and Wildlife Service maintains the Aboriginal Heritage Information Management System (formerly the Aboriginal Sites Register of NSW). This database includes a computer database and site recording cards for all recorded Aboriginal sites in NSW, in addition to a database index of archaeological reports and a library of these reports. Information from the database may be made available for a variety of uses.

What information is available?

Information relating to recorded Aboriginal sites in a particular area may be made available upon request. The information is generally available in the form of a standard report from the Register database. This report lists all recorded sites within and/or surrounding the area of interest, with each record including the site identifying number, site type, site location and Australian Map Grid co-ordinates, date of recording and the name of the recorder of the site.

If the area of interest is particularly large (eg a river catchment), a Data Licence Agreement may be required. This agreement is a legal contract document between the Director-General of the National Parks and Wildlife Service and a named client, and is designed to ensure that any data supplied under the agreement is used appropriately.

In some cases, written support from the relevant Local Aboriginal Land Council may be required before information can be provided from the Register.

How is the data provided?

Site information will generally be provided as a standard computer print out, however, digital computer formats on disk may be available for specific purposes.

Is there a charge for data?

The cost for supply of a standard report is \$30 per search area. An urgent database search may be conducted for \$60. More complex reports may incur an additional charge.

In particular circumstances there may be no charge for a report (e.g. for Aboriginal Land Councils, research purposes etc.). The waiving of any charge requires discussion with the Aboriginal Sites Registrar.

There is no charge imposed for a Data Licence Agreement, however, any data supplied under a Licence Agreement will generally be charged at the current "cost of transfer".

Are there any limitations in the data?

It is essential to note that a report from the Register does not represent a comprehensive list of all Aboriginal sites in a specified area. A report lists recorded sites only. In any given area there may be a number of undiscovered and/or unrecorded sites. As a result of this limitation, and the fact that all Aboriginal sites are protected under NSW legislation, the NPWS may recommend that a survey for Aboriginal sites is conducted where development is proposed.

Locational details are recorded as grid references. It is important to note that there *may* be errors in these recordings. If accurate site locations are required it may be necessary to confirm the locations on the ground.

If the information provided is to be used for ongoing purposes, it is recommended that regular updates are obtained as new records are continually being added to the database.

How to obtain Aboriginal sites data

To obtain information about recorded Aboriginal sites, a written request should be forwarded to the Aboriginal Sites Registrar (a request form is available if required). All requests must include;

- Company/organisation name (if applicable)
- Contact name, phone number and address details
- Purpose for which the information is required
- Copy of a topographic map with the area of interest clearly marked
- A cheque for \$30 per search area, made out to the NPWS (unless other arrangements have been made with the Registrar)

Applications should be forwarded to:

The Aboriginal Sites Registrar

Cultural Heritage Division

NPWS

PO Box 1967

Hurstville, NSW 2220.

or fax (02) 9585 6466

Further information

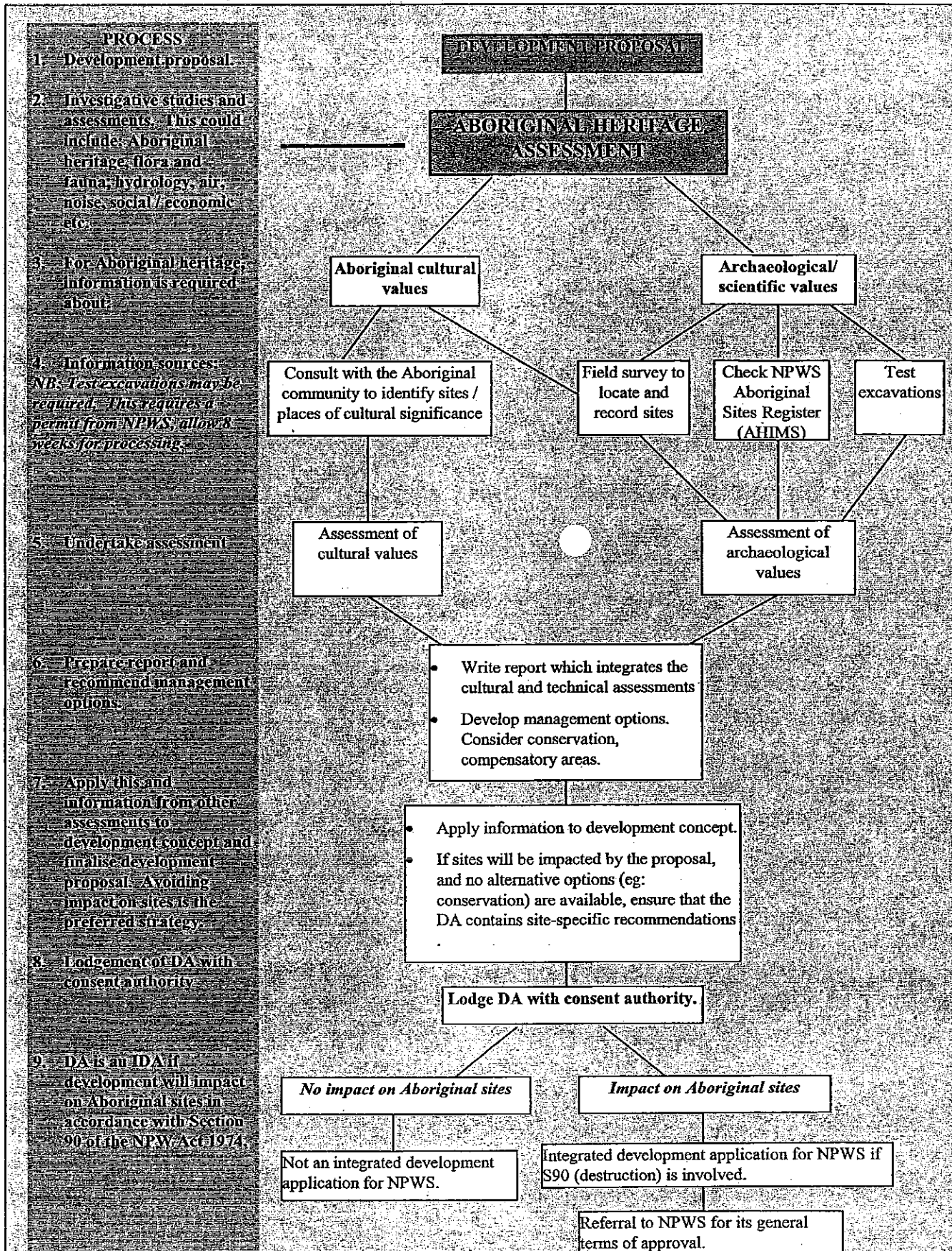
For further information about the Aboriginal Sites Register, please contact the Aboriginal Sites Registrar (02 9585 6471, fax 02 9585 6466).

EIS Requirements

Notice No: 1039773

Protection of the Environment Operations Act 1997

ATTACHMENT 2



Attachment No. 4



Department of the Environment and Heritage

Mr Chris Ritchie
Senior Environmental Planning Officer
Major Development Assessment
Dep't of Infrastructure, Planning & Natural Resources
GPO Box 3927
SYDNEY NSW 2001

Dear Mr Ritchie

PROPOSED MOIRA CATTLE FEEDLOT NEAR MATHOURA, NSW

Thank you for your letter of 3 June 2004 concerning the above proposal. We regret that this Department cannot attend the Planning Focus Meeting on 17 June 2004.

This Department administers the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Approval is needed under the Act for proposals likely to have a significant impact on defined matters of national environmental significance (NES).

The matters of NES are:

- The heritage values of listed World Heritage properties.
- The ecological character of wetlands that are listed under the Act as Ramsar Wetlands of International Importance.
- Nationally threatened species and communities which are listed under the Act (note that these species may not be the same as those listed under State legislation).
- Migratory species that are listed under the EPBC Act (these are migratory species protected under international agreements such as JAMBA and CAMBA).
- Nuclear actions.
- The Commonwealth marine environment (generally Australian waters beyond the 3nm limit of State waters).

The Commonwealth has issued *EPBC Act Administrative Guidelines on Significance* (July 2000) that give guidance on what types of actions and impacts may be considered significant and for which referral may be needed. These guidelines are available from the Department's web site (www.deh.gov.au/epbc).

Developers are responsible for examining the potential for significant impact on the matters protected under the EPBC Act and making a referral under the Act to this Department if significant impacts are likely. If the question of significance is unclear, a project can still be referred and the Department will advise whether or not approval is needed within 20 business days. A form for making a referral is available from the above web site.



INVESTOR IN PEOPLE

GPO Box 787 Canberra ACT 2601 Telephone 02 6274 1111 Facsimile 02 6274 1666
Internet: www.ea.gov.au



In this case, we note that the feedlot will be developed primarily on cleared agricultural land, but that there may some areas of remnant native vegetation potentially affected. In addition, inputs to surface water and groundwater, if not carefully managed, may have the potential to impact downstream ecosystems. In this regard, the environmental investigations should address the potential for impact on the matters of NES protected by the EPBC Act, particularly listed threatened and migratory species and downstream Ramsar Wetlands of International Significance.

If credible risks to matters of NES are identified, the proposal should be referred for consideration under the EPBC Act. Assessments at the level of an EIS under the *NSW Environmental Planning and Assessment Act 1979* can be accredited for the purposes of the EPBC Act in the event of a controlled action decision.

Please do not hesitate to contact the undersigned (02 6274 1861) if further information is needed.

Yours sincerely



Steve Mercer

Director

EPBC Act Referrals Section

Approvals and Wildlife Division

15 June 2004



NSW GOVERNMENT
Department of Planning

19 October 2005

Contact: Scott Jeffries
Phone: (02) 9228 6426
Fax: (02) 9228 6466
Email: scott.jeffries@dipnr.nsw.gov.au

Our ref: S04/01177
Your ref:

Mr Brett McLennan
Principal Environmental Planner
HLA –Envirosciences Pty Limited
PO Box 726
PYMBLE NSW 2073

Attention: Mr Duncan Peake

Dear Mr McLennan

Proposed Moira Cattle Feedlot, Moira Station, Mathoura, Murray Local Government Area – Draft Environmental Assessment

I refer to the submission of a draft Environmental Assessment for the above project on 27 September 2005. The Department has now finalised its review of the draft Environmental Assessment in consultation with the Department of Environment and Conservation.

Pursuant to section 75H of the *Environmental Planning and Assessment Act 1979*, you are advised that the draft Environmental Assessment does not adequately address the Director-General's environmental assessment requirements, as adopted on 5 September 2005. Inadequacies with the draft Environmental Assessment are detailed in the attachment to this letter, and can be summarised as follows:

1. the draft Environmental Assessment does not include a full air quality assessment, identifying all fugitive and point source emissions, and undertaken in accordance with *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2000) and draft *Assessment and Management of Odour from Stationary Sources in NSW* (EPA, 2000).

The Environmental Assessment must be updated to adequately address these matters and resubmitted to the Department. You should be aware that failure to address these issues may mean that a conclusive position on the environmental acceptability of the project may not be able to be formed, and that the project cannot be approved.

Please do not hesitate to contact Scott Jeffries on (02) 9228 6426 or scott.jeffries@dipnr.nsw.gov.au should you wish to discuss or clarify this matter.

Yours sincerely

19.10.05

Chris Wilson
A/ Deputy Director-General
As delegate for the Director-General

ATTACHMENT – INADEQUACIES WITH DRAFT ENVIRONMENTAL ASSESSMENT

The draft Environmental Assessment, *Moirra Station Cattle Feedlot Environmental Assessment* prepared by HLA-Envirosciences Pty Ltd dated September 2005, does not adequately address the following assessment requirements issued by the Director-General:

A full air quality assessment must be included in the [Environmental Assessment], particularly with regard to particulates and odour. The assessment must identify all fugitive and point source emissions during operation and must assess these parameters from a project-specific perspective in accordance with the Department of Environment and Conservation's (DEC) Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW (2000) and draft policy Assessment and Management of Odour from Stationary Sources in NSW (2000). The air quality assessment must consider any potential air quality and amenity impacts on any nearby private residences

The draft Environmental Assessment does not adequately address this requirement because:

1. **all potential odour sources have not been identified. The draft Environmental Assessment must be updated to:**
 - provide a description of the manure spreading process to be undertaken, and the locality(s) within the site where manure spreading will occur;
 - provide a description of the manure stockpiling process to be undertaken, and the locality(s) within the site where manure stockpiling will occur; and
 - detail the management practices to be undertaken to ensure that manure spreading and stockpiling will not result in an unacceptable odour impact.
2. **all potential odour receptors have not been identified. The draft Environmental Assessment must be updated to:**
 - identify all residential properties (and the location of residences within these properties) within a 10km radius of the site and classify these properties as low, medium or high sensitivity receptors with regard to odour impacts; and
 - include the Moirra Private Irrigation District Head Office as a sensitive receptor.
3. **the air quality assessment has not been prepared in accordance with the DEC's Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW (2000) and draft policy Assessment and Management of Odour from Stationary Sources in NSW (2000). The draft Environmental Assessment must be updated to:**
 - use 'near field' peak-to-mean ratios in its odour impact assessment in accordance with the *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW (2000)*. The draft odour impact assessment has applied 'far field' peak-to-mean ratios to the odour emission rates. The odour impacts at all isolated residences, and possibly Mathoura, have therefore been underestimated;
 - justify the assumed ratio of 'wind tunnel' to 'flux hood' measurements with reference to the measurements being undertaken as part of the Rangers Valley Project, and provide a further discussion of the uncertainties in the conversion of 'wind tunnel' measurements to 'flux hood' measurements. The DEC considers the conversion of 'wind tunnel' measurements to 'flux hood' measurements introduces a significant uncertainty into the odour impact assessment. The DEC are of the understanding that the further measurements

being undertaken as part of the Rangers Valley feedlot expansion project indicate the ratio of 'wind tunnel' to 'flux hood' measurements range between 10 and 300. The use of a ratio of 15 is at the low end of this range and the Environmental Assessment must justify the assumed conversion factor.

- clarify if the manure pad moisture monitoring assumed an 80,000 Standard Cattle Unit (SCU) or 80,000 head feedlot. In the manure pad daily moisture modelling conducted by EA Systems Pty Ltd, it is stated that the project will accommodate 80,000 SCU. Assuming the turn-off weight of 529kg, an 80,000 SCU feedlot is approximately equivalent to a 91,000 head feedlot. However, the Environmental Assessment describes the project as an 80,000 head feedlot. An incorrect assumption of an 80,000 SCU feedlot would result in an overestimate of manure moisture added and therefore possibly odour impacts.
 - note the significant discrepancies between the meteorological data for the site provided by the station installed at Moira Station on 2 March 2005 and the CSIRO's prognostic model 'The Air Pollution Model (TAPM)'. The Environmental Assessment must note that TAPM underestimates the frequency of light winds, stable wind conditions and calms. As it is these meteorological conditions that are the least conducive to the dispersion of odours, the use of the TAPM data may result in an underestimation of odour impacts.
-



NSW GOVERNMENT
Department of Planning

1 December 2005

Contact: Chris Ritchie
Phone: (02) 9228 6413
Fax: (02) 9228 6466
Email: chris.ritchie@dipnr.nsw.gov.au

Our ref: S04/01177
Your ref:

Mr Michael England
Senior Principal, National Practice Leader
Environmental Planning
HLA Envirosiences
PO Box 726
PYMBLE NSW 2073

Dear Mr England

Proposed Moira Cattle Feedlot, Moira Station, Mathoura, Murray LGA – Draft Environmental Assessment

I refer to the submission of a draft Environmental Assessment for the above project on 27 September 2005 and the submission of an updated draft Environmental Assessment on 18 November 2005 to address issues raised as part of the review undertaken by relevant regulatory authorities.

Pursuant to section 75H of the *Environmental Planning and Assessment Act 1979*, you are advised that the updated draft Environmental Assessment now adequately addresses the Director-General's environmental assessment requirements, as adopted on 5 September 2005.

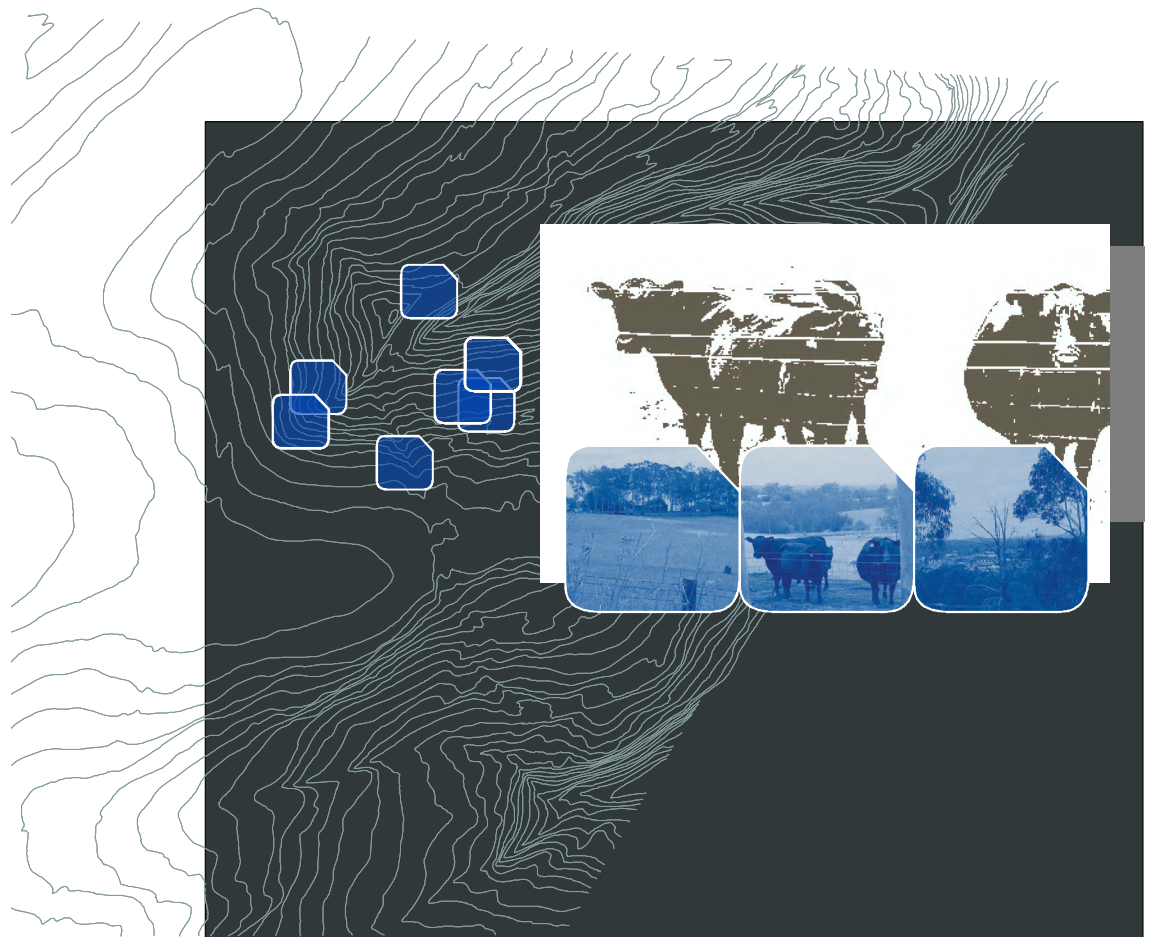
The Department has not, however, undertaken a detailed assessment of the Environmental Assessment at this time. While the document meets the Director-General's requirements, there may be issues arising from the detailed environmental assessment and public consultation process that will need to be addressed by the Proponent. You may be required to address and adequately resolve any such issues at the end of the public exhibition period as a response to the issues raised in submissions, as a Preferred Project Report that outlines any changes to the project to minimise its environmental impact or through revising the statement of commitments.

Please do not hesitate to contact Chris Ritchie on (02) 9228 6413 or chris.ritchie@dipnr.nsw.gov.au should you wish to discuss or clarify this matter.

Yours sincerely

4.12.05

Chris Wilson
A/ Deputy Director-General
As delegate for the Director-General



appendix b

community consultation

31 May 2005

RE: ENVIRONMENTAL IMPACT STATEMENT FOR PROPOSED CATTLE FEEDLOT AT MOIRA STATION

Dear Resident/Landowner,

Agricultural Equity Investments (AEI) proposes to construct and operate a cattle feedlot at Moira Station within the Murray Shire. The location of the proposed development is shown in the attached figure.

As part of the development application (DA) process, AIE has commissioned HLA-Envirosciences Pty Limited (HLA) to prepare an Environmental Impact Statement (EIS) which will accompany a DA.

The proposal would involve the construction and operation of a feedlot which would consist of feed pens with a capacity of 80,000 head of cattle. Other elements of the project include:

- Internal roads;
- Ancillary buildings;
- Effluent storage;
- Commodities;
- Receivals area;
- Freshwater storage;
- Sedimentation/holding ponds;
- Irrigation area; and
- Internal diversion of Moira Irrigation Channel.

The proposed development would incorporate best practice during construction and operational activities to ensure that any environmental impacts are minimised. The environmental assessment process will identify these practices and incorporate them into the design of the development, ensuring that any environmental impacts are appropriately dealt with.

As part of the environmental assessment, we are interested in consulting the community and addressing any issues of concern residents may have with regards to the proposed development. Your comments will be considered and taken into account whilst undertaking the environmental assessment.

AIE has provided a DVD presentation for you which shows a similar feedlot design located elsewhere in NSW, where industry best practice methods are employed. Following the completion of environmental investigations and community consultation, it is anticipated that the design of the feedlot at Moira will resemble the feedlot design displayed on the DVD.

If you would like to provide some comments and feedback on the proposed development before Monday 20th June 2005, we would like to hear from you.

You can send your written comments to:

Mr Duncan Peake
HLA-Envirosciences Pty Limited
PO Box 726
PYMBLE NSW 2073

Alternatively, you can call Duncan Peake on (02) 8484 8999 or email dpeake@hla-enviro.com.au.

It is also worth noting that following completion and submission of the environmental impact assessment, the report will be publicly exhibited at Murray Shire Council to enable the community to view the report and provide feedback and make further comments if they wish. We also anticipate convening a public information session during this public exhibition period to further involve the community in the proposed development.

Yours faithfully,

HLA-Envirosciences Pty Limited

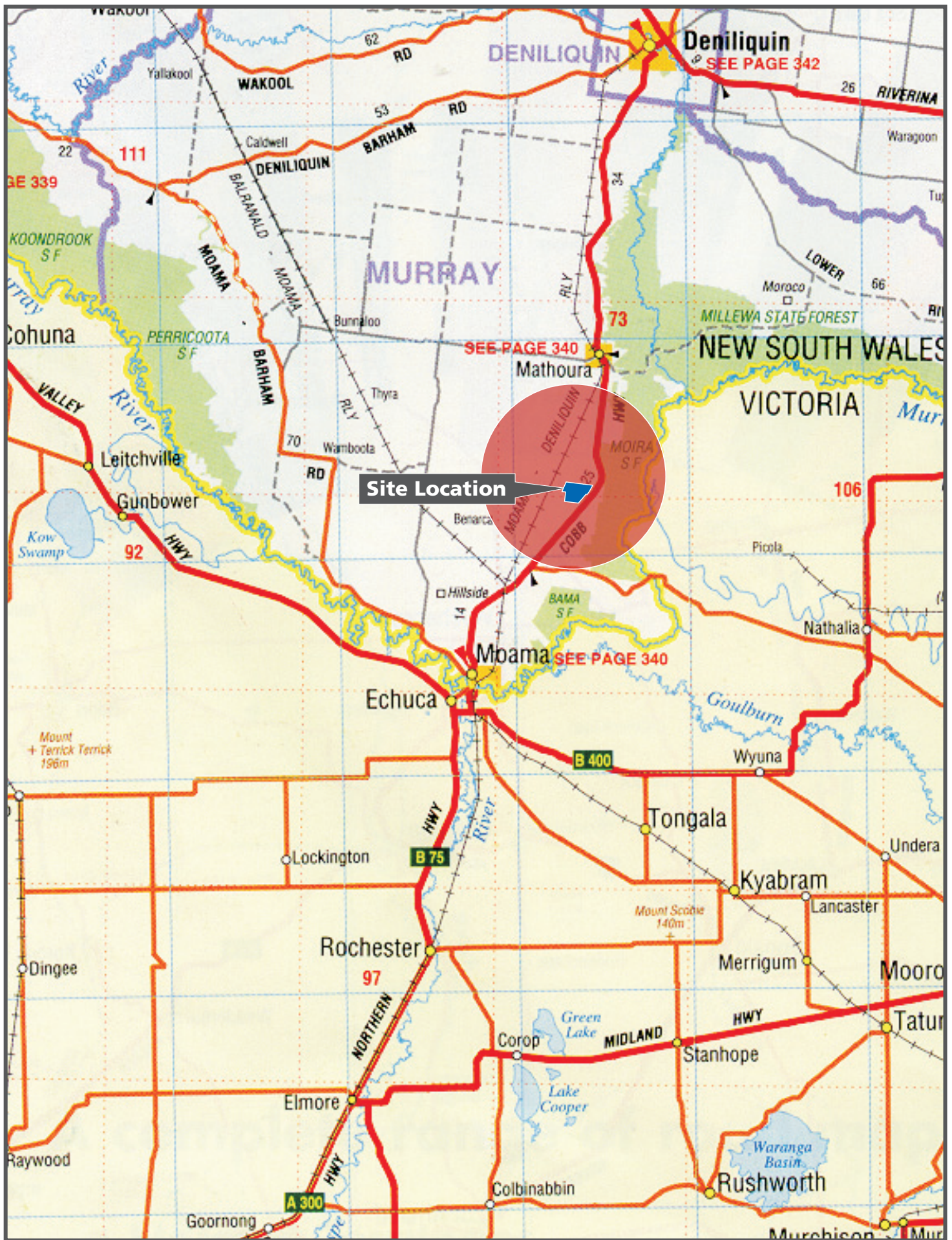
Duncan Peake
Environmental Planner

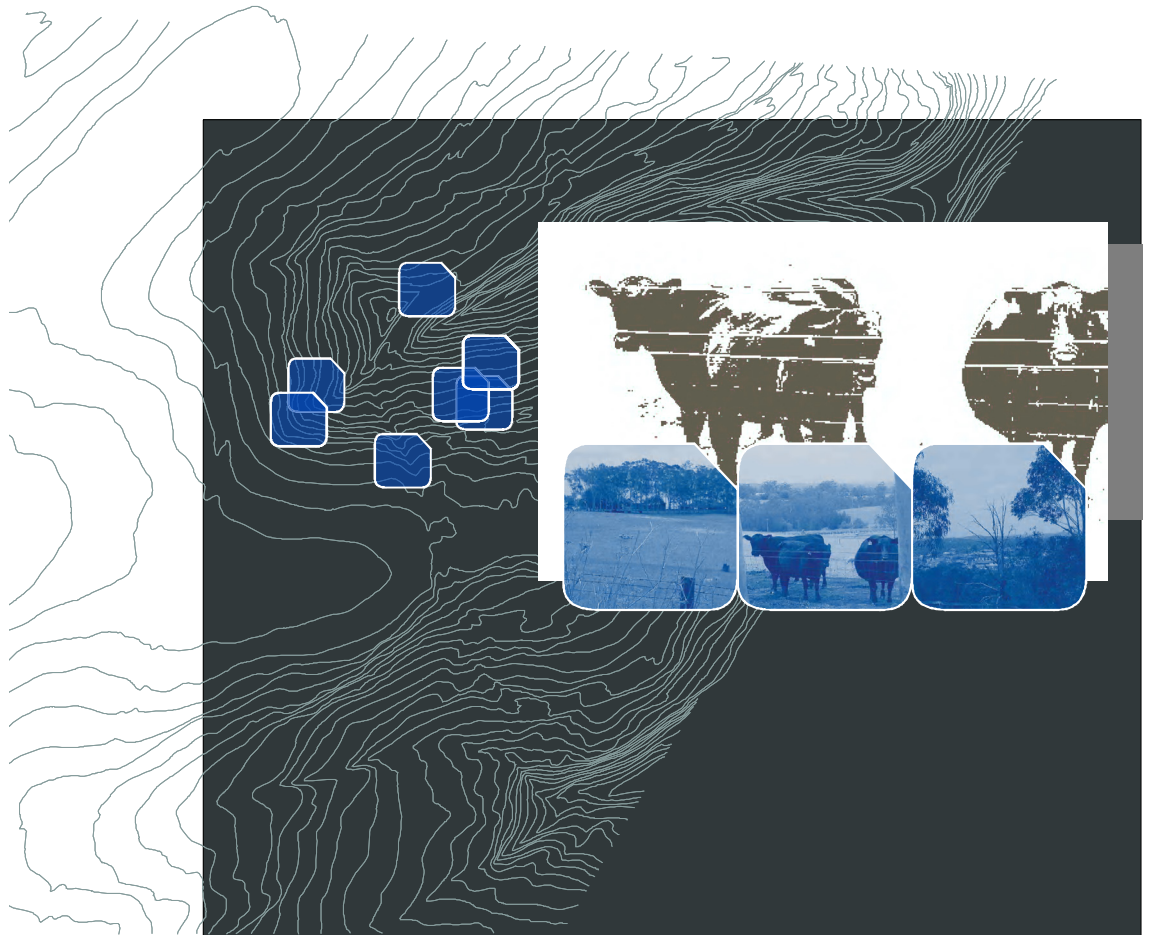


Site Location
Moira Station Feedlot



1





appendix c

odour impact assessment

**AIR QUALITY ASSESSMENT:
MOIRA CATTLE FEEDLOT**

11 November 2005

*Prepared for
Agricultural Equity Investments Pty Ltd*

*by
Holmes Air Sciences*

*Suite 2B, 14 Glen St
Eastwood NSW 2122
Phone : (02) 9874 8644
Fax : (02) 9874 8904
Email : has@holmair.com.au*

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Appendix B Joint wind speed, wind direction and stability class frequency tables
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1. INTRODUCTION

This report has been prepared by Holmes Air Sciences for Agricultural Equity Investments Pty Ltd (AEI). AEI is proposing to develop an 80,000 head cattle feedlot at Moira in southern NSW. The main purpose of this report is to quantitatively assess odour impacts that may arise during the operation of the feedlot.

The air quality assessment is based on the use of a computer-based dispersion model, CALPUFF, to predict off-site odour levels due to the operation of the feedlot. The dispersion model predictions have been compared to relevant regulatory air quality criteria.

The methodology used to assess to odour from cattle feedlots has evolved over the past years. The current assessment is consistent with the procedures outlined in the New South Wales Department of Environment and Conservation's (NSW DEC, formerly EPA) document titled "Approved Methods and Guidance for the Modelling and Assessment in NSW" (**NSW EPA, 2001^a**). It draws from experience developed from assessing an extension to the Rangers Valley feedlot near Glen Innes which involved extensive consultation with the DEC on the factors affecting odour emission rates from feedlot pads.

In summary, the report provides information on the following:

- Local setting and description of the proposed feedlot
- Discussion of the nature of odour and odour goals
- Climatic and meteorological conditions in the area
- Identification of odour sources and estimates of odour emissions
- Methods for assessing odour impacts due to the feedlot
- Discussion of the expected odour impacts

This report provides results from a number of dispersion modelling scenarios. These scenarios have been developed to present both a conservative assessment of odour impacts as well as a more realistic assessment of impacts which takes into account detailed feedlot management information.

2. LOCAL SETTING AND PROJECT DESCRIPTION

The feedlot is proposed at Moira Station, approximately 15 km to the south of Mathoura and 15 km to the north of Moama, in southern NSW. **Figure 1** shows the project location. Nearest residences are also indicated in **Figure 1**. **Figure 2** shows that the terrain is very flat over most of the study area. Vegetation is sparse to the west of the site while there is dense woodland to the east.

Total area for the property covers 1200 Ha on the west side of the Cobb Highway and 400 Ha on the east side. The property would accommodate 80,000 head of cattle with a stocking density of 12.5 m² per Standard Cattle Unit (SCU)¹. Cattle weight is estimated at 300 kg at the start of feed and 540 kg at the end of feed.

The general arrangement of the main feedlot is shown in **Figure 3**. The feedlot would include the following components:

- Feedlot pens
- Effluent storage and effluent holding
- Sedimentation ponds
- A burial pit
- Receivals area
- Commodities

It is proposed to operate the feedlot as a Class 1 feedlot. Class 1 feedlots are operated with the highest standard of design, maintenance, pad management and pen cleaning frequency.

¹ A Standard Cattle Unit is defined as a beast of 600 kg live weight at turnoff.

3. ODOUR ISSUES

This section evaluates odour in terms of measurement and air quality goals that relate to odour. There is still considerable debate in the scientific community about appropriate odour goals as determined by dispersion modelling.

3.1 Measurement of Odour

Odour is measured using panels of people who are presented with samples of odorous gas diluted with decreasing quantities of clean odour-free air. The panellists then note when the smell becomes detectable. Odour in the air is then quantified in terms of odour units which is the number of dilutions required to bring the odour to a level at which 50% of the panellists can just detect the odour, defined as one odour unit. This process is known as olfactometry.

Olfactometry can involve a “forced-choice” end point where panellists identify from multiple sniffing ports the one where odour is detected, regardless of whether they are sure they can detect odour. There is also a “yes/no” or “free choice” endpoint where panellists are required to say whether or not they can detect odour from one sniffing port. Forced-choice olfactometry generally detects lower odour levels than yes/no olfactometry.

In both cases, odorous air is presented to the panellists in increasing concentrations. For the forced-choice method, where there are multiple ports for each panellist, the concentration is increased until all panellists consistently distinguish the port with the sample from the blanks. For a yes/no olfactometer (which has only one sniffing port) one method used is to increase the concentration of odour in the sample until all panellists respond. The sample is then shut off and once all panellists cease to respond, the sample is introduced again at random dilutions and the panellists are asked whether they can detect the odour.

There are variations in the literature in the terminology for odour thresholds. The DEC has used the definition of the **detection** threshold as the lowest concentration which will elicit a response, but where the panellist is essentially guessing correctly. This corresponds to the first end point in the forced-choice olfactometry method and in the past has been the level reported in odour emission measurements from cattle feedlots. Most of the measurements were made using the Dutch NVN 2820 method which was similar to the draft European CEN method.

The odour **recognition** threshold is, by definition, the minimum concentration at which the panellist is certain they can detect the odour. This is also referred to as the certainty threshold and is the second endpoint in forced-choice olfactometry and similar to the first end point in yes/no olfactometry. The ratio between the detection and recognition thresholds can vary but is usually about 3.

There has been a general move in Europe and Australia to adopt the certainty threshold as the odour standard and to reference this to a standard concentration of butanol (40 parts per billion (ppb)). The odour levels referred to in this report are the certainty odour levels (odour detected by 50% of panellists using the recognition threshold). Australia now has a standard for measuring odour based on the certainty threshold (AS/NZS4323.3:2001).

As with all sensory methods of identification there is variability between individuals. Consequently the results of odour measurements depend on the way in which the panel is selected and the way in which the panel responses are interpreted. The process by which these imprecise measurements are translated into regulatory goals is still being refined. However the DEC has published a Draft Odour Policy which includes recommendations for odour criteria (**NSW EPA, 2001^b**). These are explained below and have been used for this assessment.

3.2 Odour goals

The determination of air quality goals for odour and their use in the assessment of odour impacts, is recognised as a difficult topic in air pollution science. The topic has received considerable attention in the past five years and the procedures for assessing odour impacts using dispersion models have been refined considerably.

The DEC has in recent times attempted to refine odour goals and the way in which they should be applied with dispersion models to assess the likelihood of nuisance impact arising from the emission of odour. However as discussed above these procedures are still being developed and odour goals are likely to be revised in the future.

There are two factors that need to be considered:

1. what "level of exposure" to odour is considered acceptable to meet current community standards in NSW and
2. how can dispersion models be used to determine if a source of odour meets the goals which are based on this acceptable level of exposure.

The term "level of exposure" has been used to reflect the fact that odour impacts are determined by several factors, the most important of which are:

- the **F**requency of the exposure
- the **I**ntensity of the odour
- the **D**uration of the odour episodes
- the **O**ffensiveness of the odour and
- the **L**ocation of the source (the so-called FIDOL factor)

In determining the offensiveness of an odour it needs to be recognised that for most odours the context in which an odour is perceived is also relevant. Some odours, for example the smell of sewage, hydrogen sulphide, butyric acid, landfill gas etc., are likely to be judged offensive regardless of the context in which they occur. Other odours such as the smell of jet fuel may be acceptable at an airport, but not in a house, and diesel exhaust may be acceptable near a busy road, but not in a restaurant.

In summary, whether or not an individual considers an odour to be a nuisance will depend on the FIDOL factors outlined above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any

individual to an odour is still unpredictable. Odour goals need to take account of these factors.

The DEC Draft Odour Policy includes some recommendations for odour criteria. They have been refined by the DEC to take account of population density in the area. **Table 1** lists the odour certainty thresholds, to be exceeded not more than 1% of the time, for different population densities.

Table 1 : Odour performance criteria for the assessment of odour

Population of affected community	Odour performance criteria (nose response odour certainty units at the 99 th percentile)
Single residence ($\leq \sim 2$)	7
~10	6
~30	5
~125	4
~500	3
Urban ($\geq \sim 2000$)	2

The difference between odour goals is based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area. The goals assume that 7 odour units at the 99th percentile would be acceptable to the average person, but as the number of exposed people increases there is a chance that sensitive individuals would be exposed. The goal of 2 odour units at the 99th percentile is considered to be acceptable for the whole population.

It is common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because Gaussian dispersion models are only able to directly predict concentrations over an averaging period of 3-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a 3-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

To determine more rigorously the ratio between the one-second peak concentrations and three-minute and longer period average concentrations (referred to as the peak to mean ratio) that might be predicted by a Gaussian dispersion model, the NSW DEC commissioned a study by Katestone Scientific Pty Ltd (see **Katestone 1995** and **1998**). This study recommended peak to mean ratios for a range of source types. The ratio is also dependent on atmospheric stability and the distance from the source. A summary table of these ratios is presented in **Appendix A**.

The DEC Odour Policy (**NSW EPA, 2001^b**) takes account of this peaking factor and the goals shown in **Table 1** are based on nose-response time.

A further complication with area sources such as feedlots is the way in which odour is measured. The predicted impacts of emissions from odorous sources will vary depending on such things as the sampling and measurement techniques used to determine odour levels from the source. The two most common sampling methods for measuring source emissions are the wind tunnel and the static flux hood methods. This will be discussed in more detail in **Section 4**. Both these methods draw samples by passing air over the surface of the source, but the wind tunnel samples at a much higher air flow rate. These measurements give significantly higher results for the same sources sampled with the flux hood. Neither method is necessarily more accurate as they are measuring in a different way. This raises the issue of which sampling method is more appropriate to use for testing compliance with DEC goals, as will be discussed later (**Section 4**).

The DEC has also indicated that while the guidelines set out in **Table 1** are default guidelines, industries may develop their own criteria, based on observed levels of impacts. A recent study commissioned by Meat and Livestock Australia, showed that using a constant emission rate of 5 ou.m³/m²/s from feedlot pads, as discussed in **Section 4.3**, a goal of 20 ou at the 99th percentile was consistent with the cattle feedlot guidelines for determining separation distances, which have been in place in Queensland for over fifteen years (**Holmes Air Sciences, 1999**). However, as will be discussed later (**Section 4**) the DEC requires that further research is necessary before this can be adopted as an approved alternative methodology for assessing cattle feedlot odour impacts in NSW.

4. ODOUR EMISSIONS FROM FEEDLOTS – BACKGROUND INFORMATION

This section discusses the difficulties in estimating odour emission rates from large area sources such as cattle feedlots where emissions are generally not constant across the site and also vary with time – being affected by meteorological conditions and site management. A wide range of emission rates for cattle feedlots can be found in the literature, varying by as much as two orders of magnitude reflecting variations in site conditions as well as measurement techniques.

The most significant factor affecting odour emissions from cattle feedlots is the state of the manure pad. Conditions which are conducive to the growth of anaerobic bacteria will give rise to the highest odour emission rates. If the manure pad is deep through infrequent cleaning and there is an episode of high rainfall and warm weather, high odour emission rates are likely to occur.

Below is a summary of the various approaches used to calculate emission rates from cattle feedlots that have been the subject of research studies and have also been applied to impact assessments in NSW.

4.1 Isolation flux hoods

The earliest odour emission rates measured from cattle feedlots were taken directly from the feedlot pad and were made using what is referred to as an isolation flux hood. Odour measurements with this methodology are generally in the range of 0.1 to 20 ou.m³/m²/s (**Ross, 1989; Carson & Round, 1990**). Emission rates were found to depend on temperature and the moisture content of the feedlot pad, which in turn was related to recent rainfall events. The way in which the feedlot was maintained, that is the depth of the feedlot pad and its moisture content as well as cattle stocking density, was an important factor in determining odour emission rate.

Subsequent comparison of these emission rates with other emission rate measurement methodologies indicates that the isolation flux hood method is likely to represent odour emission rates under calm atmospheric conditions. It is under these atmospheric conditions that maximum impacts have been observed to occur in the far field where odour is transported significant distances off-site. The emission rates were used in early modelling studies that formed the basis of the Queensland cattle feedlot guidelines. These guidelines for the basis of separation distance calculations incorporated into the NSW draft odour policy. The separation distance calculations are discussed in more detail in **Section 7.1**. They provide a simple “first pass” approach to estimating either appropriate cattle numbers for a given locations or a required separation distance based on cattle numbers. They take account of stocking density, rainfall, terrain and landuse, prevailing wind patterns and feedlot management.

4.2 Wind tunnels

More recently, wind tunnels have been used to measure odour emission rates from feedlot pads. This methodology differs from the isolation flux hood primarily in the rate at which air is drawn across the surface of the feedlot pad. Odour measurements with this technology can be two orders of magnitude greater than measurements obtained using the isolation flux chamber method (**Watts, 1992**). They

is a significant body of odour emissions monitoring data collected in the early 1990's using this method.

The reasons for the large discrepancies between the measurement methodologies are likely to reflect the fact that the measurements relate to emissions under different atmospheric conditions. Rather than being contradictory, it is likely that these measurements are complementary. As discussed above, measurements made using isolation flux hood chambers may represent emissions under stable, light wind conditions whereas measurements made with wind tunnels may represent measurements made under windy conditions or where the atmosphere is readily able to disperse emissions. It is clear that the use of wind tunnel emission rates in dispersion modelling predicts odour levels which are substantially higher than the DEC criteria for feedlots which would comply with the Queensland feedlot guidelines.

If measurements made with the wind tunnel technique are used in dispersion modelling without taking these factors into account, the predicted odour concentrations are very high under calm atmospheric conditions. It is likely that some factoring of emissions according to wind speed and stability class is required to provide a more realistic estimate of off-site emissions.

While some success has been achieved in developing models for odour emissions under a range of atmospheric conditions, the models do not provide a complete picture of all the factors which contribute to the variation in the emission rates. These models are discussed in **Section 4.4**.

4.3 Back calculations

In addition to direct measurements of emissions from feedlot surfaces, a method of back calculating based on ambient measurements has also been developed (**Smith & Kelly, 1995**). The back calculation method has some advantages over area source measurement. Firstly, it removes the heterogeneity factor involved with sampling from a large area source such as a feedlot. In a feedlot there will be varying degrees of emission rates even from a single pad. Secondly, it removes the compounding factor of how surface measurements relate to different meteorological conditions because the back calculation is done under known meteorological conditions.

Most of the measurements reported however were made under either neutral or unstable (atmospheric) conditions, that is daytime conditions, whereas most of the observed impacts from cattle feedlots occur during stable conditions such as occur early morning or evening or throughout the night.

Extensive measurements were made under just such conditions at a feedlot in NSW (**Dean & Freeman, 1994**). An average emission rate of 5 ou.m³/m²/s was calculated for a well run cattle feedlot. With this technique there was reasonable agreement between the lower emission rates determined by the ambient sampling method by **Smith & Kelly (1995)**.

4.4 Emission models

As discussed above, odour emissions from cattle feedlots arise from the products of anaerobic bacterial activity. These bacteria proliferate in warm moist conditions in

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the absence of oxygen. Odours are therefore a function of the factors connected with the state of the feedlot pad and include stocking density, moisture content, temperature of the pad and a function of the number of days since rainfall and the time to peak after rain. **Lunney & Smith (1994)** used these parameters to develop an odour emissions model. The model has the form shown below.

$$E_1 = \alpha \delta^{1.8} \theta^{0.77 T_p^{0.13}} F(\theta, T_a)$$

Equation 1

where:

- E_1 = emission rate (ou.m³/m²/s)
- α = a constant
- δ = weight in kg per m² of beast
- θ = a measure of moisture content of the pad in percent
- T_p = pad temperature
- F = function based on time after a rainfall event
- T_a = ambient average daily temperature

This equation can be applied to continuous meteorological data to estimate hourly varying odour emissions from a specific feedlot pad. An important factor which the model does not explicitly take account of is the management of the feedlot. Well managed feedlots which have relatively short pen cleaning intervals can have significantly lower odour emissions than those which have longer pen cleaning intervals.

A further model has been developed which provides information on the moisture content of the feedlot pad. This model, FSIM, was developed by E.A. Systems and is discussed in **Appendix C**. It has the advantage of incorporating aspects of feedlot management.

The estimation of odour emission rates for this study are discussed further in **Section 5**.

5. ESTIMATED ODOUR EMISSIONS

As discussed in **Section 4**, odour emission rates from cattle feedlots are difficult to estimate due to the complexity of interactions between many factors including meteorology, pen management and stocking density. In this report two approaches were adopted. Firstly, a conservative modelling study was undertaken with a constant emission rate. The second approach attempts to factor in most of the variables which contribute to odour emissions.

The first dispersion modelling scenario assumes that the feedlot pad emits at a constant odour emission rate of 5 ou.m³/m²/s. This emission rate is consistent with measurements by method of back calculation (see **Section 4.3**) for well run cattle feedlots. It is recognised that this is a simple approach which does not take into account variations in rainfall and feedlot management practices however this approach has been found to be more conservative than more detailed, and potentially more realistic, feedlot studies (see Rangers Valley Feedlot assessment (**Holmes Air Sciences, 2002** for example)). This approach, which is also consistent with the Queensland cattle feedlot guidelines, results in odour predictions which are higher than the DEC criteria.

Additional scenarios have made use of the **Lunney & Smith (1994)** emissions model. This model may be considered to more realistically portray odour emissions for this project. Factors such as stocking density, pen clean-out procedures, daily rainfall and feed can be used to estimate the pad moisture content which, in turn, can be used as input to the odour emissions model. E.A. Systems Pty Ltd have assisted by using detailed feedlot and rainfall information to derive daily pad moisture content from their FSIM model. A copy of the E.A. Systems report is provided in **Appendix C**.

E.A. Systems used the FSIM model for three scenarios as follows:

1. Run 1: Base feedlot data supplied by AEI (through Holmes Air Sciences)
2. Run 2: Base feedlot data with an assumed maximum manure depth of 50 mm compared to 25 mm
3. Run 3: Base feedlot data with an assumed maximum manure depth of 50 mm and a pen slope of 3% compared to the initial 2%

Run 2 and Run 3 were added by E.A. Systems based on their experience that a maximum manure depth of 50 mm was a more realistic estimate by current manure removal and operational practices. Also, it was suggested that a pen slope of 3%, instead of 2%, would lead to improved pen surface drying conditions.

The odour emissions model used the pad moisture content data to estimate hourly odour emission rates. It should be noted that estimates using this equation report odour emission rates in detection units using the Dutch NVN 2820 standard, discussed in **Section 3.1**. The calculated odour emissions from the model were divided by three to report the emissions in recognition or certainty units.

Table 2 provides the source information used for the dispersion modelling.

Table 2 : Source data used for the dispersion modelling

Source	Location of source corners	
	Easting (km)	Northing (km)
Feedlot pen surface	306.688	6021.435
	307.460	6021.335
	307.290	6020.043
	306.527	6020.143
Effluent holding	306.426	6021.230
	306.228	6021.255
	306.123	6020.401
	306.322	6020.377
Sediment pond 1	306.340	6020.516
	306.427	6020.505
	306.410	6020.366
	306.322	6020.377
Sediment pond 2	306.409	6021.092
	306.426	6021.230
	306.515	6021.220
	306.498	6021.081
Effluent storage	307.943	6021.003
	308.439	6020.943
	308.482	6021.290
	307.986	6021.351
Receivals area	307.566	6020.557
	307.864	6020.520
	307.839	6020.322
	307.541	6020.358
Burial pit	306.439	6021.330
	306.451	6021.429
	306.352	6021.441
	306.339	6021.342

The odour emissions associated with each dispersion modelling scenario are given in **Table 3**.

Table 3 : Odour emissions data used for the dispersion modelling

Source	Average emission rate (ou.m ³ /m ² /s)			
	Constant emission	Run 1 - model	Run 2 – model	Run 3 - model
Feedlot pen surface	5	1.9	2.0	2.0
Effluent holding	0.38 ¹	0.38 ¹	0.38 ¹	0.38 ¹
Sediment pond 1	0.38 ¹	0.38 ¹	0.38 ¹	0.38 ¹
Sediment pond 2	0.38 ¹	0.38 ¹	0.38 ¹	0.38 ¹
Effluent storage	0.38 ¹	0.38 ¹	0.38 ¹	0.38 ¹
Receivals area	5	1.9	2.0	2.0
Burial pit	5	1.9	2.0	2.0

¹Using emissions similar to anaerobic ponds (**Holmes Air Sciences, 2000**)

Peak-to-mean factors (which are a measure of concentration fluctuation in the plume) for the near-field and far-field have been applied to the estimated variable odour emissions shown in **Table 3** (Runs 1 to 3). For area sources, near-field is considered to be within one kilometre of the source (**Katestone, 1995**). Alternatively the near-field is typically 10 times the largest source dimension, either height or width. For area sources of large dimensions such as feedlot pens, which are not specifically addressed in the supporting documentation, it is useful to review the physical basis for the definition of near-field and far-field, to better estimate the extent of the near-field zone.

Close to the source, the detailed structure of the source and plume meander caused by large-scale eddies are important in determining the fluctuation intensity. This reaches a maximum when the plume size matches the dominant eddy size in the atmosphere. Under convective conditions this could be of the order of 1000 to 1500 m. For areas source of dimensions 800 to 1000 m it will not take a distance of 8-10 km (ten times the largest dimension) for this matching of plume to eddy size to occur, as the plume size is already close to typical large-scale eddy sizes.

The far-field is defined as the zone where plume rise and meandering have fully occurred and the plume is well mixed in the vertical. A distance of approximately 2 km from the source should be sufficient for this mixing to occur and for the fluctuation intensity in the plume to be independent of source characteristics as required for far-field conditions. On this basis, it has been assumed conservatively that the near-field is within 2.5 km of the edge of the pens and the far-field is more than 2.5 km.

No peak-to-mean factors were used for the modelling using constant odour emissions as this scenario was considered equivalent for comparison with the Queensland cattle feedlot guidelines. Also, the following assumptions have been used for generating odour emissions from the odour emissions model.

- The ratio of wind tunnel to flux hood measurements is 15
- The ratio of detection to certainty units is 3
- Average beast weight is 34 kg/m²/beast
- Emissions have adjusted for wind speed according to the relationship described by **Smith & Watts (1994)**
- Peak-to-mean factors of 2.5 and 2.3 apply for unstable and stable conditions respectively

It is recognised that there is unlikely to be a fixed relationship between wind tunnel and flux hood measurements. Further measurements as part of the Rangers Valley project are being undertaken to improve the understanding of feedlot odour emissions and these types of uncertainties however these data are not available for analysis. **Appendix D** provides some analysis of historical odour emissions from wind tunnels and flux hoods carried out as part of the Rangers Valley expansion study. The result was that a ratio of 15 was deemed a reasonable interim value, while still

providing a level of conservatism. The use of a ratio higher than 15 would be a less conservative approach.

Figures 6 to 8 show the estimated odour emissions generated by the odour emissions model. Also shown on these graphs are the pad moisture content and the rainfall. The higher odour emissions can be seen to occur near the rainfall events.

The derived emission rates are generally within the range found by **Ross (1989)** and **Carson & Round (1990)** for isolation flux hoods (that is, between 0.1 and 20 ou.m³/m²/s; refer to **Section 4.1**).

6. LOCAL ENVIRONMENT

6.1 Dispersion meteorology

The meteorology in the study area would be influenced by several factors including the local terrain and land-use. On a relatively small scale, winds would be largely affected by the local topography (see **Figure 2** for a representation of the local terrain). At larger scales, winds are affected by synoptic scale winds, which are modified by sea breezes near the coast in the daytime in summer (also to a certain extent in the winter) and also by a complex pattern of regional drainage flows that develop overnight.

In the air quality assessment undertaken in this report it is not necessary to understand the complex mechanisms that affect air movements in the area, it is simply necessary to ensure that these air movements are incorporated into the dispersion modelling studies that are done. A limitation of common Gaussian plume dispersion models (such as AUSPLUME) is that they assume that the meteorological conditions are the same spatially over the entire modelling domain for any given hour. This may be adequate for sources in relatively uncomplicated terrain however when the terrain or landuse is more complex the meteorological conditions can be more accurately represented using wind field and puff models. Gaussian plume dispersion models are also considered inappropriate to predict concentrations more than about 10 km from the source.

In the last decade there has been a significant improvement in the capability of dispersion models to handle dispersion in areas where complex wind flows occur. In this assessment we have made extensive use of the CALPUFF dispersion model. The CALPUFF model makes use of wind fields generated by the CALMET model. CALMET generates a three-dimensional wind field on an hourly basis by taking observations of winds at selected locations and interpolating these to produce information on wind speed and direction at a grid of regularly spaced points covering the area of interest. Modifications that are imposed on this interpolated wind field (by topography and differential heating and differential surface roughness) are then applied to the winds at each grid point to develop a final wind field.

The final wind field reflects the effect of local topography and the effects of different temperatures experienced by water bodies and land surfaces as well as different surface roughness that arise because of changes in vegetation or other variations in land use such as the presence of residential developments, etc.

A wind field has been generated by CALMET for each hour of the 2003 calendar year using meteorological data generated by CSIRO's prognostic model (The Air Pollution Model, TAPM). TAPM is a prognostic model which has the ability to generate meteorological data for any location in Australia (from 1997 onwards) based on synoptic information determined from the six hourly Limited Area Prediction System (LAPS) (**Puri et al., 1997**). The model is discussed further in the accompanying user manual (see **Hurley, 2002**). TAPM is able to generate all meteorological parameters required by the CALMET model. CALMET has then essentially used the TAPM data to determine wind patterns over the entire modelling domain given information on the local land use and terrain features.

A summary of the data and parameters used as part of the meteorological component of this study are shown in **Table 4**.

Table 4 : Summary of meteorological parameters used for this study

TAPM (v 2.0)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	25 x 25 x 20
Year of analysis	Jan 2003 to Dec 2003
Centre of analysis	Moira (35°56' S, 144°51' E)
CALMET (v 5.5)	
Meteorological grid domain	26 km (east-west) x 38 km (south-north)
Meteorological grid resolution	1 km
Surface meteorological stations	1 site at Moira using data generated by TAPM
Upper air meteorological station	1 site at Moira using data generated by TAPM
Simulation length	8760 hours (Jan 2003 to Dec 2003)

The wind data generated by TAPM for Moira have been prepared into annual and seasonal windroses which are presented in **Figure 4**. The windroses show the frequency of wind speeds and wind directions. On an annual basis TAPM suggests that the predominant winds are from the south. Summer and autumn wind patterns are similar to the annual pattern. In winter the most common winds are from the north while in the winds during spring are mainly from west-southwest and southerly winds.

The percentage of calms (periods where winds are less than 0.5 m/s) is simulated by TAPM at less than 1% with an average wind speed of 3.6 m/s. It should be noted that TAPM is a prognostic model and data generated for Moira should be considered as an estimate of meteorological conditions occurring in the area. A meteorological station was installed for this project at Moira Station on 2 March 2005. The data generated for the site by TAPM has shown good agreement with the first few months of wind data collected by the weather station.

Figure 5 shows a snapshot of winds simulated by the CALMET model using the TAPM data as input. The diagram shows the effect of the terrain and landuse on the flow of winds for a particular set of atmospheric conditions.

Dispersion models typically require information on atmospheric stability class² and mixing height³. Plume dispersion models usually assume that the atmospheric

² In dispersion modelling stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford-Turner stability class assignment scheme there are six stability classes A through to F. Class A relates to unstable conditions such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions.

stability is uniform over the entire study domain and these estimates are commonly calculated from measurements of sigma-theta, cloud cover information or solar radiation and temperature. Hourly estimates of mixing height can be determined by a combination of empirical methods and/or soundings.

The CALPUFF dispersion model, however, obtains estimates of atmospheric stability and mixing height from the CALMET meteorological model. CALMET determines these parameters using the cloud cover data and temperature profiles it is provided in order to run. The output of the CALMET model can subsequently be processed to extract meteorological information for any site of interest in the modelling domain, including atmospheric stability. **Table 5** provides the frequency of occurrence of the six stability class as determined by CALMET for Moira.

It can be seen from **Table 5** that the most common stability class, as determined by CALMET, is F-class (29.2%). Dispersion of pollutants is slow under these circumstances as F-class stabilities are generally associated with light winds and night-time conditions. The distribution of stability classes from TAPM was very similar to those from CALMET although D-class was determined to be the most common stability.

Table 5 : Frequency of occurrence of stability classes in the area

Stability Class	Moira by TAPM, 2003 data	Moira by CALMET using TAPM as input, 2003 data
A	6.1	1.6
B	11.8	11.8
C	14.4	18.5
D	27.0	20.0
E	17.1	18.9
F	23.6	29.2
Total	100	100

Joint wind speed, wind direction and stability class frequency tables for the output directly from TAPM are presented in **Appendix B**.

As discussed, an automatic weather station was installed on-site on 2 March 2005. An analysis of these data, as well as a comparison with the TAPM data, is provided in **Appendix B**.

6.2 Local climatic conditions

Local meteorology is also recorded by the Bureau of Meteorology at Mathoura. Temperature, humidity and rainfall data collected from this station are presented in **Table 6 (Bureau of Meteorology, 2005)**.

³ The term mixed-layer height refers the height of the turbulent layer of air near the earth's surface, into which ground-level emissions will be rapidly mixed. A plume emitted above the mixed-layer will remain isolated from the ground until such time as the mixed-layer reaches the height of the plume. The height of the mixed-layer is controlled mainly by convection (resulting from solar heating of the ground) and by mechanically generated turbulence as the wind blows over the rough ground.

Temperature data show that January is typically the warmest month with a mean daily maximum of 31.4°C. July is the coldest month with a mean daily minimum of 3.3°C. Rainfall data collect at Mathoura show that October is, on average, the wettest month with a mean rainfall of 44.8 mm over 8 rain days. Annual average rainfall is 443 mm.

Table 6 : Climatic information for the study area

Mathoura	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
Mean Daily Max Temp (deg C)	31.4	30.3	27.5	22.1	16.9	14.1	13	14.9	18.1	21.7	25.4	28.6	22
Mean Daily Min Temp (deg C)	15.5	15.2	13.2	9.2	6.1	4.3	3.3	4.2	6	8.7	10.7	13.1	9
Mean 9am Air Temp (deg C)	23.8	22.4	20	15.6	10.7	8	7	9	12.4	16.1	19.3	21.6	15.5
Mean 9am Relative Humidity (%)	45	50	56	68	80	85	85	80	68	60	49	47	64
Mean 3pm Air Temp (deg C)	30.5	29.4	26.9	20.9	15.4	13.2	12.2	14.9	17.2	21	24.6	27.6	24.8
Mean 3pm Relative Humidity (%)	29	31	37	-	-	-	-	56	52	45	35	33	38
Mean Rainfall (mm)	32.1	23	35.3	29.6	43.3	36.9	42.7	44.4	44.5	44.8	33.5	32.6	442.8
Mean no. of Rain days	3.8	3.6	4.3	5.4	8.5	9.1	10.8	10.9	9.5	8.4	6.2	5	85.4

Station number 074069 MATHOURA STATE FOREST, 1949 to 2004; Latitude (deg S): -35.8115; Longitude (deg E): 144.9017; State: NSW

Source : Bureau of Meteorology (2005)

7. APPROACH TO ASSESSMENT

There are two primary methods for assessing air quality impacts from cattle feedlots. The two methods are:

1. Generic calculations (known as a Level 1 assessment), and
2. Odour dispersion modelling (Level 2 or 3 assessment).

Both approaches have been undertaken in this study. The details behind each approach are discussed below.

7.1 Generic calculations (Level 1)

Level 1 odour assessments for cattle feedlots use a simple method to determine the separation distance between the feedlot and the nearest receptor. As discussed in **Section 3.2**, The methods to determine the separation distances are outlined in the DEC *Draft Policy: Assessment and Management of Odour from Stationary Sources in NSW (EPA, 2001^b)*. They are based on the Queensland Department of Primary Industry guidelines (QDPI) originally developed in 1989 and recently revised.

The minimum separation distance are determined in either of two ways:

- Comparing recommended fixed separation distances with those which exist between the feedlot site and particular features, or
- Calculating the separation distance using cattle numbers and site-specific factors.

Level 1 assessment allows a quick initial assessment to determine if the proposal would be feasible in terms of odour impacts. To determine the separation distance between a source and receptor a simple formula is used. This formula (**Equation 2**) links the number of cattle (N) and site-specific factors (S) to the minimum separation distance (D).

$$N = \left(\frac{D}{S} \right)^2$$

Equation 2

where:

- N = Number of cattle
- D = Separation distance in metres
- S = Composite site factor
= S1 x S2 x S3 x S4 x S5

The composite site factor (S) has a large influence on how many head of cattle or how close to the nearest receptor a feedlot can be. It is comprised of five site factors that are related to the emission of odour from the feedlot. A brief description of the five site factors is given below.

The stocking factor (S1) is dependent on the cattle density (square metres per head) and the class of feedlot. The class of a feedlot is based on the management practices undertaken at the feedlot, with respect to various odour control procedures. Therefore the stocking factor is lower when odour control practices are strict and the density of cattle is low.

The receptor factor (S2) considers the location of receptors that surround the feedlot. Different receptor factors are used depending on whether the closest receptor is a town or a single rural residence. Towns have a higher receptor factor than single rural residences. Like the draft DEC odour guidelines in **Section 3.2**, the receptor factor is not linked to different levels of odour acceptability between towns and rural residences, but based on considerations of risk. This report assesses the impact on the single rural residences and the nearest townships.

The terrain factor (S3) takes into consideration the surrounding topography. Receptors situated in valleys into which air from a feedlot could drain during stable conditions would result in a higher terrain factor. Likewise, feedlots located where terrain would assist dispersion would result in a lower terrain factor.

The vegetation factor (S4) is related to the density of vegetation near the feedlot. Heavy tree cover near the feedlot would increase the surface roughness⁴ of the area, assisting the dispersion of emissions.

The wind frequency factor (S5) gauges the direction of wind from a particular direction. A high frequency of wind blowing from the feedlot towards a receptor will have a higher wind frequency factor. Therefore, the separation distance between the feedlot and receptor would have to be increased to take account of the high frequency of wind from the direction of the feedlot.

7.2 Dispersion modelling (Level 2 or 3)

Potential impacts of the proposed facility on the surrounding area have been assessed using CALPUFF. The CALMET/CALPUFF modelling system is considered to be one of the most sophisticated models available. CALPUFF is an advanced computer-based dispersion model that simulates the dispersion of emissions by representing emissions as a series of puffs emitted sequentially. Provided the rate at which the puffs are emitted is sufficiently rapid, the puffs will overlap and the serial release will represent a continuous release. The advantage of the puff modelling approach over the steady state Gaussian models such as ISCST3 and AUSPLUME, which have also been widely used in source dispersion assessments in the past, is that the progress and dispersion of each individual puff can be treated separately and can be made to account for local wind conditions and the way in which wind conditions at a particular place vary with time.

The way in which the model has been used in this study has been to predict the 1-hour average odour levels at a set of receptors arranged 26 km by 38 km around the site. Spacing between receptors was set at 1 km. This region has been chosen to include the nearest sensitive receptors as well as to provide an indication of the extent of any

⁴ Surface roughness is the influence that the ground has on causing turbulence in the overlying atmosphere. The larger the surface roughness is, the more turbulence is generated and the greater the dispersion of odour emissions.
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odour impacts. The 1-hour averaging times, corrected for nose-response times for all but the first scenario, have been used for consistency with the DEC odour goals.

The modelling has been performed using the meteorological data discussed in **Section 6.1** and the odour emissions estimates from **Section 5**. Odour sources have been modelled as area sources and located according to the site layout. All hours in the meteorological data file have been simulated with an emission rate from the feedlot. This approach would be considered to be a Level 3 assessment.

For the purposes of presenting the results, the maximum predicted odour level at each receptor has been retained by the model and a contour plot has been prepared showing the distribution of these highest 1-hour levels. The contour plots do not represent the dispersion pattern at any particular instant in time, but show the highest predicted 1-hour average odour level that occurred at each location. These maxima are used to show odour levels which can possibly be reached under the modelled conditions. Plots of the odour levels at the 99th percentile have also been compiled. The 99th percentile plots are used for comparison with the DEC odour criteria.

As discussed in **Section 5**, the first scenario of the CALPUFF modelling was based on the use of a constant odour emission rate (5 ou.m³/m²/s). The **Lunney & Smith (1994)** odour emission model was used for subsequent scenarios.

The odour emissions model allowed to dispersion modelling to reflect changes to feedlot management practices, stocking densities, rainfall events and variable emissions from the feedlot pad. This approach is considered to be a more realistic simulation of odour emissions than simply using a constant odour emissions. It was found in the Rangers Valley study that the variable odour emissions (with peak-to-mean factors) generally resulted in lower predicted odour impacts for the nearest residences than modelling using a constant odour emission.

There are a number of factors to also consider when comparing the Moira feedlot to the Rangers Valley study. Firstly, the annual average rainfall is much lower at the Moira site than at the Rangers Valley site (443 mm for Moira compared with around 850 mm for Rangers Valley). Fewer rainfall events generally leads to lower odour emissions from feedlots. However, the benefits from lower rainfall at Moira would be offset somewhat by a higher stocking density (12.5 m²/head for Moira feedlot compared with 13.5 m²/head for the Rangers Valley feedlot).

8. ASSESSMENT OF IMPACTS

Generic calculations and dispersion modelling has been used for the assessment of the feedlot. The results from both approaches are discussed in the following two sections.

8.1 Generic calculations

As a quick investigation into the feasibility of the proposed feedlot, a Level 1 odour impact assessment has been undertaken. The method for calculating the minimum separation distance between the feedlot and a receptor type were presented in **Section 7.1**. Results for the Level 1 assessment are shown below in **Table 7** for single residences and for the nearest towns (see **Figure 1** for locations).

As discussed in **Section 7.1** the composite site factor (S) is related to the stocking density, receptor type, terrain, vegetation and wind frequency factors as presented in the DEC guidelines. Some of the assumptions used for calculation of the composite site factor are given below.

- Stocking factor (S1): Same for all receptor types. Annual average rainfall less than 750 mm. Class 1 feedlot and stocking density of 12.5 m²/head. Average beast weight of 420 kg used.
- Receptor factor (S2): Receptors types chosen for the assessment included "Rural residence", "Medium towns with 500-2000 people" and "Large towns with >2000 people".
- Terrain factor (S3): "Flat" chosen for all receptor types.
- Vegetation factor (S4): "Few trees, long grass" used for all receptor types.
- Wind frequency factor (S5): "Normal wind conditions" chosen for all receptor types, ie. between 5% and 60% of winds blowing towards receptor (± 40 degrees from source) over the year.

Table 7 : Calculated separation distances at nearby residences

Receptor type	S1	S2	S3	S4	S5	Composite site factor (S)	Calculated minimum separation distance (m)*	Actual separation distance (m)
Single residence	54.7	0.3	1	0.9	1	14.8	4,176	<2,000
Medium town (Mathoura)	54.7	1.2	1	0.9	1	59.1	16,702	13,000
Large town (Moama)	54.7	1.6	1	0.9	1	78.7	22,270	20,000

* Based on 80,000 head

Composite site factors have been obtained from DEC draft guidelines (**NSW EPA, 2001^b**). From the results shown in **Table 7** it can be seen that the calculated minimum separation distances are greater than the actual distances from each receptor type to the feedlot.

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As the Level 1 assessment approach is considered to be more of a screening exercise, the results are designed to be conservative. It should be noted that the DEC guidelines state that Level 1 assessments may not be suitable for very large cattle feedlots.

A more refined investigation has been undertaken which was based on dispersion modelling (Level 3 assessment). The results from the Level 3 investigations are discussed below.

8.2 Dispersion modelling

The model runs were undertaken using the meteorological data described in **Section 6.1** and the estimated odour emissions described in **Section 5**. Results from the odour dispersion modelling are presented in **Figure 9**. The CALPUFF model input file can be provided on request.

This section provides an interpretation of the predicted concentrations of odour. Results have been presented in two formats. These two formats are:

- Maximum 1-hour average odour levels, and
- Odour levels at the 99th percentile

Odour levels at the 99th percentile have been presented for comparison with the DEC odour criteria. **Figures 9 to 12** show the model results due to the proposed feedlot operations. **Table 8** shows the results for each receiver location. Predictions above the DEC criteria are shown in bold red font.

The figures present the predicted odour levels based on near-field peak-to-mean factors. As discussed in **Section 5** receptors within 2.5 km of the feedlot pens have been assumed to be in the near-field zone and receptors more than 2.5 km from the pens have been assumed to be in the far-field zone. The relevant predicted odour levels are presented in the table and the near-field receptors are marked with an asterisk.

Table 8 : Predicted odour levels due to Moira Feedlot

Location	Description	Odour concentration at the 99 th percentile (ou) For individual residences the number of predicted number of hours above the odour criteria is shown in parentheses				Odour criteria
		Constant emissions	Run 1: Base data	Run 2: 50 mm pad depth	Run 3: 50 mm pad depth, 3% slope	
R1	House ¹	22	5 (88)	5 (93)	5 (90)	6
R2*	House	100	32 (912)	35 (935)	33 (930)	7
R3	House	21	5 (88)	5 (98)	5 (89)	7
R4*	House	62	17 (569)	17 (622)	17 (617)	6
R5*	House	62	16 (555)	16 (622)	17 (614)	6
R6	House	35	7 (211)	8 (264)	8 (260)	7
R7	House	25	6 (117)	6 (121)	6 (118)	6
R8	House	23	5 (93)	6 (115)	6 (112)	6
R9	House	22	4 (66)	5 (94)	5 (93)	6
R10	House	21	4 (46)	5 (85)	5 (81)	6
R11	House	25	7 (147)	8 (156)	7 (151)	7
R12*	House	41	14 (279)	15 (288)	15 (281)	7
R16	House	21	4 (49)	5 (88)	5 (83)	6
R17	House	16	3 (30)	4 (53)	4 (51)	6
R18	House	13	4 (60)	4 (61)	4 (58)	7
R19	House	5	2 (12)	2 (12)	2 (13)	7
R20	House	6	2 (12)	2 (11)	2 (13)	7
Barmah	Town	2	1	1	1	5
Moama	Town	1	1	1	1	2
Mathoura	Town	6	1	2	2	3

¹ Moira Private Irrigation District Head Office

* Receptors within the near-field zone

From **Section 3.2**, the DEC Draft Odour Policy includes recommendations for odour criteria which take account of population density in the area. If it is assumed that the population density on the sliding scale of odour criteria (see **Table 1**) apply to a population per square kilometre (km²), then an odour criterion may be established for each receptor, based on the approximate lot size of the receptor. Therefore, the odour criterion of 7 odour units (single residence) would apply to a receptor of lot size approximately 1 km². Then, assuming there are 2.6 persons per household (lot), the odour criterion of 6 odour units (10 people per km²) would apply to receptor lots of approximately 0.26 km² (i.e. 2.6/10) and so on for the 5, 4, 3 and 2 odour criteria. This methodology has been used to derive the odour criteria appropriate for each receptor location as shown in **Table 8**. Further discussion on the appropriate odour criteria for each receptor location is provided in **Appendix E**.

Apart from differences due to population density, it has been assumed that all receptors have similar sensitivity to odour, based on a potential exposure for 24-hours per day in a private residential setting. In reality, there will be different levels of sensitivity in the community being assessed. For example, properties which also

operate livestock activities may have more tolerance to feedlot odour than others, although this is not necessarily the case. Furthermore, land ownership and usage can change over time. Staff at the Moira Irrigation District Head Office (R1) would not be present 24-hours a day and would therefore not experience the same frequency of odours as residential receptors. However for the purposes of this study, all receptors have been assessed to the most stringent standard appropriate for the population density.

A tiered approach to assessing these results was adopted. Firstly, the predicted odour concentration using constant emissions was compared with the odour criteria. This is a conservative approach and if the predicted concentration was below the odour criteria then it was considered that no odour impact would be observed at that location. If the predicted concentration was above the odour criteria then the result obtained using variable odour emissions was considered.

For all locations, the use of constant odour emissions gave higher results than using variable odour emissions. This was expected as the constant odour emission rates were derived from feedlots and areas with higher rainfall than the Moira feedlot. The low rainfall of the area would help to minimise the frequency of high odour emission events. For this reason the results from using the odour emission model are considered to represent a reasonably realistic variation in emissions and expected odour impacts. The differences between the variable emission scenarios (Run 1, Run 2, and Run 3) appear to be minor.

Residences R1 to R20 have been identified to be within about ten kilometres of the feedlot site. Although some of the results show that odour levels are predicted to be slightly below the odour criteria (say, for example, predictions of 5 odour units from **Table 8**), it would be difficult to say that odours from the feedlot would not be detectable on occasions at these locations. Residences further from the feedlot site would be expected to experience lower odour levels and frequency of odour events than residences closer to the site. From the dispersion modelling, R2, R4, R5, R6, R11 and R12 are predicted to experience odour levels at the 99th percentile which are above the associated odour unit criterion.

Predicted odour impacts at the town of Barmah are considered to be low. Using the conservative “constant emissions” approach the predicted odour levels due to the feedlot at the town of Barmah are approximately 2 odour units. The population of Barmah is assumed to be of the order of 30 resulting in a relevant odour criteria of 5 odour units. This suggests that odour impacts due to the feedlot would be acceptable at Barmah. Predicted odour levels at Barmah using variable odour emissions are lower at around 1 odour unit.

Predicted 99th percentile odour levels at Moama are of the order of 1 odour unit when the dispersion modelling is based on the use of constant emissions and less than 1 odour unit (rounded up to 1 in **Table 8**) for variable odour emissions. The population of Moama is of the order of 4,000 and the relevant odour criteria would therefore be 2 odour units (from **Table 1**). Based on the dispersion modelling the odour impacts from the feedlot at Moama are taken to be acceptable.

At Mathoura, the predicted 99th percentile odour levels due to the feedlot are 6 odour units by the conservative approach. This prediction has been determined for November 2005 _____ Holmes Air Sciences

the southern edge of Mathoura. Given that the population of Mathoura is approximately 860 the relevant DEC odour criteria is 3 odour units. A more refined approach of using variable odour emissions reduced the predicted odour levels significantly – to about 2 odour units. This is below the odour criteria and is therefore taken to be an acceptable level of impact.

The frequency and magnitude of cumulative odour impacts of the project would be expected to be small. There are two other known feedlots in the study area. Lenian feedlot is a 5,000 head feedlot situated approximately 26 km to the west-northwest of the project site. Amaroo feedlot, also with 5,000 head, is located approximately 9 km to the north of the project site and west of Mathoura. The DEC odour policy suggests that odour sources of similar odour character may need to be modelled together to determine cumulative odour impacts. The odour policy also indicates that modelling multiple sources may be necessary if the sources are sufficiently close to one another, however, this is not well defined. The size of the odour sources may be an important consideration for determining whether sources are sufficiently close.

Cumulative impacts of the Moira project with the Lenian feedlot would be considered to be very small, given that the distance between these two sources is large. Cumulative odour impacts with the Amaroo feedlot may possibly be observed either to the south of the Moira feedlot or to the north of the Amaroo feedlot. There are no known receptors directly to the south of the Moira feedlot site and cumulative odour impacts in this area should therefore not be of concern. To the north of the Amaroo feedlot, the contribution from the Moira feedlot is predicted to be of the order of 2 odour units (at the 99th percentile). The management practices of the Amaroo feedlot will determine any cumulative odour impacts observed to the north of this site, however, given the relatively small feedlot size and the 9 km distance between sources, cumulative odour impacts should be both low and infrequent.

9. CONCLUSIONS

This report has assessed the air quality impacts associated with the proposed Moira feedlot in southern NSW. Dispersion modelling has been used to predict off-site odour levels due to the feedlot and these odour levels have been compared with relevant odour criteria noted by the DEC.

The conclusions of the assessment can be summarised as follows:

- Odour from the feedlot is likely to be detectable on occasions at the nearest residences (marked R1 to R20, from **Figure 1**)
- The highest odour impacts would be observed at the residences closest to the feedlot with locations R2, R4, R5, R6, R11 and R12 predicted to experience odour levels above the odour goal
- Odour levels at the remaining individual residences are predicted to be below the odour goal however some predictions are close to the goal suggesting that these locations may not be free from odour impacts
- Odour impacts at the towns of Barmah, Moama and Mathoura are predicted to be acceptable
- The low rainfall of the area would be beneficial for minimising the frequency of odour events

Further collection of on-site meteorological data will improve the reliability of the dispersion model predictions.

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APPENDIX A PEAK-TO-MEAN RATIOS

Table A1 : Recommended factors for estimating peak concentrations for different source types, distances and stabilities

Source type	Stability	Near field				Far field			p
		i_{max}	x_{max}	P/M 60	P/M 3	i	P/M 60	P/M 3	
Area	Neutral, Convective	0.5	500 – 1000	2.5	1.9	0.4	2.3	1.7	0.15
	Stable	0.5	300 – 800	2.3	1.7	0.3	1.9	1.4	0.10
Line	Neutral, Convective	1.0	350	6	2.8	0.75	6	2.8	0.25
	Stable	1.0	250	6	2.8	0.65	6	2.8	0.25
Surface point	Neutral	2.5	200	25	10	1.2	5 - 7	3	0.2
	Stable	2.5	200	25	10	1.2	5 - 7	3	0.2
	Convective	2	1000	12	7	0.6	3 - 4	2.5	0.15
Tall point	Neutral, Stable	4.5	5 h	35	8	1.0	6	1.3	0.5
	Convective	2.3	2.5 h	17	4	0.5	3	1.1	0.5
Wake affected point	Neutral, Convective	0.4	-	2.3	1.4	-	2.3	1.4	0.1
Volume	Neutral, Convective	0.4	-	2.3	1.4	-	2.3	1.4	0.1

i_{max} is maximum centreline intensity of concentration

x_{max} is the approximation location of i_{max} in metres

P/M 60 is the peak-to-mean ratio for long averaging times (typically 1 hour), at a probability of 10^{-3}

P/M 3 is the best estimates of the peak-to-mean ratio for 3 minute averages, at probability 10^{-3}

p is the averaging time power law exponent

h is stack height

Source: **Katestone Scientific (1998)**

APPENDIX B
JOINT WIND SPEED, WIND DIRECTION AND STABILITY CLASS
FREQUENCY TABLES AND METEOROLOGICAL DATA ANALYSIS

MOIRA BY TAPM - 2003 simulation

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)									
WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001256	0.001484	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.003425
NE	0.001370	0.001826	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.003995
ENE	0.000799	0.001027	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.002626
E	0.001027	0.001712	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.003425
ESE	0.001142	0.002740	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.003995
SE	0.000913	0.003311	0.001256	0.000000	0.000000	0.000000	0.000000	0.000000	0.005479
SSE	0.001484	0.001826	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.003995
S	0.000799	0.002626	0.001142	0.000000	0.000000	0.000000	0.000000	0.000000	0.004566
SSW	0.000457	0.002397	0.001256	0.000000	0.000000	0.000000	0.000000	0.000000	0.004110
SW	0.000342	0.003539	0.001598	0.000000	0.000000	0.000000	0.000000	0.000000	0.005479
WSW	0.000228	0.002055	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.002968
W	0.000799	0.001826	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002740
WNW	0.000571	0.001370	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.002397
NW	0.000799	0.001370	0.001027	0.000000	0.000000	0.000000	0.000000	0.000000	0.003196
NNW	0.000799	0.001484	0.001027	0.000000	0.000000	0.000000	0.000000	0.000000	0.003311
N	0.001027	0.001370	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002511
CALM									0.003082
TOTAL	0.013813	0.031963	0.012443	0.000000	0.000000	0.000000	0.000000	0.000000	0.061301

MEAN WIND SPEED (m/s) = 2.14
NUMBER OF OBSERVATIONS = 537

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)									
WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001142	0.001256	0.003311	0.001370	0.000000	0.000000	0.000000	0.000000	0.007078
NE	0.000685	0.000799	0.004452	0.001941	0.000000	0.000000	0.000000	0.000000	0.007877
ENE	0.000342	0.001484	0.005023	0.000685	0.000000	0.000000	0.000000	0.000000	0.007534
E	0.000685	0.001027	0.001826	0.000000	0.000000	0.000000	0.000000	0.000000	0.003539
ESE	0.000342	0.001484	0.002283	0.000000	0.000000	0.000000	0.000000	0.000000	0.004110
SE	0.000228	0.001826	0.003767	0.000000	0.000000	0.000000	0.000000	0.000000	0.005822
SSE	0.001256	0.004680	0.005251	0.001256	0.000000	0.000000	0.000000	0.000000	0.012443
S	0.001027	0.004110	0.007192	0.002968	0.000000	0.000000	0.000000	0.000000	0.015297
SSW	0.000342	0.002740	0.006164	0.001370	0.000000	0.000000	0.000000	0.000000	0.010616
SW	0.000228	0.003653	0.004110	0.000228	0.000000	0.000000	0.000000	0.000000	0.008219
WSW	0.000114	0.000228	0.003196	0.001370	0.000000	0.000000	0.000000	0.000000	0.004909
W	0.000342	0.001142	0.003425	0.000342	0.000000	0.000000	0.000000	0.000000	0.005251
WNW	0.000000	0.000913	0.002626	0.000685	0.000000	0.000000	0.000000	0.000000	0.004224
NW	0.000114	0.001712	0.003082	0.000685	0.000000	0.000000	0.000000	0.000000	0.005594
NNW	0.000228	0.002055	0.003653	0.001370	0.000000	0.000000	0.000000	0.000000	0.007306
N	0.000114	0.001826	0.004338	0.000571	0.000000	0.000000	0.000000	0.000000	0.006849
CALM									0.001484
TOTAL	0.007192	0.030936	0.063699	0.014840	0.000000	0.000000	0.000000	0.000000	0.118151

MEAN WIND SPEED (m/s) = 3.35
NUMBER OF OBSERVATIONS = 1035

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000571	0.000685	0.001256	0.002854	0.000342	0.000000	0.000000	0.000000	0.005708
NE	0.000913	0.001941	0.003196	0.002626	0.000228	0.000000	0.000000	0.000000	0.008904
ENE	0.001027	0.001941	0.001712	0.001256	0.000342	0.000000	0.000000	0.000000	0.006279
E	0.000799	0.001712	0.001484	0.000000	0.000114	0.000000	0.000000	0.000000	0.004110
ESE	0.001142	0.001142	0.001484	0.000000	0.000000	0.000000	0.000000	0.000000	0.003767
SE	0.000457	0.000228	0.002055	0.000000	0.000000	0.000000	0.000000	0.000000	0.002740
SSE	0.001370	0.001712	0.003539	0.005137	0.000571	0.000000	0.000000	0.000000	0.012329
S	0.000685	0.001941	0.005365	0.005936	0.001941	0.000228	0.000000	0.000000	0.016096
SSW	0.000342	0.002968	0.004452	0.006849	0.003196	0.000228	0.000000	0.000000	0.018037
SW	0.000571	0.001484	0.002511	0.004110	0.001484	0.000342	0.000000	0.000000	0.010502
WSW	0.000342	0.001370	0.003767	0.004909	0.001826	0.000000	0.000000	0.000000	0.012215
W	0.000457	0.001142	0.002283	0.002511	0.000799	0.000228	0.000000	0.000000	0.007420
WNW	0.000000	0.001598	0.002055	0.003311	0.001941	0.000457	0.000000	0.000000	0.009361
NW	0.000000	0.001484	0.002854	0.002854	0.000457	0.000342	0.000000	0.000000	0.007991
NNW	0.000228	0.000799	0.001484	0.003767	0.001484	0.000114	0.000000	0.000000	0.007877
N	0.000114	0.002169	0.002283	0.003311	0.000913	0.000342	0.000000	0.000000	0.009132
CALM									0.001256
TOTAL	0.009018	0.024315	0.041781	0.049429	0.015639	0.002283	0.000000	0.000000	0.143721

MEAN WIND SPEED (m/s) = 4.23

NUMBER OF OBSERVATIONS = 1259

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000913	0.002169	0.001712	0.006279	0.001598	0.000571	0.000000	0.000000	0.013242
NE	0.000799	0.003425	0.003082	0.003539	0.000913	0.000000	0.000000	0.000000	0.011758
ENE	0.000799	0.004224	0.004795	0.002055	0.000000	0.000000	0.000000	0.000000	0.011872
E	0.001256	0.006849	0.001941	0.000114	0.000114	0.000000	0.000000	0.000000	0.010274
ESE	0.001484	0.006621	0.001256	0.000571	0.000000	0.000000	0.000000	0.000000	0.009932
SE	0.000913	0.003653	0.001941	0.000685	0.000000	0.000000	0.000000	0.000000	0.007192
SSE	0.001598	0.006050	0.003082	0.002511	0.000228	0.000000	0.000000	0.000000	0.013470
S	0.001027	0.006963	0.010274	0.007877	0.001027	0.001370	0.000114	0.000000	0.028653
SSW	0.001484	0.005251	0.005251	0.005251	0.000913	0.000571	0.000457	0.000000	0.019178
SW	0.001256	0.005936	0.006279	0.004566	0.000913	0.000571	0.000457	0.000000	0.019977
WSW	0.000457	0.003196	0.005365	0.004566	0.001712	0.000913	0.000685	0.000000	0.016895
W	0.000571	0.003881	0.003881	0.009247	0.003767	0.003311	0.001484	0.000457	0.026598
WNW	0.000457	0.002283	0.003311	0.004566	0.002626	0.002854	0.001484	0.000799	0.018379
NW	0.000228	0.003767	0.003995	0.005822	0.001826	0.000913	0.001142	0.000913	0.018607
NNW	0.000342	0.005594	0.003653	0.004795	0.002626	0.001027	0.000571	0.000114	0.018721
N	0.001142	0.005479	0.005251	0.006393	0.003196	0.001027	0.000114	0.000000	0.022603
CALM									0.002169
TOTAL	0.014726	0.075342	0.065068	0.068836	0.021461	0.013128	0.006507	0.002283	0.269521

MEAN WIND SPEED (m/s) = 4.24

NUMBER OF OBSERVATIONS = 2361

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000342	0.001484	0.005822	0.002169	0.000000	0.000000	0.000000	0.000000	0.009817
NE	0.000685	0.000571	0.005594	0.001826	0.000000	0.000000	0.000000	0.000000	0.008676
ENE	0.000799	0.000799	0.005365	0.000685	0.000000	0.000000	0.000000	0.000000	0.007648
E	0.000342	0.002397	0.003653	0.000000	0.000000	0.000000	0.000000	0.000000	0.006393
ESE	0.000685	0.001712	0.003653	0.000000	0.000000	0.000000	0.000000	0.000000	0.006050
SE	0.000913	0.001027	0.004680	0.000000	0.000000	0.000000	0.000000	0.000000	0.006621
SSE	0.000685	0.000342	0.012100	0.001712	0.000000	0.000000	0.000000	0.000000	0.014840
S	0.000114	0.001712	0.020890	0.003311	0.000000	0.000000	0.000000	0.000000	0.026027
SSW	0.000114	0.000228	0.007648	0.001142	0.000000	0.000000	0.000000	0.000000	0.009132
SW	0.000342	0.002169	0.005594	0.001256	0.000000	0.000000	0.000000	0.000000	0.009361
WSW	0.000000	0.001598	0.011187	0.001598	0.000000	0.000000	0.000000	0.000000	0.014384
W	0.000114	0.001142	0.009018	0.002968	0.000000	0.000000	0.000000	0.000000	0.013242
WNW	0.000228	0.000685	0.006507	0.001598	0.000000	0.000000	0.000000	0.000000	0.009018
NW	0.000000	0.002169	0.003196	0.002055	0.000000	0.000000	0.000000	0.000000	0.007420
NNW	0.000000	0.001484	0.007078	0.001027	0.000000	0.000000	0.000000	0.000000	0.009589
N	0.000114	0.001712	0.008447	0.002397	0.000000	0.000000	0.000000	0.000000	0.012671
CALM									0.000571
TOTAL	0.005479	0.021233	0.120434	0.023744	0.000000	0.000000	0.000000	0.000000	0.171461

MEAN WIND SPEED (m/s) = 3.75

NUMBER OF OBSERVATIONS = 1502

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000342	0.008790	0.003425	0.000000	0.000000	0.000000	0.000000	0.000000	0.012557
NE	0.000342	0.006393	0.004909	0.000000	0.000000	0.000000	0.000000	0.000000	0.011644
ENE	0.000913	0.006621	0.002740	0.000000	0.000000	0.000000	0.000000	0.000000	0.010274
E	0.000685	0.013699	0.005708	0.000000	0.000000	0.000000	0.000000	0.000000	0.020091
ESE	0.000913	0.016667	0.004452	0.000000	0.000000	0.000000	0.000000	0.000000	0.022032
SE	0.000571	0.012671	0.005137	0.000000	0.000000	0.000000	0.000000	0.000000	0.018379
SSE	0.000228	0.016895	0.009018	0.000000	0.000000	0.000000	0.000000	0.000000	0.026142
S	0.001027	0.018265	0.014384	0.000000	0.000000	0.000000	0.000000	0.000000	0.033676
SSW	0.000342	0.016781	0.005708	0.000000	0.000000	0.000000	0.000000	0.000000	0.022831
SW	0.000000	0.007420	0.005822	0.000000	0.000000	0.000000	0.000000	0.000000	0.013242
WSW	0.000000	0.005479	0.003425	0.000000	0.000000	0.000000	0.000000	0.000000	0.008904
W	0.000228	0.003425	0.001370	0.000000	0.000000	0.000000	0.000000	0.000000	0.005023
WNW	0.000342	0.002397	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.003425
NW	0.000000	0.006164	0.003196	0.000000	0.000000	0.000000	0.000000	0.000000	0.009361
NNW	0.000342	0.005936	0.002283	0.000000	0.000000	0.000000	0.000000	0.000000	0.008562
N	0.000114	0.006393	0.002854	0.000000	0.000000	0.000000	0.000000	0.000000	0.009361
CALM									0.000342
TOTAL	0.006393	0.153995	0.075114	0.000000	0.000000	0.000000	0.000000	0.000000	0.235845

MEAN WIND SPEED (m/s) = 2.72

NUMBER OF OBSERVATIONS = 2066

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)									
WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.004566	0.015868	0.016210	0.012671	0.001941	0.000571	0.000000	0.000000	0.051826
NE	0.004795	0.014954	0.022032	0.009932	0.001142	0.000000	0.000000	0.000000	0.052854
ENE	0.004680	0.016096	0.020434	0.004680	0.000342	0.000000	0.000000	0.000000	0.046233
E	0.004795	0.027397	0.015297	0.000114	0.000228	0.000000	0.000000	0.000000	0.047831
ESE	0.005708	0.030365	0.013242	0.000571	0.000000	0.000000	0.000000	0.000000	0.049886
SE	0.003995	0.022717	0.018836	0.000685	0.000000	0.000000	0.000000	0.000000	0.046233
SSE	0.006621	0.031507	0.033676	0.010616	0.000799	0.000000	0.000000	0.000000	0.083219
S	0.004680	0.035616	0.059247	0.020091	0.002968	0.001598	0.000114	0.000000	0.124315
SSW	0.003082	0.030365	0.030479	0.014612	0.004110	0.000799	0.000457	0.000000	0.083904
SW	0.002740	0.024201	0.025913	0.010160	0.002397	0.000913	0.000457	0.000000	0.066781
WSW	0.001142	0.013927	0.027626	0.012443	0.003539	0.000913	0.000685	0.000000	0.060274
W	0.002511	0.012557	0.020091	0.015068	0.004566	0.003539	0.001484	0.000457	0.060274
WNW	0.001598	0.009247	0.015639	0.010160	0.004566	0.003311	0.001484	0.000799	0.046804
NW	0.001142	0.016667	0.017352	0.011416	0.002283	0.001256	0.001142	0.000913	0.052169
NNW	0.001941	0.017352	0.019178	0.010959	0.004110	0.001142	0.000571	0.000114	0.055365
N	0.002626	0.018950	0.023288	0.012671	0.004110	0.001370	0.000114	0.000000	0.063128
CALM									0.008904
TOTAL	0.056621	0.337785	0.378539	0.156849	0.037100	0.015411	0.006507	0.002283	1.000000
MEAN WIND SPEED (m/s) = 3.56									
NUMBER OF OBSERVATIONS = 8760									

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

A : 6.1%
 B : 11.8%
 C : 14.4%
 D : 27.0%
 E : 17.1%
 F : 23.6%

STABILITY CLASS BY HOUR OF DAY

Hour	A	B	C	D	E	F
01	0000	0000	0000	0043	0148	0174
02	0000	0000	0000	0044	0139	0182
03	0000	0000	0000	0045	0130	0190
04	0000	0000	0000	0049	0120	0196
05	0000	0000	0000	0101	0108	0156
06	0000	0000	0000	0213	0071	0081
07	0000	0011	0089	0207	0038	0020
08	0001	0090	0092	0182	0000	0000
09	0027	0129	0124	0085	0000	0000
10	0069	0133	0101	0062	0000	0000
11	0087	0123	0099	0056	0000	0000
12	0096	0110	0108	0051	0000	0000
13	0097	0089	0122	0057	0000	0000
14	0067	0107	0122	0069	0000	0000
15	0054	0102	0119	0090	0000	0000
16	0036	0072	0134	0123	0000	0000
17	0003	0069	0077	0216	0000	0000
18	0000	0000	0072	0227	0027	0039
19	0000	0000	0000	0199	0054	0112
20	0000	0000	0000	0071	0115	0179
21	0000	0000	0000	0035	0134	0196
22	0000	0000	0000	0041	0140	0184
23	0000	0000	0000	0048	0136	0181
24	0000	0000	0000	0047	0142	0176

STABILITY CLASS BY MIXING HEIGHT

Mixing height	A	B	C	D	E	F
<=500 m	0141	0440	0609	1845	1460	2063
<=1000 m	0179	0254	0281	0338	0034	0002
<=1500 m	0184	0260	0297	0140	0008	0000
<=2000 m	0018	0035	0035	0013	0000	0001
<=3000 m	0015	0046	0037	0025	0000	0000
>3000 m	0000	0000	0000	0000	0000	0000

MIXING HEIGHT BY HOUR OF DAY

Hour	0000 to 0100	0100 to 0200	0200 to 0400	0400 to 0800	0800 to 1600	1600 to 3200	Greater than 3200
01	0141	0169	0039	0013	0003	0000	0000
02	0126	0175	0043	0017	0004	0000	0000
03	0123	0172	0047	0017	0006	0000	0000
04	0127	0165	0051	0018	0004	0000	0000
05	0128	0162	0050	0020	0005	0000	0000
06	0129	0158	0048	0024	0006	0000	0000
07	0203	0107	0032	0019	0003	0001	0000
08	0200	0101	0050	0011	0002	0001	0000
09	0162	0099	0072	0032	0000	0000	0000
10	0087	0070	0094	0089	0025	0000	0000
11	0032	0057	0063	0131	0081	0001	0000
12	0010	0024	0059	0109	0155	0008	0000
13	0006	0009	0032	0094	0201	0023	0000
14	0004	0006	0026	0072	0227	0030	0000
15	0005	0007	0018	0071	0227	0037	0000
16	0003	0012	0026	0069	0214	0041	0000
17	0014	0047	0046	0063	0157	0038	0000
18	0076	0078	0040	0055	0089	0027	0000
19	0147	0089	0068	0047	0014	0000	0000
20	0181	0120	0045	0016	0003	0000	0000
21	0184	0130	0036	0010	0005	0000	0000
22	0175	0144	0033	0010	0003	0000	0000
23	0164	0152	0035	0010	0004	0000	0000
24	0148	0162	0038	0013	0004	0000	0000

Meteorological data analysis

As discussed in the main report TAPM has been used to derive the meteorological conditions for Moira in the absence of a complete year of on-site meteorological data. The CALMET model has used the TAPM output to generate a year-long three-dimensional wind-field for input to the CALPUFF air dispersion model. CALPUFF has then been used to predict off-site odour levels due to the proposed feedlot. The purpose of this section is to provide some analysis of the available on-site meteorological data and to determine whether the use of these data in the dispersion modelling, instead of the TAPM generated data, would significantly change the predictions and conclusions of the study.

At the time of writing, the data available from the on-site weather station included 10-minute records from 2 Mar 2005 to 12 Aug 2005. The data were subsequently processed into hourly records of temperature, wind speed, wind direction, atmospheric stability and mixing height - a form suitable for the AUSPLUME dispersion model. Stability was assigned using sigma-theta for each hour of the dataset.

For comparison, hourly records of temperature, wind speed, wind direction and stability were extracted from the CALMET wind-field for the proposed feedlot site. These data are referred to as the TAPM 2003 data for the purposes of this analysis as the TAPM output has been used as input to the CALMET model.

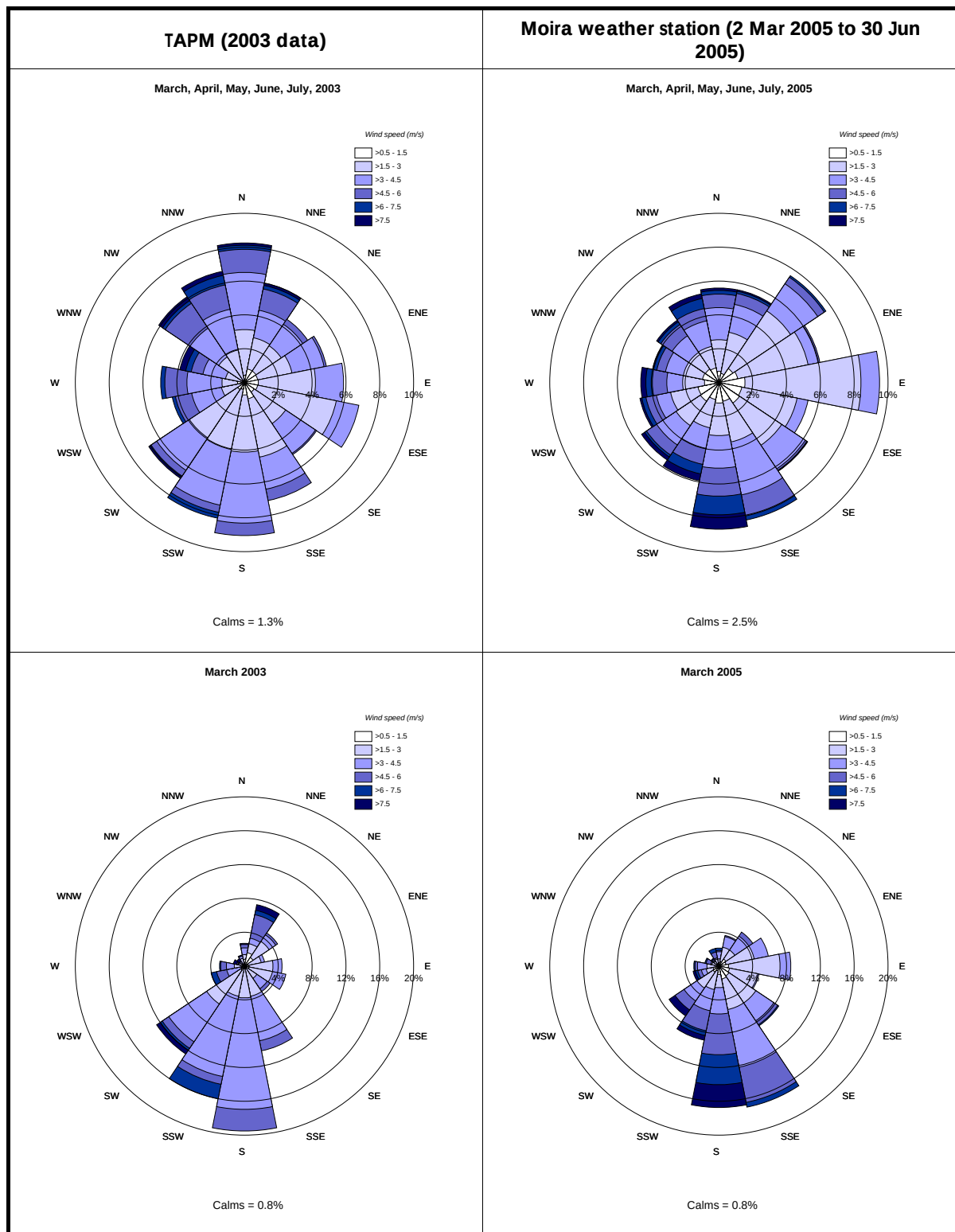
The meteorological data analysis includes the following information:

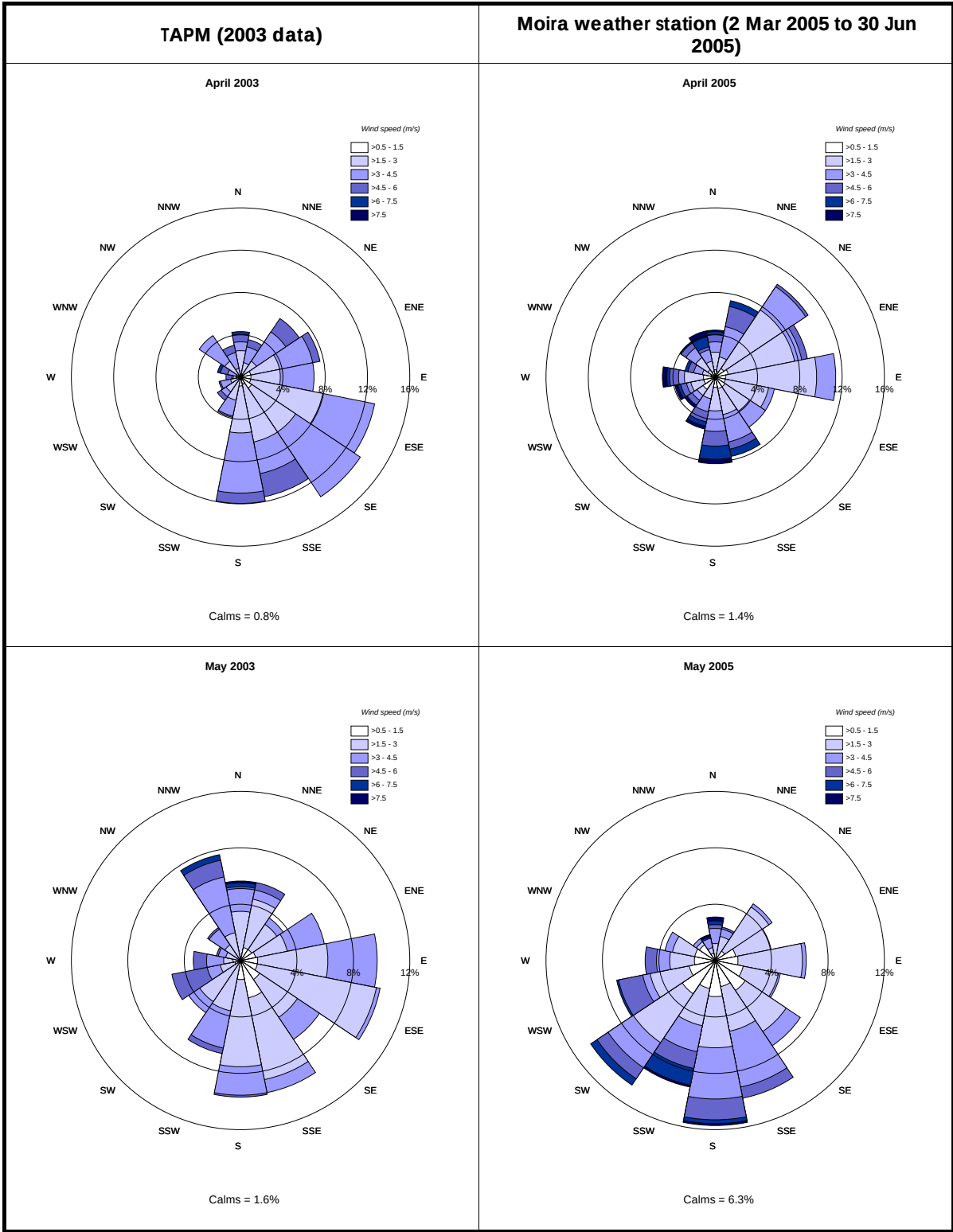
- Comparisons of windroses
- Comparisons of data statistics
- Discussion and implications for current modelling results

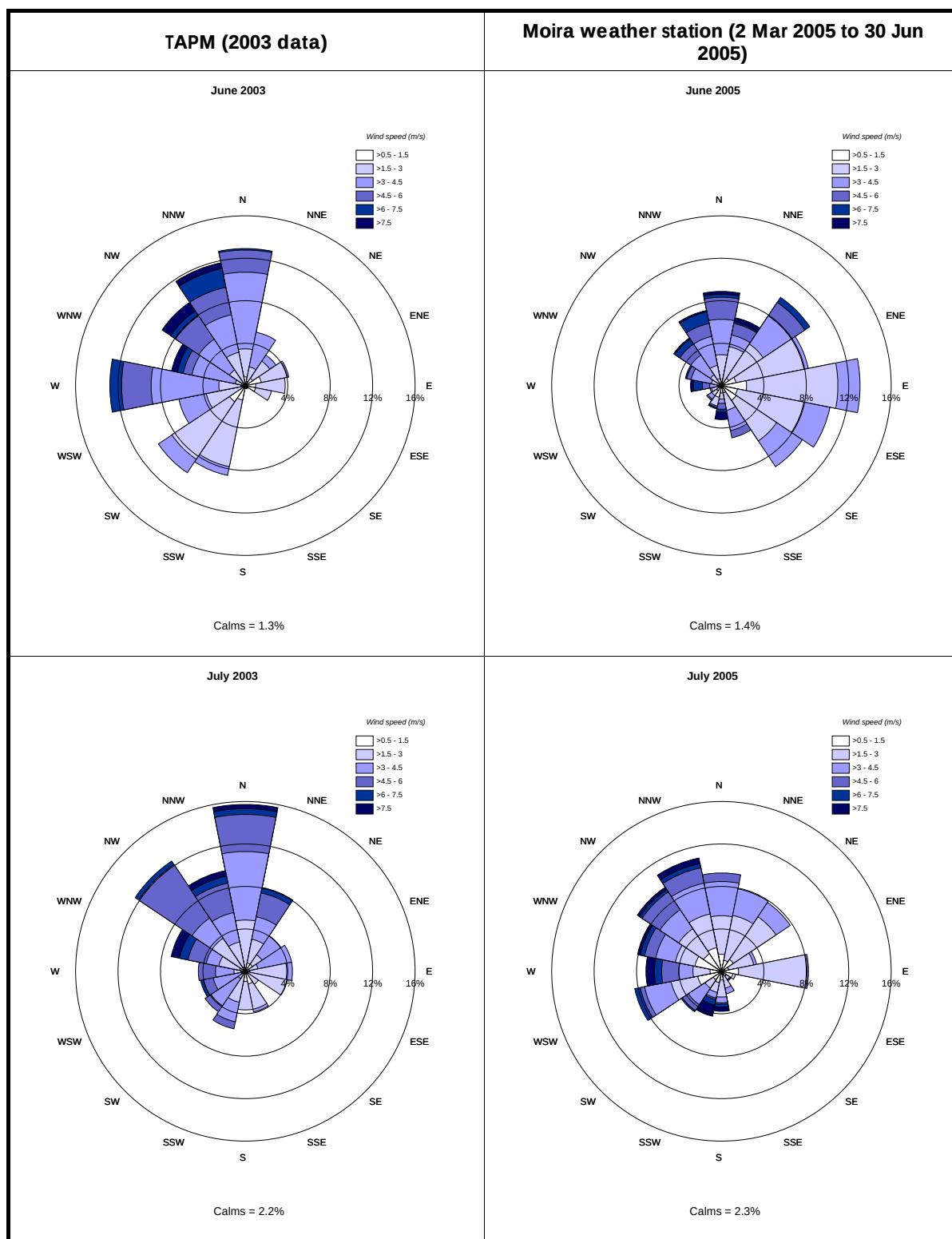
It should be noted that the statistics of both datasets would not be expected to be identical as there will be differences in meteorology from year to year (this analysis compares 2003 data with 2005 data).

Windroses for the period March to July and for each month are presented below in **Table B1**. These windroses have been created from hourly records of wind speed and wind direction.

Table B1 : Comparisons of windroses







For the windroses showing all data in the March to July period (top two figures of **Table B1**), the pattern of winds are reasonably well distributed around the compass in both datasets. The frequency of wind directions are very close for each wind sector although some differences can be found depending on the level of scrutiny employed. The frequency of winds from each wind sector ranges between 4% and 10% in both datasets. By comparing the frequency of each wind direction, it can be

seen that the differences between the two datasets amounts to no more than about 3%.

The percentage of calm periods (when the wind speed is less than or equal to 0.5 m/s) are considered to be very similar in all months for both datasets. The month of May is perhaps the exception where the percentage of calms in the TAPM 2003 data was 1.6% compared with 6.3% for the on-site data.

June appeared to be the only month where differences between the wind patterns were more obvious than other months. For this month, the winds in the TAPM 2003 data were generally from the N to SW (anti-clockwise) sectors. The on-site 2005 data showed winds in this month were from the N to SE (clockwise) sectors.

The most weighting for the comparisons should be given to those which compare the data covering the entire March to July period. Comparisons of the shorter time periods (that is, monthly) would be expected exhibit more variation due to slight variations from year to year.

Table B2 compares statistics on mean wind speeds, percentage of calms and frequency of occurrence of stability classes.

Table B2 : Comparisons of data statistics

Data period	Mean wind speed (m/s)	Calms (wind speed <0.5 m/s, %)	Frequency of occurrence of stability classes (%)					
			A	B	C	D	E	F
TAPM (2003)								
Mar-Jul 2003	3.2	1.3	0.4	10.0	16.4	19.8	17.1	36.2
Mar 2003	3.5	0.8	0.9	15.7	18.5	17.1	17.9	29.8
Apr 2003	3.1	0.8	0.6	14.9	17.5	13.6	17.2	36.3
May 2003	2.7	1.6	0.3	11.7	17.1	13.3	10.8	46.9
Jun 2003	3.3	1.3	0.0	4.0	13.8	30.1	18.1	34.0
Jul 2005	3.5	2.2	0.0	3.9	15.3	25.0	21.8	34.0
Moira weather station (Mar 2005 to Jun 2005)								
Mar-Jul 2005	3.0	2.5	4.5	2.6	5.8	34.5	26.3	26.2
Mar 2005	3.6	0.8	7.5	5.9	9.2	34.1	21.7	21.5
Apr 2005	3.1	1.4	7.2	3.6	6.7	32.1	25.3	25.1
May 2005	2.5	6.3	5.6	2.0	5.2	28.2	24.5	34.4
Jun 2005	3.1	1.4	1.7	1.4	5.7	38.8	30.6	21.9
Jul 2005	2.9	2.3	0.8	0.4	2.6	39.4	29.2	27.7

The statistics on mean wind speeds and percentage of calm periods for each month are considered to be very close, although as discussed above, the on-site data recorded a slightly higher percentage of calms than the TAPM 2003 data for the month of May (6.3% compared with 1.6%).

The distribution of stability classes in the TAPM 2003 data shows a relatively even distribution from B-class through to E-class. The frequency of F-class stabilities tended to be higher than all other stabilities.

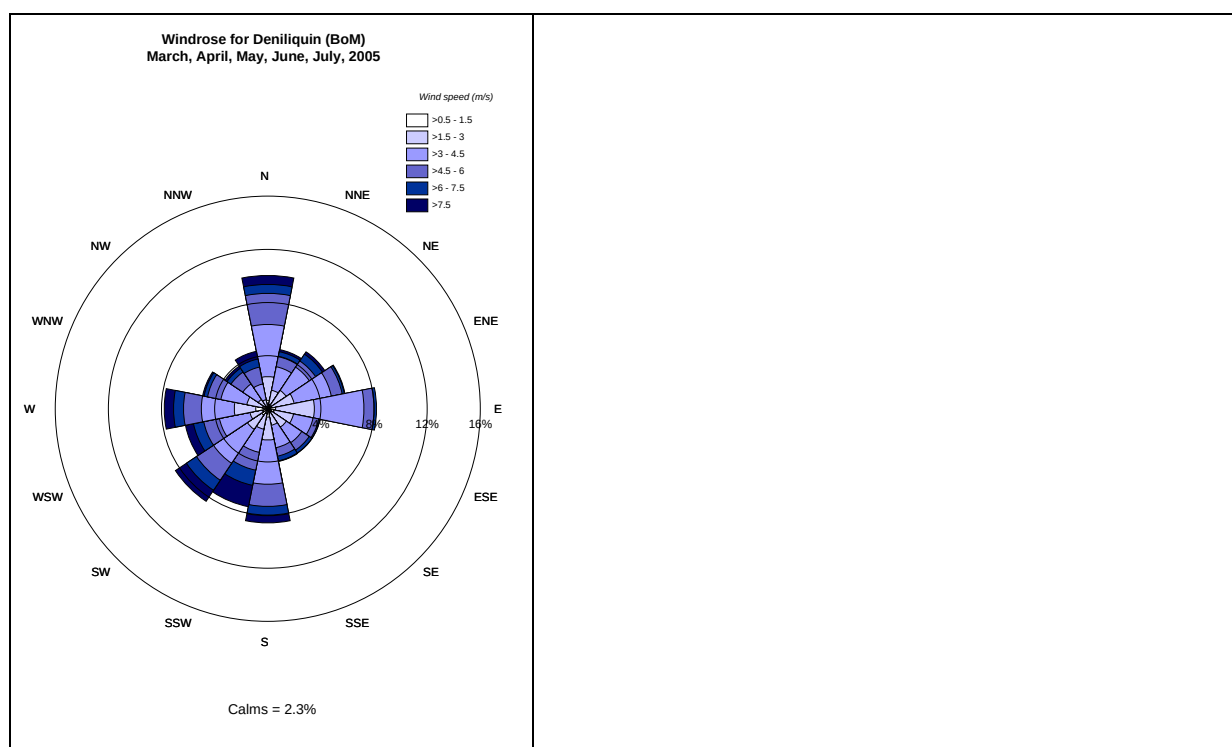
The stabilities in the on-site data were generally determined to be distributed between D, E and F classes for most of the time. Overall (that is, for the entire data period) D-class was determined to be the most common stability. Some differences

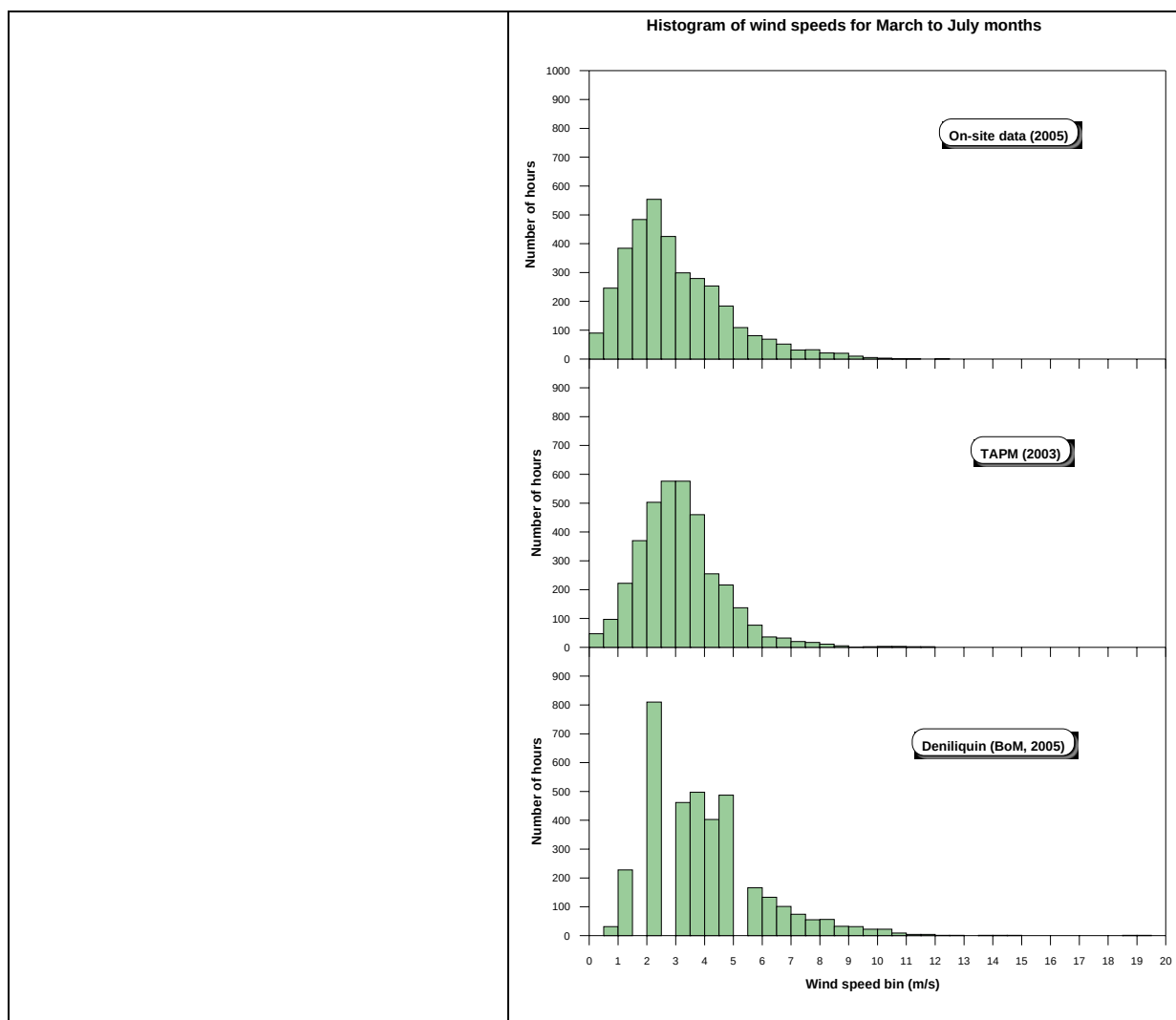
between the stability class distributions for the two datasets may be explained by the two different stability class calculation procedures used.

Based on the frequency of occurrence of stability classes, the prevalence of F classes in the TAPM data would suggest that the use of these data is a potentially more conservative approach than using the on-site data.

Meteorological data have also been obtained from an automatic weather station (AWS) at Deniliquin Airport. This station is operated by the Bureau Meteorology and is approximately 45 km to the north of the proposed feedlot site. The data obtained from this site include hourly records of temperature, wind speed and wind direction. Wind direction was recorded at 10 degree increments.

A windrose showing the pattern of winds for the period March to July 2005 is presented below as well as a histogram of wind speeds from the three datasets. The measured mean wind speed for this period was 3.9 m/s and the frequency of calm periods was 2.3%. The windrose below can be compared with the top two windroses shown in **Table B1**. The pattern of winds in the TAPM 2003 data appears to show closer agreement to the on-site data than the Deniliquin data. The TAPM 2003 data are considered to be a more appropriate choice than the Deniliquin data for dispersion modelling in the project area.





The conclusions of this analysis are therefore summarised as follows:

- Mean wind speeds between the TAPM 2003 and on-site 2005 data are very similar for the available on-site data period.
- Frequency of occurrence of calm periods between the TAPM 2003 and on-site 2005 data are very similar for the available on-site data period.
- There are some variations in wind patterns from month to month (some variation from year to year would also be expected) however for the available on-site data period, the TAPM 2003 and on-site 2005 data are considered to be very similar.

Based on these conclusions, the use of a year long on-site meteorological dataset in the dispersion modelling should be expected to result in a similar predicted extent and frequency of odour impacts compared with the TAPM driven dispersion modelling.

The close agreement between the TAPM 2003 and on-site 2005 data may be explained by the simple topography of the area where TAPM would be expected to perform well.

APPENDIX C
FSIM MODELLING CONDUCTED BY E.A. SYSTEMS

~ Commercial-in-Confidence ~

Moira Feedlot FSIM Modelling

Report Number 20892.4645



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by



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1

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1. Introduction

A feedlot is proposed at Moira Station, approximately 15 kilometres south of Mathoura in Southern NSW. It is proposed that the feedlot will accommodate 80,000 head.

An air quality assessment is required for development application purposes. The air quality assessment will incorporate odour emission estimates which will require manure pad moisture content. E.A. Systems Pty Limited have completed modelling of pad moisture content using the FSIM modelling program on behalf of Holmes Air Sciences.

E.A. Systems completed three modelling 'runs' or various characteristics at the proposed feedlot:

- Run 1 – Base data as supplied by Holmes Earth Sciences,
- Run 2 – Base data with an assumed maximum manure depth of 50 mm compared to 25 mm.
- Run 3 – Base data with a maximum manure depth of 50 mm and a pen slope of 3% compared to the initial 2%.

The results of these 'runs' are forwarded to Holmes Air Sciences as electronic files. The addition of 'runs' 2 and 3 are included to indicate variations in manure pad moisture content levels dependent on manure depth and pen slope. From industry experience, E.A. Systems suggests that a maximum manure depth of 50 mm is more realistic based on manure removal and operational practices, and that a pen slope of 3 % will lead to improved pen surface drying conditions.

2. FSIM Background

2.1 Feedlot hydrology and manure moisture content

In Australia, feedlot pens are generally open-air structures¹. Consequently, feedlot pens will intercept rainfall and other forms of natural precipitation², much like any other catchment. However, some differences, in terms of accessions of water, are readily apparent. These differences include:

- The voiding of urine and faeces by the housed livestock, which will add substantial quantities of water to the manure pad, and
- Additional water might from time to time be purposefully applied to the animals or pen surface to either cool stock during periods of heat stress or to suppress fugitive dust emissions from the pen surface in dry weather.

The amount of water directly added by stock to each unit area of the feedlot catchment will depend on class of stock³ being housed and the stocking density. Figure 1 provides the relationship between the amount of water typically added per year, in the form of urine and faeces, by feedlot cattle having liveweights of 300, 450, 600 and 750 kilograms (Lott, 1994).

¹ Not fully rooved structures (some feedlots provide shade structures covering 10 – 20 % of the pen area) nor are feedlot cattle generally housed inside a building

² Precipitation includes all atmospheric condensation products including rain, snow, dew, hail, etc.

³ The class of stock being largely a function of animal liveweight and the duration of an animal's residence (total days on feed) and reflects intended market (eg. Jap Ox, Korean, domestic, EU, etc)

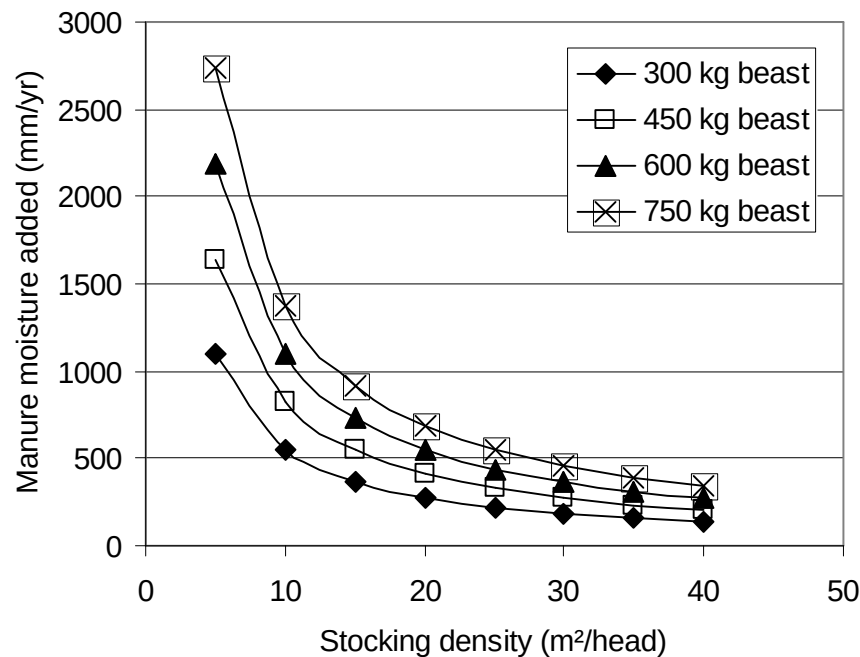


Figure 1. Water added in the form of manure by various liveweight cattle at stocking densities of between 5 and 40 m²/head (Lott, 1994)

From Figure 1 it can be seen that the amount of water added increases exponentially as stocking density is increased (as m²/beast decreases). Similarly, the amount of water added also increases as the liveweight of the housed animals increases (although not in a direct linear relationship⁴). The data provided in Figure 1 are for cattle on the Darling Downs in southern Queensland.

In a hydrological sense, the runoff yield determining features of a feedlot catchment are not dissimilar to those of any other catchment. The runoff discharged by any catchment, and by definition⁵, the amount of incident rainfall subsequently lost to the atmosphere (by evaporation), lost to percolation or deep drainage and retained, as soil moisture, in or on the surface matrix (soil in a normal catchment) is dependent upon the following (Shaw, 1999):

- Antecedent⁶ moisture conditions,
- Surface roughness,
- Surface gradient,
- Water storage potential of the matrix, and
- Infiltration rate.

2.2 The FSIM feedlot hydrology model

FSIM (Lott, 1998) is a hydrological model developed specifically for feedlot catchments. The model has a number of components that consider various issues, such as the storage performance of the holding pond and the irrigation demands of the wastewater utilisation area. These particular facets are not directly related to manure moisture content. However, the basic module of the FSIM model is a component that predicts runoff from a feedlot catchment; a factor that is directly related to manure moisture content.

⁴ Dry matter intake (feed) and therefore water intake is not a linear function of cattle liveweight as the maintenance nutritional requirements of cattle (the basal nutrient requirements that need to be met before any growth or increase in liveweight can occur) are an exponential function of liveweight (eg. maintenance metabolisable energy requirement $\propto$ liveweight^{0.75}).

⁵ There is a material or mass balance relationship between source precipitation and the various sinks.

⁶ Antecedent relates to the prior or preceding circumstances

2.2.1 Runoff from the feedlot pen surface

To estimate runoff from the feedlot pen surface, the FSIM model uses distributed parameters⁷ in a deterministic⁸, quantitative mass balance model. The various parameters account for a range of factors including feedlot design, classes of stock, ration types, manure management, climatic influences, and feedlot waste utilisation practices.

The feedlot management parameters in the model include variables such as stocking density, animal liveweight and manure management practices. Some of the general effects of stocking density and animal liveweight on moisture accessions have been previously described (page 1). Stocking density and animal liveweight will also directly affect the rate at which manure is deposited on the pen surface. The effects of manure management practices are more complex. The model provides concurrent daily-step mass balances for water and manure solids.

The hydrograph⁹ for the runoff from a rainfall event in a feedlot catchment can be determined using the following relationship (Lott, 1994 and 1998):

$$R = P - S_t - S_d - I \quad \text{Equation 1}$$

Where: R = runoff during precipitation (mm),
 P = precipitation (mm),
 S_t = temporary storage (mm),
 S_d = depression storage (mm),
 I = infiltration (mm), and

For a given rainfall event, Equation 1 reduces to:

$$R = P - L \quad \text{Equation 2}$$

Where: L = loss of water on the surface (mm),
 $= I + S_d + E$, and
 E = evaporation.

Similarly, the change in the volume of water stored in and on the surface of the manure (ΔS) can be determined as:

$$\Delta S = P - E - R - I_p \quad \text{Equation 3}$$

Where: ΔS = $\Delta S_w + \Delta S_d$
 ΔS_w = change in water stored in the manure pad (mm), and
 I_p = percolation below the zone of stored water (mm).

The component variables in the above relationships are represented diagrammatically in Figure 2.

⁷ Distributed parameters models attempts to account for the influence of spatial or temporal variability on the model's independent variables (parameters) by applying its governing equations at the small elemental scales within which the parameters are assumed to be uniform (as opposed to a lumped parameter model)

⁸ Deterministic models are models for which there is only one outcome for a given set of circumstances or input data. The converses are stochastic models where many end of period values are possible.

⁹ The change in water flow (runoff) over an arbitrary time interval

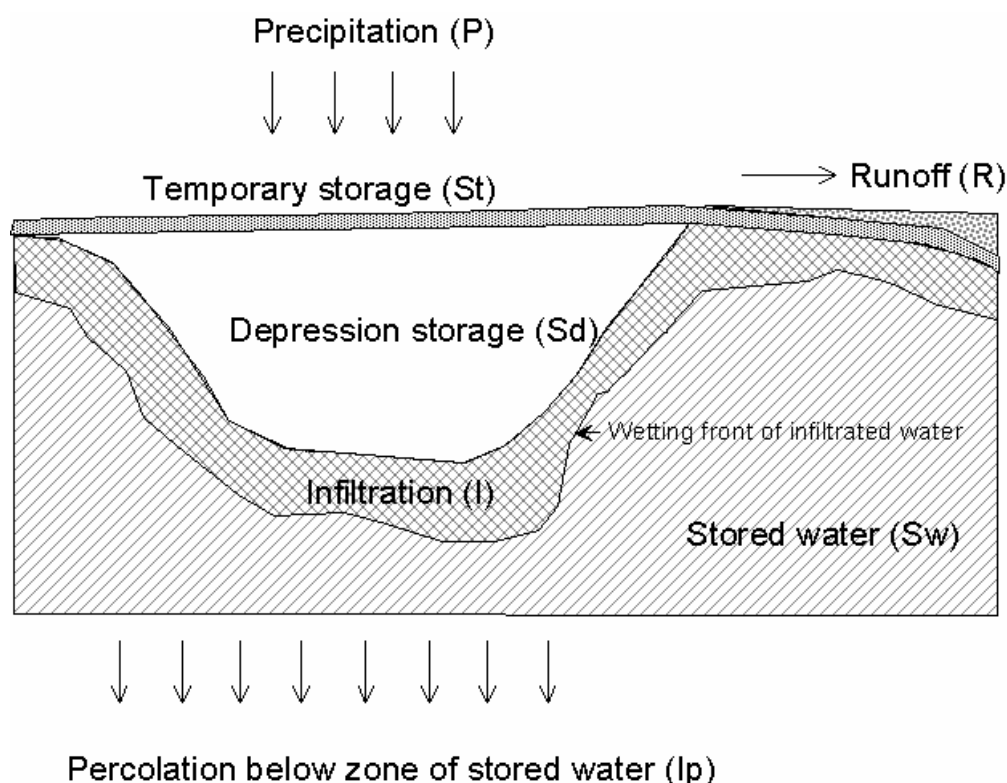


Figure 2. Component variables in the water balance of the feedlot pen surface (Lott, 1998)

Lott (1998) demonstrated that the magnitude of the temporary storage (S_t) and percolation (I_p) were relatively minor¹⁰ in a feedlot pen, but still significant variables. Conversely, the magnitude of the depression storage (S_d) and infiltration (I) were found to be substantial and, in part, functions of the extant condition of manure on the feedlot pen surface.

Lott (1994) had found that the surface condition of manure on the pen surface can be classified into one of four distinct classes:

1. Powdery, smooth and dry,
2. Smooth, compacted and moist,
3. Rough and wet (puggy), and
4. Smooth and saturated.

Importantly, the following relationships were found to apply (Lott, 1994 and 1998)

- The maximum runoff occurs under conditions 2 and 4,
- The maximum sediment erosion occurs under conditions 1 and 4,
- Maximum odour nuisance and least runoff occurs under condition 3, and
- Minimum odour nuisance and minimum runoff occurs under condition 2.

The occurrence of the above four conditions can be related to the manure moisture content¹¹, and in turn the liquid¹² and plastic¹³ limits of feedlot manure, and to manure depth (Lott, 1998). The relationship between manure moisture content and surface condition is shown in Figure 3.

¹⁰ But still quantifiable

¹¹ Manure moisture content and manure bulk density was determined by taking 42 mm diameter profile cores of the manure on the pen surface

¹² The moisture content at which a manure sample, to which water has been progressively added, starts to behave as a liquid

¹³ The moisture content at which a manure sample, to which water has been progressively added, can be subjected to plastic deformation (does not break or crumble when rolled into a 3 mm thread)

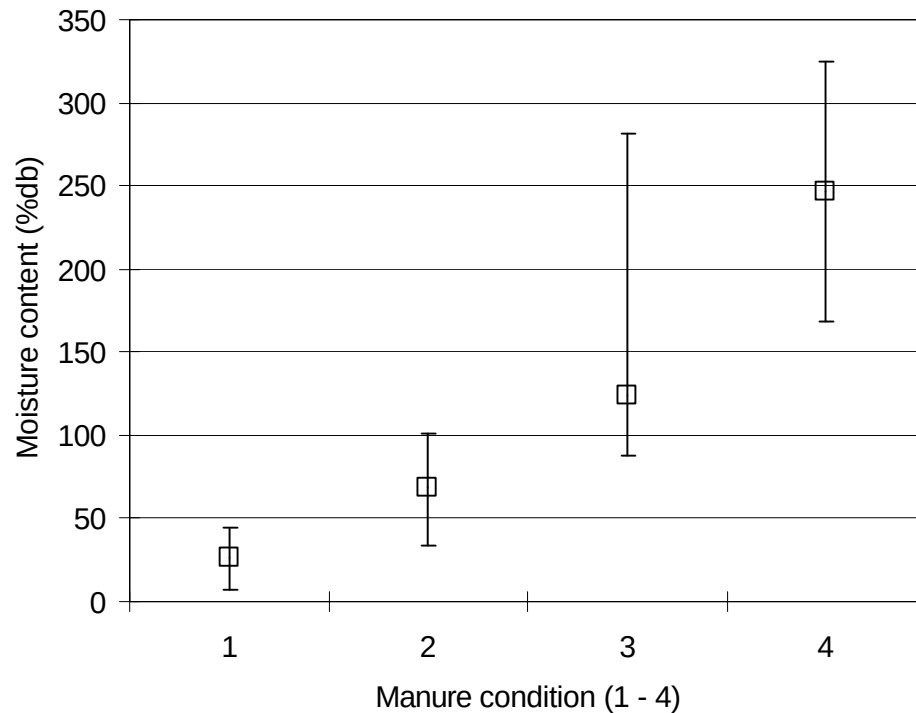


Figure 3. Mean moisture content (€) and the range ($\pm$) of extreme values associated with manure conditions 1 – 4 in 60 manure profile samples collected at four feedlots in southern Queensland (source Lott, 1998)

Depression storage (S_d in Equation 1) was then demonstrated to be a function of the gradient of the pen surface¹⁴ and the surface roughness¹⁵. Under conditions 1, 2 and 4, the surface roughness values associated with each of these conditions was found to be constant¹⁶. A regression equation¹⁷ was developed to determine surface roughness value from manure depth and moisture content ($r^2 = 0.70$) under surface condition 3 (rough and wet manure). A further regression equation¹⁸ was developed that determined depression storage (S_d) from percentage slope and surface roughness ($r^2 = 0.80$) for all four manure conditions (Lott, 1998).

Stored moisture (S_w in Equation 3) is estimated in FSIM, on a daily basis, using a mass balance¹⁹ that incorporates the following moisture related variables:

- Precipitation,
- Runoff,
- Infiltration,
- Evaporation,
- Percolation,
- Depression storage, and
- Manure moisture accessions (principally faeces and urine).

A similar mass balance concurrently considered changes in the manure dry matter resident on the pen surface. These changes were associated with:

¹⁴ The steeper the pen surface the less water can be stored in surface depressions

¹⁵ Surface roughness was measured by determining the micro-relief of surface of the manure in rectangular plots sampled at a grid spacing of 30 mm x 50 mm and determining the mean variation in surface elevation

¹⁶ ± 7.6 , ± 7.6 & ± 14.0 mm respectively

¹⁷ Surface roughness = $0.077 \times \text{manure depth} - 0.00093 \times \text{moisture content}^2 + 0.326 \times \text{moisture content} - 2.547$

¹⁸ Depression storage = $1.974 - 0.3845 \times \text{pen slope} + 0.2986 \times \text{surface roughness}$

¹⁹ The 'law' of the conservation of mass states that where reactions take place, matter cannot be created or destroyed and mass will be preserved within the system (system input = output + accumulation/depletion)

- Manure production by the livestock,
- Manure harvesting (pen cleaning) operations,
- Manure losses in surface runoff, and
- Manure losses due to microbial degradation of the organic matter component of the manure resident on the pen surface.

Algorithms were developed to allow FSIM to inter-relate manure moisture content, manure bulk density and manure depth (Lott, 1998).

Lott (1998) provided multi-stage relationships²⁰ for estimating evaporation from the manure based on the Penman & Monteith estimate of potential evaporation (E_o). Lott also established a relationship for estimating infiltration (I) on the basis of rainfall intensity and the available storage capacity in the manure profile.

Daily values for all the variables in the above lists are therefore either known or can be readily and reliably estimated using the developed algorithms. Consequently, it is now possible to model the hydrological status of a feedlot pen surface, including component variables such as manure moisture content and manure dry matter, on a daily step basis.

2.2.2 *Runoff from 'hard' areas in feedlot catchment*

The 'hard' surfaces in a feedlot catchment includes areas such as concrete aprons, roofs, the drainage system, roads and laneways and compacted other gravel surfaces. While generally of lesser areal extent than the pen surface feedlot catchment, these surfaces do provide high yields in storm events and can make significant contributions to runoff.

Typically, no or very minor infiltration occurs in these areas. Consequently, aside from the loss of rainfall associated with depression storage²¹ on these surfaces, all subsequent rainfall is represented directly in runoff. Lott (1998) determined initial loss values for these hard surfaces.

2.2.3 *Runoff from 'soft' areas in the feedlot catchment*

The 'soft' portions of a feedlot catchment represent grassed or vegetated areas. These are often relatively minor components of the feedlot catchment, although this is not always the case.

The component of the FSIM model that calculates runoff from this part of the feedlot is analogous to the widely accepted and extensively used USDA SCS²² runoff model. The USDA SCS runoff model, stated in SI units, uses the following algorithm (Mockus, 1969 and Morwood, 1984):

$$R = \frac{\left[P - 5 \times \left(\frac{1000}{k} - 10 \right) \right]^2}{P + 20 \times \left(\frac{1000}{k} - 10 \right)} \quad \text{Equation 4}$$

Where: R = runoff (mm),
 P = precipitation²³ (mm), and
 k = a catchment index (curve number) representative of the soil-cover complex in the catchment.

²⁰ The stages being (1) a rapid linear drying phase, (2) a slower, intermediate, curvilinear phase and (3) a very slow, linear phase with the applicable thresholds being the plastic limit (stage 1 to 2) and the laboratory air dry manure moisture content (stage 2 to 3)

²¹ A function of surface roughness

²² United States Department of Agriculture Soil Conservation Service

²³ The relationship is only valid if $P > 0.2S$; $R = 0$ when $P < 0.2S$.

Different values of the catchment index, k_1 , k_2 and k_3 , are applied to represent respectively very dry, typical or normal, or very wet antecedent soil moisture conditions in the catchment (Mockus, 1964). The seasonal conditions consistent with these antecedent soil condition factors have been determined for agricultural catchments in Australia (Morwood, 1984) and are broadly similar to those applied in the USA (Mockus 1964 & 1969).

The USDA SCS runoff model has proven reliable and reasonably accurate over the 50 years since it was originally developed. Consequently, a suitable level of confidence can be applied to predictions made using this methodology.

2.3 Conclusion

The approach used in the FSIM model is validated by the model being based on mass balance principles and the use of well established or statistically valid relationships. The runoff component of model was successfully calibrated and verified by an intensive study undertaken in four catchments in three feedlots in southern Queensland. These catchments were monitored²⁴ over a six year period between 1990 and 1996. Simulations were also run to test model performance under various climatic regimes by using meteorological datasets²⁵ for 30 centres in eastern Australia, between Cooktown and Wagga Wagga (Lott, 1998). Therefore, having been subject to this degree of validation, calibration and verification, there can be a reasonable degree of confidence in the reliability of predictions made by the FSIM model.

3. Model Runs

Three 'runs' of the FSIM model were completed to determine modelled manure pad moisture conditions. The electronic data files modelled by the program will be forwarded to Homes Earth Sciences.

- **Run 1 – base data**

Holmes Air Sciences provided E.A. Systems with base data regarding feedlot characteristics

- **Run 2 – manure depth 50 mm**

The maximum manure depth was increased to 50 mm from the supplied base data for 25 mm. From previous industry experience, E.A. Systems believe that a maximum manure depth of 50 mm is more realistic. Maintaining manure depths at 25 mm will require a intensive works and manure removal program.

- **Run 3 – manure depth 50 mm, pen slope 3%**

In addition to an increase of manure depth, industry experience has indicated to E.A. Systems that a pen slope of 3% is more appropriate than the suggested 2%. This increase in slope will improved pen draining conditions, and hence drying conditions. This will result in a decrease in both the intensity and duration of odour events.

²⁴ Monitoring included pluviometer, hydrograph (from flumes with a rotary drum recorder), potential evaporation, manure moisture content and manure bulk density measurements

²⁵ Meteorological datasets varied in length between 9 years (Wentworth) and 113 years (Tamworth) with most >25 years in length

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APPENDIX D
DISCUSSION OF RATIO BETWEEN WIND TUNNEL AND FLUX HOOD
MEASUREMENTS (FROM RANGERS VALLEY STUDY)

Information provided to the DEC and Department of Planning as part of the Rangers Valley Feedlot Expansion project.

Emissions from Flux Hoods and Wind Tunnels

Odour emissions from area sources measured using wind tunnels are typically higher than those measured using isolation flux hoods. The difference between the two methods is due largely to the fact that wind tunnels sample with a much higher flow rate and are believed to draw odour from the source. The ratio of the wind tunnel to flux hood odour emission rates is of interest for the Rangers Valley Feedlot Expansion study as an odour emission model (**Lunney and Smith, 1994**), which is based on measurements using wind tunnels, has been used to estimate odour emissions from the feedlot. In order to compare dispersion modelling results with current NSW EPA odour criteria the resultant odour emissions from the odour emissions model need to be adjusted to account for the disparity between the two measurement techniques. A review of the information available on the differences between the two techniques is provided below. The conclusions of this review were that there was an order of magnitude difference between the two techniques.

Review of information on emissions from flux hoods vs wind tunnels

This section summarises the available information on the differences in odour emission rates measured by wind tunnels and isolation flux hoods. The investigation is to develop an adjustment factor for emissions from cattle feedlot pen surfaces to provide an overall emission rate which is consistent with the NSW EPA ambient odour criteria.

There has been considerable debate in the scientific community on the appropriateness of the isolation flux hood and the wind tunnel for measurements of emissions from area sources. Measurements can be quite similar or can vary by a factor of 200. The difficulty in interpreting these differences has been compounded by the fact that odour emission rates from cattle feedlots are highly variable and will be dependent amongst other factors upon temperature and moisture content of the feedlot pad. It is highly unlikely that there will be one factor which covers all emission situations from a cattle feedlot pad.

In previous studies we have argued that the measurements made with a wind tunnel, which can be two orders of magnitude higher than those measured with an isolation flux hood, may be representative of emissions under unstable atmospheric conditions while the isolation flux hood is more representative of emissions under stable atmospheric conditions (**Holmes, 1999**). It is under stable atmospheric conditions that maximum impacts usually occur because of poor dispersion, although emissions may be higher under warm unstable conditions, the emissions will disperse much more rapidly.

For the assessment of Rangers Valley an emissions model developed by Smith and Lunney was used. This model is based on emissions that were measured under daytime conditions in a warm climate. These emissions are likely to be representative of emissions under neutral to unstable atmospheric conditions. What the model does not capture are emissions under cooler and stable conditions. As noted above these are the atmospheric conditions with poorest dispersion and if these atmospheric conditions are coupled with emissions that are too high for those conditions then the dispersion model will over-predict.

Table D1 provides a summary of odour emissions from pen surfaces at Australian feedlots. They are measurements made with isolation flux hoods and wind tunnels. The measurements made with isolation flux hoods are much less comprehensive than those made with wind tunnels. Further, the measurements made with flux hoods were generally with a less sensitive method of olfactometry. Olfactometry has generally increased in sensitivity by a factor of about 10 over the past 5-10 years based on changes in odour thresholds for H₂S (**AWT, person. comm.**)

Table D1 : Measurements of odour emissions from pen surfaces at Australian feedlots

Location	Emission rate (ou m ³ /m ² /s)	Sampling method	Pad moisture content (% db)	Source
Peechelba, Vic	0.11	Flux hood	N/A	Ross 1989
Cannon Hill, Qld	0.5 to 2.0	Flux hood	35 to 85	Carson & Round 1990
Kerwee, Qld	13 to 700	Wind tunnel	35 to 183	Watts 1992
Yanco, NSW	5 to 21	Wind tunnel	Dry to moist	Freeman 1992

It is interesting to note that the measurements made with the wind tunnel at Yanco Feedlot, which were made during the cooler months, were substantially lower than those made at the Kerwee Feedlot in Queensland which range from 13 to 700. The measurements with the isolation flux hoods were substantially lower again, about two orders of magnitude.

We are not aware of any studies where there have been side-by-side comparisons of the isolation flux hood and the wind tunnel on cattle feedlot pen surfaces. There is one study that we are aware of in NSW on sewage treatment plant sources and these data are summarised in **Table D2**. These results were provided by Matt Davies of Sinclair Knight Merz and they consisted of a comparison of a US EPA style flux hood with a wind tunnel. Two sewage treatment plants were investigated and two sources at each were measured. The ratios here range between 60 and almost 200. However not all source types are accounted for in this study.

Table D2 : Odour measurements at various STPs in May 1999

Source	US EPA Hood (Odour units)	Wind Tunnel (Odour units)	Odour Concentration (ou)				Ratio of SOER (wind tunnel/flux hood)
			US EPA Hood		Wind Tunnel		
			Flow rate/square metre (m/s)	Specific odour emission rate (ou.m/s)	Flow rate/square metre (m/s)	Specific odour emission rate (ou.m/s)	
Cessnock – settling tank			3.42E-04	3.59E+00	9.38E-02	4.02E+02	1.12E+02
Cessnock – humus tank	720	480	3.42E-04	2.46E-01	9.38E-02	4.60E+01	1.87E+02
Kurri Kurri – inlet works	6610	1450	3.42E-04	2.26E+00	9.38E-02	1.36E+02	6.02E+01
Kurri Kurri – settling tank	2460	1720	3.42E-04	8.41E-01	9.38E-02	1.61E+02	1.92E+02

A pragmatic approach was adopted for the Gerroa STP (**Holmes, 2001**) where initial modelling for the EIA had been undertaken with wind tunnel measurements and assessed against an odour goal of 15 ou 99.5 percentiles with no peak to means factors. This was a guideline developed by Sydney Water based on odour complaint data. The EPA requested that the STP be assessed according to their criteria. A review of data collected at other STPs indicated that there was about a 20 fold overall difference in odour emission rates comparing wind tunnel with isolation flux hoods. When the assumed emission rates were divided by 20 and peak-to-mean (P/M) included, the 2 ou 99th percentile corresponded reasonably well to the 15 ou 99.5th percentile with no peaking factors

Studies have also been undertaken by the Centre for Waste Water Treatment (**Jiang and Kaye, 1996**) looking at emissions of pure compounds from area sources. These studies compared emissions of acetone, methyl ethyl ketone and toluene and results are provided in **Table D3**. The differences range from very little to a factor of about 6.

Table D3 : Specific emission rates (SER) for model compounds

Sampling method	Isolation chamber (mg/min-m ²)	Wind tunnel system (mg/min-m ²)	SER - Ratio
<i>Acetone</i>			
Experiment 1	80.3	351.9	0.151
Experiment 2	115	652.8	0.176
<i>Methyl Ethyl Ketone</i>			
Experiment 1	0.373	0.802	0.465
Experiment 2	0.458	0.618	0.741
<i>Toluene</i>			
Experiment 1	0.569	0.650	0.875
Experiment 2	0.679	0.619	1.096
Experiment 3	0.658	0.681	0.966

Jiang, (2002) also referred to a comparison of the total odour emission rate (TOER) using an isolation chamber (flux hood) and a wind tunnel for odour emissions from sources associated with piggeries. This study suggests that the ratio of wind tunnel odour emission rates to flux hood odour emission rates is of the order of 20. While the study did not present any supporting data, it is consistent with other available data.

In summary, the factors for adjusting wind tunnel data to isolation flux hood data range from 1 to 200 where comparative studies have been made. It is clear however, that even when differences in odour measurement methodology are allowed, emissions from feedlots surfaces are higher if a wind tunnel is used than if an isolation flux hood is used, therefore a factor of more than 1 is appropriate.

The feedlot odour emissions model as it stands is based on an empirical formula derived from measured emission rates. These emission rates have been, to some extent, verified by back calculation from ambient measurements under reasonably controlled conditions where the emissions from small areas of specially constructed

pens have been measured by both wind tunnel and ambient measurements. We believe these measurements are the best available but that they relate to neutral to unstable atmospheric conditions and therefore do not capture the “bottom end” of the range. For this reason the model will over predict. We also believe that the wind tunnel does not capture the bottom end of the range and does not represent emissions under quiescent conditions. The isolation flux hood measurements under these conditions are likely to be more suitable.

A suggested way forward is based on the following:

- Available data for cattle feedlots shows one to two orders of magnitude difference between measurements made with flux hoods and wind tunnels
- Side-by side measurements from a range of liquid surfaces shows a similar range of differences
- There is unlikely to be one factor which fits all circumstances and all source types
- A pragmatic approach for a sewage treatment plant has been to divide wind tunnel emissions by a factor of 20 to provide consistency with the NSW EPA odour criteria
- A similarly pragmatic approach is suggested here and a factor in the order of ten to twenty is suggested. This is based on (a) the fact that typically, reported emissions from cattle feedlots are two orders of magnitude higher for wind tunnels measurements than for flux hood measurements and (b) at the time the odour measurement technology used to analyse the flux hood data was less sensitive than the method used to analyse the wind tunnel data by about one order of magnitude. This leaves one order of magnitude difference between the two methods.

A factor of 20 has been used in the past, a factor of 10 is likely to be overly conservative, and therefore a factor of 15 is proposed as a reasonable “fit” to reality, while still providing a level of conservatism.

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APPENDIX E
DETERMINATION OF APPROPRIATE ODOUR
CRITERIA FOR EACH RECEPTOR LOCATION

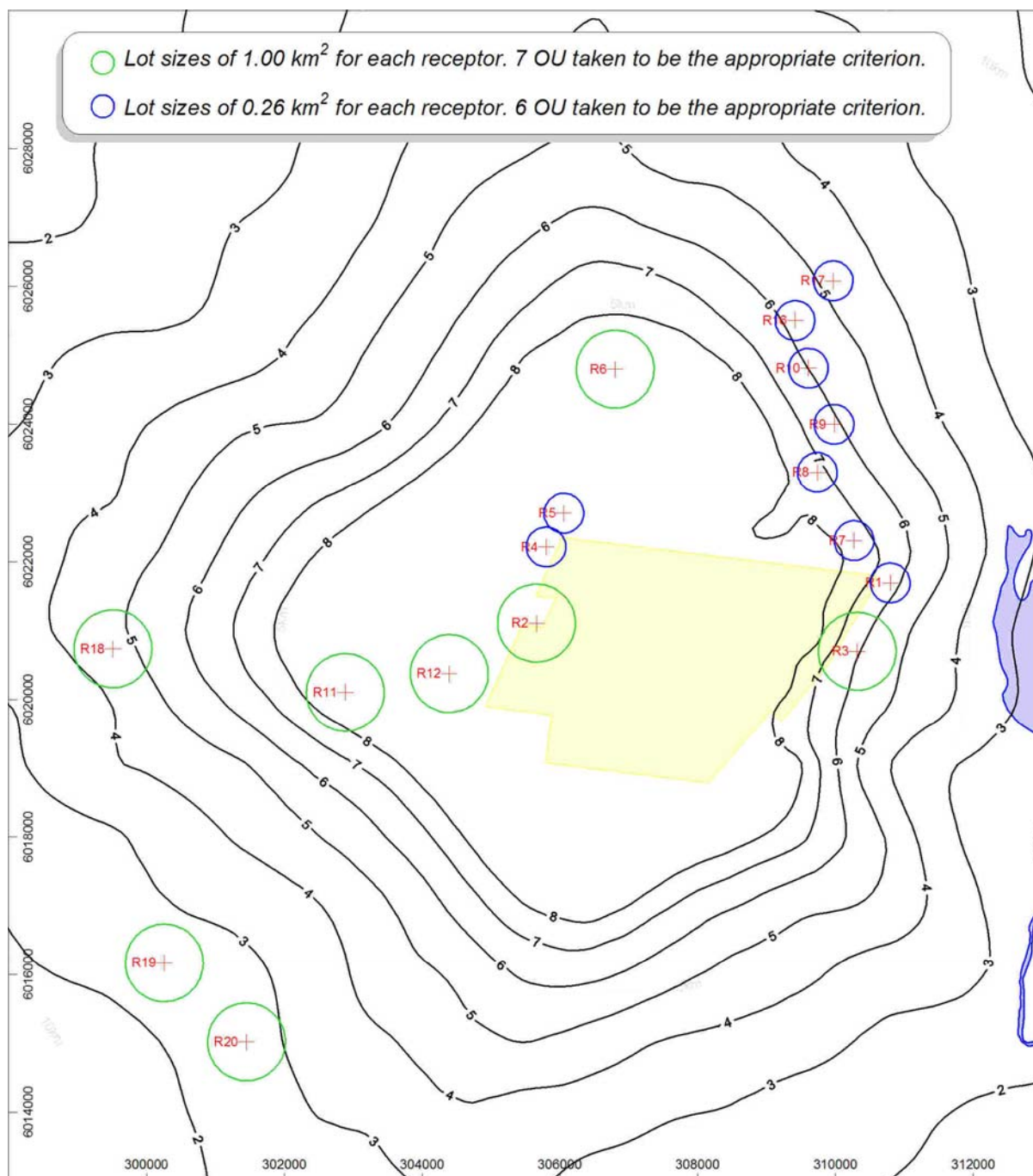
Determination of appropriate odour criteria for each receptor location

For this project each population density band listed in the DEC odour criteria has been taken to apply per square kilometre in order to determine a single odour criterion for each receptor location. A single residence, with an odour criterion of 7 odour units, has been assumed to occupy a minimum lot size of 1 km². For a population density of 10 people (per km²) and with an odour criterion of 6 odour units, a lot size of approximately 0.26 km² results when it is assumed that there are 2.6 people per lot. This approach can be used to work out approximate lot sizes for the 5, 4, 3 and 2 odour criteria with their associated population densities.

The plot below has been created in order to determine appropriate odour criterion for each rural residence surrounding the proposed feedlot site, based on the above methodology. Green circles were constructed around each receptor location to define an area of 1 km². If the circle surrounding a receptor did not overlap any circle of another receptor then the appropriate odour criterion was taken to be 7 odour units (at the 99th percentile). However, if two 1 km² circles overlapped then the size of the circles was reduced to define 0.26 km² (shown as blue circles) and 6 odour units was taken to apply at the two receptors.

The analysis has resulted in the following odour criteria being applied for this project:

- 7 odour units at the 99th percentile for R2, R3, R6, R11, R12, R18, R19
- 6 odour units at the 99th percentile for R1, R4, R5, R7, R8, R9, R10, R16, R17

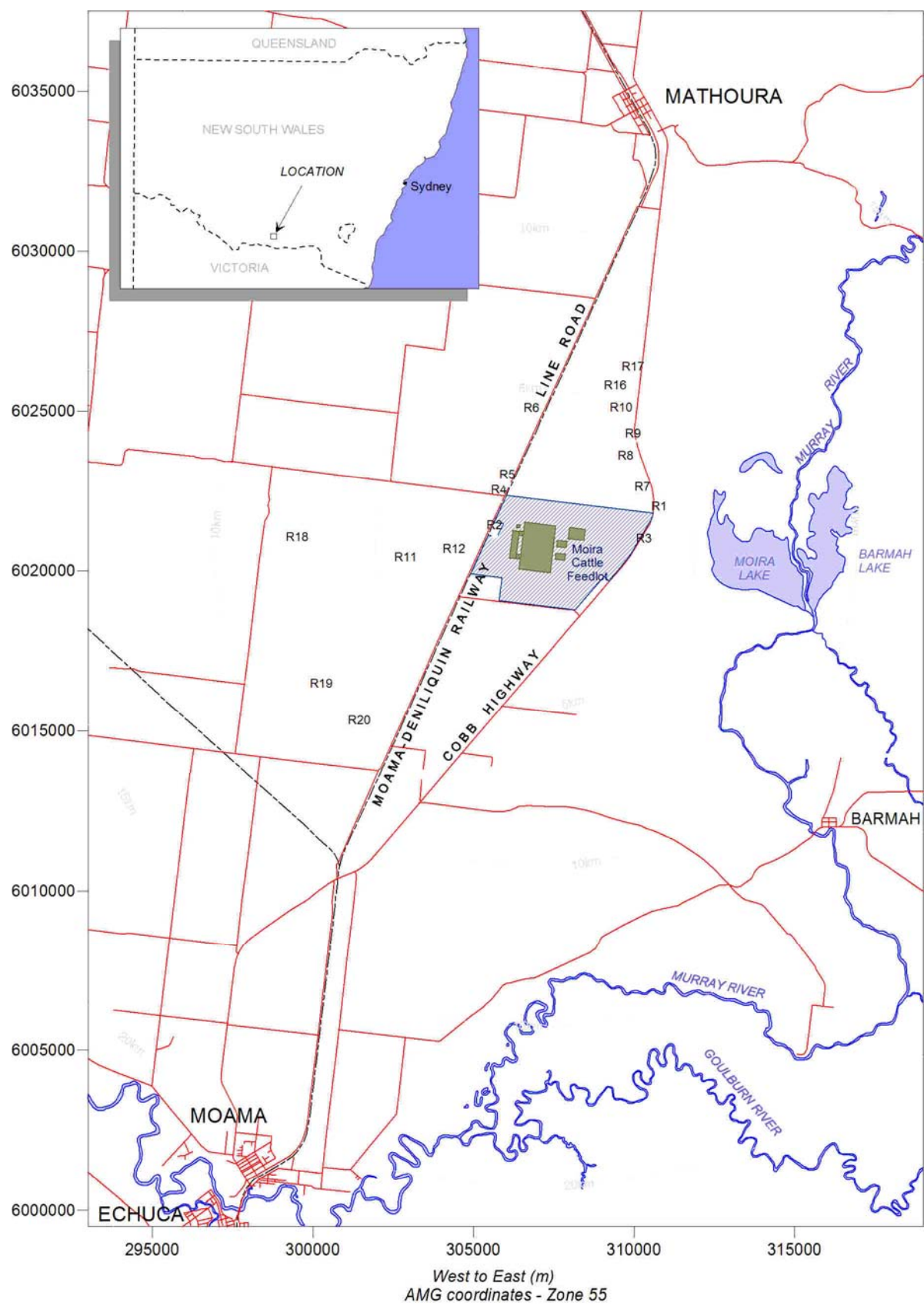


Odour levels at the 99th percentile

Predicted odour levels due to Moira feedlot (odour units)

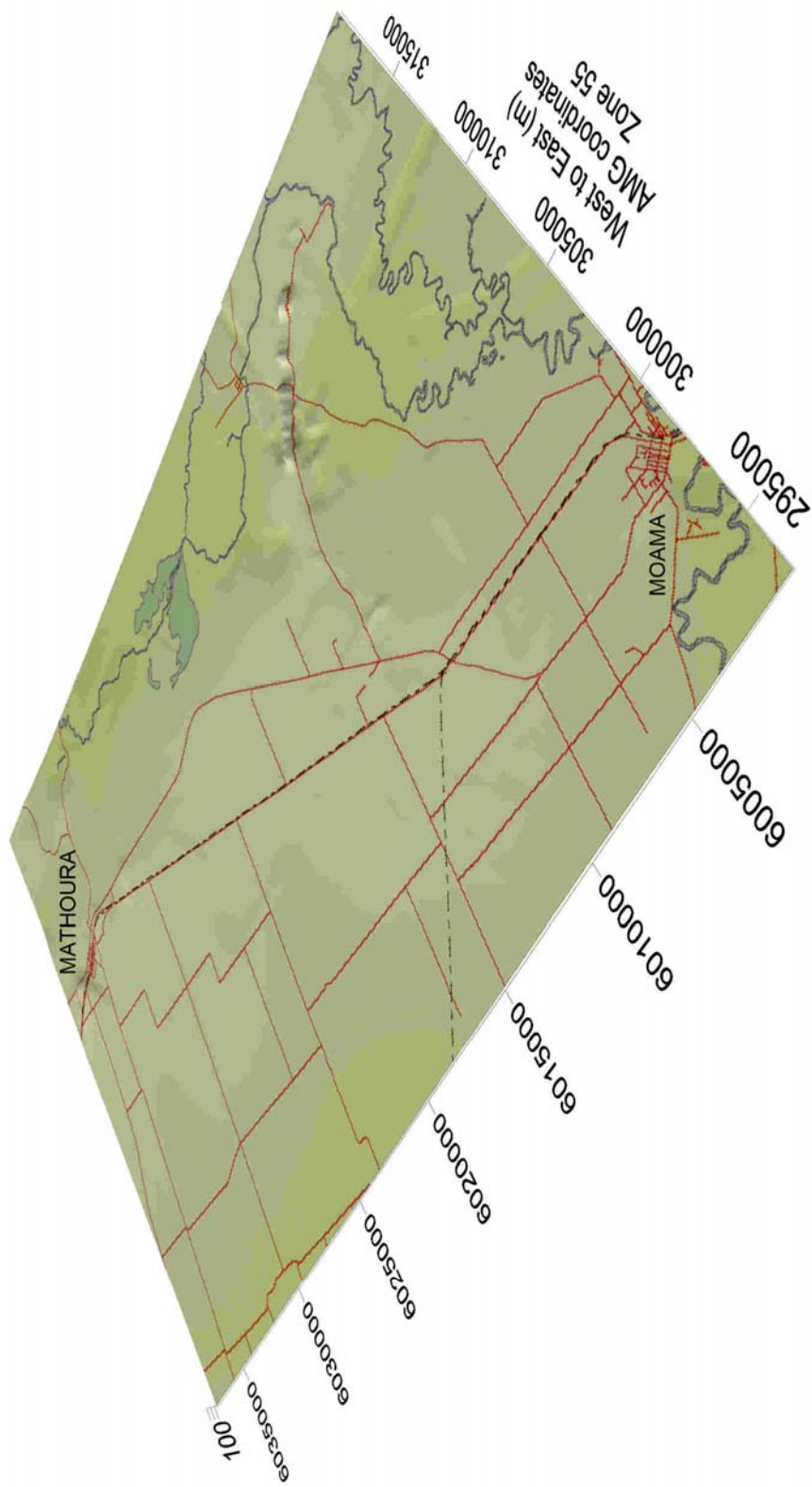
Variable odour emission rate from odour emissions model. Run 2. CALPUFF

FIGURES



Location of study area

FIGURE 1



Pseudo 3-dimensional representation of study area

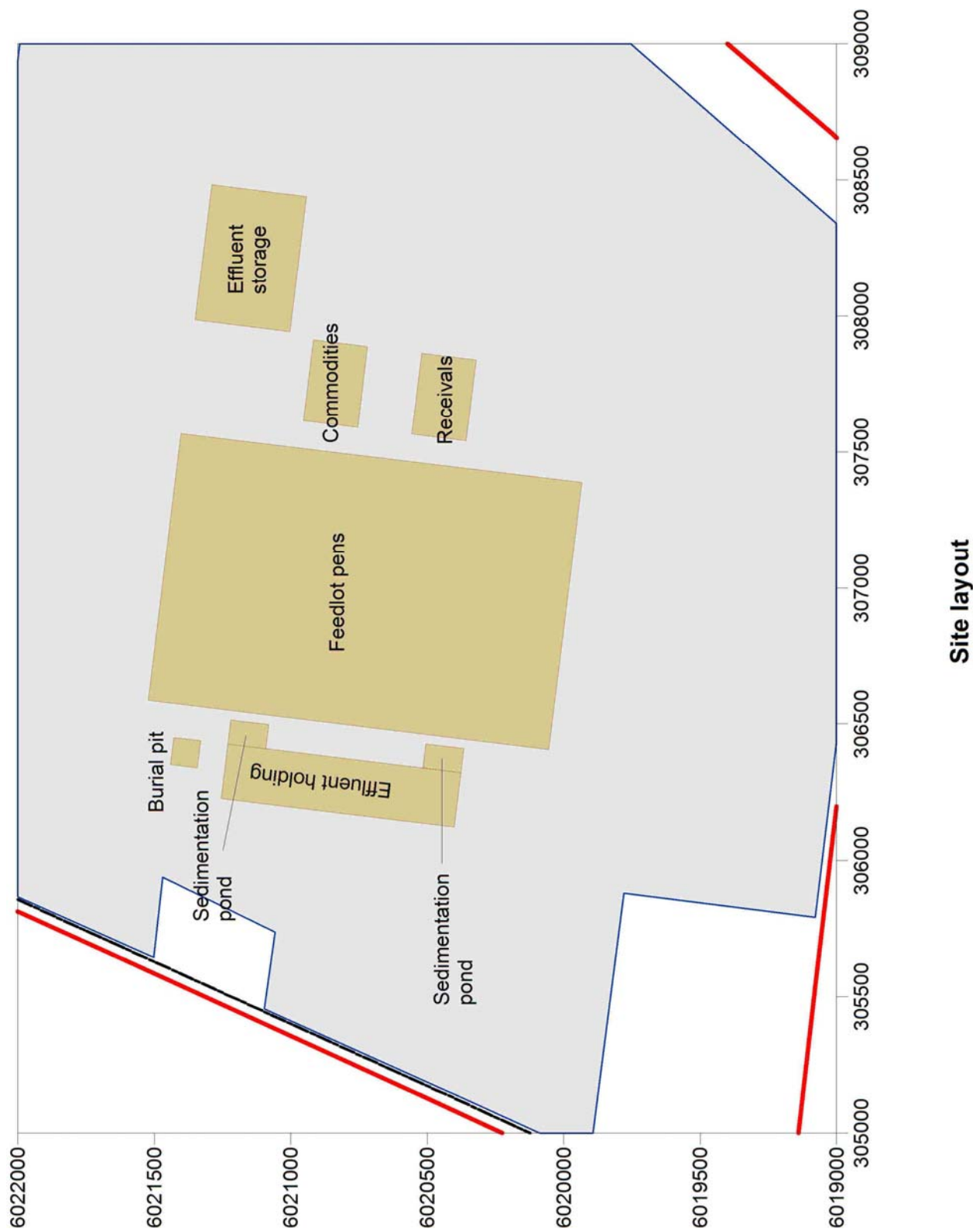


FIGURE 3

Annual and Seasonal Windroses for Moira 2003 (TAPM)

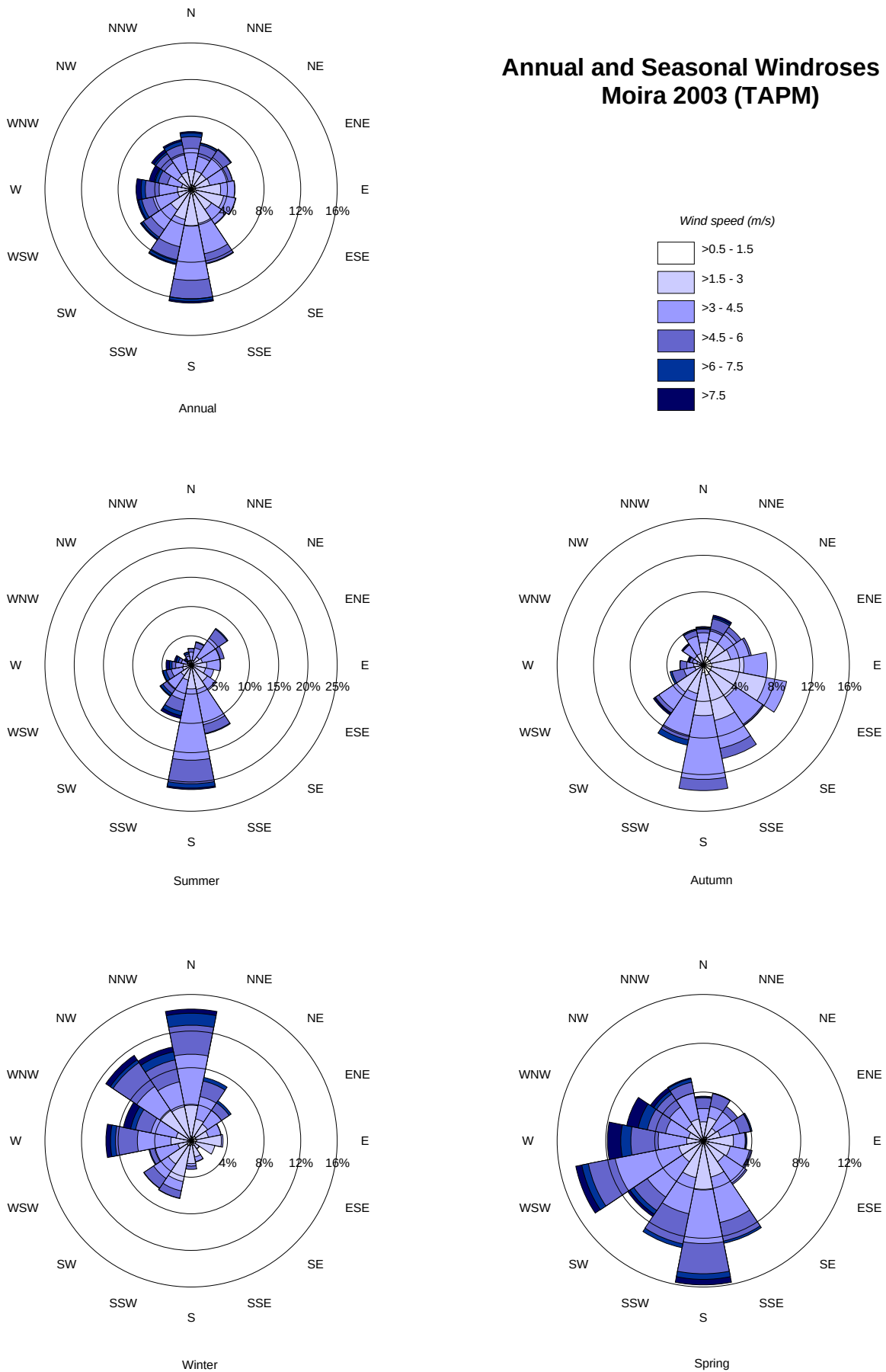
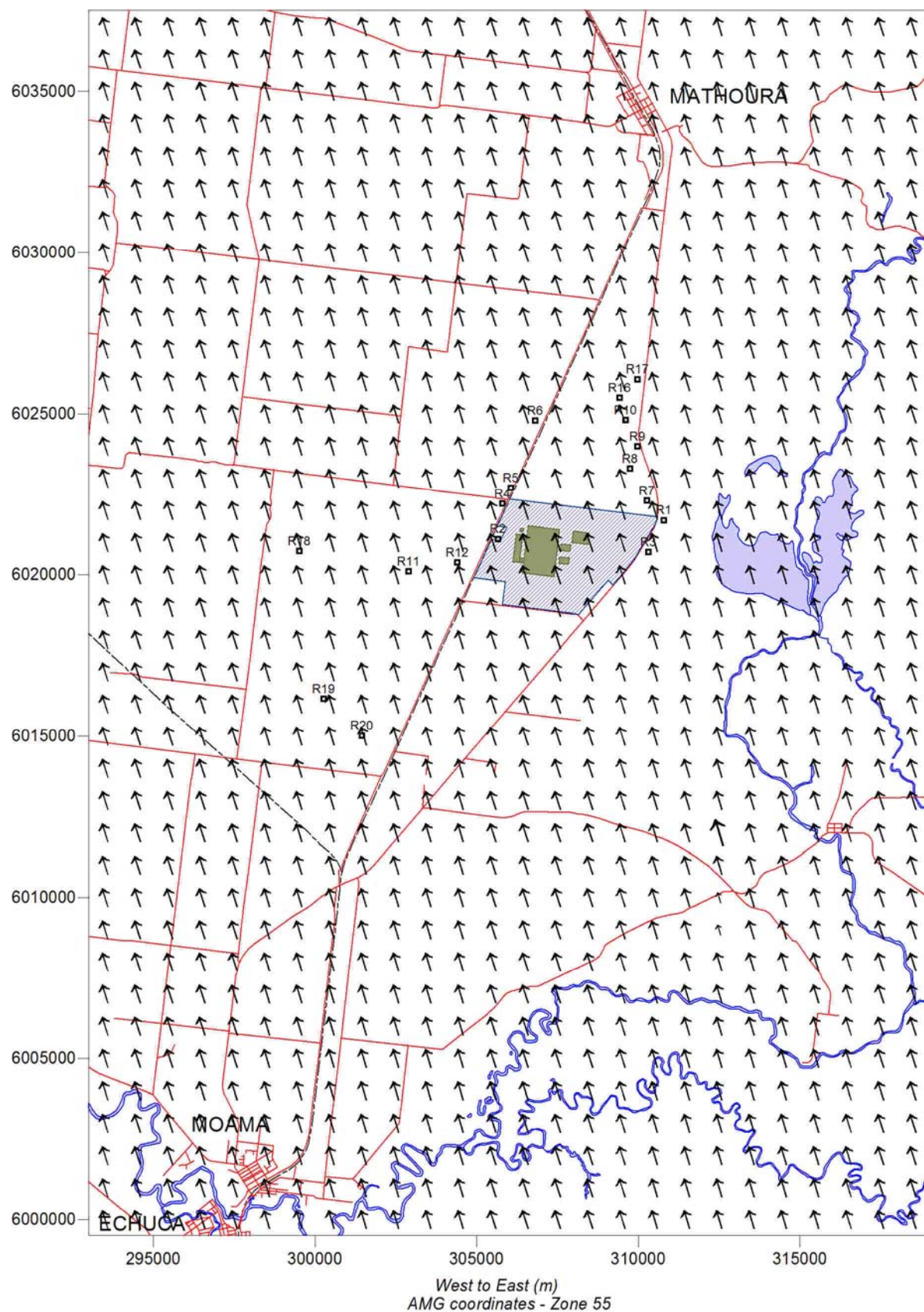


FIGURE 4



**Snapshot of wind patterns as simulated by CALMET
(Hour 1 of 3 Jan 2003)**

Variable odour emissions as determined by the odour emissions model for Run 1

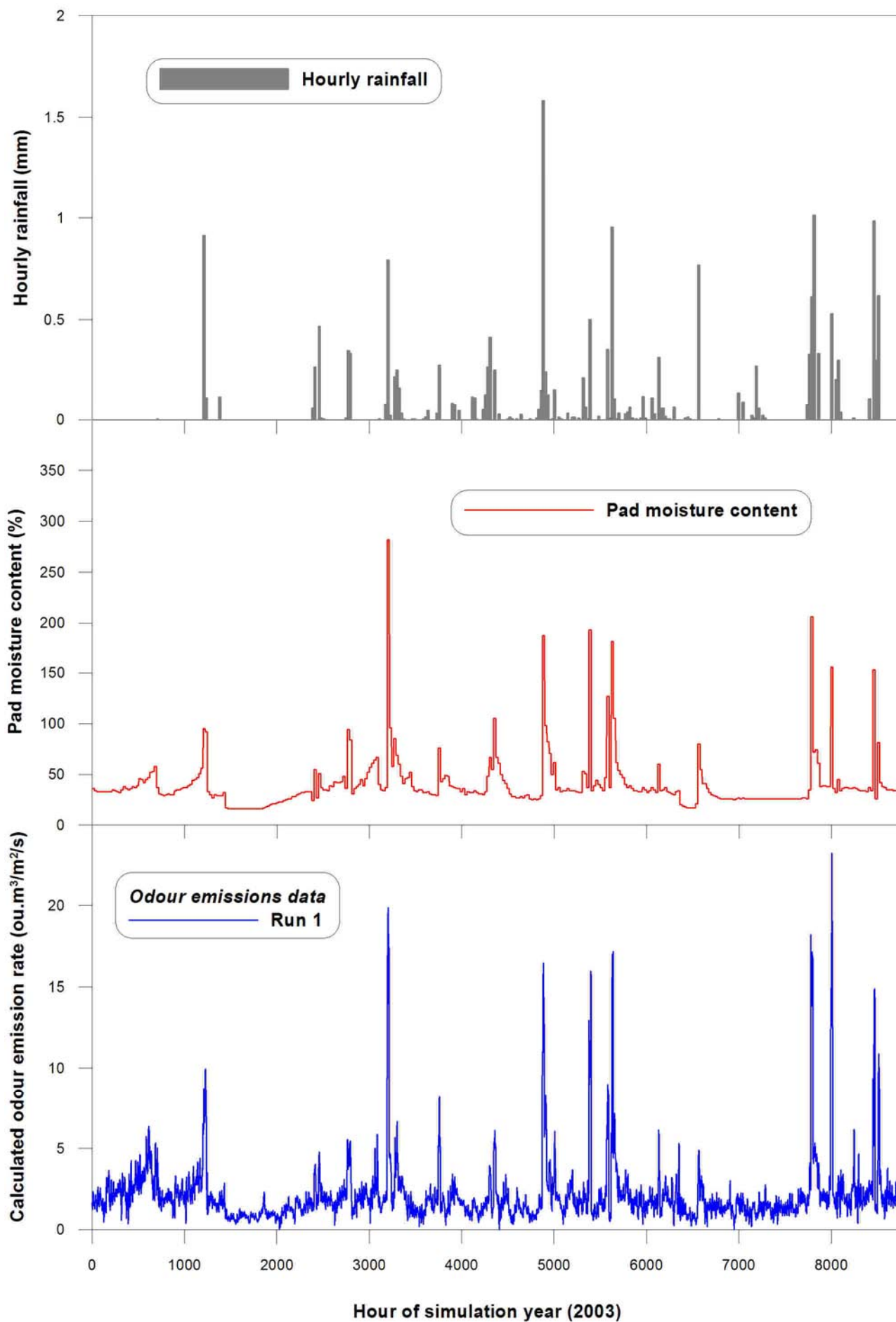


FIGURE 6

Variable odour emissions as determined by the odour emissions model for Run 2

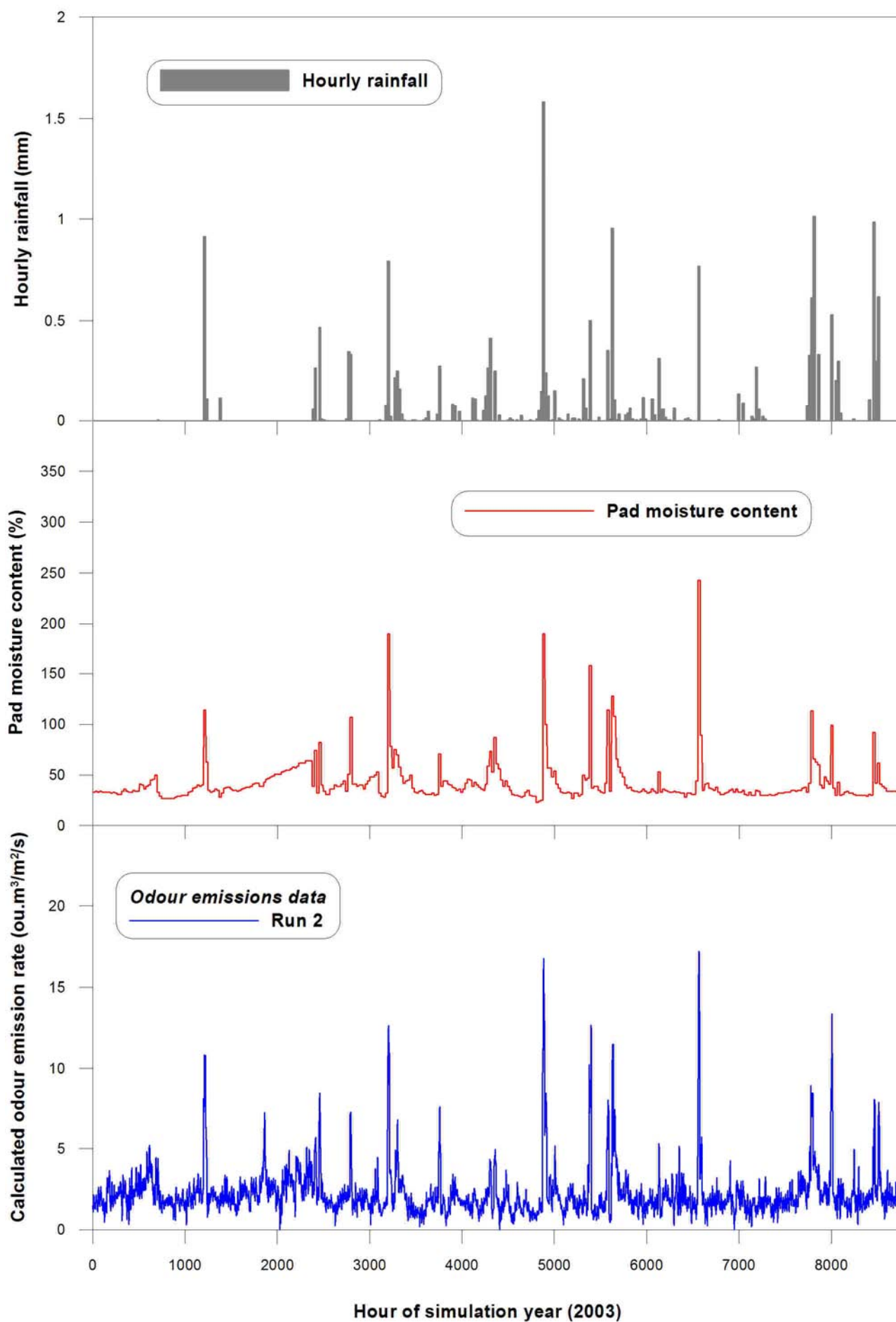


FIGURE 7

Variable odour emissions as determined by the odour emissions model for Run 3

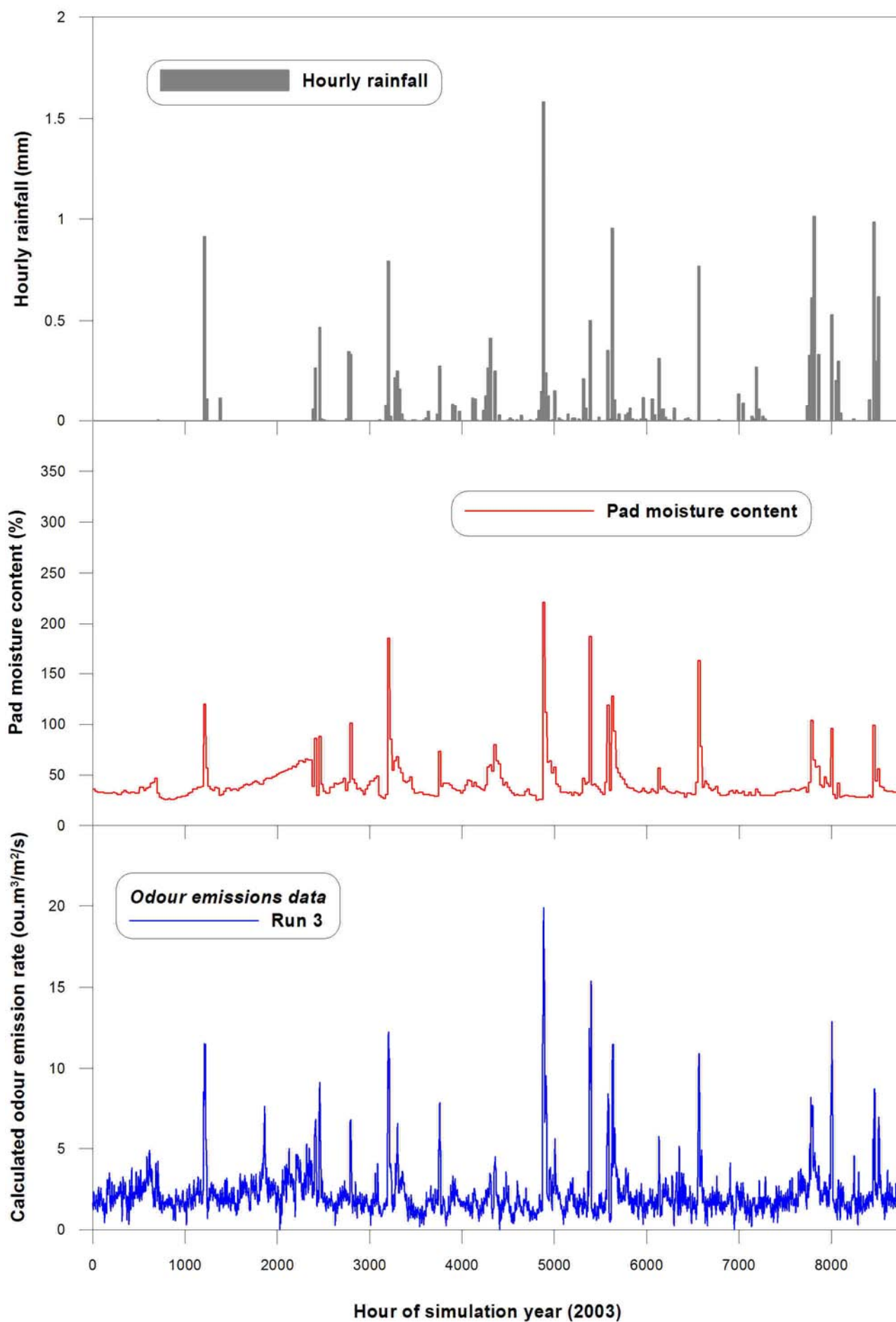
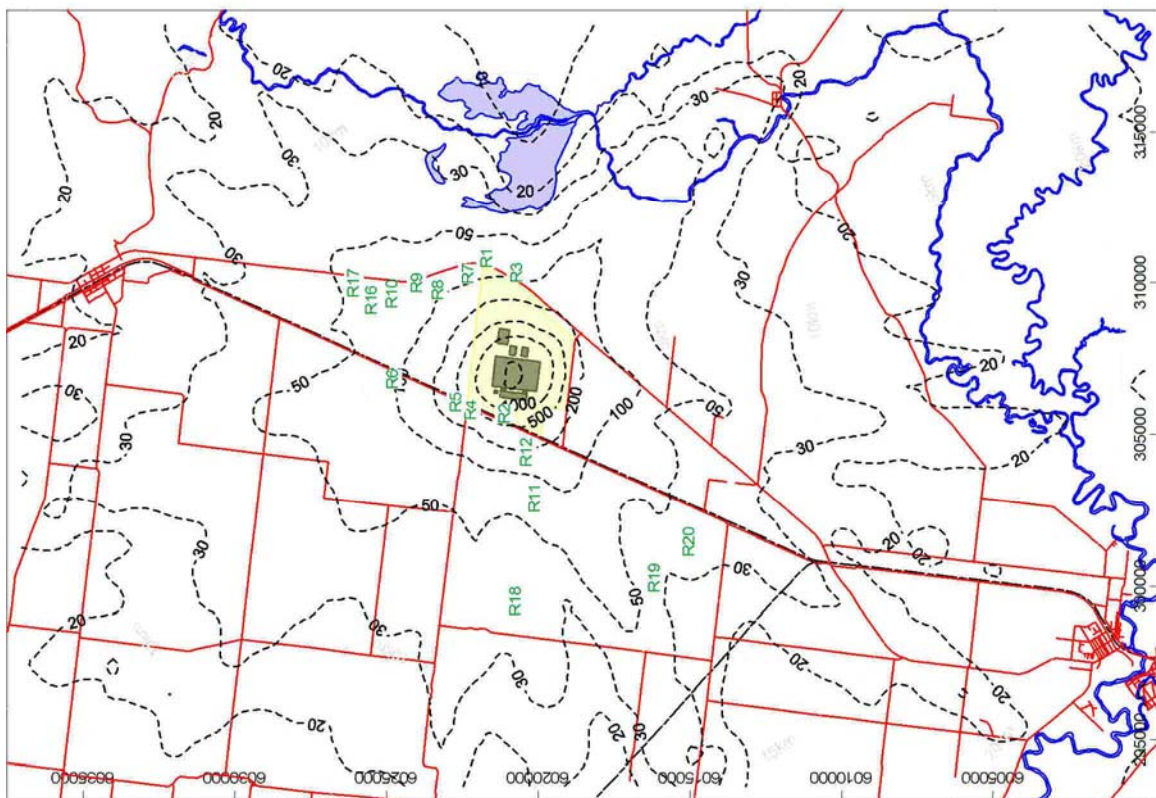
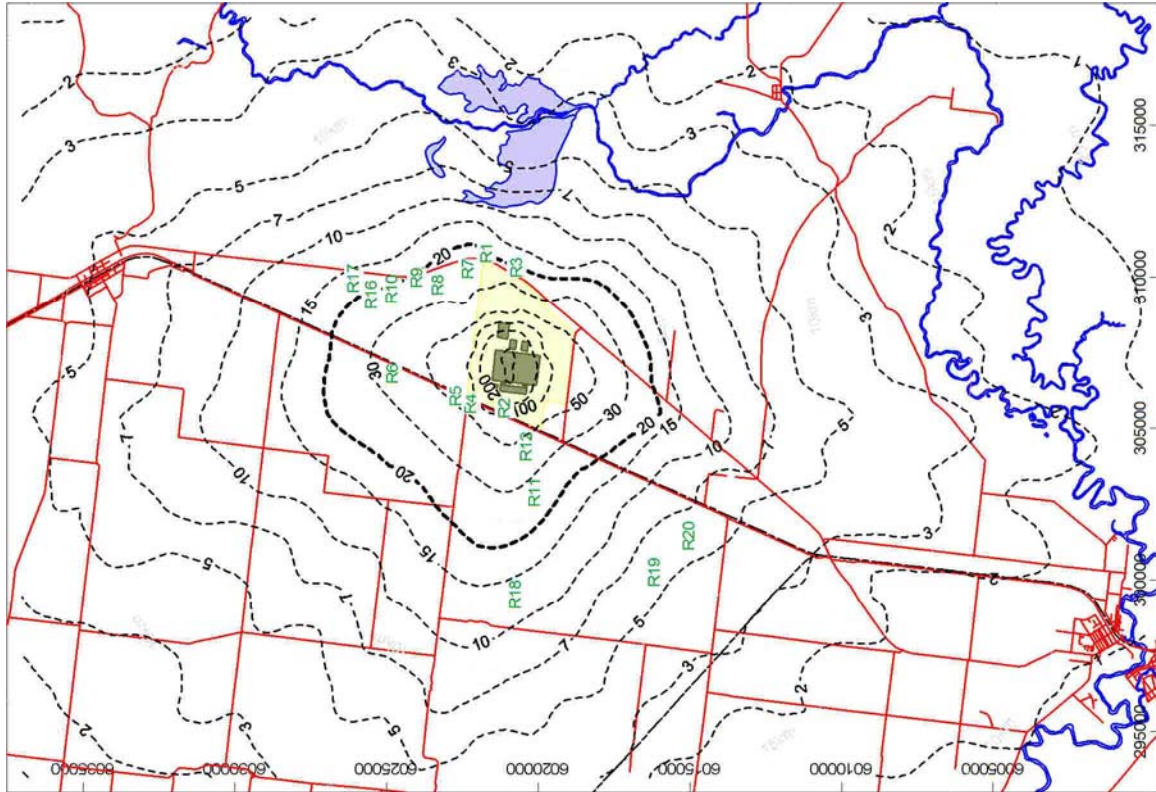


FIGURE 8

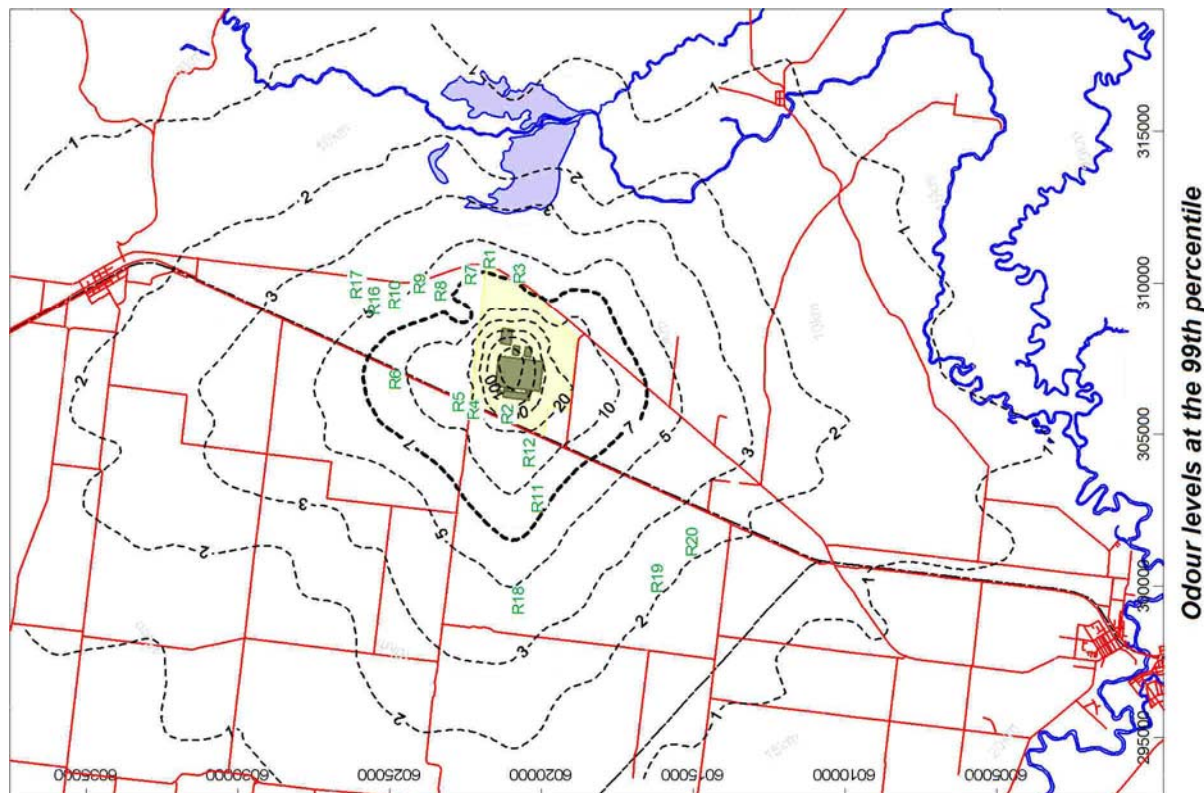
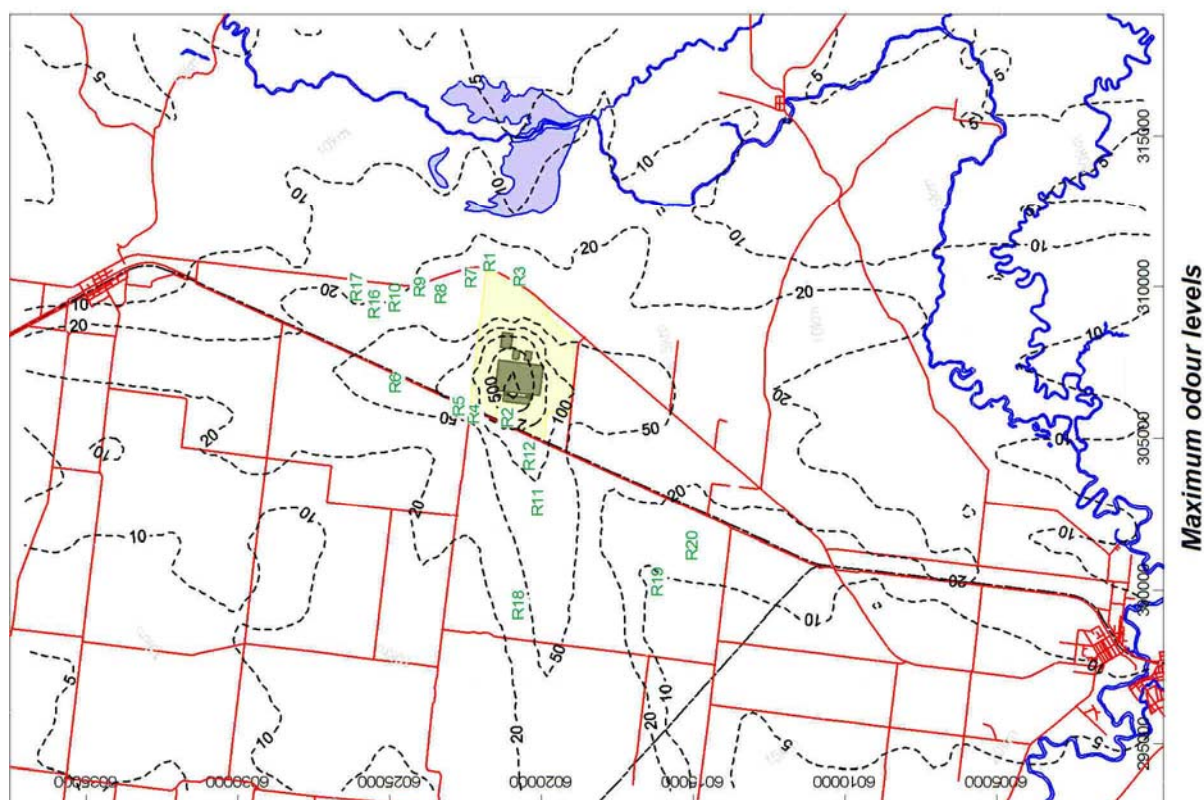


Maximum odour levels

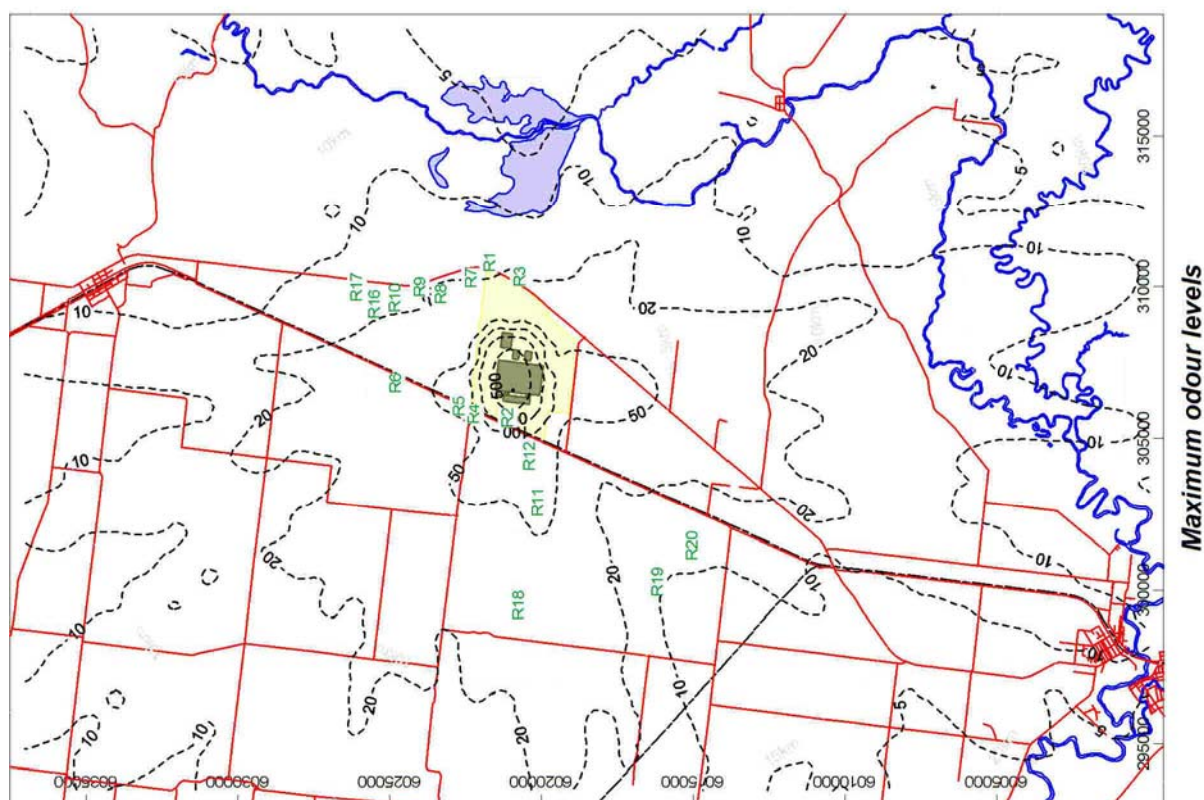


Odour levels at the 99th percentile

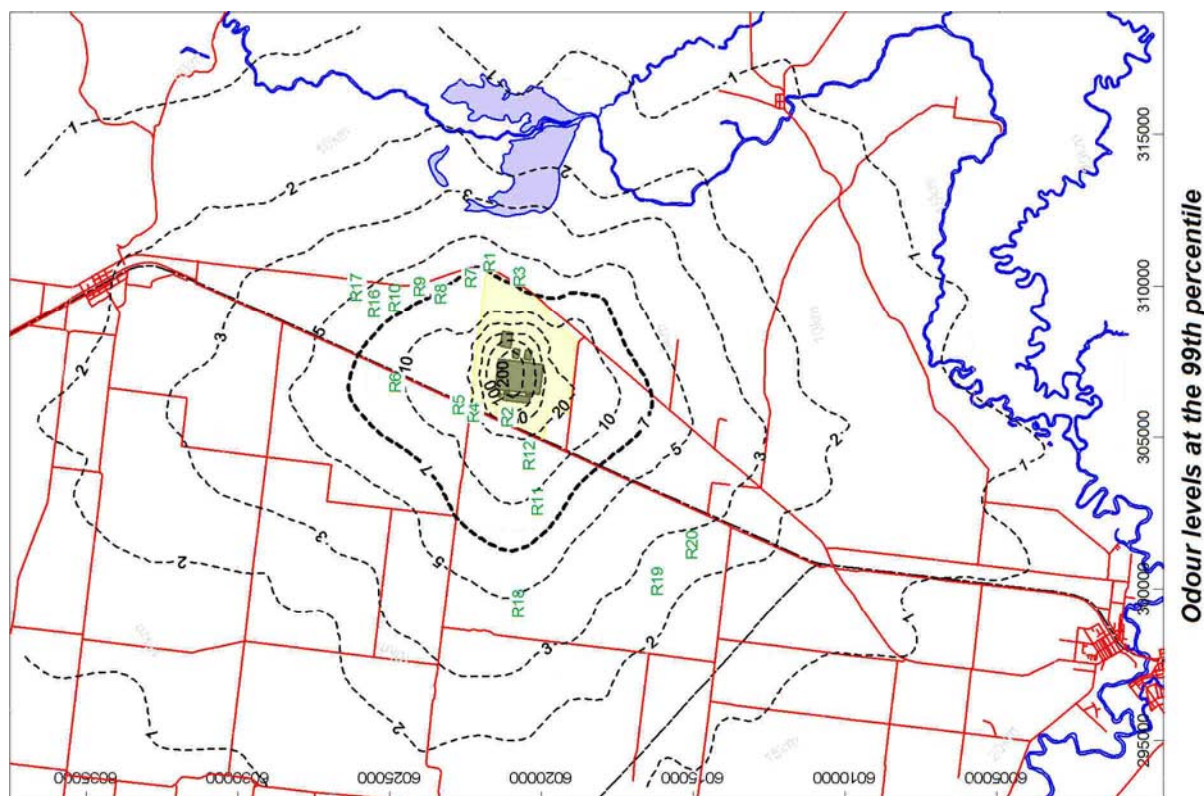
Predicted odour levels due to Moira feedlot (odour units)
 Constant odour emission rate of 5 ou.m³/m²/s. CALPUFF



Predicted odour levels due to Moira feedlot (odour units)
Variable odour emission rate from odour emissions model. Run 1. CALPUFF

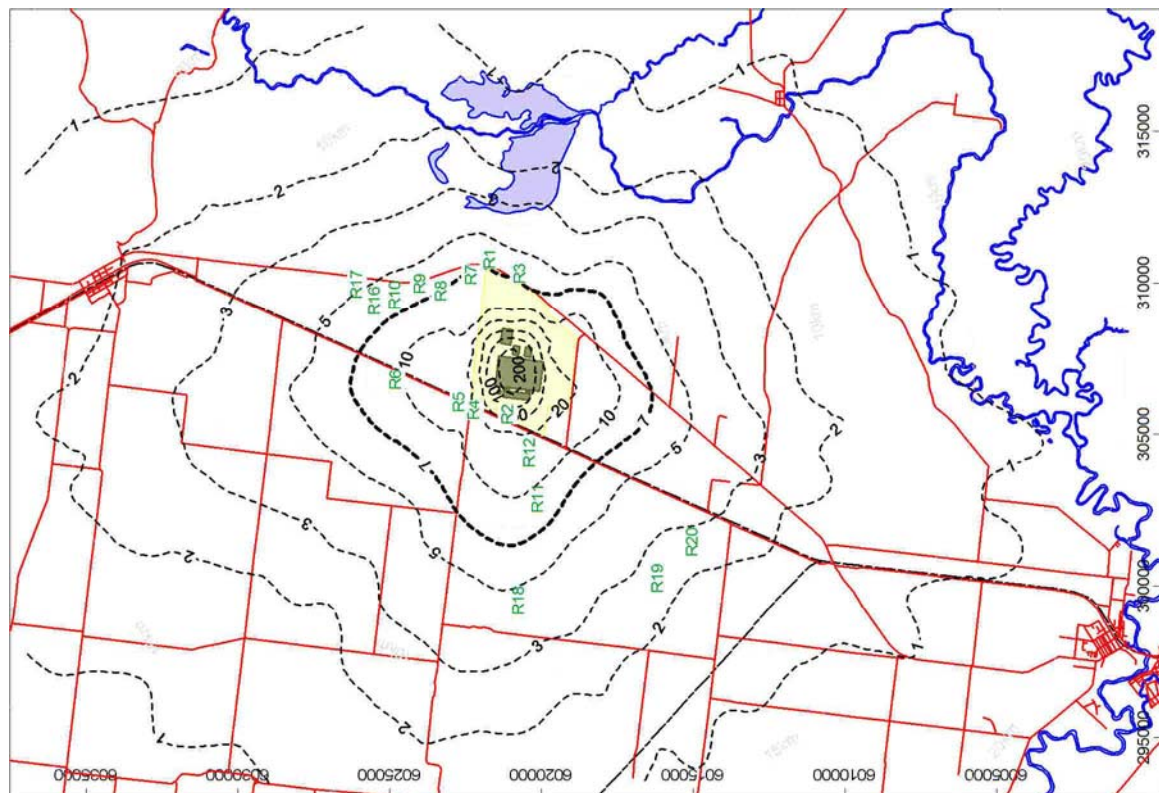


Maximum odour levels

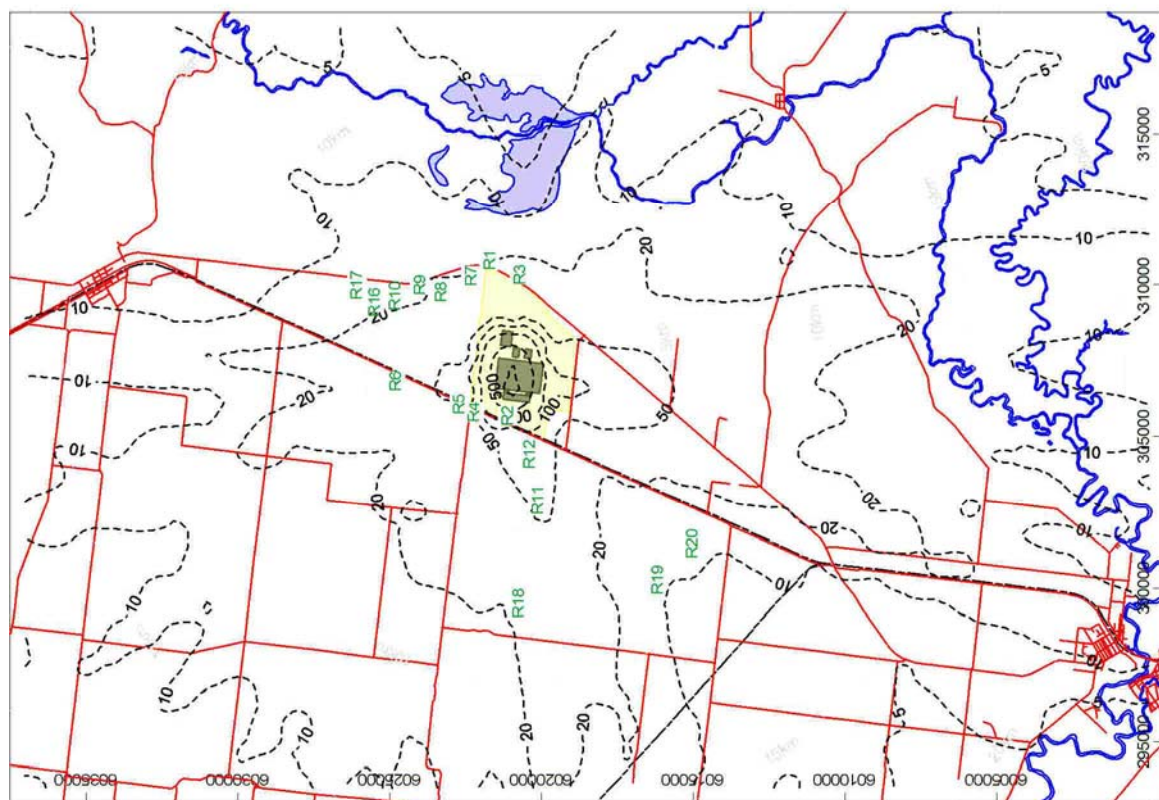


Odour levels at the 99th percentile

Predicted odour levels due to Moira feedlot (odour units)
Variable odour emission rate from odour emissions model. Run 2. CALPUFF

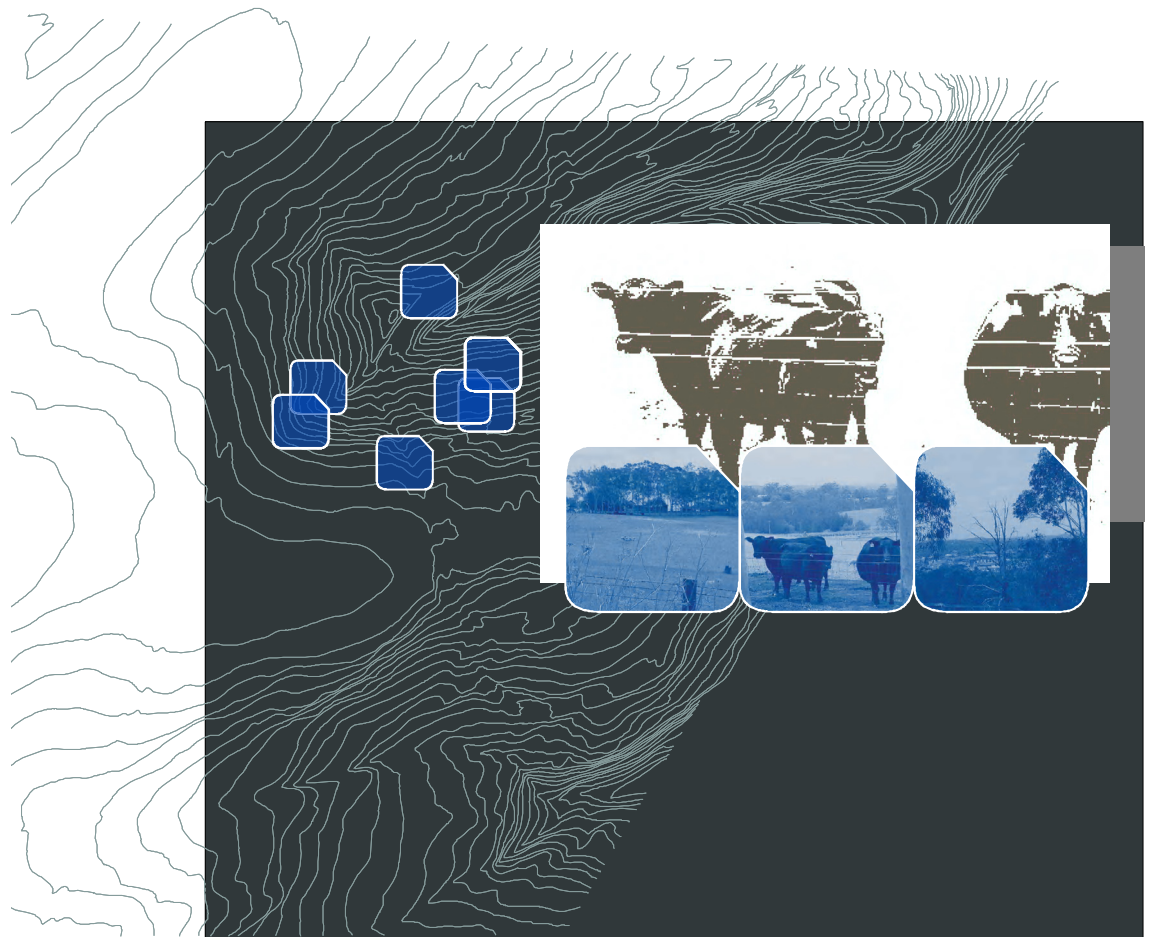


Odour levels at the 99th percentile



Maximum odour levels

Predicted odour levels due to Moira feedlot (odour units)
Variable odour emission rate from odour emissions model. Run 3. CALPUFF



appendix d

preliminary geotechnical investigation



Agricultural Equity Investments Pty
Ltd

**Proposed 80,000 Head Feedlot at
"Moira Station", Mathoura**

Preliminary Geotechnical Investigation

Report



July 2005



GHD LongMac
Consulting geotechnical engineers and geologists

12 July 2005

Agricultural Investments Pty Ltd
Suite 22B The Lindfield Centre, 12 Tyron Road
LINDFIELD NSW 2070

Our ref: 21/13507//AW095 Rev 2.doc

Attn: Mr Tony Camphin

Dear Tony

**Proposed 80,000 Head Feedlot at "Moir Station", Mathoura
Preliminary Geotechnical Investigation**

We are pleased to present herein an update of our report on the above geotechnical investigation. This report includes a summary of our previously reported discussion and recommendations (Rev 0, dated 6 May 2005) and minor changes from the Rev 1 report issued 26 June 2005.

The factual results of the field investigation and laboratory testing are presented, together with comments and recommendations in relation to expected excavation characteristics, effluent and fresh water-retaining structures, groundwater levels, and discussion of subsurface conditions with respect to design and construction issues.

We trust that this report is satisfactory for your needs. Please contact either of the undersigned should you have any questions in regard to this report or require further assistance with this project.

Yours faithfully
GHD-LongMac

Prepared by

Reviewed by

Richard Chandler
Senior Geotechnical Engineer

Tony Colenbrander
Operations Manager



Controlled Document No. 1

PRELIMINARY GEOTECHNICAL INVESTIGATION

for

PROPOSED 80,000 HEAD FEEDLOT AT "MOIRA STATION", MATHOURA

for

AGRICULTURAL EQUITY INVESTMENTS PTY LTD

REF: 21/13507/

DATE: 12 July 2005

Rev No. 2



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Figure

Figure 1 Test Location Plan



Standard Sheets

General Notes
Glossary of Symbols
Soil Description
Rock Description
Laboratory Testing

Appendices

- A Profile Logs (TP01 to TP32 and BH01)
- B Geotechnical Laboratory Test Results
- C Agricultural Laboratory Test Results

1. Introduction

This report presents the results of geotechnical investigation conducted for the proposed 80,000 head cattle feedlot located at "Moirra Station", Mathoura, southern NSW. Mr Tony Camphin of Agricultural Equity Investments Pty Ltd (AEI) commissioned the investigation on the basis of our proposal dated 20 January 2005 (GHD-LongMac reference AV952).

We understand that as part of the approvals process for the proposed development, an Environment Impact Statement (EIS) is required. We understand that HLA Envirosiences Pty Ltd will prepare the EIS and that this report will be included as an appendix to the EIS document.

The objectives of the geotechnical investigation were to

- ▶ Assess geotechnical issues for water-retaining structures (freshwater and effluent storage dams, sedimentation and holding ponds/basins, compacted earthworks embankments), feedlot pens, commodities and receivals areas.
- ▶ Provide a general discussion on groundwater issues.
- ▶ Undertake a limited assessment of soil issues for the proposed effluent/ wastewater irrigation areas.

Mr Chris Kelly of Frank Rennick and Co. provided GHD-LongMac with preliminary layout drawings prepared prior to the commencement of the field investigation, showing the main components of the proposed development. These drawings were subsequently updated on 21 February 2005 and have been used for the geotechnical assessment and presentation of information. Frank Rennick and Co provided information on the proposed depths of excavation and embankment heights for the various dams and ponds proposed for the site.

This report should be read in conjunction with the attached General Notes.

2. Proposed 80,000 Head Cattle Feedlot

The proposed project involves the establishment of a cattle feedlot with the following main components:

- ▶ Feedlot Pens for 80,000 head of cattle covering an area of approximately 145 hectares;
- ▶ A Freshwater Storage Dam of 1000 MI capacity involving site excavation to a depth of 2 metres (approximately 700 metres x 450 metres);
- ▶ A Receivals and Commodity area covering approximately 12 hectares;
- ▶ Two Freshwater Basins involving site excavation to a depth of 3.5 metres (each approximately 120 metres x 190 metres);
- ▶ An Effluent Storage Dam (wastewater/irrigation storage dam) of approximately 800 MI involving site excavation to a depth of 2 metres (approximately 850 metres x 400 metres);
- ▶ A Holding Pond involving site excavation to a depth of 6.4 metres (approximately 170 metres x 860 metres);
- ▶ Four Sedimentation Ponds (located near the holding pond) involving site excavation to a depth of 4.6 metres (each approximately 60 metres x 100 metres);
- ▶ A Burial Pit located near the Feedlot Pens and the Holding Pond; and
- ▶ A number of Effluent (wastewater) Irrigation Areas covering a total of approximately 380 hectares. These irrigation areas have been identified by Frank Rennick and Co. as Irrigation Areas 1 to 5, with individual areas ranging from 23.6 hectares (No. 5) to 140.0 hectares (No. 3). With the exception of most of Irrigation Area 3, the irrigation areas proposed for the development are currently developed for flood irrigation.

The layout of the proposed development based is shown on Figure 1.

3. Method of Investigation

3.1 Preliminaries

Prior to commencement of the fieldwork the following was undertaken:

- ▶ Discussions with Murray Irrigation with regard to background/groundwater information for the area.
- ▶ Collation of geological and topographic information covering the area.
- ▶ On site discussions with the “Moira Station” farm manager, Mr Brian Salmon, regarding the position of any underground services on the property.

3.2 Summary of Geotechnical Factors

The geotechnical assessment was undertaken to provide information on the following:

- ▶ General subsurface conditions in the feedlot pen, pond, dam, basin, and receivals and commodities areas.
- ▶ Excavation conditions in the Effluent Storage Dam (wastewater/irrigation storage dam), Freshwater Storage Dam, Sedimentation Pond, Holding Pond and Freshwater Basin areas.
- ▶ Suitability of the proposed excavated material for use as compacted earthworks.
- ▶ Batter angles for compacted earthwork embankments and cut slopes.
- ▶ Foundation preparation for proposed fill areas.
- ▶ Permeability of excavated material proposed for compacted earthworks.
- ▶ Soil compaction requirements.

3.3 Summary of Agricultural Issues

The investigation in the proposed effluent disposal/irrigation area was undertaken to provide factual information on the following:

- ▶ General subsurface conditions.
- ▶ Insitu permeability of the near surface soils.
- ▶ Chemical composition of the near surface soils for agricultural purposes (selected analytes).
- ▶ Near surface groundwater conditions.

3.4 Fieldwork

A series of test pits, numbered (TP01 to TP32), were excavated between 16 and 21 February 2005 under the full time supervision of a geotechnical engineer from GHD Long-Mac. The test pit locations were distributed over the entire proposed development area. The depth of excavation at each test pit location was determined on the basis of type of facility and depth of excavation (if any) proposed at the investigation location. The depth of the test pit excavations ranged from 2.0 metres at TP07 (Irrigation Area) to 5.5 metres at TP01 (Holding

Pond). A 20 tonne Komatsu excavator (PC 200 LC) provided by "Moir Station" was used to excavate the test pits.

A borehole (BH01) was drilled in the vicinity of the proposed Holding Pond at the western end of the site to a depth of 12.0 metres. A standpipe piezometer was installed at this location to about the maximum depth of the borehole.

The borehole was advanced through the soil profile by auger drilling using solid flight augers fitted with a V bit. Standard Penetration Tests (SPT) were undertaken at 2 metres intervals commencing at a depth of 2 metres to assess the strength (consistency) of the soils encountered by the borehole.

Percolation tests were undertaken at three locations within the proposed irrigation area (test pits TP07, TP23 and TP30) to assess the permeability of the near surface soils. These tests were mainly undertaken in the sandy clay topsoil/disturbed horizon and the immediately underlying high plasticity clay. The percolation tests involved the drilling of a 100 mm diameter hand auger borehole to the underside of the topsoil layer, "saturation" with water, and monitoring water levels over time.

The location of the test pits and the borehole are shown on the attached Figure 1. The test pits and borehole were located in the field by GPS measurements, with reference to the corner peg for each of the proposed facilities (placed by Mr Chris Kelley of Frank Rennick and Co.) and nearby site features such as fences and irrigation channels. The co-ordinates shown of the test pit and borehole log sheets are the GPS co-ordinates obtained in the field, and are therefore approximate.

The surface levels shown on the log sheets were interpolated from the contour levels shown on the Frank Rennick and Co. drawings; with reference to the plotted location based on the GPS co-ordinates. The surface levels shown on the log sheets are therefore approximate.

The borehole and test pit logs are contained in Appendix A. These should be read in conjunction with the attached Standard Sheets which explain the terms, abbreviations and symbols used together with an explanation of the logging procedures and their limitations.

3.5 Groundwater Monitoring

A standpipe piezometer was installed at borehole BH01 to monitor near surface ground water conditions in the vicinity of the proposed Holding Pond. The screened section at this location was placed over the base three metres of the borehole (about 9m to 12m deep). This standpipe was constructed with a fine gravel surround over the screened section and with clay cuttings above it.

On 22nd February 2005 groundwater readings were taken at two bores that were installed at some time prior to the current geotechnical investigation. These bores are identified as follows:

- ▶ A Department of Land and Water Conservation (DLWC) Bore No. 473, located near the north eastern corner of the property in the Cobb Highway road reserve.
- ▶ An "Unnamed Bore" (125 mm diameter PVC casing) located immediately south of the disused shearing shed/ruins and adjacent to a gravel access road within the property. Installation details for this bore are not known, except that it extends to a maximum

depth of 29.2 metres below the top of the casing identified by GHD-LongMac during the geotechnical investigation. The top of casing was 0.15 metres above adjacent ground level.

Groundwater was not encountered at any test pit or at borehole BH01 at the time of the field investigation. All the groundwater readings obtained during the investigation are contained in Table 1 in Section 5.2.

3.6 Geotechnical Laboratory Testing

A selection of soil samples was recovered from the test pits and borehole, and returned to our NATA accredited laboratory for testing. A programme of soil classification tests was conducted on the soil samples as a basis for confirming the tactile field soil classifications and providing information for design and construction. This testing comprised the following:

- ▶ Particle Size Distribution.
- ▶ Hydrometer testing for fine particle size distribution.
- ▶ Atterberg Limits and Linear Shrinkage.
- ▶ Emerson Crumb (dispersion) Tests.
- ▶ Field Moisture Content.
- ▶ Standard Compaction.
- ▶ Compacted permeability.

The geotechnical laboratory results are presented in Appendix B.

3.7 Agricultural Laboratory Testing

A number of soil samples were collected from shallow test pits excavated in the existing and proposed irrigation areas and were dispatched to a specialist laboratory for testing of agricultural characteristics.

These “agricultural” soil samples generally comprised topsoil (typically 0 – 0.1m depth) and samples of the underlying clay soils. The maximum “agricultural” soil sample depth was 1.3 metres.

This testing comprised the following:

- ▶ Cation Exchange Capacity (CEC) including exchangeable Sodium (Na), Potassium (K), Magnesium (Mg), Aluminium (Al) and Calcium (Ca).
- ▶ pH.
- ▶ Conductivity.
- ▶ Total Kjeldahl Nitrogen (TKN).
- ▶ Bray Phosphorus.
- ▶ P-Sorp.
- ▶ Organic Matter.

The agricultural laboratory results are presented in Appendix C.

4. Site Conditions and Regional Geology

4.1 Site Description

“Moira Station” is located between Mathoura and Moama/Echuca in southern NSW and occupies an area of approximately 1,200 hectares. The Cobb Highway is located along the eastern property boundary, with Stud Farm Lane to the south and the Moira Irrigation channel to the north. Other agricultural properties and small rural landholdings are located to the west. The property is located approximately 12 km south of Mathoura and approximately 24 km north of Moama/Echuca.

At the time of the field investigation, the property was used for agricultural purposes. This involved flood irrigation, cropping, cattle and sheep grazing. Extensive areas of the property had been laser levelled for flood irrigation. A relatively undisturbed area of the property located south west of the proposed feed pens area and west of Irrigation Area 3, was “swampy” at the time of the field investigation.

4.2 Regional Geology and Soils

Examination of the 1:500,000 Geological Series Sheet for the area (Urana, reference SI 55-13-14, First Edition, 1972) indicates the area is underlain by Quaternary Alluvium comprising sand, silt, clay and gravel. A geomorphic map (1:500,000 Geomorphic Map of the Riverine Plain of South Eastern Australia, 1973), details the nature and position of the alluvial deposits in the area such as Stream Traces. Stream Traces are features identified by aerial photography as indicative of ancient stream flow. The following type of alluvial deposits were identified on the Geomorphic Map at the site:

- ▶ A Plain with Scalds (wind erosion of the surface soils) over the majority of the property.
- ▶ A Confined Stream Trace, greater than 650 metres wide, at the south western corner of the property.
- ▶ An Unconfined Stream Trace along the southern side of the property.

Available information indicates (McNally, 1997), that in engineering terms, the “Stream Trace” materials are typically well-graded, rounded quartz sand, with a small portion of fine gravel. The fines within the “Stream Trace” materials are typically aggregated clay particles, which are dispersive.

4.3 Regional Groundwater

Information on regional groundwater level was obtained from the Cadell Community’s Land and Water Management Plan publication (January 2001) prepared by the Cadell Land and Water Management Plan Working Group. The document was obtained from Murray Irrigation located in Deniliquin.

Figure 2.11b of the plan indicates that groundwater at the site is in the vicinity of 20 metres to 22 metres below the surface.

5. Subsurface Conditions

5.1 Field Investigation

5.1.1 Test Pits and Borehole

Reference should be made to the test pit and borehole logs attached in Appendix A for a detailed description of the subsurface strata encountered at the individual test pit and borehole sites.

In general terms, the investigation confirmed the presence of an alluvial soil profile as indicated by the Geological and Geomorphic sheets. A generalised description of the various strata encountered at the site is given below.

Surface Topsoil/Disturbed Layer

Apart from the topsoil encountered by test pit TP25, the surface layer encountered typically comprised brown, low plasticity sandy clay to a depth of about 0.1 metres. At most of the test locations this surface layer had been formed during construction of the irrigation areas (laser levelling) and with subsequent disturbance by ploughing.

At test pit TP25 the surrounding area appeared relatively undisturbed with a number of large trees in the vicinity. At this location the topsoil comprised dark grey, medium grained clayey sand. The underlying material at test pit TP25, to a depth of 0.3 metres, comprised brown, low plasticity sandy clay, similar in texture to the topsoil encountered over the majority of the site.

Alluvial Clayey Soils

Clayey alluvial soils were encountered at all test pit locations below the topsoil layer. These soils generally comprised high plasticity clay underlain by medium plasticity clay, with layers of sandy clay at some locations. These units are described below:

- ▶ Moist, red-brown or brown, stiff, high plasticity clay containing a trace of fine-grained sand. This material was encountered typically from a depth of 0.1 metres, extending to depths of between 0.7 metres to 1.3 metres. This unit is underlain by:
- ▶ Moist becoming slightly moist at depth, mottled in colour, very stiff, medium plasticity clay containing a trace of fine-grained sand. These materials comprised a mixture of colours including grey brown, red-brown, yellow brown, light grey brown and grey.
- ▶ At a number of locations sandy clay soils were encountered. The layer thickness was not determined at all test pit locations as some test pits were terminated upon the depth capacity of the excavator. The encountered layer thickness ranged from 0.8 metres to greater than 2.5 metres. These materials were typically low or medium plasticity and very stiff. These materials were mottled and comprised a mixture of colours including grey brown, yellow brown, light grey brown, grey, and brown.

At borehole BH01 (Holding Pond Area) clay soils were encountered to a depth of 7.0 metres. These clay soils were consistent with the clay soils encountered by the adjacent test pits.

Alluvial Sandy Soils

Sandy soils were encountered in test pits TP25 (below 2.9 metres), TP26 (between 3.0 metres and 4.3 metres), TP27 (below 2.0 metres), and TP32 (below 2.3 metres). Interbedded sand and clay layers were encountered by borehole BH01 below a depth of 7.0 metres. The sandy soils typically comprised light grey and yellow brown, fine to medium grained sand. Clayey sand material was encountered in test pit TP26 (between 3.0 metres and 4.3 metres) and borehole BH01 (between 9.8 metres and 10.0 metres).

Alluvial Silty Soils

Sandy silt soils were encountered in test pit TP29 between the depths of 2.3 metres and 3.2 metres. The materials above and below this layer were medium plasticity clay.

5.1.2 Percolation Tests

The percolation tests indicate that ploughing and land forming have disturbed the surface sandy clay topsoil layer, and that the permeability of the immediately underlying material is consistent with high plasticity clay soils.

5.2 Groundwater

The groundwater levels noted during the geotechnical investigation are summarised in the following table.

Table 1 Recorded Groundwater Levels Below Ground Level

Borehole Number	Maximum Borehole Depth (m)	Groundwater Depth After Drilling (m)	Groundwater Depth on 21 February 2005 (m)	Groundwater Depth on 22 March 2005 (m)
BH01	12.0	Not encountered	-	Not encountered (advised by AEI following a site visit on 22 March 2005)
DLWC Bore No. 473	DLWC record	-	24.70	-
Shearing shed/ruins Bore	29.05	-	19.05	-

5.3 Geotechnical Laboratory Results

The laboratory results are presented in Appendix B and summarised in the following table.

Table 2. Summary of Geotechnical Laboratory Results

Test Pit	Sample Depth (m)	Description	FMC (%)	LL (%)	PI (%)	LS (%)	ECN	SMDD (t/m ³)	SOMC (%)	<2µm (%)	k (m/s)
TP01	0.27 - 0.4	High plasticity, red brown, Clay.	24.7	52	33	13.0	1	-	-	66	-
TP02	5.0 - 5.4	Medium plasticity, grey with yellow brown, Clay.	16.1	36	22	10.5	1	1.79	16.9	47	6x10 ⁻¹¹
TP09	2.0 - 2.5	High plasticity, grey brown, Clay.	21.8	56	37	13.5	1	1.66	22.1	63	8x10 ⁻¹¹
TP13	0.3 - 0.5	High plasticity, red brown, Clay.	26.6	54	33	13.5	1	-	-	68	-
TP16	2.8 - 3.1	High plasticity, grey brown and yellow brown, Clay.	19.4	58	39	14.5	1	-	-	61	-
TP17	1.0 - 1.5	High plasticity, grey brown, Clay.	25.2	59	39	15.0	1	1.61	23.9	58	1x10 ⁻¹⁰
TP19	1.0 - 1.2	High plasticity, grey brown, Clay.	19.8	60	39	18.5	2(M)	1.67	21.5	52	-
TP21	0.5 - 0.6	Medium to high plasticity, red brown, Clay.	22.9	48	28	12.0	1	-	-	38	-
TP21	1.5 - 2.0	Medium to high plasticity, red brown and grey brown, fine grained sand, sandy Clay.	16.9	48	27	14.5	2(M)	1.65	19.7	35	9x10 ⁻¹¹
TP26	3.5 - 4.0	Fine to medium grained, light grey and orange, Sand, with clay.	11.7	-	-	--	-	-	-	10	-
TP28	0.3 - 0.5	High plasticity, red brown, Clay	27.5	61	40	18	1	-	-	59	-
TP28	2.5 - 3.0	High plasticity, grey brown mottled yellow brown, Clay	26.0	66	44	18.5	1	1.59	24.8	58	-

Where: - = not determined PL = plastic limit SMDD = standard max dry density
FMC = field moisture content PI = plasticity index SOMC = standard optimum moisture content
LL = liquid limit PI = LL-PL k = remoulded/compacted permeability
ECN Emerson Class Number LS = linear shrinkage <2µm = % clay

The geotechnical laboratory results are discussed in the following sections.

5.3.1 *Dispersive Soils*

The ECN test results generally were Class 1 with two Class 2(M) samples. These results show that the clay soils at the site are dispersive. Dispersive soils are a known cause of “piping failures” of water-retaining earth embankments, such as dams and ponds. Various methods (both design and construction) need to be adopted to mitigate the impact of dispersive soils. These aspects are discussed in Section 6 of this report.

5.3.2 *Clay Soil Permeability*

Both laboratory permeability tests (falling head) of remoulded soil samples, and particle size distribution tests were undertaken as part of the permeability assessment of the clay soils proposed for compacted earthworks embankments and clay liners. The falling head permeability tests results (four tests undertaken) were in the range of 1×10^{-10} m/sec to 9×10^{-11} m/sec with the samples tested described as medium plasticity clay, high plasticity clay, and medium to high plasticity sandy clay soils. The result for the sandy clay soil sample (test pit TP21, 1.5 to 2.0 metres) was 9×10^{-11} m/sec. It is noted that a value of 1×10^{-9} m/sec is generally considered the maximum value in situations where environmental concerns may be an issue. The falling head permeability test samples were remoulded to a nominal 98% SMDD prior to test.

The percentage of soil particles less than $2\mu\text{m}$ (that is, the “clay” fraction) may be used as an indicator of soil permeability. The results obtained were in the range of 35% to 68%, with most results above approximately 50%. These soil samples were described as medium plasticity or high plasticity clays, with the exception of a medium plasticity sandy clay sample from the Freshwater Dam area (test pit TP21, 1.5 to 2.0 metres). This sandy clay soil has a clay fraction of 34% and approximately 30% sand ($75\mu\text{m}$ to 2.36mm), with the remainder being silt and gravel.

5.3.3 *Atterberg Limits and Soil Plasticity*

Atterberg Limit (Liquid Limit, Plastic Limit and Plasticity Index) and Linear Shrinkage tests were undertaken to assess the plasticity and shrinkage potential of the clay soils at the site. A total of 11 Atterberg Limit and 11 Linear Shrinkage tests were undertaken. The Liquid Limit results were in the range of 36% to 66%, indicating that the clay soils at the site vary from medium plasticity to high plasticity. The red brown clay soils encountered nearer the surface tended to be high plasticity.

The Linear Shrinkage results were in the range of 10.5% to 18.5% with most results above 13%. The higher results (in the range of 15% to 18.5%) were of samples taken from the Freshwater Storage Dam, Effluent Storage Dam and Freshwater Basin areas. The Linear Shrinkage results indicate the clay soils at the site are susceptible to cracking and shrink/swell movements with variations in moisture content. Various methods (both design and construction) may be adopted to mitigate the impact of cracking soils. These aspects are discussed in Section 6 of this report.

5.3.4 Soil Compaction and Field Moisture Content

Compaction tests (maximum dry density and optimum moisture content) and field (in-situ) moisture tests were undertaken as part of the assessment of the clay soils proposed for bulk earthworks. The difference between field moisture content and optimum moisture content can be used as an indication of the amount of moisture conditioning that would be required during construction (and undertaken by the earthworks contractor). It is noted that the in-situ moisture of the soils at the site will vary with rainfall and irrigation practices.

Standard compaction tests were performed on six clay soil samples taken from the Freshwater Storage Dam, Effluent Storage Dam, Holding Pond and Freshwater Basin areas. The standard maximum dry density (SMDD) results ranged from 1.59 t/m³ to 1.79 t/m³ and the optimum moisture content (SOMC) from 16.9% to 24.8%. These results are typical of clayey soils.

A total of 12 Field Moisture tests were undertaken, comprising 11 clay soil samples and one sand soil sample. Of the clay soil samples, the results were in the range of 16.1% to 27.5% indicating generally moist soil conditions at the time of the investigation. It is noted that most of the samples were taken from areas that had been developed for flood irrigation, and it is therefore likely these results are affected by irrigation practices at the site.

5.4 Agricultural Laboratory Results

The agricultural laboratory results are presented in Appendix C and summarised in the following table.

Table 3. Summary of Agricultural Laboratory Results

Test Pit	Depth (m)	Description	CE C (%)	ESP (%)	pH (1:5)	EC (μS/cm)	TKN (mg/kg)	Bray P (mg/kg)	P-Sorp (mg/kg)	OM (%)
TP06	0 – 0.1	Low plasticity, brown, sandy Clay (topsoil)	9.8	1.7	6.0	220	1500	3.9	420	2.5
TP06	0.1 – 0.3	High plasticity, red brown, Clay	9.1	0.7	8.6	1020	630	1.5	480	0.61
TP07	0 – 0.17	Medium plasticity, sandy Clay (topsoil)	14.3	9.8	6.5	210	1600	8.5	450	2.8
TP07	0.2 – 0.4	High plasticity, red brown, Clay	20.3	20.2	8.3	830	700	1.0	430	0.62
TP07	1.1 – 1.3	Medium plasticity, grey brown, Clay	37.5	4.3	7.4	4130	390	2.5	420	0.15
TP23	0 – 0.1	Low plasticity, brown, sandy Clay (topsoil)	8.5	8.5	5.6	210	1700	9.0	440	2.9

Test Pit	Depth (m)	Description	CE C (%)	ESP (%)	pH (1:5)	EC (μS/cm)	TKN (mg/kg)	Bray P (mg/kg)	P-Sorp (mg/kg)	OM (%)
TP23	0.3 – 0.5	High plasticity, red brown, Clay	20.7	18.1	8.0	470	1000	1.0	480	1.5
TP31	0 – 0.13	Low plasticity, brown, sandy Clay (topsoil)	7.8	4.1	5.9	250	1600	15	360	3.3
TP31	0.2 – 0.4	High plasticity, red brown, Clay	18.9	13.3	8.4	190	750	<0.5	500	0.86
TP31	0.8 – 1.0	High plasticity, grey brown and light grey, Clay	16.8	23.8	8.9	390	480	1.5	340	0.2

Where: nt = not determined EC = electrical conductivity P-Sorp = phosphorus soption
 CEC = cation exchange capacity TKN = total Kjeldahl nitrogen OM = organic matter
 ESP = exchangeable sodium % Bray P =Bray phosphorus

We understand that the assessment of the above results will undertake by others.

6. Geotechnical Discussion

6.1 Geotechnical Issues

6.1.1 General

The nature of the proposed development and the investigation undertaken by GHD-LongMac has identified a number of geotechnical issues that need to be considered for the site. These include the following:

- Treatment of dispersive soils.
- Variable subsurface conditions (clayey and sandy soils) and potentially undetected “Stream Traces” within the subsurface profile.
- Clay soil plasticity and cracking potential.
- Soil permeability.
- Stability of compacted earthworks embankments for effluent and water-retaining structures.
- Stability of excavated slopes within effluent and water-retaining structures.
- Compaction and moisture content requirements for bulk earthworks.

Each of these issues is addressed below. In assessing the site, reference should be made to the test pit and borehole logs attached in Appendix A for a detailed description of the encountered subsurface conditions at each test location, and the summary tables contained in this report for information on groundwater levels and laboratory results.

In summary, the investigation typically encountered clayey soils, with some underlying sandy layers at depth of 2.0 metres (TP27) to 7.0 metres (BH01). The clayey soils were assessed as alluvial in nature, consistent with the information shown on the Geological Series Sheet for the area (Urana) and the geomorphic map (Riverine Plain of South Eastern Australia) as detailed in Section 4.2 of this report. The sandy layers were assessed as alluvial deposits known as “Stream Traces” and were contained within the generally clayey subsurface profile. The encountered “Stream Traces” tended to be concentrated near the central part of the site (test pits TP25, TP26, TP27). It is noted that borehole BH01 encountered sand layers below the termination depth of the test pit investigations (due to excavator depth limitations).

The strengths of the alluvial clayey soils are typically in the range stiff to hard, and the sandy soils were typically loose, resulting in frequent sidewall collapse within the test pits within this material. The moisture content of the clay soils was typically moist and likely to have been influenced by irrigation practices at the site.

6.1.2 Dispersive Soils and Sand Layers

The soils at the site are dispersive and are therefore not appropriate for construction of the proposed effluent and water-retaining structures, unless modified or replaced with suitable material. Dispersive soils have been successfully used for construction of water-retaining structures using the following techniques:

- ▶ The addition of an appropriate percentage of gypsum (calcium sulphate) to the clay soil during construction.
- ▶ Stipulation of an appropriate construction specification for bulk earthworks with respect to both compaction and moisture content.
- ▶ Controls and verification during construction to ensure the adopted construction specification and design is followed.

Due to the confirmed presence of sand layers within and below the predominately clay (dispersive) subsurface profile, the presence of sand layers near and within the “cut” area of the reservoirs will need to be further assessed to verify the design and the layout of the facilitates. A “piping failure” through insitu clay material to an adjacent sand layer may be possible if an insufficient depth/distance of clay material separates these material types. At this stage it can be confirmed that sand layers are present in the vicinity of the proposed Holding Pond and Freshwater Basins. The sand layers could also adversely impact on the ability of the dams, ponds and basins to retain water.

For these reasons, and as part of a comprehensive investigation that will be required prior to development, it is recommended that additional geotechnical investigation/survey is undertaken to further assess sand layers and their impact within and adjacent the proposed reservoir areas. This additional work may include:

- ▶ An “electromagnetic” survey to establish the position of sand layers and “Stream Traces”.
- ▶ Drilling of a sufficient number of additional boreholes (to be grouted on completion).

Alternatively, all the dams and ponds could be lined on the assumption that underlying adverse sand layers are present.

Provided appropriate design and construction measures are undertaken, together with any required additional site investigation, the presence of dispersive soils is not expected to be a significant constraint to the proposed development.

6.1.3 *Soil Cracking and Plasticity*

The clay soils encountered by the investigation typically ranged from medium to high plasticity. The Linear Shrinkage results indicate the clay soils at the site are susceptible to cracking and shrink/swell movements with variations in moisture content. Methods that may be adopted to mitigate the impact of cracking soils include:

- ▶ Maintaining water in the reservoirs at all times to prevent drying out of the clay.
- ▶ Modifying the plasticity and shrinkage characteristics of the clay by adding an appropriate percentage of lime or gypsum.
- ▶ Encapsulating higher plasticity material within the placed earthworks.
- ▶ Topsoiling with less plastic material.

Provided appropriate design and construction measures are undertaken, the presence of potentially cracking soils is not expected to be a significant constraint to the proposed development.

6.1.4 Soil Permeability

The permeability and particle size distribution tests undertaken have confirmed the presence of suitable, relatively impermeable, clay soils at the site. The textural and physical characteristics of the tested clay samples indicate that these relatively impermeable clay soils are uniformly distributed across the site.

At the Holding Pond site it has been confirmed (borehole BH01) that a clay liner (or appropriate alternative) is required at the base of the reservoir.

6.1.5 Excavation

Excavation of the ponds, basins and dams to the proposed invert depths is expected to be in predominantly clay soils. Excavation of these materials is expected to be achievable using conventional earthmoving equipment such as excavators, backhoes and scrapers.

6.1.6 Stability of Compacted Earthworks Embankments

Provided the earthworks structures are constructed to an appropriate specification, the following batter slopes are recommended for preliminary design:

- ▶ Fill batters located on the external side of the embankment to be constructed at a slope of 2:1 (Horizontal: Vertical).
- ▶ Fill batters located on the interior side of the embankment (water retaining) to be constructed at a slope of 3:1 (Horizontal: Vertical).

6.1.7 Stability of Excavated Slopes

The following batter slopes are recommended for preliminary design:

- ▶ Cut batters located within the reservoir area to be constructed at a slope of 3:1 (Horizontal: Vertical).

6.1.8 Compaction and Moisture Content for Bulk Earthworks

It is recommended that earthworks is undertaken to an engineering specification prepared for the project. The following is recommended for preliminary design:

- ▶ Compacted earthworks embankments to be placed at a minimum of 95% Standard dry density ratio and at a moisture content between 3% dry and 1% wet of Standard optimum moisture content.
- ▶ Compacted clay liners to be placed at a minimum of 98% Standard dry density ratio and at a moisture content between 3% dry and 1% wet of Standard optimum moisture content.

6.2 Groundwater

Groundwater is expected to underlie the site at a depth of approximately 20 metres to 22 metres and is therefore not expected to be a development constraint.

Reference should be made to Table 1 for the summary of the groundwater levels that were encountered during the investigation. We note that groundwater levels are also subject to seasonal variations and are therefore expected to vary from the levels encountered during the investigation.

6.3 Construction Issues

It is recommended that placed earthworks is tested by a NATA registered soil laboratory at a test frequency appropriate to the development. AS 3798-Guidelines on Earthworks for Commercial and Residential Developments, provide recommendations for test frequencies and compaction levels for various types of developments.

It is recommended that the effluent and water-retaining structures be constructed under the full time presence of a geotechnical engineer/geotechnician on site. This would enable:

- ▶ Inspection and approval of stripped areas prepared by the earthworks contractor for the placement of fill.
- ▶ Confirmation that the earthworks construction techniques are in accordance with specification.
- ▶ Inspection of the reservoir area excavations for sand layers and bands, and input into any design changes that may be subsequently required.

6.4 Further Investigation

Following submission of the EIS document we understand that additional geotechnical investigations will be undertaken as part of the detailed design process.

It is expected that the final layout and design of the facilities will be modified from the preliminary layout (as used by this assessment), to account for sand layers/"Stream Traces" and any other unfavourable subsurface conditions. It is recommended that the additional geotechnical investigation recommended above is to be undertaken at this stage so that appropriate geotechnical design input is proved into the detailed design process.

7. Summary and Conclusions

Based on the results of the preliminary geotechnical investigation undertaken by GHD-LongMac, the following generalised site conditions were encountered. Reference should be made to the relevant sections of the report and appendices for a detailed appreciation of site conditions.

- ▶ Alluvial soils were predominantly encountered by the investigation and these typically comprised clay materials. The clay soils are dispersive and typically of medium plasticity or medium to high plasticity. The test results indicate that the clay soils encountered have a permeability less than 1×10^{-9} m/sec.
- ▶ "Stream Traces" of typically fine to medium grained sandy soils were encountered at a number of test locations. These layers of sandy soil are located within the generally clayey subsurface profile.
- ▶ Alluvial materials were referenced by the geomorphic map and geological sheet for the area.
- ▶ Groundwater is expected to underlie the site at a depth of approximately 20 metres to 22 metres.

Based on the provided preliminary layout drawings and the advised excavation depths and embankment heights, we conclude that the site can be developed for the proposed 80,000 head cattle feedlot provided appropriate design, further geotechnical investigation as required, construction control and verification is undertaken. The development issues are mainly related to effluent and water-retaining structures. These aspects are summarised below. However, reference should be made to the relevant sections of the report for details.

- ▶ The impact of dispersive soils can be mitigated by well-accepted engineering design and control methods. These measures include the modification of clay liners and embankment earthworks with gypsum and adoption of an appropriate construction specification for engineered fill.
- ▶ The impact of sandy soils in the proposed development area can be mitigated by appropriate design, further geotechnical investigation as required, and appropriate construction control and verification. Design measures include the provision of compacted clay liners to seal the effluent and water-retaining structures where "Stream Traces" are present.
- ▶ The impact of potentially cracking clay soils can be mitigated by a number of measures. These include maintaining water or effluent in the reservoirs to prevent drying out of the clay, encapsulating higher plasticity material within the placed earthworks, and/or modifying the plasticity and shrinkage characteristics of the clay by adding an appropriate percentage of lime or gypsum.
- ▶ Groundwater is not expected to be a development constraint.

We conclude from the preliminary geotechnical investigation undertaken that conventional engineering solutions can be adopted to address the geotechnical constraints identified at the site to enable construction of an 80,000 head cattle feedlot.

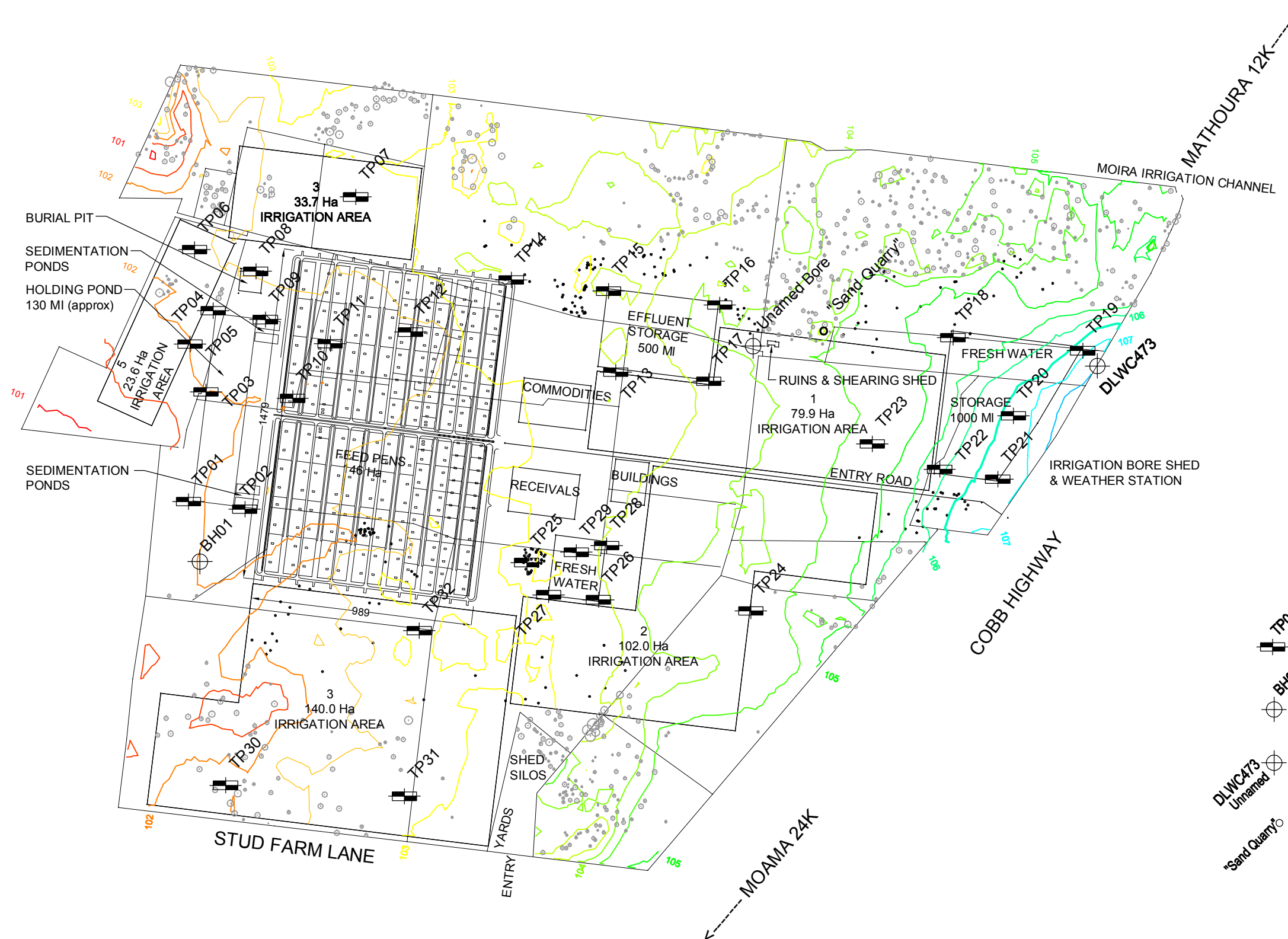
GHD-LONGMAC PTY LTD



Figure

Figure 1

Test Location Plan



LEGEND

- TP01 TEST PIT (BY GHD-LM)
- BH01 BOREHOLE (BY GHD-LM)
- DLWC473 BOREHOLE (BY OTHERS)
- "Sand Quarry" LOCALITY

NOTE: PLOTTED LOCATIONS ARE FROM GPS CO-ORDINATES AND ARE THEREFORE APPROXIMATE.

0 200 400 600 800 1000m

SCALE IN METRES (1:20000 BEFORE REDUCTION)

REFERENCE: BASE PLAN PROVIDED BY FRANK RENNIK & COMPANY PTY. LIMITED, PLAN 3315-3A.DWG 05/02/2005.

NOTE: AMG (AGD66) ZONE 55

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"MOIRA STATION" COBB HIGHWAY, MATHOURA PROPOSED 80,000 HEAD CATTLE FEEDLOT TEST LOCATION PLAN

Designed: RAC
Drawn: RM
Checked: Date: 26/4/05
File name: 2113507_F01.DWG

Figure No: 1
Job No: 21/13507
Scale: AS SHOWN



Standard Sheets

General Notes

Glossary of Symbols

Soil Description

Rock Description

Laboratory Testing

GENERAL NOTES



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The report contains the results of a geotechnical investigation conducted for a specific purpose and client. The results should not be used by other parties, or for other purposes, as they may contain neither adequate nor appropriate information. In particular, the investigation does not cover contamination issues unless specifically required to do so by the client.

TEST HOLE LOGGING

The information on the test hole logs (boreholes, test pits, exposures etc.) is based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results). The test hole logs include both factual data and inferred information. Reference should be made to the relevant sheets for the explanation of logging procedures (Soil and Rock Descriptions, Core Log Sheet Notes etc.).

GROUNDWATER

Unless otherwise indicated, the water levels presented on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level depending on material permeabilities (i.e. depending on response time of the measuring instrument). Further, variations of this level could occur with time due to such effects as seasonal, environmental and tidal fluctuations or construction activities. Confirmation of groundwater levels, phreatic surfaces or piezometric pressures can only be made by appropriate instrumentation techniques and monitoring programmes.

INTERPRETATION OF RESULTS

The discussion or recommendations contained within this report normally are based on a site evaluation from discrete test hole data. Generalised, idealised or inferred subsurface conditions (including any geotechnical cross-sections) have been assumed or prepared by interpolation and/or extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions do occur in the natural environment, particularly between discrete test hole locations. Additionally, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site. Furthermore, conditions may change at the site from those encountered at the time of the geotechnical investigation through construction activities and constantly changing natural forces.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed or reported should be referred to this firm for appropriate assessment and comment.

GEOTECHNICAL VERIFICATION

Verification of the geotechnical assumptions and/or model is an integral part of the design process - investigation, construction verification, and performance monitoring. Variability is a feature of the natural environment and, in many instances, verification of soil or rock quality, or foundation levels, is required. There may be a requirement to extend foundation depths, to modify a foundation system or to conduct monitoring as a result of this natural variability. Allowance for verification by geotechnical personnel accordingly should be recognised and programmed during construction.

FOUNDATIONS

Where referred to in the report, the soil or rock quality, or the recommended depth of any foundation (piles, caissons, footings etc.) is an engineering estimate. The estimate is influenced, and perhaps limited, by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The material quality and/or foundation depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications should provide for variations in the final depth, depending upon the ground conditions at each point of support, and allow for geotechnical verification.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in our geotechnical report, or other technical information, for the inclusion in contract documents or engineering specification of the subject development, such reproductions should include at least all of the relevant test hole and test data, together with the appropriate standard description sheets and remarks made in the written report of a factual or descriptive nature.

Reports are the subject of copyright and shall not be reproduced either totally or in part without the express permission of this firm.

GLOSSARY OF SYMBOLS

This standard sheet should be read in conjunction with all test hole log sheets and any idealised geological sections prepared for the investigation report.

GENERAL

Symbol	Description	Symbol	Description
D	Disturbed Sample	PZ	Piezometer Installation
U	Undisturbed Sampled (suffixed by sample size or tube diameter in mm if applicable)	R	Rising Head Permeability Test
C	Core Sample (suffixed by diameter in mm)	F	Falling Head Permeability Test
SV	Shear Vane Test (suffixed by value in kPa)	PBT	Plate Bearing Test
SPT	Standard Penetration Test (with blows per 0.15m)	→	Water Inflow (make)
N	SPT Value	←	Water Outflow (loss)
PK	Packer Test	▽	Temporary Water Level
PM	Pressuremeter Test	▼	Final Water Level
PP	Pocket Penetrometer (suffixed by value in kPa)	●	Point Load Test (axial)
IMP	Impression Device Test	○	Point Load Test (diametric)
HB	SPT hammer bouncing		

SOIL SYMBOLS

Main Components

	SAND		CLAY		SILT
	GRAVEL		FILL		TOPSOIL

Minor Components

	sandy		clayey		silty
	gravelly		vegetation, roots		

Note: Natural soils are generally a combination of constituents, e.g.

	sandy CLAY
---	------------

ROCK SYMBOLS

Sedimentary

	SANDSTONE		SHALE
	CLAYSTONE		CONGLOMERATE
	SILTSTONE		COAL

Igneous

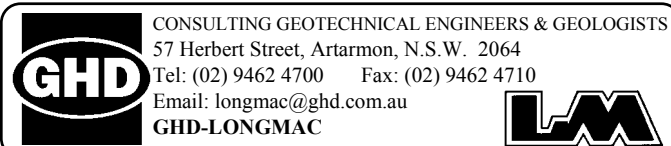
	GRANITE
	IGNEOUS DYKE

Note: Additional rock symbols may be allocated for a particular project.

NATURAL FRACTURES (Coding)

Fracture Type	Orientation	Shape	Roughness	Others
JT Joint	For vertical non-oriented core ... "Dip" angle (eg. 5°) measured relative to horizontal	PLN Planar	POL Polished	DIS Discontinuous
BP Bedding Plane Parting	For inclined non-oriented core ... "Angle" measured relative to core axis.	CU Curved	SLK Slickensided	TI Tight
SM Seam	For inclined oriented core ... "Dip" angle and "Dip Direction" angle (eg. 45°/225° mag.)	UN Undulating	SO Smooth	OP Open
FZ Fragmented Zone	VT Vertical	ST Stepped	RF Rough	
SZ Shear Zone	HZ or 0° Horizontal	IR Irregular	VR Very Rough	
VN Vein	d degrees			
Infilling or Coating				
CN Clean				
X Carbonaceous				
CLAY Clay				
KT Chlorite				
CA Calcite				
FE Iron Oxide				
MI Micaceous				
QZ Quartz				

SOIL DESCRIPTION



This procedure involves the description of a soil in terms of its visual and tactile properties, and relates to both laboratory samples and field exposures as applicable. A detailed soil profile description, in association with local geology and experience, will facilitate the initial (and often complete) site assessment for engineering purposes.

The method involves an evaluation of each of the items listed below and is in general agreement with both Australian Standard AS 1726 (the Site Investigation Code) and ASTM D2487 and D2488.

MOISTURE

The moisture condition of the soil is most applicable for cohesive soils as a precursor to the assessment of consistency and workability. The moisture condition is described as:-

Dry (dusty, dry to the touch) **Slightly Moist** **Moist** (damp, no visible water) **Very Moist** or **Wet** (visible free water, saturated condition)

In addition, the presence of any seepage or free water is noted on the testhole logs.

COLOUR

Colour is important for correlation of data between testholes and during subsequent excavation operations. The prominent colour is noted, followed by (spotted, mottled, streaked etc.) then secondary colours as applicable. Colour is usually described at as-received moisture condition, though both wet and dry colours may also be appropriate.

CONSISTENCY/RELATIVE DENSITY

This assessment is based on the effort required to penetrate and/or mould the soil, and is an indicator of shear strength.

Granular soils are generally described in terms of density index as listed in AS 1726. These soils are inherently difficult to assess and normally a penetration test procedure (SPT, DCP or CPT) is used in conjunction with published correlations. Alternatively, in-situ density tests can be conducted in association with minimum and maximum densities performed in the laboratory.

Cohesive soils can be assessed by direct measurement (shear vane), or estimated approximately by tactile means and/or the aid of a geological pick as given on the following table. It is emphasised that a “design shear strength” must take cognisance of the in-situ moisture content and the possible variations of moisture with time.

Term	Tactile Properties	Unconfined Compressive Strength q_u (kPa)
Very Soft	Extrudes from fingers when squeezed	<25
Soft	Easily penetrated by thumb about 30-40 mm. Pick head can be pushed in up to shaft. Moulded by light finger pressure.	25-50
Firm	Penetrated by thumb 20-30 mm with moderate effort. Sharp end of pick pushed in 30-40 mm. Moulded by strong finger pressure.	50-100
Stiff	Indented by thumb about 5 mm with moderate effort. Pick pushed in up to 10 mm. Cannot be moulded in fingers.	100-200
Very Stiff	Readily indented by thumb nail. Slight indentation produced by pushing pick into soil.	200-400
Hard	Difficult to indent with thumb nail. Requires power tools for excavation.	>400

STRUCTURE/OTHER FEATURES

The soil structure is generally applicable to cohesive soils and refers to the presence or absence of joints and layering. Typical terms use are intact (no joints), fissured (closed joints), shattered (open joints), slickensided (polished joints indicative of movement), and stratified/laminated. In addition, the presence of other features (ferricrete nodules, timber inclusions) should also be noted as applicable.

For granular soils, an assessment of grading (well, uniform or poor), particle size (fine, medium etc.) and angularity and shape may also be given.

SOIL TYPE

The soil is described in terms of its estimated grain size composition and the tactile behaviour (plasticity of any fines (less than *0.06 mm)). This system does not differentiate on grading below 0.06 mm, in accordance with the Unified Soil Classification (USC) procedure.

Furthermore, as most natural soils frequently are combinations of various constituents, the primary soil is described and modified by minor components. In brief, the system is as follows:-

Coarse Grained Soils		Fine Grained Soils	
% Fines	Modifier	% Coarse	Modifier
5	omit, or use “trace”	15	omit, or use “trace”
5-12	describe as “with clay/silt” as applicable	15-30	described as “with sand/gravel” as applicable
>12	prefix soil as “silty/clayey” as applicable	>30	prefix soil as “sandy/gravelly” as applicable

(*The 200# sieve (0.075 mm) is commonly used in practice to differentiate between fine and coarse grained soils).

Note: For soils containing both sand and gravel the minor coarse fraction is omitted if less than 15%, or described as “with sand/gravel” as applicable when greater than 15%.

The appropriate USC symbol may also be given after the soil type description in accordance with ASTM D2487 and D2488.

ORIGIN

An attempt is made, where possible, to assess origin (transported, residual, pedogenic, or fill etc.) since this assists in the judgement of probable engineering behaviour. This assessment is generally restricted to field logging activities. An interpretation of landform is a useful guide to the origin of transported soils (e.g. colluvium, talus, slide debris, slope wash, alluvium, lacustrine, estuarine, aeolian and littoral deposits) while local geology and remnant fabric will assist identification of residual soils.

ROCK DESCRIPTION



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This method is based on Australian Standard AS 1726 and is orientated to the field logging of diamond drill core, but may be used for the profiling of natural exposures and cuttings, as applicable. The procedure involves a visual and tactile assessment of the rock mass and the nature of defects within it in order to facilitate a prediction of engineering behaviour.

DESCRIPTION: Rock Type is described on the basis of origin (sedimentary, metamorphic and igneous) with the common types listed below:-

Sedimentary				Metamorphic	Igneous				
Clastic	Non clastic (chemical)	Non clastic (organic)	Pyroclastic	Slate Phyllite Schist Quartzite Gneiss	Extrusive Intrusive (medium grained) (coarse grained)	Acid	Intermediate		Basic
Conglomerate Sandstone Siltstone Shale Claystone	Limestone Chert Gypsum Salt	Coal Some Limestone	Tuff Agglomerate Volcanic Breccia			Rhyolite	Trachyte	Andesite	Basalt
						Quartz Porphyry	Porphyry	Porphyry	Dolerite
						Granite	Syenite	Diorite	Gabbro

Colour is given to assist in rock identification and the interpolation of field data. Colour is usually described at as-received moisture condition, though both wet and dry colours may also be appropriate.

Texture refers to the degree of crystallinity and granularity (grain size) and the fabric relationship between the constituents of a rock. Often only grain size is given for simplified descriptions of certain sedimentary rocks.

Structure and texture are commonly used synonymously in describing rocks since there is no clear delineation between terms. In general, structure refers to large-scale features recognisable in the field (banding, lineation, massive, porphyritic, schistose etc.). For sedimentary rocks in particular, the thickness of sedimentary layering (bedding) is described as:-

Thinly laminated	<6mm	very thinly bedded	20-60mm	medium bedded	0.2-0.6m	very thickly bedded	>2m
Laminated	6-20mm	thinly bedded	60-200mm	thickly bedded	0.6-2m		

In addition, mineral composition, hardness, alteration, cementation is given as applicable.

WEATHERING: The assignment of weathering is somewhat subjective. Weathering assists identification and does not imply engineering behaviour. No distinction is drawn between chemical weathering and alteration for most engineering purposes. These procedures are collectively described as “weathering” using the following terms which do not describe the related strength change. This system is general, and in this format may not apply to all rock types. Carbonate rocks generally do not conform to this classification.

Term	Symbol	Definition
Completely Weathered	CW	Residual soil with rock fabric not visible.
Extremely Weathered	EW	The rock exhibits soil-like properties though the texture of the original rock is still evident.
Highly Weathered	HW	Limonite staining or colour change affects the whole of the rock mass and other signs of chemical or physical decomposition are evident.
Moderately Weathered	MW	Staining extends throughout the whole of the rock mass and the original colour is no longer recognisable.
Slightly Weathered	SW	Partial staining or discolouration of the rock mass, usually by limonite, has taken place.
Fresh	FR	Rock mass unaffected by weathering.

ESTIMATED STRENGTH: This refers to the strength of the rock substance and not that of the rock mass. The strength of the rock substance is estimated by the Point Load Strength Index $I_s(50)$ and refers to the strength measured in the direction normal to the bedding for sedimentary rocks. A field guide is given below:-

Term	Symbol	$I_s(50)$ MPa	Field Guide (The core refers to a 150mm long x 50mm dia. sample)
Extremely Weak	EW	<0.03	Remoulded by hand to a material with soil properties.
Very Weak	VW	0.03-0.1	May be crumbled in the hand. Sandstone is “sugary” and friable.
Weak	W	0.1-0.3	The core may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
Medium Strong	MS	0.3-1.0	The core may be broken by hand with considerable difficulty. Readily scored with knife.
Strong	S	1-3	The core cannot be broken by unaided hands, can be slightly scratched or scored with knife.
Very Strong	VS	3-10	The core may be broken readily with hand held hammer. Cannot be scratched with knife.
Extremely Strong	ES	>10	The core is difficult to break with hand held hammer. Rings when struck with a hammer.

DEFECTS: This important feature can control the overall engineering behaviour of a rock mass. All types of natural fractures across which the core is discontinuous are noted. These fractures include bedding plane partings, joints and other defects but exclude artificial fractures such as drilling breaks. The nature of the defects (joints, bedding partings, seams, zones and veins) is also noted with description, orientation, infilling or coating, shape, roughness, thickness, etc. given generally in accordance with AS 1726. The spacing of natural fractures excludes bedding partings unless there is evidence that they were separated prior to drilling. This notwithstanding, bedding partings maybe considered as planes of weakness in an engineering assessment.

LABORATORY TESTING



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GENERAL

Samples extracted during the fieldwork stage of a site investigation may be “disturbed” or “undisturbed” (as generally indicated on the trial hole logs) depending upon the nature and purpose of the sample as well as the method of extraction, transportation, extrusion and testing. This aspect should be taken into account when assessing test results, which must of necessity reflect the effects of such disturbance.

All soil properties (as measured by laboratory testing) exhibit inherent variability and thus a certain statistical number of tests is required in order to predict an average property with any degree of confidence. The site variability of soil strata, future changes in moisture and other conditions and the discrete sampling positions must also be considered when assessing the representative nature of the laboratory programme.

Certain laboratory test results provide interpreted soil properties as derived by conventional mathematical procedures. The applicability of such properties to engineering design must be assessed with due regard to the site, sample condition, procedure and project in hand.

TESTING

Laboratory testing is normally carried out in accordance with Australian Standard AS 1289 as amended, or RTA Standards when specified. The routine Australian Standard tests are as follows:-

Moisture Content	Test 2.1.1	
Liquid Limit	Test 3.1.1	)
Plastic Limit	Test 3.2.1	) collectively known as Atterberg Limits
Plasticity Index	Test 3.3.1	)
Linear Shrinkage	Test 3.4.1	
Particle Density	Test 3.5.1	
Particle Size Distribution	Tests 3.6.1, 3.6.2 and 3.6.3	
Emerson Class Number	Test 3.8.1	)
Percent Dispersion	Test 3.8.2	) collectively, Dispersive Classification
Pinhole Dispersion Classification	Test 3.8.3	)
Organic Matter	Test 4.1.1	
Sulphate Content	Test 4.2.1	
pH Value	Test 4.3.1	
Resistivity	Test 4.4.1	
Standard Compaction	Test 5.1.1	
Modified Compaction	Test 5.2.1	
Dry Density Ratio	Test 5.4.1	
Minimum Density	Test 5.5.1	
Density Index	Test 5.6.1	
California Bearing Ratio	Tests 6.1.1 and 6.1.2	
Shear Box	Test 6.2.2	
Undrained Triaxial Shear	Test 6.4.1	
One Dimensional Consolidation	Test 6.6.1	
Constant Head Permeability	Akroyd	

Where tests are used which are not covered by appropriate standard procedures, details are given in the report.

LABORATORY

Our laboratory is a Registered Laboratory in the terms of registration with the National Association of Testing Authorities (NATA) for the listed tests.

The oedometer, triaxial and shear box equipment are fully automated for continuous operation using computer controlled data acquisition, processing and plotting systems.



Appendix A

Profile Logs (TP01 to TP32 and BH01)

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP01

SHEET 1 OF 1

Position: 306117E, 6020401N

Surface RL: 101.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 16/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION
			Moisture, colour, consistency, structure, SOIL TYPE (origin)
	0		Slightly moist, light brown, firm, sandy CLAY, fine grained sand (disturbed/topsoil).
D	0.27		Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium). 0.40m, as above, but brown MC>PL.
D	0.75		Moist, grey brown with red brown mottle, very stiff, medium plasticity, CLAY [MC=PL], trace fine grained sand (alluvium).
	1		1.30m, as above, but light grey brown and yellow brown mottled.
D	2.00		Slightly moist, grey brown and yellow brown, very stiff, medium plasticity, CLAY [MC=PL], trace fine grained sand (alluvium).
	3		
	4		
	4.50		Slightly moist, grey and light grey brown, very stiff, low plasticity, sandy CLAY [MC=PL], sand is fine grained (alluvium).
D	5.50		End of hole at 5.5 metres. Depth limit of excavator.
	6		No groundwater encountered.

PROFILE 2113507.GPJ GHD.GDT 18/05/05

See standard sheets for
details of abbreviations
& basis of descriptions



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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP02

SHEET 1 OF 1

Position: 306368E, 6020367N

Surface RL: 102.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 16/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION
			Moisture, colour, consistency, structure, SOIL TYPE (origin)
	0		
	0.20		Slightly moist, light brown, firm, sandy CLAY, fine grained sand (disturbed/topsoil).
			Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).
	1		
	1.00		Moist, grey brown, very stiff, friable, medium plasticity, sandy CLAY [MC>PL], sand is fine grained (alluvium).
	2		
	2.20		Moist, light grey brown and yellow brown mottled, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			
	3		
	4		
	4.50		Moist, grey with yellow brown mottle, stiff, medium plasticity, CLAY [MC>PL], with fine grained sand (alluvium).
B			
	5		
	5.40		End of hole at 5.4 metres. No refusal to excavator bucket. No groundwater encountered.
	6		

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP03

SHEET 1 OF 1

Position: 306195E, 6020890N

Surface RL: 102.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 16/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION
			Moisture, colour, consistency, structure, SOIL TYPE (origin)
	0		
	0.20		Dry, brown, stiff, medium plasticity, sandy CLAY, [MC<PL], fine grained sand (disturbed/topsoil).
			Very moist, brown, very stiff, high plasticity, CLAY [MC>>PL] (alluvium).
	1		
	1.30		Moist, grey brown with slight light grey mottle, hard, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
	2		
	3		
	3.00		Moist, light grey brown and yellow brown mottled, hard, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
	4		
	5		
	5.30		End of hole at 5.3 metres. Depth limit of excavator. No groundwater encountered.
	6		

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP04

SHEET 1 OF 1

Position: 306256E, 6021259N

Surface RL: 102.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 16/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, light brown, firm, sandy CLAY, fine grained sand (disturbed/topsoil). Very moist, brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).	
	1			
	1.30		Moist, grey brown with slight red brown mottle, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	2			
D				
	3			
D				
	3.00		Moist, grey brown, yellow brown and light grey mottled, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	4			
	4.50		Moist, light grey brown and yellow brown mottled, very stiff, medium plasticity, CLAY [MC = PL], trace fine grained sand (alluvium).	
	5			
D				
	5.50		End of hole at 5.5 metres. Depth limit of excavator. No refusal to excavator bucket. No groundwater encountered.	
	6			

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP05

SHEET 1 OF 1

Position: 306124E, 6021104N

Surface RL: 102.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, [MC<PL], fine grained sand (disturbed/topsoil).
D				Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).
			0.75	Moist, grey brown mottled, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D	1			
	2		2.40	End of hole at 2.4 metres. No refusal to excavator bucket. No groundwater encountered.
	3			
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP06

SHEET 1 OF 1

Position: 306144E, 6021525N

Surface RL: 102.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, low plasticity, sandy CLAY MC<PL], fine grained sand (disturbed/topsoil).
D				Moist, red brown, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
			0.60	Moist, grey brown mottled, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D	1			
			2.20	End of hole at 2.2 metres. No refusal to excavator bucket. No groundwater encountered.
	2			
	3			
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP07

SHEET 1 OF 1

Position: 306863E, 6021760N

Surface RL: 102.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.17	Slightly moist, brown, stiff, medium plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil).
D				Moist, red brown, very stiff, high plasticity, CLAY, fine grained sand (alluvium).
			0.70	Moist, grey brown with red brown mottle, medium plasticity, CLAY, trace fine grained sand (alluvium).
D	1			1.1m, as above, but grey brown mottled.
			2.00	End of hole at 2.0 metres. No refusal to excavator bucket. No groundwater encountered.
	2			
	3			
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP08

SHEET 1 OF 1

Position: 306417E, 6021428N

Surface RL: 102.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).	
	0.70		Moist, grey brown with slight red brown and yellow brown mottle, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	1			
	2			
D				
	3			
	3.20		Moist, yellow brown and grey mottled, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	3.60		Moist, yellow brown and grey mottled, stiff, medium plasticity, sandy CLAY [MC>PL], fine grained sand (alluvium).	
D				
	4			
	4.80		End of hole at 4.8 metres. No refusal to excavator bucket. No groundwater encountered.	
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP09

SHEET 1 OF 1

Position: 306460E, 6021213N

Surface RL: 102.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
B	0		0.12	Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL] (alluvium).
	1		0.90	Moist, grey brown, stiff, high plasticity, CLAY [MC>PL], (alluvium).
	2			
	3		3.00	Moist, grey brown with yellow brown mottle, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	4			
	5			4.7m, sand content increasing with depth.
	5.20			End of hole at 5.2 metres. Depth of limit of excavator. No refusal to excavator bucket. No groundwater encountered.
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP10

SHEET 1 OF 1

Position: 306582E, 6020861N

Surface RL: 102.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Moist, dark brown, stiff, medium plasticity, sandy CLAY [MC>PL], fine grained sand (alluvium).
	1		1.10	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D	2		1.90	Moist, yellow brown and grey brown, low plasticity, sandy CLAY [MC=PL] (alluvium).
	3		3.50	Moist, grey brown and yellow brown mottled, medium plasticity, CLAY [MC=PL], trace fine grained sand (alluvium).
	4		4.50	End of hole at 4.5 metres. No refusal to excavator bucket. No groundwater encountered.
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP11

SHEET 1 OF 1

Position: 306749E, 6021105N

Surface RL: 102.30m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 4m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, dark brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).
D				
	1		1.00	Moist, grey brown with slight red brown mottle, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D				
	2			
				Grey brown mottled and friable at depth.
D			3.00	End of hole at 3.0 metres. No refusal to excavator bucket. No groundwater encountered.
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP12

SHEET 1 OF 1

Position: 307108E, 6021157N

Surface RL: 102.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, dark brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).	
	0.80		Moist, grey brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	2.50		End of hole at 2.5 metres. No refusal to excavator bucket. No groundwater encountered.	
	3			
	4			
	5			
	6			

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP13

SHEET 1 OF 1

Position: 308023E, 6020978N

Surface RL: 103.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	0.80			Moist, brown and yellow brown, stiff, medium plasticity, CLAY [MC>PL], some fine grained sand (alluvium).
B	1.50			Moist, grey brown and grey, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	2.6m			2.6m, as above, greater proportion of grey.
	4.00			End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.

PROFILE 2113507 GPJ GHD GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP14

SHEET 1 OF 1

Position: 307557E, 6021390N

Surface RL: 103.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 4m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Moist, red brown, stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	0.80		Moist, grey and grey brown, stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).	
	2.00		Moist, grey brown and yellow brown, stiff, medium plasticity, sandy CLAY [MC≈PL], fine grained sand (alluvium).	
	3.0		3.0m, as above, but low plasticity, increasing sand content.	
	3.80		End of hole at 3.8 metres. No refusal to excavator bucket. No groundwater encountered.	
	4			
	5			
	6			

PROFILE 2113507 GPJ GHD GDT 18/05/05

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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP15

SHEET 1 OF 1

Position: 307991E, 6021340N

Surface RL: 103.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).
	0.80		0.80	Moist, grey brown with red brown mottle, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
B	1.60		1.60	Moist, grey with grey brown mottle, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand, trace calcite (alluvium).
	4.00		4.00	End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.

PROFILE 2113507 GPJ GHD GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD
Project: PROPOSED 80,000 HEAD FEEDLOT
Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP16

SHEET 1 OF 1

Position: 308487E, 6021278N **Surface RL:** 104.00m approx (AHD) **Processed:** HW
Method of Exploration: 20t Komatsu Excavator PC 200LC **Hole Size:** 1.1m x 5m **Checked:**
Date: 18/02/05 **Logged by:** RAC **Date:**

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	0.60		Moist, grey brown mottled, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
B	1.20		Moist, grey mottled, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	2.30		Moist, grey brown and yellow brown mottled, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
D	3.60		Moist, brown, very stiff, medium plasticity, sandy CLAY [MC≈PL], fine to coarse grained sand, trace medium gravel (alluvium).	
D	4.40		End of hole at 4.4 metres. No refusal to excavator bucket. No groundwater encountered.	
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

See standard sheets for
details of abbreviations
& basis of descriptions



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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP17

SHEET 1 OF 1

Position: 308438E, 6020938N

Surface RL: 103.60m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
B	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Slightly moist, dark brown, hard, high plasticity, CLAY [MC<PL] (alluvium).
	0.80		0.80	Moist, grey brown, very stiff, high plasticity, CLAY [MC>PL], trace fine to medium grained sand (alluvium).
	1.50		1.50	Moist, light brown, medium plasticity, CLAY [MC>PL], some fine grained sand (alluvium).
	2.80		2.80	Moist, yellow brown, grey brown and grey mottled, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
B	4.00		4.00	End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP18

SHEET 1 OF 1

Position: 309528E, 6021133N

Surface RL: 105.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>>PL trace], some fine grained sand (alluvium).
D			0.80	Moist, light brown, very stiff, medium plasticity, sandy CLAY [MC≈PL], fine grained sand (alluvium).
D			1.60	Moist, grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
D			2.90	Becoming Moist, lighter grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
	4		4.30	End of hole at 4.3 metres. No refusal to excavator bucket. No groundwater encountered.

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP19

SHEET 1 OF 1

Position: 310107E, 6021074N

Surface RL: 106.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL] (alluvium).
	0.60		0.60	Moist, grey brown, very stiff, high plasticity, CLAY [MC≈PL], trace fine to medium grained sand (alluvium).
B	1			
	2		2.20	Moist, brown and grey brown mottled, very stiff, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
D				
	3		3.20	Slightly moist, light grey brown mottled, hard, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
	4		4.20	End of hole at 4.2 metres. No refusal to excavator bucket. No groundwater encountered.
	5			
	6			

PROFILE 2113507 GPJ GHD GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP20

SHEET 1 OF 1

Position: 309798E, 6020784N

Surface RL: 106.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
B	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], fine grained sand (alluvium).
	0.60		0.60	Moist, brown, very stiff, medium plasticity, CLAY [MC ≈ PL], trace fine grained sand (alluvium).
	1.60		1.60	Moist, grey brown and red brown mottled, very stiff, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
D	3		3.10	Slightly moist, grey and grey brown with slight yellow brown and red brown mottle, hard, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
	4		4.00	End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD
Project: PROPOSED 80,000 HEAD FEEDLOT
Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP21

SHEET 1 OF 1

Position: 309728E, 6020501N	Surface RL: 106.60m approx (AHD)	Processed: HW
Method of Exploration: 20t Komatsu Excavator PC 200LC	Hole Size: 1.1m x 5m	Checked:
Date: 19/02/05	Logged by: RAC	Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION
			Moisture, colour, consistency, structure, SOIL TYPE (origin)
	0		
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, medium to high plasticity, CLAY [MC>PL], trace fine to medium grained sand (alluvium).
D	0.60		Moist, grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
	1		
B	1.50		Slightly moist, red brown and grey brown mottled, very stiff, medium plasticity, sandy CLAY [MC<PL], fine to medium grained sand, trace medium to coarse white semi-rounded gravel (alluvium).
	2		
	2.80		Slightly moist, yellow brown, grey and red brown mottled, hard, medium plasticity, sandy CLAY [MC<PL], fine to medium grained sand (alluvium).
D	3		
	4		
	4.20		End of hole at 4.2 metres. No refusal to excavator bucket. No groundwater encountered.
	5		
	6		

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP22

SHEET 1 OF 1

Position: 309731E, 6020500N

Surface RL: 105.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	0.60		0.60	Moist, grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
	1.60		1.60	Slightly moist, red brown and grey brown, very stiff, medium plasticity, sandy CLAY, fine grained sand, trace medium to coarse white semi-rounded gravel (alluvium).
	3.20		3.20	Slightly moist, grey, grey brown and red brown with black staining, hard, low plasticity, sandy CLAY [MC<PL], fine to medium grained sand (alluvium), (vesicular).
	4.10		4.10	End of hole at 4.1 metres. No refusal to excavator bucket. No groundwater encountered.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP23

SHEET 1 OF 1

Position: 309452E, 6020525N

Surface RL: 104.70m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			0.60	Slightly moist, grey brown with red brown mottled, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
D			1.60	Moist, grey brown and red brown mottled, very stiff, medium plasticity, CLAY [MC<PL], trace fine grained sand, trace medium to coarse gravel (alluvium).
	2		2.20	End of hole at 2.2 metres. No refusal to excavator bucket. No groundwater encountered.
	3			
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP24

SHEET 1 OF 1

Position: 308626E, 6019913N

Surface RL: 104.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.13	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			0.70	Moist, grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
D	1		2.50	Moist, grey brown, red brown and yellow brown mottled, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
			2.90	End of hole at 2.9 metres. No refusal to excavator bucket. No groundwater encountered.

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP25

SHEET 1 OF 1

Position: 307626E, 6020129N

Surface RL: 103.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 15/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Slightly moist, dark grey, loose, clayey SAND, medium grained sand, low plasticity fines (topsoil).	
	0.30		Moist, brown, very stiff, low plasticity, sandy CLAY, fine grained sand (alluvium).	
			Moist, brown, very stiff, high plasticity, CLAY, trace fine grained sand (alluvium).	
	1			
	1.20		Moist, light grey brown mottled yellow brown, very stiff, low plasticity, CLAY, fine to medium grained sand (alluvium).	
	2			
D			Very sandy, vesicular.	
	2.90			
D	3		Dry, white and yellow brown mottled, inferred medium dense, medium grained, SAND (alluvium).	
	4			
	4.00		End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.	
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP26

SHEET 1 OF 1

Position: 307946E, 6019963N

Surface RL: 103.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
			0.70	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			3.00	Slightly moist, light grey and orange, fine to medium grained, SAND, with clay (layers to 400mm) interbedded with clayey sand (alluvium).
			4.30	Slightly moist, yellow brown and light grey, medium plasticity, sandy CLAY [MC<PL] (alluvium).
			5.10	End of hole at 5.1 metres. No refusal to excavator bucket. No groundwater encountered.

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP27

SHEET 1 OF 1

Position: 307724E, 6019985N

Surface RL: 103.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
B	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	0.70		0.70	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	2		2.00	Slightly moist, light grey and yellow brown, inferred loose, fine to medium grained, SAND (alluvium).
	4		4.00	End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.
				Test pit sidewall collapse in sand from 2.0 to 4.0m

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP28

SHEET 1 OF 1

Position: 307983E, 6020204N

Surface RL: 103.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, dark brown, very stiff, high plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, stiff, high plasticity, CLAY [MC>PL], trace sand (alluvium).
D			0.60	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	1			
			1.80	Moist, grey brown mottled yellow brown, high plasticity, CLAY [MC>PL], with fine to medium grained sand (alluvium).
	2			
B				
	3			
	4			
			4.80	End of hole at 4.8 metres. No refusal to excavator bucket. No groundwater encountered.
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP29

SHEET 1 OF 1

Position: 307847E, 6020175N

Surface RL: 103.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	0.60		Moist, light grey, very stiff, medium plasticity, CLAY [MC=PL], trace fine grained sand (alluvium).	
	1			
	2		grading to.	
	2.30		Moist, light grey brown with yellow brown mottle, low plasticity, sandy SILT, fine grained sand (alluvium).	
	3			
	3.20		Moist, grey brown, very stiff, medium plasticity, CLAY, trace fine grained sand (alluvium).	
	4			
	4.80		End of hole at 4.8 metres. No refusal to excavator bucket. No groundwater encountered.	
	5			
	6			

PROFILE 2113507 GPJ GHD GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP30

SHEET 1 OF 1

Position: 306282E, 6019135N

Surface RL: 102.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 21/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.12	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			0.60	Moist, grey brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			1.20	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL] (alluvium).
			2.50	End of hole at 2.5 metres. No refusal to excavator bucket. No groundwater encountered.

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP31

SHEET 1 OF 1

Position: 307080E, 6019086N

Surface RL: 102.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 21/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.13	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil).
D				Moist, red brown, very stiff, high plasticity, CLAY [MC>PL] (alluvium).
			0.60	
				Dry, grey brown and light grey, hard, high plasticity, CLAY, trace fine grained sand (alluvium).
D	1			
			1.70	
				Dry, grey brown, light grey and brown mottled, hard, medium plasticity, sandy CLAY, fine grained sand (alluvium).
	2			
			2.40	
				End of hole at 2.4 metres. No refusal to excavator bucket. No groundwater encountered.
	3			
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

See standard sheets for
details of abbreviations
& basis of descriptions



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Job No.

21/13507

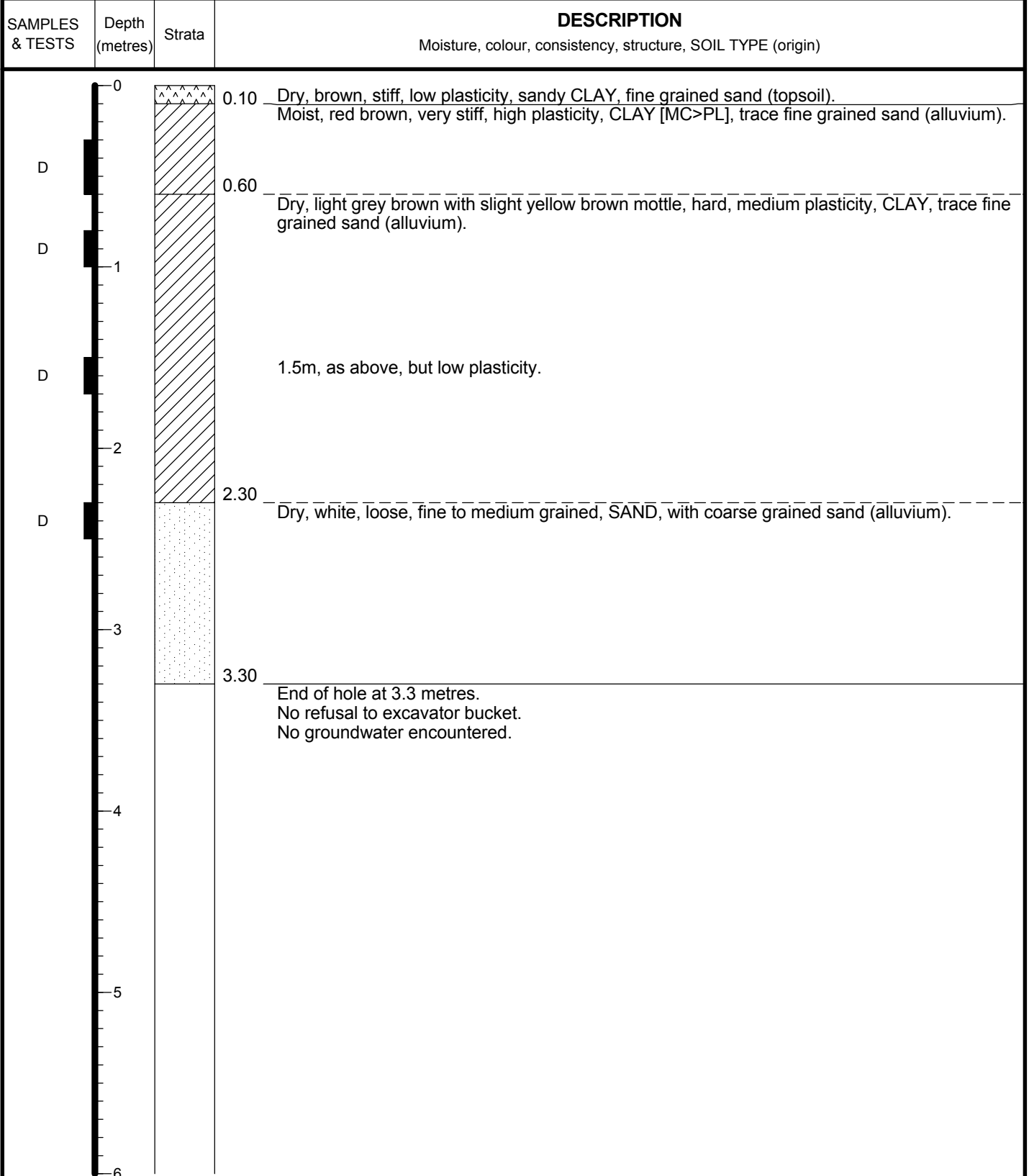
PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD
Project: PROPOSED 80,000 HEAD FEEDLOT
Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP32

SHEET 1 OF 1

Position: 307146E, 6019825N	Surface RL: 103.00m approx (AHD)	Processed: HW
Method of Exploration: 20t Komatsu Excavator PC 200LC	Hole Size: 1.1m x 4m	Checked:
Date: 21/02/05	Logged by: RAC	Date:



PROFILE 2113507.GPJ GHD.GDT 18/05/05

See standard sheets for details of abbreviations & basis of descriptions



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Job No.

21/13507

BOREHOLE LOG SHEET WITH STANDPIPE PIEZOMETER

Client : AGRICULTURAL EQUITY INVESTMENTS PTY LTD
Project : PROPOSED 80,000 HEAD FEEDLOT
Location : "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. BH01**SHEET 1 OF 2**

Position : 306320E, 6020374N **Surface RL:** 102.00m approx (AH) **Angle from Horiz. :** 90° **Processed :** HW
Rig Type : Angove **Mounting :** Trailer **Contractor :** Lloyd Angove Drilling **Driller :** Lloyd Angove **Checked :**
Date Started : 22/02/05 **Date Completed :** 22/02/05 **Logged by :** RAC **Date :**

DRILLING					BOREHOLE DESCRIPTION			PIEZOMETER	
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS	PIEZOMETER LOG COMPONENTS
V-bit auger	Nil	Nil	SPT 5/8/15 N=23	0.10		CL CH	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (topsoil).	SPT hammer bouncing	
				0.60		CL/ CH	Very moist, red brown, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).		
				2.50		CL/ CH	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).		
				5.00		CL/ CH	Moist, light grey brown and grey with slight yellow brown mottle, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).		
			SPT 2/4/10 N=14	5.50		CL	Moist, light grey and yellow brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium). 5.5m, as above, but [MC ≈ PL].		
				7.00		SP	Slightly moist, light brown, fine to medium grained, SAND, trace coarse grained sand (alluvium).		
			SPT 6/12/16 N=28	7.80		CL	Slightly moist, light grey, low plasticity, sandy CLAY, medium grained sand (alluvium).		
				8.00		CL/ CH	Slightly moist, yellow brown and light grey, hard, medium plasticity, CLAY [MC<PL], trace fine grained sand, isolated fine size rounded gravel (alluvium).		
			SPT 16/40 for 150mm HB N=ref	9.30		SP	Dry, white, inferred loose, fine grained, SAND (alluvium).		
				9.80		CL	grading to. Dry, white and yellow brown, low		
10.00									

See standard sheets for details of abbreviations & basis of descriptions



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**Job No.****21/13507**

COREHOLE 2113507.GPJ GHD.GDT 18/05/05

HOLE No. BH01

SHEET 1 OF

SHEET 1 OF

Processed : HW

Checked :

Date :

Date Logged :

[illegible]

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21/13507

COREHOLE 2113507.GPJ GHD.GDT 18/05/05

CORE LOG SHEET WITH STANDPIPE PIEZOMETER

Client : AGRICULTURAL EQUITY INVESTMENTS PTY LTD
Project : PROPOSED 80,000 HEAD FEEDLOT
Location : "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. BH01

SHEET 2 OF

Position : 306320E, 6020374N Surface RL: 102.00m approx (AH) Angle from Horiz. : 90°
Rig Type : Angove Mounting : Trailor Contractor : Lloyd Angove Drilling Driller : Lloyd Angove
Casing Dia. : Barrel (m) : Bit : Bit Condition :
Date Started : 22/02/05 Date Completed : 22/02/05 Logged by : RAC Date Logged :

progress		DESCRIPTION	WEATHERING	Estimated Strength		NATURAL FRACTURES		PIEZOMETER LOG	COMPONENTS
DRILLING & CASING	WATER			Is ₍₅₀₎ MPa	Is ₍₅₀₎ MPa	Spacing (mm)	ADDITIONAL DATA (joints, partings, seams, fracture or shear zones and veins)		
		ROCK TYPE, colour, grain size, structure (texture, mineral composition, hardness, alteration, cementation, etc. as applicable) and moisture, colour, consistency, structure, SOIL TYPE (origin)							
		plasticity, clayey SAND, fine grained sand (alluvium). Dry, light grey and yellow brown banded, dense, fine grained, SAND, some clay (alluvium).							
		11.0m, becoming fine to medium grained, trace coarse grained sand.							
		End of hole at 12.0 metres.							
		No groundwater encountered.							



Appendix B

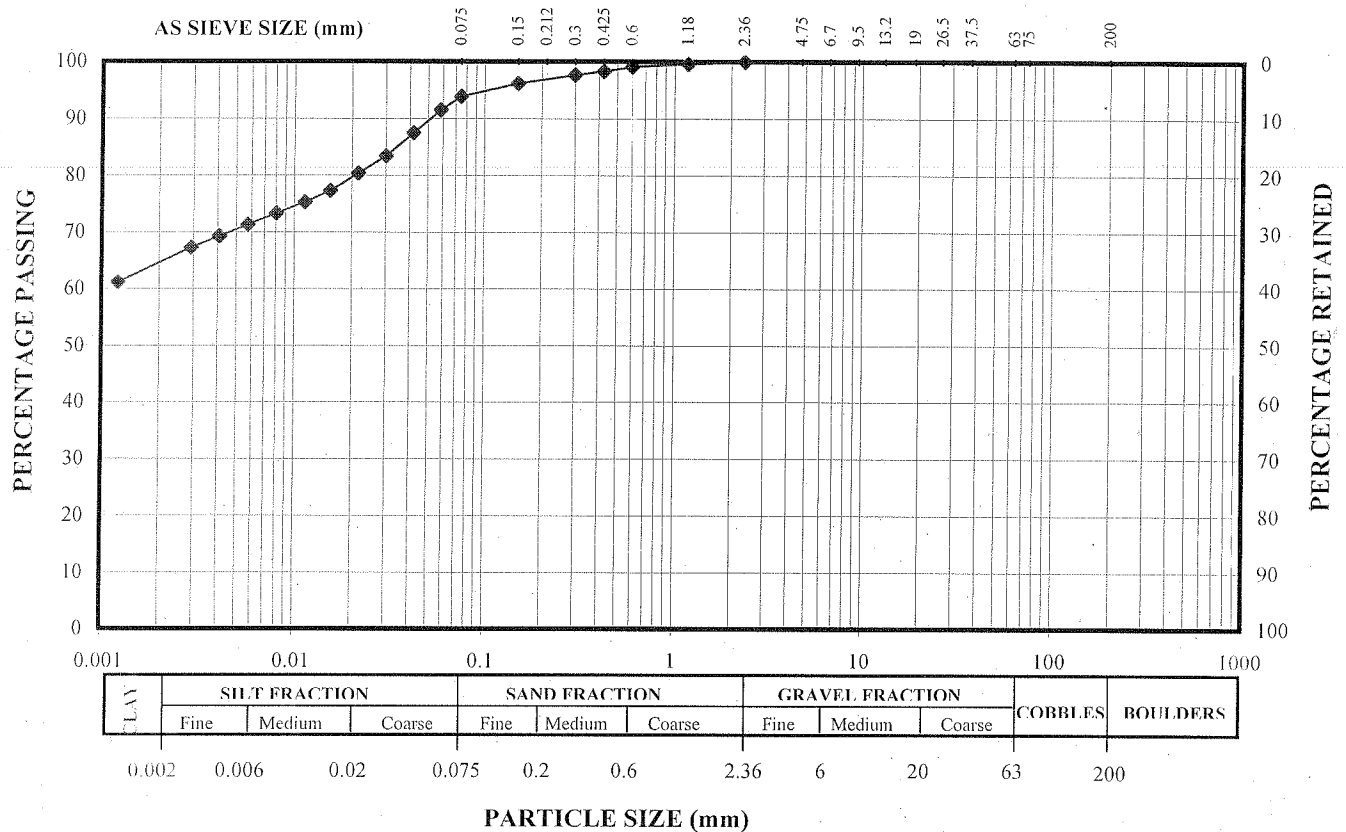
Geotechnical Laboratory Test Results

SOIL CLASSIFICATION REPORT

Trial Hole: TP01
Depth: 0.27 to 0.40
Sample No: 3742/01

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

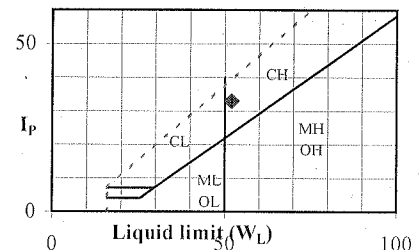
PARTICLE DENSITY 2.65 (assumed)

PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Red brown CLAY



INDEX PROPERTIES (%)

Liquid Limit = 52 Plastic Limit = 19
Plasticity Index = 33 Linear Shrinkage % = 13.0

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

REMARKS:

Tested by: MG
Date tested: 11.03.05
Checked by: *[Signature]*
Date checked: 20.04.05



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Tel: 9462 4700 Fax: 9462 4710



Authorised Signatory:

[Signature]
DBROOME
22/4/05



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JOB No. 2113507

REPORT No. 13462

Ref: FASWUTD/LAD/START/SIEVE

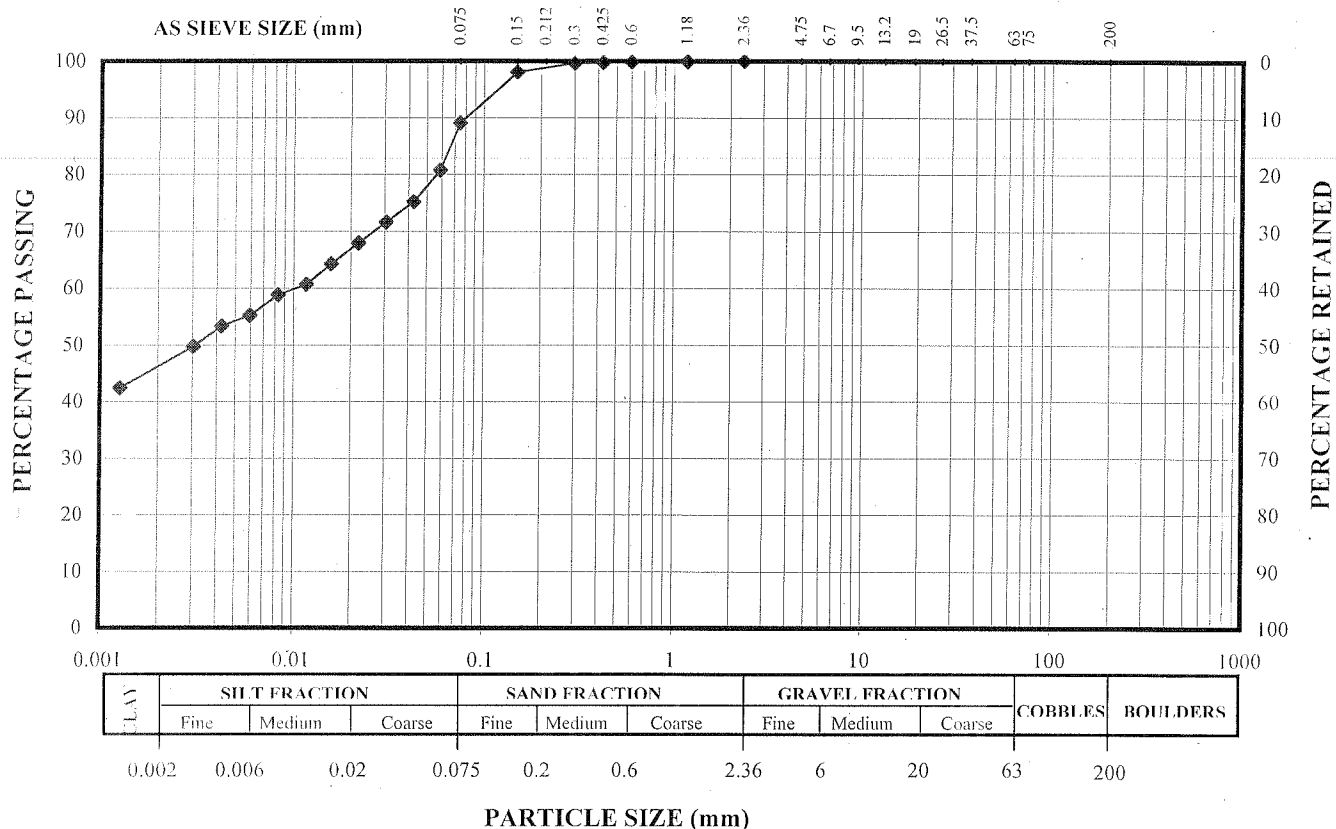
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SOIL CLASSIFICATION REPORT

Trial Hole: TP02
Depth: 5.0 to 5.4.
Sample No: 3742/02

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

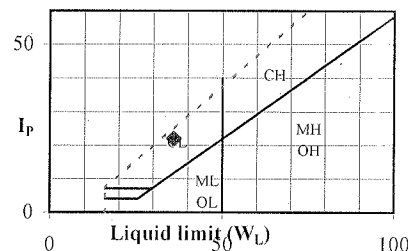
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CL

SOIL NAME: Grey and yellow brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 36 Plastic Limit = 14
Plasticity Index = 22 Linear Shrinkage % = 10.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 11.03.05
Checked by: *gk*
Date checked: 20-04-05



GHD LONGMAC

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Authorised Signatory:

Debbie
22/4/05



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JOB No. 2113507

REPORT No. 13463

Ref: PASWUTLELABSTARTSIEVE

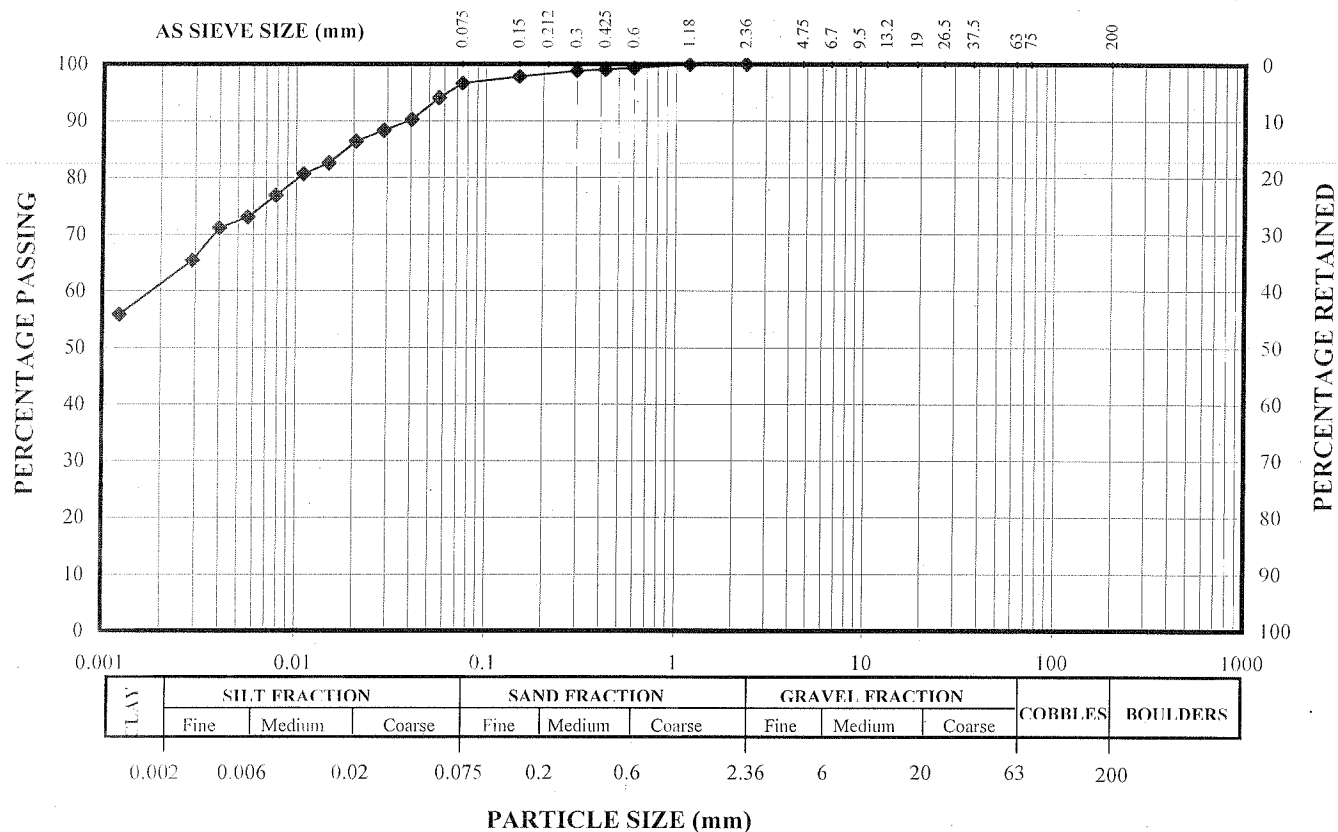
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SOIL CLASSIFICATION REPORT

Trial Hole: TP09
Depth: 2.0 to 2.5
Sample No: 3742/03

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moir Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

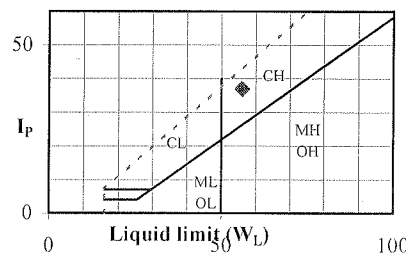
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Grey/brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 56 Plastic Limit = 19
Plasticity Index = 37 Linear Shrinkage % = 13.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 11.03.05
Checked by: *gk*
Date checked: 20-04-05



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JOB No. 2113507

REPORT No. 13464

Ref: FASWUT/LAB/START/SIEVE

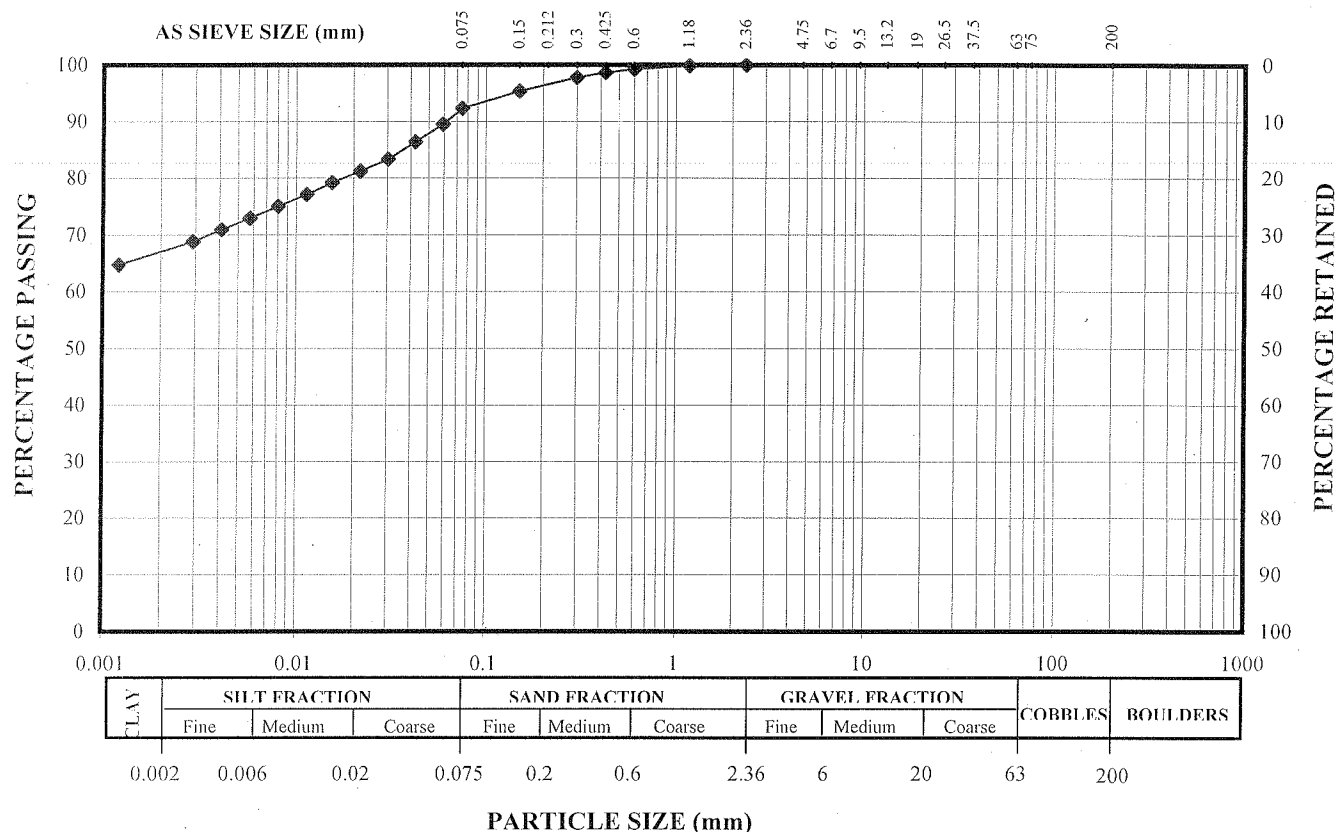
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SOIL CLASSIFICATION REPORT

Trial Hole: TP13
Depth: 0.3 to 0.5
Sample No: 3742/04

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moira Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.3

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (measured)

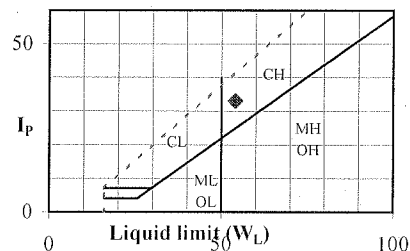
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Red brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 54 Plastic Limit = 21
Plasticity Index = 33 Linear Shrinkage % = 13.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *gcu*
Date checked: 20.04.05



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JOB No. 2113507

REPORT No. 13465

Ref: PASWUTHALABSTARTSIEVE

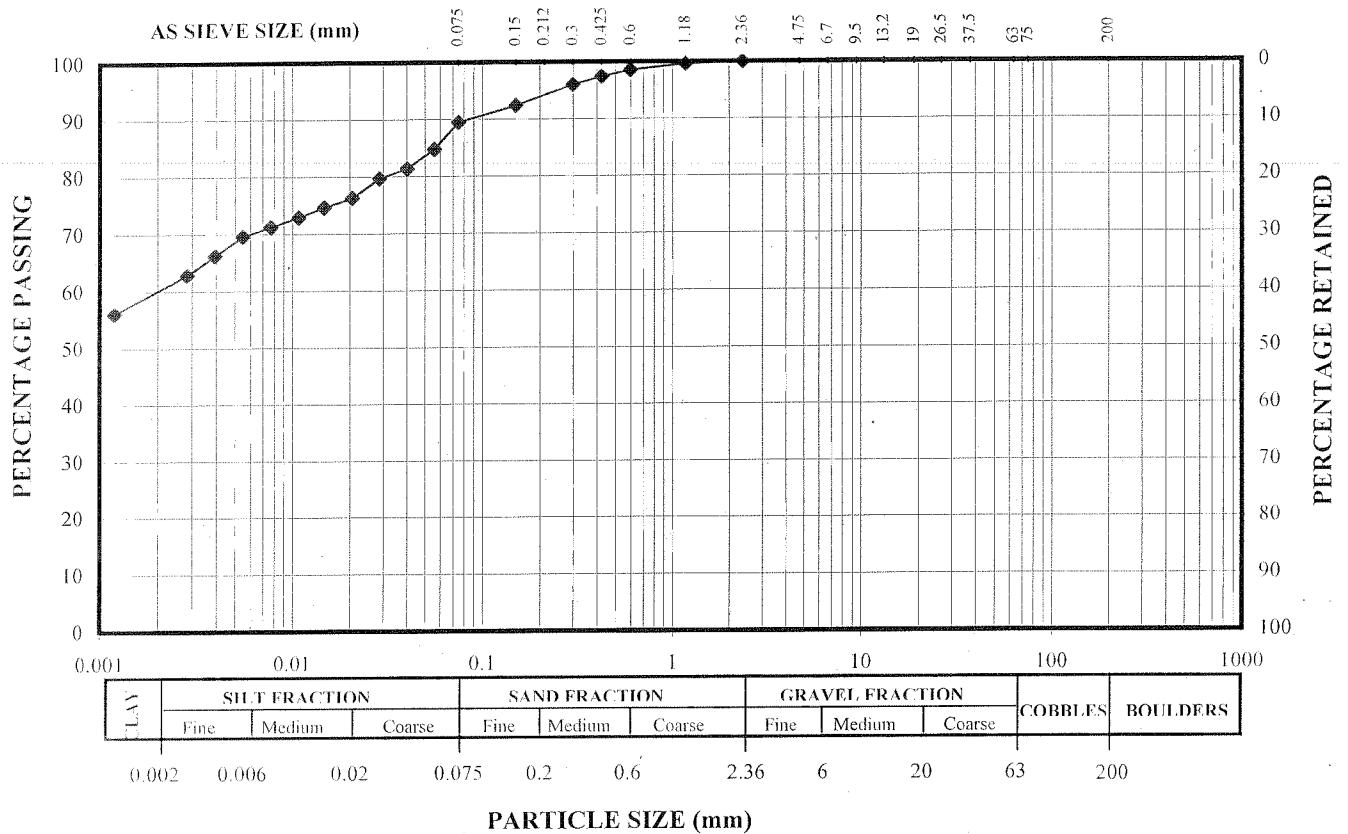
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SOIL CLASSIFICATION REPORT

Trial Hole: TP16
Depth: 2.8 to 3.1
Sample No: 3742/05

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moira Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.3

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

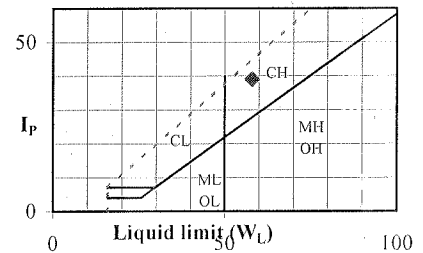
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Orange/brown/grey Light brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 58 Plastic Limit = 19
Plasticity Index = 39 Linear Shrinkage % = 14.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *AB*
Date checked: 22-03-05



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Authorised Signatory:

[Signature]
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JOB No. 2113507

REPORT No. 13466

Ref: PARWUTHLABSSTARTSHEET

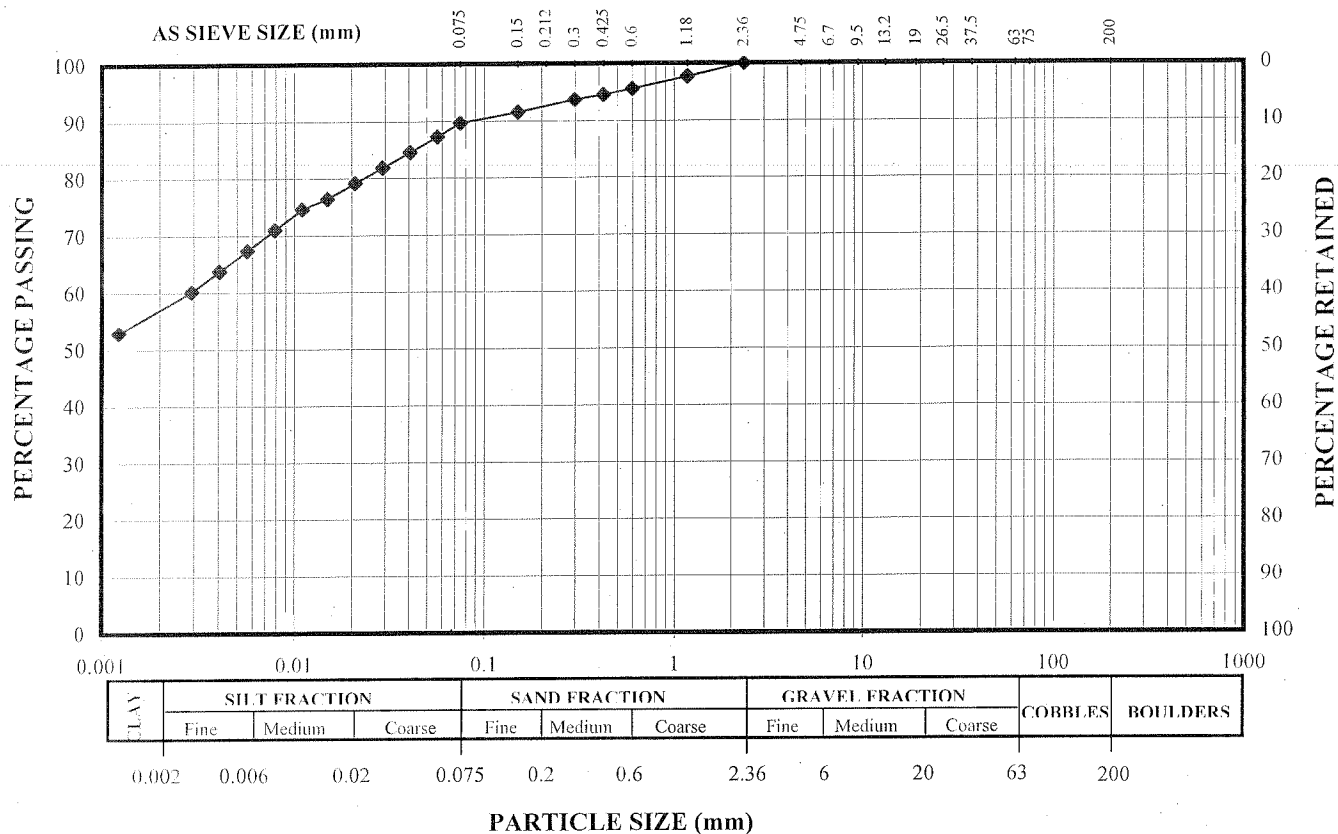
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SOIL CLASSIFICATION REPORT

Trial Hole: TP17
Depth: 1.0 to 1.5
Sample No: 3742/06

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moira Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.3

OTHER TESTS

GRADING

$C_u = D_{60} / D_{10} =$ not determinable

$C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

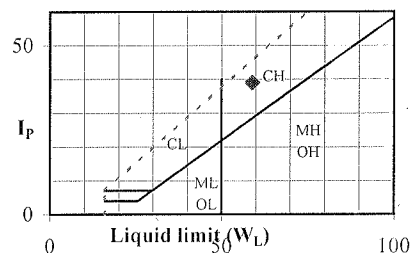
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Grey/brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 59

Plastic Limit = 20

Plasticity Index = 39

Linear Shrinkage % = 15.0

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 11.03.05
Checked by: *GO*
Date checked: 22-03-05



GHD LONGMAC

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Authorised Signatory:

[Signature]
22/4/05



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JOB No. 2113507

REPORT No. 13467

RGE FSWUTHLABS STARTSIVE

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Soil Index Properties - Report

Report No. : 13503

Client: Agricultural Equity Investment Pty Ltd

Job Number: 2113507

Project: Proposed 80,000 Head Feed Lot

Location: " Moira Station ", Mathoura

TEST METHODS :	Moisture Content	-	☒	AS1289.2.1.1	☐	RTA T120
	Liquid Limit (Four Point)	-	☒	AS1289.3.1.1	☐	RTA T102
	Liquid Limit (One Point)	-	☐	AS1289.3.1.2	☐	RTA T108
	Plastic Limit	-	☒	AS1289.3.2.1	☐	RTA T109
	Plasticity Index	-	☒	AS1289.3.3.1	☐	RTA T103
	Linear Shrinkage	-	☒	AS1289.3.4.1	☐	RTA T113

Sample History : Sampled by GHD-LONGMAC (Geotechnical)

Laboratory Sample No.	Client Sample ID	Test Hole	Depth (m)	Description	NBD/ NDD (t/m ³)	FMC (%)	LL (%)	PL (%)	PI (%)	LS (%)
3742/01	n/a	TP01	0.27 to 0.40	Red brown CLAY	nt	24.7	52	19	33	13.0
3742/02	n/a	TP02	5.00 to 5.40	Grey & yellow brown CLAY	nt	16.1	36	14	22	10.5
3742/03	n/a	TP09	2.00 to 2.50	Grey/brown CLAY	nt	21.8	56	19	37	13.5
3742/04	n/a	TP13	0.30 to 0.50	Red brown CLAY	nt	26.6	54	21	33	13.5
3742/05	n/a	TP16	2.80 to 3.10	Orange/brown/grey Light brown CLAY	nt	19.4	58	19	39	14.5
3742/06	n/a	TP17	1.20 to 1.50	Grey brown CLAY	nt	25.2	59	20	39	15.0
3742/07	n/a	TP19	1.00 to 1.20	Grey brown CLAY	nt	19.8	60	21	39	18.5
3742/08	n/a	TP21	0.50 to 0.60	Red brown CLAY	nt	22.9	48	20	28	12.0

Abbreviations :

LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
LS Linear Shrinkage
FMC Field Moisture Content
n/a not applicable
nt not tested
n/av not available

NDD Natural Dry Density
NBD Natural Bulk Density

Sample History

☐ Natural ☐ Air Dried ☒ Oven Dried

Preparation Method

☐ Wet ☒ Dry

Type of Test

☒ Four Point ☐ One Point

Type of Test

☒ 125mm ☐ 150mm ☐ 250mm

Note :

Tested by:	GV
Date tested:	29/03/05
Checked by:	
Authorised Signatory:	
Date:	22/4/05



GHD - LONGMAC

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Soil Index Properties - Report

Report No. : 13504

Client: Agricultural Equity Investment Pty Ltd

Job Number: 2113507

Project: Proposed 80,000 Head Feed Lot

Location: " Moira Station ", Mathoura

TEST METHODS :	Moisture Content	-	☒ AS1289.2.1.1	☐ RTA T120
	Liquid Limit (Four Point)	-	☒ AS1289.3.1.1	☐ RTA T102
	Liquid Limit (One Point)	-	☐ AS1289.3.1.2	☐ RTA T108
	Plastic Limit	-	☒ AS1289.3.2.1	☐ RTA T109
	Plasticity Index	-	☒ AS1289.3.3.1	☐ RTA T103
	Linear Shrinkage	-	☒ AS1289.3.4.1	☐ RTA T113

Sample History : Sampled by GHD-LONGMAC (Geotechnical)

Laboratory Sample No.	Client Sample ID	Test Hole	Depth (m)	Description	NBD/ NDD (t/m ³)	FMC (%)	LL (%)	PL (%)	PI (%)	LS (%)
3742/09	n/a	TP21	1.50 to 2.00	Red/brown & grey/brown sandyCLAY	nt	16.9	48	21	27	14.5
3742/10	n/a	TP26	3.50 to 4.00	Light grey orange SAND with clay	nt	11.7	nt	nt	nt	nt
3742/11	n/a	TP28	0.30 to 0.50	Red/brown CLAY	nt	27.5	61	21	40	18.0
3742/12	n/a	TP28	2.50 to 3.00	Grey/brown & yellow brown CLAY	nt	26.0	66	22	44	18.5

Abbreviations :

LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
LS Linear Shrinkage
FMC Field Moisture Content
n/a not applicable
nt not tested
n/av not available

NDD Natural Dry Density
NBD Natural Bulk Density

Sample History

☐ Natural ☐ Air Dried ☒ Oven Dried

Preparation Method

☐ Wet ☒ Dry

Type of Test

☒ Four Point ☐ One Point

Type of Test

☐ 125mm ☐ 150mm ☐ 250mm

Note :

Tested by:	GV
Date tested:	29/03/05
Checked by:	<i>[Signature]</i>
Authorised Signatory:	<i>[Signature]</i> OBROONE
Date:	22/4/05



GHD - LONGMAC

57 Herbert St, Artarmon 2064
Tel: (02) 9462 4700 Fax: (02) 9462 4710

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Report No. : 13505a

Client : Agricultural Equity Investment Pty Ltd

Project : Proposed 80,000 Head Feed Lot

Location : "Moira Station", Mathoura

TEST METHOD : AS1289.3.8.1

Job No.	2113507
---------	---------

Sample No.:	n/a
-------------	-----

Test Hole No.:	n/a
----------------	-----

Depth (m) :	n/a
-------------	-----

Client Sample ID :	n/a
--------------------	-----

Sample History : Sampled by GHD LongMac Geotechnical

Date Sampled : 18/02/05

Type of Water : Distiled

Water Temperature °C : 21

TEST RESULTS

[illegible]

Notes : Report re-issued 11/05/05 - correction to depth for sample 3742/06

Tested by:	GV
------------	----

Date tested:	10/03/05
--------------	----------

Checked by:	
-------------	---

Authorised
Signatory :

Date:



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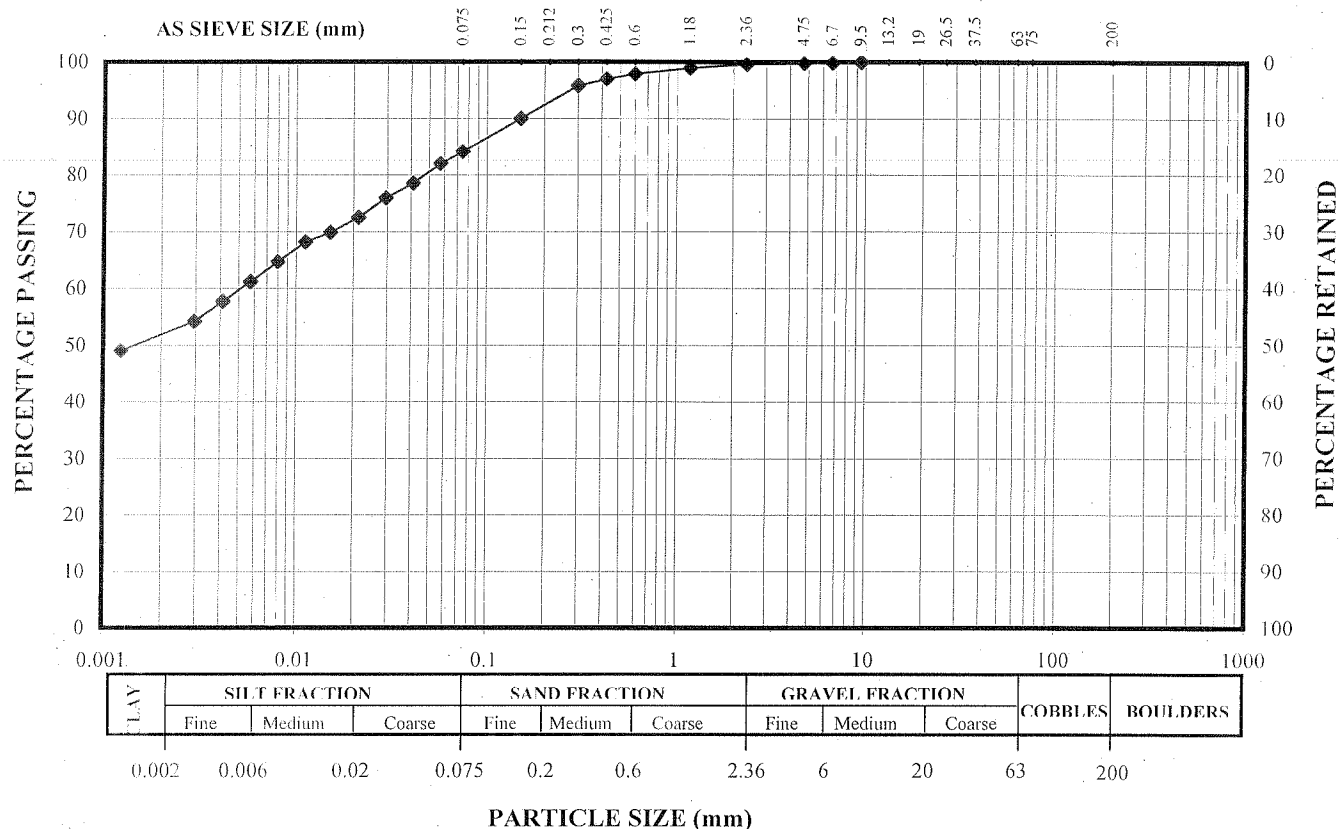
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SOIL CLASSIFICATION REPORT

Trial Hole: TP19
Depth: 1.0 to 1.2
Sample No: 3742/07

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

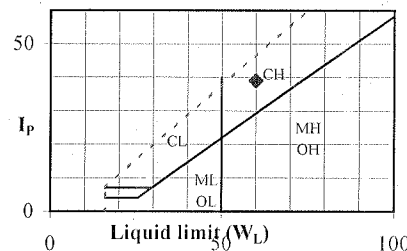
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Grey brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 60 Plastic Limit = 21
Plasticity Index = 39 Linear Shrinkage % = 18.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 11.03.05
Checked by: *el*
Date checked: 20-04-05



GHD LONGMAC

57 Herbert St, Artarmon NSW, 2064
Tel: 9462 4700 Fax: 9462 4710

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Authorised Signatory:

DBROOME
22/4/05



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JOB No. 2113507

REPORT No. 13507

R/E FSWUTHLA/BSSTARTSIEVE

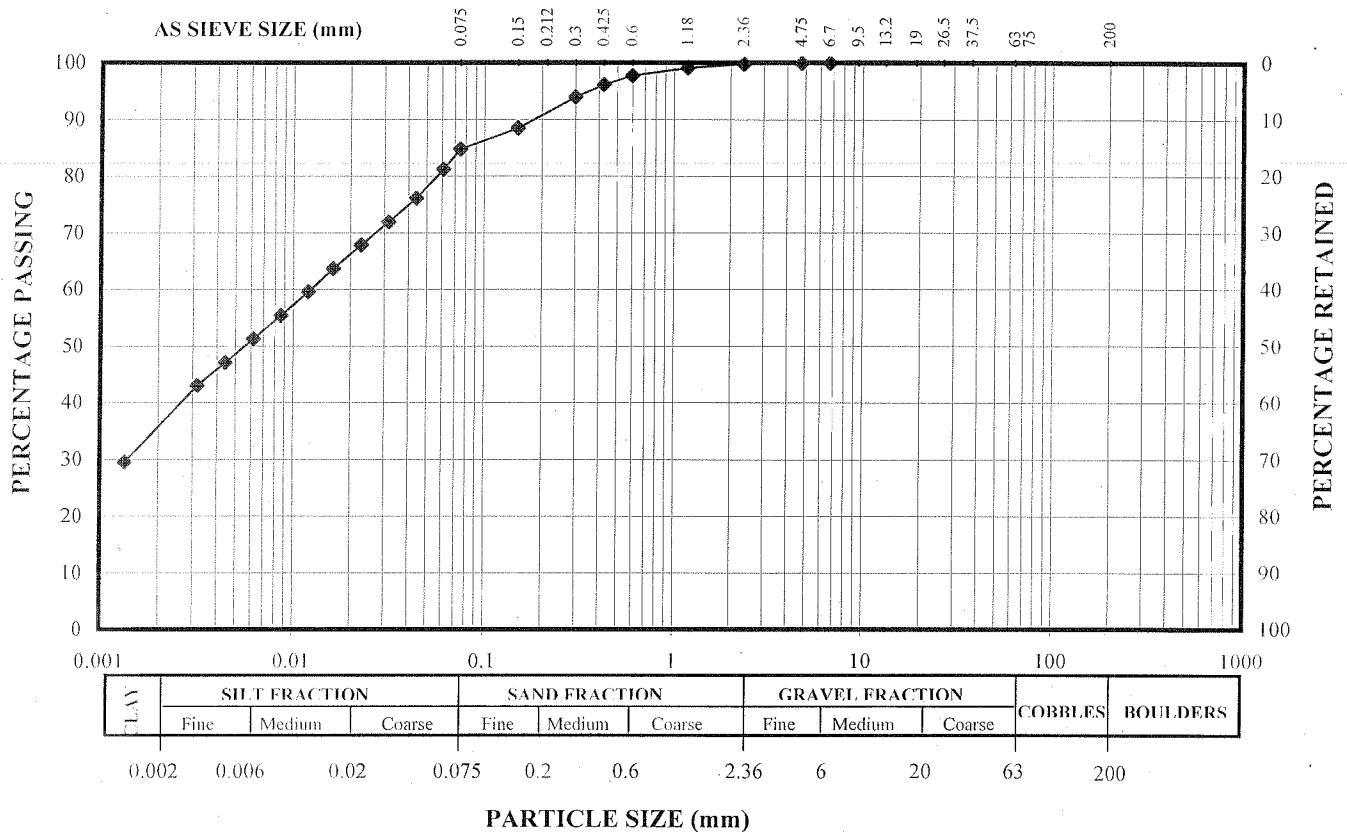
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SOIL CLASSIFICATION REPORT

Trial Hole: TP21
Depth: 0.5 to 0.6
Sample No: 3742/08

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moir Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

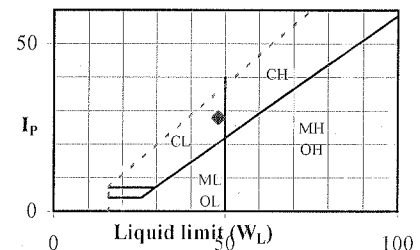
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CL

SOIL NAME: Red brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 48 Plastic Limit = 20
Plasticity Index = 28 Linear Shrinkage % = 12.0

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *CU*
Date checked: 20-09-05



GHD LONGMAC

57 Herbert St, Artarmon NSW, 2064
Tel: 9462 4700 Fax: 9462 4710

GEOTECHNICAL TESTING SERVICES



Authorised Signatory:

DBROOKE
22/4/05



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JOB No. 2113507

REPORT No. 13508

Ref: FISHWILLABSTARTSIEVE

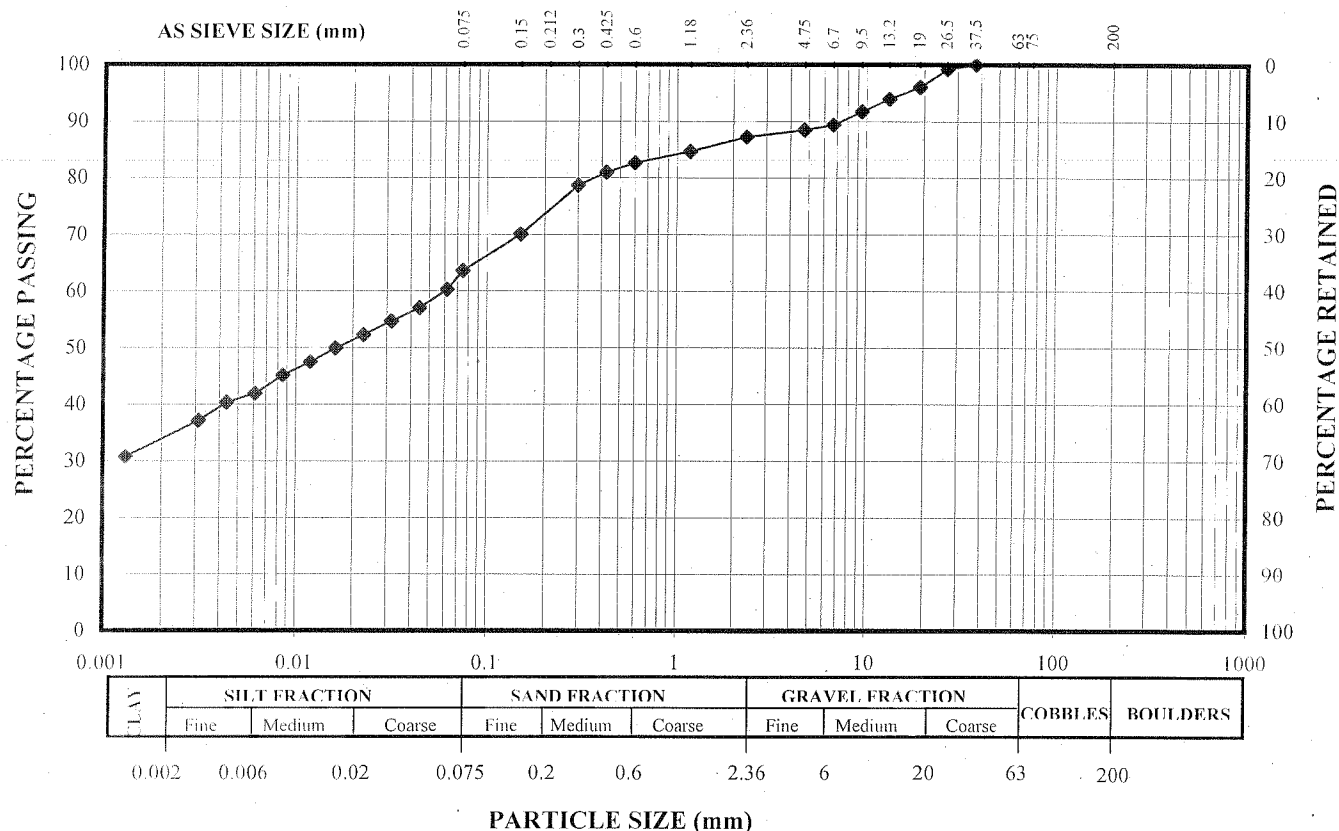
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SOIL CLASSIFICATION REPORT

Trial Hole: TP21
Depth: 1.5 to 2.0
Sample No: 3742/09

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

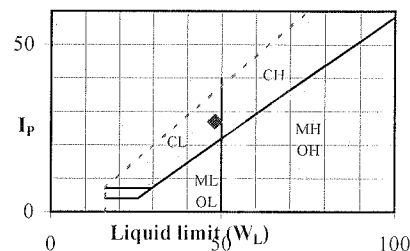
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CL

SOIL NAME: Red/brown & grey brown sandy CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 48 Plastic Limit = 21
Plasticity Index = 27 Linear Shrinkage % = 14.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *EL*
Date checked: 20.04.05



GHD LONGMAC

57 Herbert St, Artarmon NSW, 2064

Tel: 9462 4700 Fax: 9462 4710

GEOTECHNICAL TESTING SERVICES



Authorised Signatory:

[Signature]
OBLOOKE
22/4/05



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JOB No. 2113507

REPORT No. 13509

Ref: FSWUTH/LAB/START/SIEVE

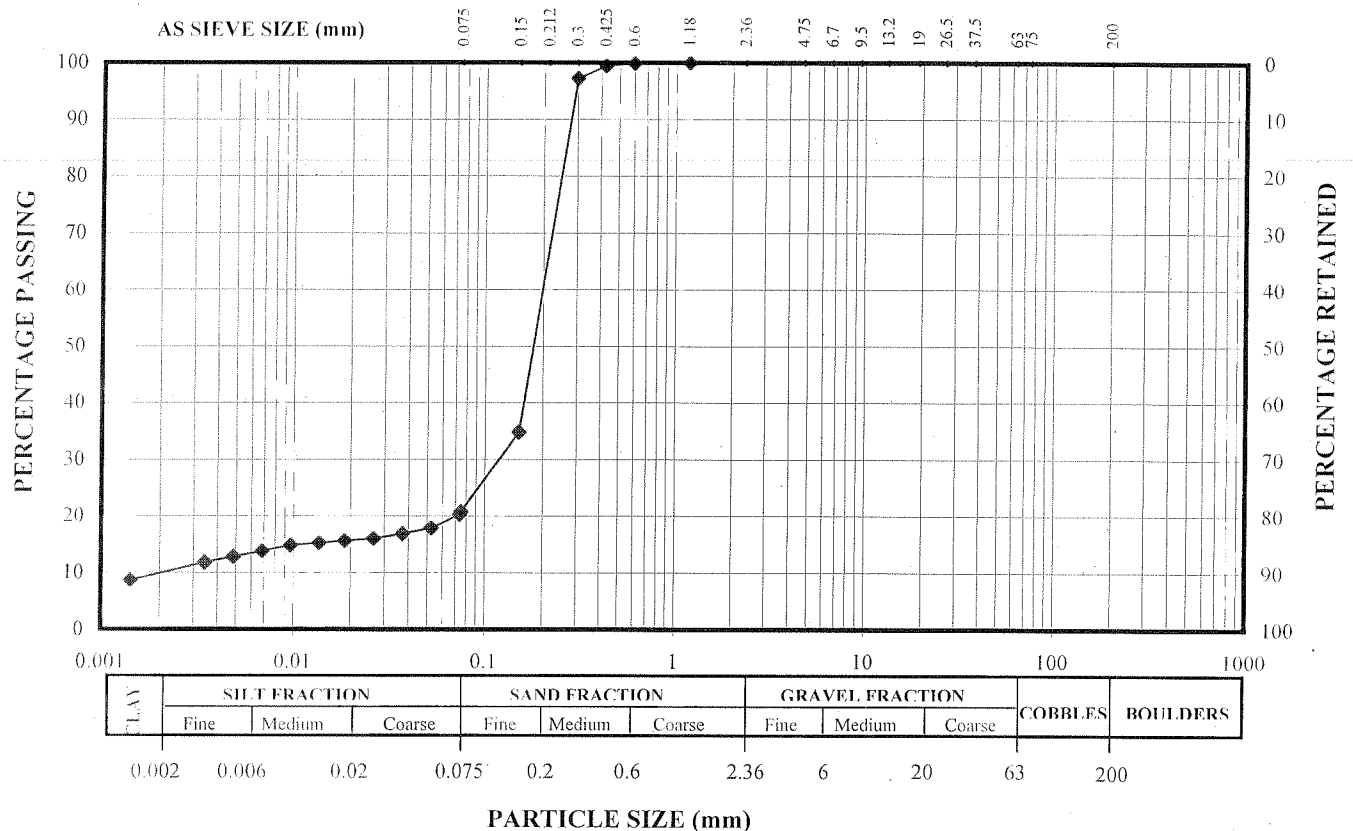
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SOIL CLASSIFICATION REPORT

Trial Hole: TP26
Depth: 3.5 to 4.0
Sample No: 3742/10

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical.



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.3

OTHER TESTS

GRADING

$$C_u = D_{60} / D_{10} = 92.2$$

$$C_c = D_{30}^2 / (D_{10} \times D_{60}) = 32.2$$

PARTICLE DENSITY 2.65 (assumed)

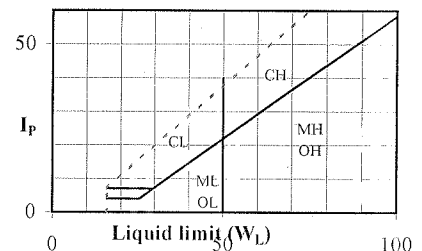
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL:

SOIL NAME: Light grey & orange SAND with clay

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = N/A

Plastic Limit = N/A

Plasticity Index = N/A

Linear Shrinkage % = Not determined

Atterberg Limits (History/preparation)

Liquid Limit (type of test)

Linear Shrinkage (mould size)

Tested by: MG
Date tested: 14.03.05
Checked by: *SL*
Date checked: 20.04.05



GHD LONGMAC

57 Herbert St, Artarmon NSW, 2064

Tel: 9462 4700 Fax: 9462 4710

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Authorised Signatory:

[Signature]
22/4/05



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JOB No. 2113507

REPORT No. 13510

Ref: FSWUTILABNSSTARTSUE

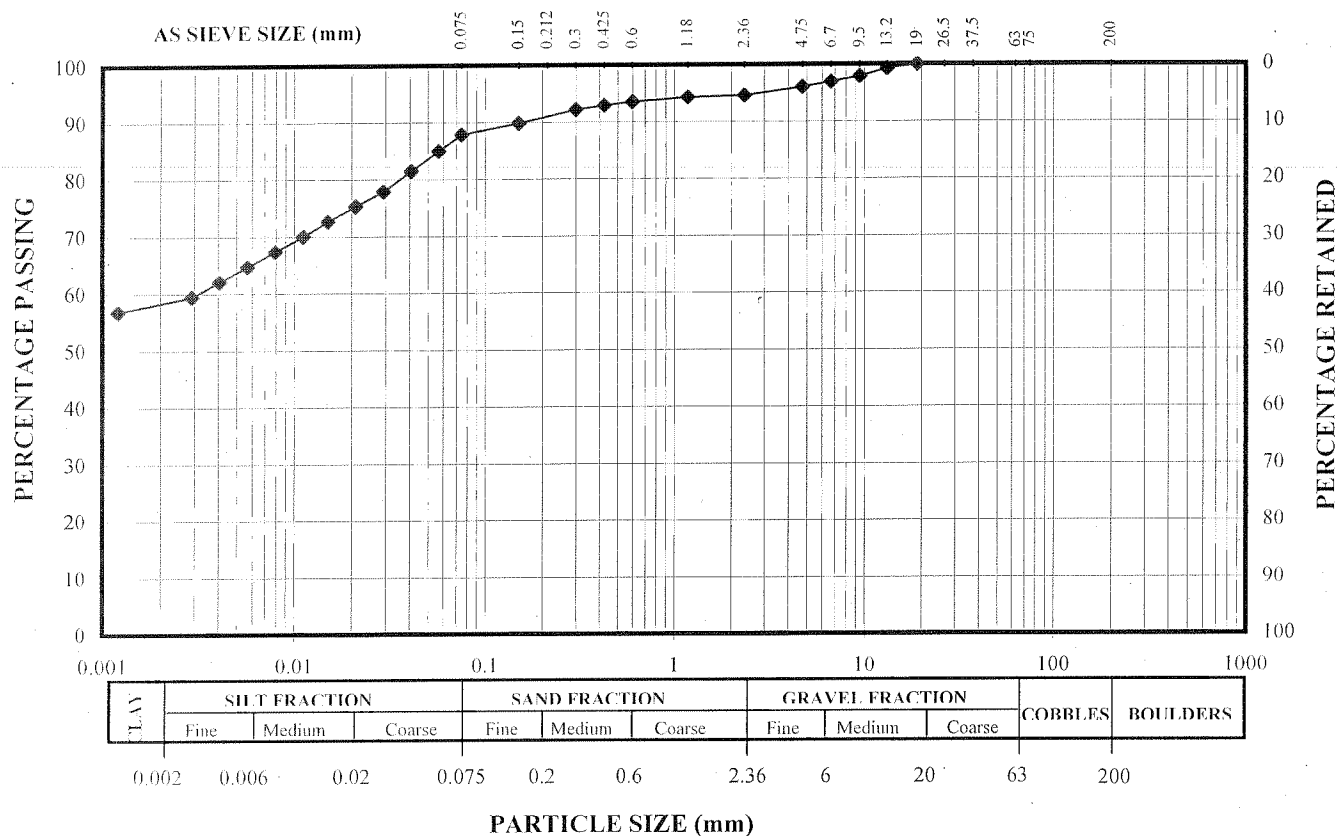
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SOIL CLASSIFICATION REPORT

Trial Hole: TP28
Depth: 0.3 to 0.5
Sample No: 3742/11

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moira Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

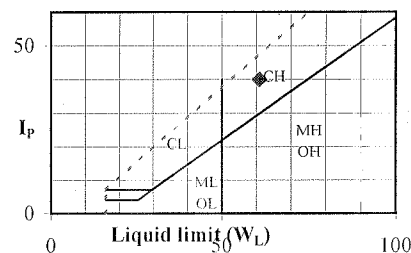
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Red/brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 61 Plastic Limit = 21
Plasticity Index = 40 Linear Shrinkage % = 18.0

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

250 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *gao*
Date checked: 22-03-05



GHD LONGMAC

57 Herbert St, Artarmon NSW, 2064

Tel: 9462 4700 Fax: 9462 4710

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Authorised Signatory:

DeRose
22/4/05



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JOB No. 2113507

REPORT No. 13511

R&P: FSW/UTD/LAB/ST/ART/SP/VE

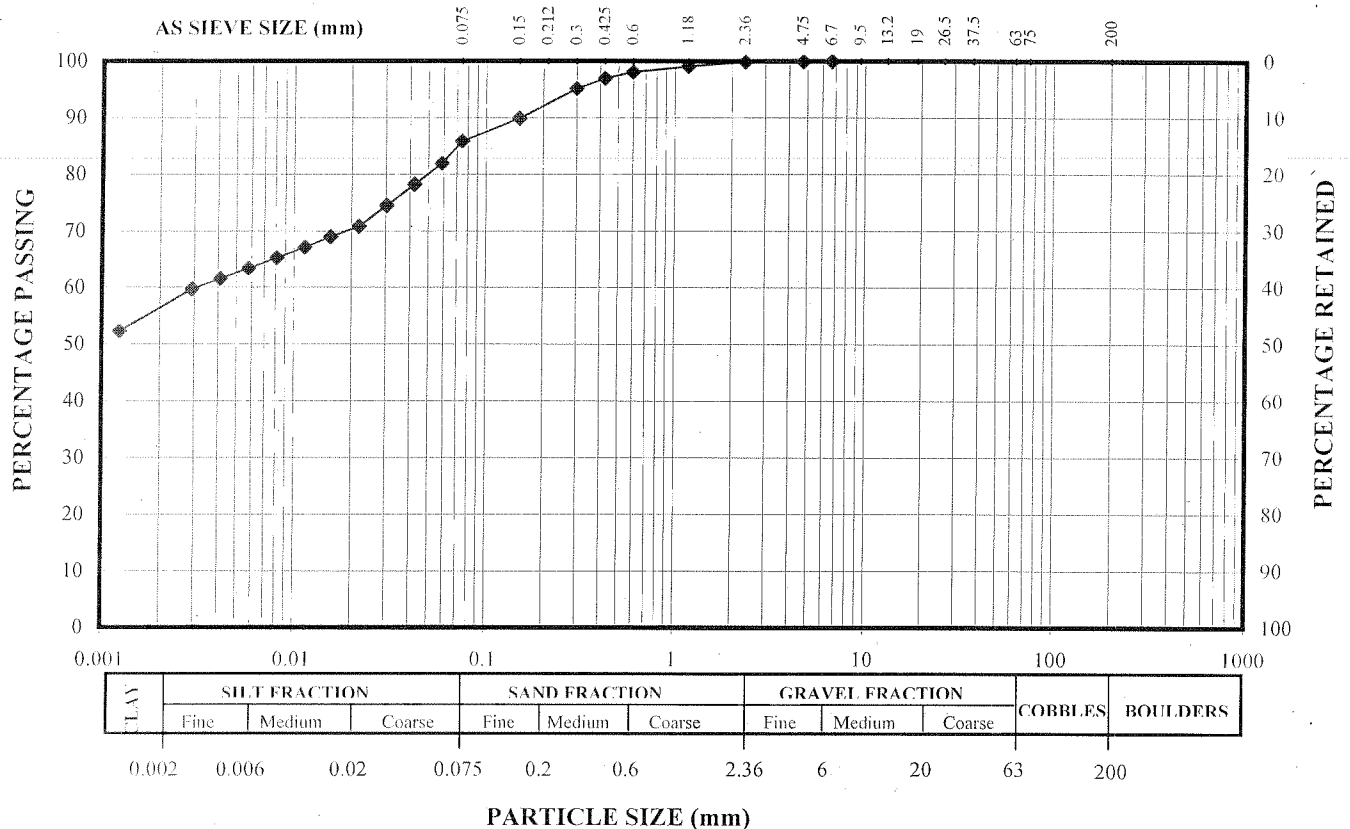
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SOIL CLASSIFICATION REPORT

Trial Hole: TP 28
Depth: 2.5 to 3.0
Sample No: 3742/12

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

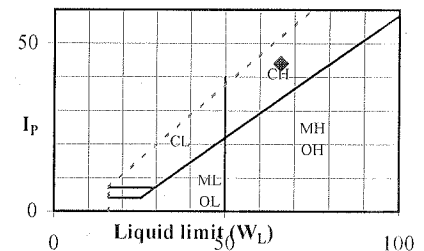
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Grey brown & yellow brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 66 Plastic Limit = 22
Plasticity Index = 44 Linear Shrinkage % = 18.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *gl*
Date checked: 20.04.05



GHD LONGMAC

57 Herbert St, Artarmon NSW, 2064

Tel: 9462 4700 Fax: 9462 4710

GEOTECHNICAL TESTING SERVICES



Authorised Signatory:

DBLOOMIE
22/4/05



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JOB No.

2113507

REPORT No.

13512

Ref: FSWUTHLABSSTARTSIEVE

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Compaction (Tabulated) - Report

Report No. : 13513

Client: Agricultural Equity Investment Pty Ltd

Job No.: 2113507

Project: Proposed 80,000 Head Feed Lot

Location: " Moira Station ", Mathoura

TEST METHOD : Compaction : AS1289.5.1.1

Moisture Content : AS1289.2.1.1

Sample Number :	3742/02	3742/03	3742/06	3742/07	3742/09	3742/12
Test Hole Number :	TP02	TP09	TP17	TP19	TP21	TP28
Test Hole Depth : (m)	5.00 to 5.40	2.00 to 2.50	1.00 to 1.50	1.00 to 1.20	1.50 to 2.00	2.50 to 3.00
Chainage : (m)	n/a	n/a	n/a	n/a	n/a	n/a
R.L. : (m)	n/a	n/a	n/a	n/a	n/a	n/a
Location :	n/a	n/a	n/a	n/a	n/a	n/a
Date Sampled :	n/a	n/a	n/a	n/a	n/a	n/a
Time Sampled :	n/a	n/a	n/a	n/a	n/a	n/a
Client Sample ID :	n/a	n/a	n/a	n/a	n/a	n/a
Compaction Type :	Standard	Standard	Standard	Standard	Standard	Standard
+19.0 mm Oversize : (%)	0	0	0	0	3.9	0
+37.5 mm Oversize : (%)	0	0	0	0	0	0
Natural Moisture Content : (%)	16.1	21.8	25.2	19.8	16.9	26.0
Optimum Moisture Content : (%)	16.9	22.1	23.9	21.5	19.7	24.8
Maximum Dry Density : (t/m ³)	1.79	1.66	1.61	1.67	1.65	1.59
Soil Description :	Grey & yellow brown CLAY	Grey/brown CLAY	Grey/brown CLAY	Grey/brown CLAY	Red/brown & yellow brown sandy CLAY	Grey/brown & yellow brown CLAY

OVERALL COMMENTS :

Tested by:	GV
Date tested:	22/03/05
Checked by:	<i>[Signature]</i>
Approved Signatory:	<i>[Signature]</i> D. BROOKER
Date:	22/4/05



GHD - LONGMAC

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PERMEABILITY BY FALLING HEAD

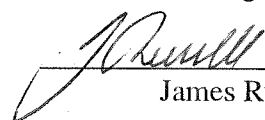
TEST PROCEDURE: AS1289 5.1.1, KH 2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client: GHD Longmac Pty Ltd	Certificate No. 503619-FHP
Project: 2113507 – Moira Station	Date: 2/4/05
Sample No.	503619
Client's ID;	3742/02
Test Pit No.	02
Depth (m):	5.0-5.4
Max. Dry Density (t/m ³):	*1.79
Optimum Moisture Content (%):	*17.0
Placement Moisture Content (%):	17.5
Placement Wet Density (t/m ³):	2.05
Density Ratio at Placement:	97.5
PERMEABILITY: $k_{20} = 6 \times 10^{-11} \text{ m/s}$	
Remarks: * The sample and compaction data were supplied by the client. The specimen was remoulded to a target of 98% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.	



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Authorised Signatory


James Russell



PERMEABILITY BY FALLING HEAD

TEST PROCEDURE: AS1289 5.1.1, KH 2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client: GHD Longmac Pty Ltd

Certificate No. 503620-FHP

Project: 2113507 – Moira Station

Date: 2/4/05

Sample No.	503620
Client's ID;	3742/03
Test Pit No.	09
Depth (m):	2.0-2.5
Max. Dry Density (t/m ³):	*1.66
Optimum Moisture Content (%):	*22.0
Placement Moisture Content (%):	22.1
Placement Wet Density (t/m ³):	1.99
Density Ratio at Placement:	98.0

PERMEABILITY:

$$k_{20} = 8 \times 10^{-11} \text{ m/s}$$

Remarks: * The sample and compaction data were supplied by the client. The specimen was remoulded to a target of 98% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.



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Authorised Signatory

James Russell



PERMEABILITY BY FALLING HEAD

TEST PROCEDURE: AS1289 5.1.1, KH 2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client: GHD Longmac Pty Ltd	Certificate No. 503621-FHP
Project: 2113507 – Moira Station	Date: 2/4/05
Sample No.	503621
Client's ID;	3742/06
Test Pit No.	17
Depth (m):	1.0-1.5
Max. Dry Density (t/m ³):	*1.61
Optimum Moisture Content (%):	*24.0
Placement Moisture Content (%):	24.2
Placement Wet Density (t/m ³):	1.96
Density Ratio at Placement:	98.0
PERMEABILITY: $k_{20} = 1 \times 10^{-10} \text{ m/s}$	
Remarks: * The sample and compaction data were supplied by the client. The specimen was remoulded to a target of 98% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.	



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Authorised Signatory

James Russell

PERMEABILITY BY FALLING HEAD

TEST PROCEDURE: AS1289 5.1.1, KH 2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client: GHD Longmac Pty Ltd

Certificate No. 503622-FHP

Project:

Date: 2/4/05

Sample No.	503622
Client's ID;	3742/09
Test Pit No.	21
Depth (m):	1.5-2.0
Max. Dry Density (t/m ³):	*1.65
Optimum Moisture Content (%):	*20.0
Placement Moisture Content (%):	20.2
Placement Wet Density (t/m ³):	1.94
Density Ratio at Placement:	98.0

PERMEABILITY:

$$k_{20} = 9 \times 10^{-11} \text{ m/s}$$

Remarks: * The sample and compaction data were supplied by the client. The specimen was remoulded to a target of 98% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.



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NATA Accredited Laboratory Number 9926

Authorised Signatory


James Russell



Appendix C

Agricultural Laboratory Test Results

WATER TEST

Page 1 of 6

Office:
PO BOX 591
SEVEN HILLS NSW 2147

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8294
Fax: (02) 9838 8919
A.C.N. 098 982 140
A.B.N. 76 098 982 140

ANALYTICAL REPORT for:

GHD LONGMAC PTY LTD

LOCKED BAG 2727
ST LEONARDS NSW 1590

ATTN: R.CHANDLER

JOB NO: WQ0202
CLIENT ORDER: 21/13507
DATE RECEIVED: 01/03/05
DATE COMPLETED: 21/03/05
TYPE OF SAMPLES: SOILS
NO OF SAMPLES: 10

NATA Accredited Laboratory

Number: 1884



NATA ENDORSED TEST REPORT
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.....
Issued on 23/03/05
Sue Wyman
(Laboratory Supervisor)

WATER TEST

Page 2 of 6

ANALYTICAL REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

SAMPLES		Ex.Na MEQ%	Ex.K MEQ%	Ex.Ca MEQ%	Ex.Mg MEQ%	Ex.Al MEQ%	CEC MEQ%
1	TP06/0.0	0.17	0.72	5.3	3.05	<0.1	9.8
2	TP06/0.1	0.06	0.32	4.10	4.65	<0.1	9.1
3	TP07/0.0	1.40	0.18	5.1	7.0	<0.1	14.3
4	TP07/0.2	4.10	0.26	6.2	9.7	<0.1	20.3
5	TP07/1.1	1.60	0.38	29.1	6.0	<0.1	37.5
6	TP23/0.0	0.72	0.30	3.50	3.25	<0.1	8.5
7	TP23/0.3	3.75	0.05	6.8	9.8	<0.1	20.7
8	TP31/0.0	0.32	0.62	4.75	1.65	<0.1	7.8
9	TP31/0.2	2.51	0.79	10.1	5.3	<0.1	18.9
10	TP31/0.8	4.00	0.12	7.1	5.4	<0.1	16.8
DUPLICATES:							
2	TP06/0.1	0.05	0.29	4.20	4.55	<0.1	9.1
MDL		0.01	0.01	0.01	0.01	0.1	0.1
Method Code		WA20	WA20	WA20	WA20	WA20	S7
Preparation		P5	P5	P5	P5	P5	P5

WATER TEST

Page 3 of 6

ANALYTICAL REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

SAMPLES	ESP %	pH 1:5	COND. uS/cm	*TKN mg/kg	*PO4-P mg/kg	*P.SORF mg/kg
1 TP06/0.0	1.7	6.0	220	1500	39	420
2 TP06/0.1	0.7	8.6	1020	630	1.5	480
3 TP07/0.0	9.8	6.5	210	1600	8.5	450
4 TP07/0.2	20.2	8.3	830	700	1.0	430
5 TP07/1.1	4.3	7.4	4130	390	2.5	420
6 TP23/0.0	8.5	5.6	210	1700	9.0	440
7 TP23/0.3	18.1	8.0	470	1000	1.0	480
8 TP31/0.0	4.1	5.9	250	1600	15	360
9 TP31/0.2	13.3	8.4	190	750	<0.5	500
10 TP31/0.8	23.8	8.9	390	480	1.5	340
DUPLICATES:						
2 TP06/0.1	0.5	8.6	1010	600	1.0	470
MDL	0.1	0.1	5	20	0.5	1
Method Code	ESP	S1	S3	WA14	WA51	S9
Preparation	P5	P5	P5	P5	P5	P5

WATER TEST

Page 4 of 6

ANALYTICAL REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

SAMPLES	O.M. %
1 TP06/0.0	2.5
2 TP06/0.1	0.61
3 TP07/0.0	2.8
4 TP07/0.2	0.62
5 TP07/1.1	0.15
6 TP23/0.0	2.9
7 TP23/0.3	1.5
8 TP31/0.0	3.3
9 TP31/0.2	0.86
10 TP31/0.8	0.20
DUPLICATES:	
2 TP06/0.1	0.59

MDL	0.01
Method Code	C4
Preparation	P5

RESULTS ON DRY BASIS

WATER TEST

Page 5 of 6

LABORATORY DUPLICATE REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

Sample Number	Analyte	Units	MDL	Sample Result	Duplicate Result	%RPI
TP06/0.1	Ex.Na	MEQ%	0.01	0.06	0.05	17
TP06/0.1	Ex.K	MEQ%	0.01	0.32	0.29	10
TP06/0.1	Ex.Ca	MEQ%	0.01	4.10	4.20	2
TP06/0.1	Ex.Mg	MEQ%	0.01	4.65	4.55	2
TP06/0.1	Ex.Al	MEQ%	0.1	<0.1	<0.1	0
TP06/0.1	CEC	MEQ%	0.1	9.1	9.1	0
TP06/0.1	ESP	%	0.1	0.7	0.5	33
TP06/0.1	pH		0.1	8.6	8.6	0
TP06/0.1	COND.	uS/cm	5	1020	1010	1
TP06/0.1	*TKN	mg/kg	20	630	600	5
TP06/0.1	*Available P	mg/kg	0.5	1.5	1.0	38
TP06/0.1	*P.Sorption	mg/kg	1	480	470	2
TP06/0.1	Organic Matter	%	0.01	0.61	0.59	3

Acceptance criteria:

RPD <50% for low level (<20xMDL)
RPD <30% for medium level (20-100xMDL)
RPD <15% for high level (>100xMDL)
No limit applies at <2xMDL

MDL = Method Detection Limit

All results are within the acceptance criteria

ANALYTICAL REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

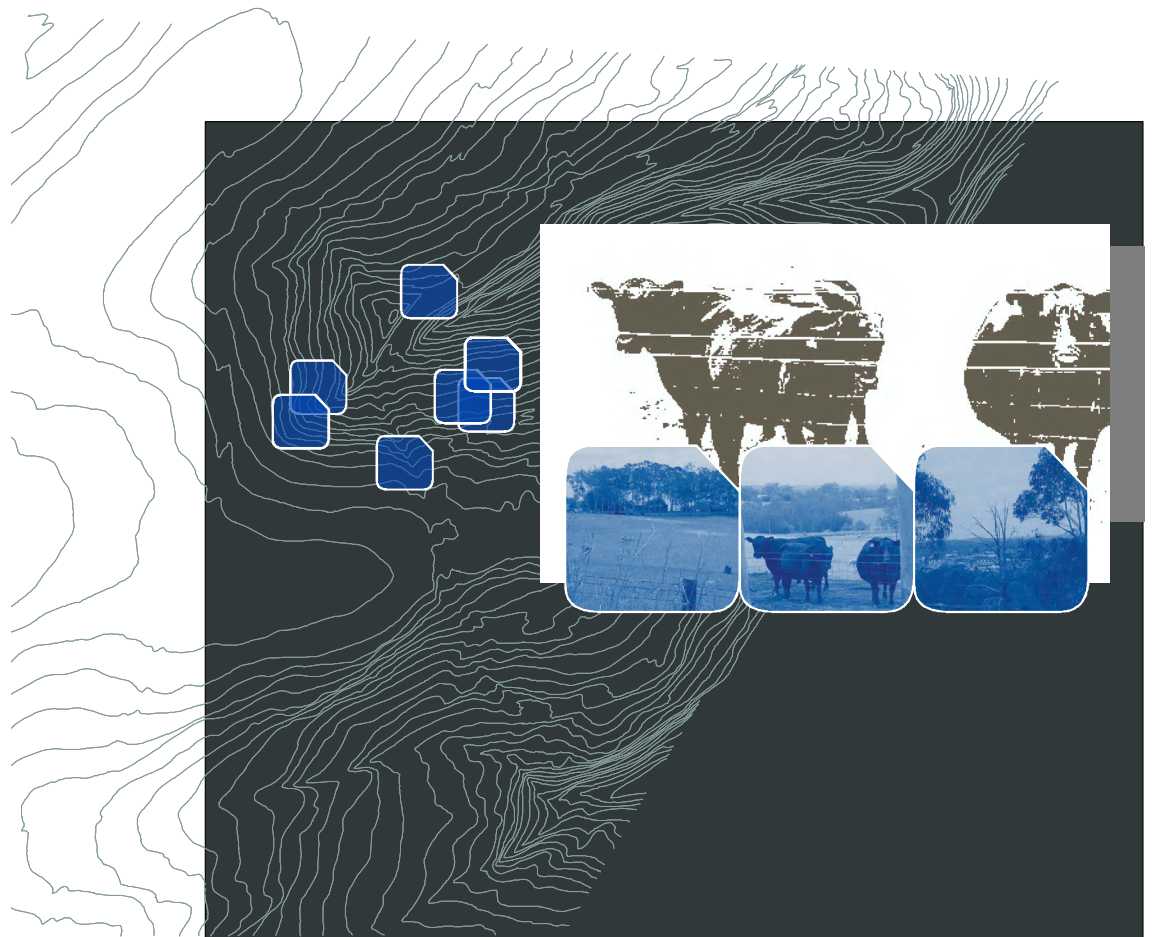
METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory.

P5	Sample dried, split and crushed to -150um
WA20	Exchangeable Metal - Silver Thiourea extract Determined by APHA 3500D/3111B
S7	Cation Exchange Capacity - Silver Thiourea Method
ESP	Exchangeable Sodium Percent Determined by Calculation
S1	pH - 1:5 water extract Determined by APHA 4500B
S3	Conductivity - 1:5 soil/water extract Determined by APHA 2510B
*WA14	Total Kjeldahl Nitrogen Determined by APHA 4500B
*WA51	Available Phosphate - Bray Extract Determined by APHA 4500F
*S9	Phosphorus Sorption - Dept of Agriculture Standard Method Determined by APHA 4500F
C4	Organic Matter - AS1289 D4.1.1

*The laboratory's NATA registration does not cover performance of this service

A preliminary report was faxed on 21/03/05



appendix e

effluent irrigation assessment

Effluent Irrigation Assessment Moira Cattle Feedlot

18 November 2005

Agricultural Equity Investments

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DISTRIBUTION

Effluent Irrigation Report Moira Cattle Feedlot

18 November 2005

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FIGURES

Figure 1 Site Layout

APPENDICES

- Appendix A Climate Averages for Australian Sites – Deniliquin (Wilkinson St) and Mathoura State Forest
- Appendix B Effluent Treatment and Irrigation Schematic

1 INTRODUCTION

1.1 Objectives

Agricultural Equity Investments Pty Ltd (AEI) is proposing to develop an 80,000 head cattle feedlot in southern NSW at Moira Station, approximately 8km south of Mathoura. The feedlot is to be developed in an area designated Zone 1(a) General Rural in the Murray Shire Local Environmental Plan. This zoning states that feedlot development is permissible with consent.

This Effluent Irrigation Report presents current information on the project and outlines the assessment of the site for the designated effluent irrigation areas. The report includes the following:

- Feedlot Site
 - Location
 - Groundwater
 - Climate
- Feedlot Project Description
 - Components
- Environmental Issues
 - Effluent treatment
 - Effluent irrigation

2 FEEDLOT SITE

2.1 Moira Station

The location of the feedlot site is on the Cobb Highway, 8km south of Mathoura (**Figure 1**). It is bounded on the west by the Deniliquin-Bendigo railway, the east by the Moira Marshes leading to the Murray River and the Highway runs through the property. The property includes 1200 Ha on the west side of the highway where the feedlot will be located.

The property is currently used for irrigation and grazing and has a 1,000 ML water licence from the river and bore licence of 4,700 ML.

2.2 Soil

The NSW Feedlot Manual contains a table regarding soil suitability, shown in **Table 1**.

Table 1: Soil Suitability for feedlot components

Component	Minimum desirable soil requirements
Effluent irrigation area	Deep well drained soil, suitable for irrigation pasture production and at least an occasional irrigated crop, moderate to high water holding capacity, not prone to waterlogging within the root zone.
Manure application area	Soils well suited to improved pasture or dryland cropping; able to withstand cultivation without incurring significant erosion or major soil structural degradation; not prone to surface waterlogging or frequent inundation.
Cattle pens and manure holding ponds	Plant growth not an issue; stable soil surface under wide range of moisture contents; low permeability subsoil; not prone to mass movement (such as a landslide).
Sedimentation systems and holding ponds	Plant growth not an issue; must contain a dense clay horizon of low permeability at least 0.5m thick.
Buildings and roadways	Plant growth not an issue; soils well suited to engineering purposes (that is, not prone to mass movement, free of acid sulphate conditions or highly compressible material at depth).

Detailed soil profile testing on the property was undertaken by bore log and trench excavation to a depth of 5.5m based on Preliminary Geotechnical Investigation (PGI) report (GHD LM, 2005). This testing shows that there are several thick clay bands intermittently to a depth of 4 to 6 metres below the site. This work suggests the low permeability sub soil found is suitable for a feedlot.

The soil report (GHD LM 2005) also shows the soil to be appropriate for irrigation. In addition, the property has been an irrigation property for some time. This suggests that it is suitable for irrigation of liquid effluent. Details of data obtained from irrigation modelling are presented in **Section 5**.

2.3 Groundwater

The NSW Feedlot Manual has the following requirements:

- Effluent irrigation should always be separated from watercourses, with a minimum distance of 25 metres;
- A feedlot is unsuitable on a site where groundwater is within 1-5m of the surface; and
- Protect groundwaters by avoiding areas where there are existing shallow or rising groundwater tables, perched water tables, groundwater recharge areas or where groundwater is already polluted.

The national guidelines require the following:

"A feedlot should not be sited above groundwater recharge areas or useable underground water resources unless those can be demonstrably protected. For example, protected by one or more impervious geological strata and/or by considerable depth."

In the Cadell Community's Land and Water Management Plan publication, Figure 2.11b shows the area to have deep groundwater at approximately 20 - 22m and of relatively low salinity. This is consistent with the PGI undertaken by GHD (2005). An existing water bore of 29.2m¹ depth near the abandoned shearing shed which encountered groundwater at 19 m depth in February 2005.

From the aerial photography in Figure 1 Site Layout, the proposed Effluent Irrigation areas are over 25m from the nearest permanent watercourses. This therefore satisfies the above criteria.

2.4 Climate

The NSW Feedlot Manual recommends that feedlots be sited in areas of less than 750 mm rainfall. Mean rainfall for the area near Moira is 443 mm.

Rainfall data at Mathoura State Forest will be used. Evaporation data from Deniliquin (Wilkinson Street) will be used.

2.4.1 Temperature, Rainfall and Evaporation

Table 1 presents data source from the Bureau of Meteorology for Mathoura State Forest, approximately 10km north of the site.

Data from this table indicate that average monthly maximum temperatures range from a maximum of 31.4 °C in January (summer) to a minimum of 13.0 °C in July (winter).

Rainfall data for 1949 – 2004 show an average annual rainfall of approximately 443 mm with rain generally falling on 85.4 days per year or approximately 23 % of days.

Evaporation data from Deniliquin (Wilkinson Street) show total yearly evaporation to be 1839 mm/year. Bureau of Meteorology data is shown in **Appendix A**.

¹ GHD Preliminary Technical Investigation Report March 2005 - Table 1

Table 2: Moira Climatic Data ²

Mathoura	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Daily Max Temp (deg C)	31.4	30.3	27.5	22.1	16.9	14.1	13.0	14.9	18.1	21.7	25.4	28.6	22.0
Mean Daily Min Temp (deg C)	15.5	15.2	13.2	9.2	6.1	4.3	3.3	4.2	6.0	8.7	10.7	13.1	9.0
Mean 9am Air Temp (deg C)	23.8	22.4	20.0	15.6	10.7	8.0	7.0	9.0	12.4	16.1	19.3	21.6	15.5
Mean 9am Relative Humidity (%)	45	50	56	68	80	85	85	80	68	60	49	47	64
Mean 3pm Air Temp (deg C)	30.5	29.4	26.9	20.9	15.4	13.2	12.2	14.9	17.2	21.0	24.6	27.6	24.8
Mean 3pm Relative Humidity (%)	29	31	37	-	-	-	-	56	52	45	35	33	38
Mean Rainfall (mm)	32.1	23.0	35.3	29.6	43.3	36.9	42.7	44.4	44.5	44.8	33.5	32.6	442.8
Mean no. of Rain days	3.8	3.6	4.3	5.4	8.5	9.1	10.8	10.9	9.5	8.4	6.2	5.0	85.4

Station number 074069 MATHOURA STATE FOREST, 1949 to 2004; Latitude (deg S): -35.8115; Longitude (deg E): 144.9017; State: NSW

² Bureau of Meteorology Climate Data 2005

3 FEEDLOT PROJECT

3.1 Layout

The feedlot would be similar to the design of the Ravensworth feedlot at Hay. The feedlot is shown in **Figure 1**.

The Moira Feedlot will conform to Queensland Reference Manual Class 1 Feedlot.

3.2 Areas

The area inside of the controlled drainage area is shown in Table 3.

As shown, it includes a total area of 201 Ha.

Table 3: Controlled Drainage Data

Site	Area Ha	Runoff Co-efficient*	Runoff + ML/mm of rainfall
Pens	98	0.8	0.784
Roads	12	1.0	0.120
Drains	18	0.8	0.144
Ponds *	43	1.0	0.430
Effluent Storage Pond	18	1.0	0.180
Receivals and Commodities	12	0.8	0.096
Total	201		1.754

*
Runoff Coefficients are chosen as follows:

For Pens, Drains and Receivals and Commodities areas, 0.8 is used as recommended in Queensland guidelines.

For Roads, 1.0 is used because these areas will be sealed.

For Ponds, 1.0 is used since they collect all rainwater falling on their surface.

+ Runoff is given in ML/mm and is calculated as follows:

$$\text{Runoff (ML/mm)} = \frac{\text{Area (Ha)} \times 10,000 \times \text{Runoff Co-Efficient} \times 0.001}{1000}$$

*
Includes manure storage area

4 ENVIRONMENTAL ISSUES

4.1 Environmental Controls

Environmental controls will be as shown in the extract from *Use of Effluent Irrigation* (DEC 2004) as shown in **Table 5**.

Monitoring requirements will involve yearly analysis of soils from the effluent disposal area and three monthly analysis of groundwater. Analysis of manure and the wastewater will also be required. These monitoring requirements will be set by DEC in the operating licence and details will be included in the site Environmental Management Plan.

An Environmental Management Plan will be prepared prior to commencement of operations.

4.2 Waste Disposal

4.2.1 Solid Waste

Based on the NSW Feedlot Manual estimate of 1.3 tonnes of waste per animal per annum, it is expected that approximately 100,000 tonnes of manure will be produced each year.

The National Guidelines for Beef Cattle Feedlots, (ARMCANZ) lists the following guideline.

Effluent and manure Utilisation Areas

Adequate land needs to be available to enable the effluent and manure generated to be utilised on site, unless an acceptable off-site utilisation method is available and is approved. The soil types need to be suitable for and able to sustain the agronomic regimes proposed. Further, the area available needs to be able to accommodate the hydrologic, nutrient, salt and organic loads involved. That is, there should be no deleterious build up of these materials in the soil.

Manure may be utilised on and/or off site. Again, the soil types need to be suitable for and able to sustain the agronomic regimes proposed. In addition, the area available needs to be able to accommodate the nutrient, salt and organic loads involved and able to protect any underlying useable groundwaters, whether the effluent and manure are utilised on or off site.

All solid waste will be composed on site and then transported off site for disposal by sale.

4.2.2 Liquid Waste

For each of the north and south sections of the feedlot, collected liquid waste effluent would typically drain into a sedimentation pond. Liquid manure is first settled in one of the two available sedimentation ponds adjacent to either the north or south sections. The second pond will be off-line and used for drying the solids and the alternative is in active use handling the collected runoff wastes. Supernatant liquid from the sedimentation ponds then drains into a 130ML holding pond. From there it is pumped to a 500ML Effluent Storage Pond.

4.2.2.1 Sedimentation Ponds

The sizing of the sedimentation ponds is set out below and includes those areas draining to the sedimentation ponds.

Site	Area Ha	Runoff Coefficient
Feed Pen	98	0.8
Roads	12	1.0
Drains	18	0.8
Receivals/Commodities	12	0.8
Sedimentation Ponds	2	1.0

From these data, Peak Flow Rate (1 in 20 year 1 hour event) Rational Method, Australian Rainfall and Runoff = 9.6622m³/sec

Proposed Sedimentation Ponds 95m x 46m at Floor = 5069m³ at overflow.

Total of four ponds with two in use and two allowed to dry for maintenance.

Volume calculated from the formula $V = Qp(L/W) \lambda/v$

Reference: NSW Feedlot Manual

V	Sedimentation System Volume m ³
Qp	Peak inflow Rate (m ³ /s) – AR1 of 20 Year Event = 9.6622
L/W	Length to Width Ratio = 2.065
V	Flow Velocity (m/s) Max = .005m/s
λ	2.5 (NSW Feedlot Manual)

$$V = 9,978\text{m}^3$$

Therefore the required minimum size of each sedimentation pond is 4,989m³. Pond size will be 5,069m³.

4.2.2.2 Holding Pond

The volume of the Holding Pond has been calculated based on the need to contain a 1 in 20 year, 24 hour rain event. This is as follows:

1 in 20, 24 hour event	=	83.04mm
Runoff (see Table 3)	=	1.574 ML/mm *
Total Runoff	=	1.52 x 83.04
	=	130.7ML

* Not including the Effluent Storage Pond

The Storage Pond will be 130ML. As soon as a rain event begins and effluent is flowing to the storage pond, pumping to the Effluent Storage will begin.

4.2.2.3 Effluent Storage

The Effluent Storage pond size has been calculated as follows.

The volume of liquid effluent is determined from the liquid and solid manure wastes and precipitation less evaporation. For the purposes of determining effluent runoff two estimates are compared:

- As shown in Section 5.5, a total volume of 1043 ML/ annum will be collected in a 90 % year; and
- Runoff estimated from 12.5m²/head stocking ratio and the feedlot area based on the FSIM modelling³ producing 800mm/year manure moisture added. This produced an estimate of 1,024ML/annum.

These data are essentially identical.

In relation to nutrients, *Table 7.2* within the *NSW Feedlot Manual*, has typical concentrations of liquid waste following passing through both the sediment pond and holding basin structures and these are provided in **Table 4**. These values will be assumed to be a typical basis for the effluent irrigation design.

Table 4: Settled Effluent Quality from Holding Pond

Parameter	Units	Value per day
BOD	mg/L	500
Total Nitrogen (TN)	mg/L	148
Total Phosphorus (TP)	mg/L	40
K	mg/L	460
Na	mg/L	260
Ca	mg/L	100
Mg	mg/L	72
Cl	mg/L	620
SAR	mg/L	4.6
EC	dS/m	4.5
pH		8

A schematic of the treatment of the effluent is provided in **Appendix B** Effluent Treatment and Irrigation Schematic.

4.2.3 Classification of Effluent for Environmental Management

DEC (2004) provides a classification of effluent as low, medium or high strength according to its concentration of nitrogen, phosphorus, BOD₅, TDS and other potential contaminants. This is shown in *Table 3.1* of DEC (2004).

³ Moira Feedlot FSIM Modelling EASystems April 2005 Fig 1 based on detailed models of cattle feedlots on the Darling Downs Qld between 1990 and 1996 (Lott 1998)

Comparing **Table 5** with **Table 4** above, it can be seen that the effluent is classified as high strength. As shown in DEC (2004) *Sections 4.2 and 4.7*, this requires a storage pond that will contain all wastewater in the event of a 90th percentile wet year.

Table 5: Classification of effluent for environmental management

Constituent	Strength (average concentration mg/L) ¹		
	Low ²	Medium	High
Total Nitrogen	<50	50-100	>100
Total phosphorus	<10	10-20	>20
BOD ₅	<40	40-1,500	>1,500
TDS ³	<600	600-1,000	>1,000-2,500
Other pollutants (eg. metals, pesticides)	Effluent with more than five times ⁴ the ANZECC and ARMCANZ (2000) long-term water quality trigger values for irrigation waters must be considered high strength for the purpose of establishing a strength class for runoff and discharge controls and will require close examination to ensure soil is not contaminated.		
Grease and Oil	Effluent with more than 1,500mg/L of grease and oil must be considered high strength and irrigation rates and practices must be managed to ensure soil and vegetation is not damaged.		

Source: **Table 3.1 (DEC, 2004)**

- Notes:**
1. Average concentrations established from a minimum of 12 representative samples, collected at regular intervals over a year.
 2. Effluent generated by municipal sewage treatment plants with secondary treatment will generally be considered to be low strength.
 3. Refer to Section 3.7 for relationship of TDS to EC.
 4. Criteria of five times the ANZECC and ARMCANZ (2000) long-term irrigation criteria have been selected as nominal criteria at which the level of those contaminants warrants a higher level of management of the reuse system for the following reasons. This criteria when applied to 1ML/d of effluent irrigated over 100 hectares would take approximately 10 years for soil contaminant levels in the top 15cm of soil to rise to near the soil contaminant criteria for Cadmium, Chromium and Zinc, which are the most sensitive heavy metal pollutants in this scenario. This criteria is also approximately half the value for Nickel, Mercury, Beryllium and Arsenic at which the effluent would be considered a liquid waste and would need to be managed and disposed of according to the DEC's *Environmental Guidelines for the Assessment, Classification and Management of Liquid and Non-Liquid Waste (EPA, 1999a)*

As stated in **Section 4.2.2**, the BOD is in the medium range of 40-1500 mg/L. However, the likely facultative conditions in the holding and storage ponds is unlikely to reduce the high range nitrogen levels to below the 100mg/L threshold. On this basis, the effluent is classified as high strength.

The storage calculations in this report are based on high strength wastewater and therefore the 90th percentile storage calculations will be applied.

In reference to *Section 3.1* of DEC 2004, effluent water from the proposed Moira feedlot is not considered to be a 'controlled aqueous waste' as under *Section 2.1.3* and *3.3.1* of the DEC's *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes*.

5 EFFLUENT IRRIGATION DESIGN FACTORS

For an effluent irrigation system to be ecologically sustainable a number of factors must be considered to ensure that irrigated plants and the environment do not become stressed by the wastewater or by the organic, nutrient or chemical loadings applied. Relevant factors are outlined in the sections below.

5.1 Soils

The properties and type of soils on any site can determine the suitability of a site for irrigation of wastewater. DEC 2004 outlines the typical soil characteristics required for wastewater irrigation systems. Some of the determining factors which have been assessed within the soils include:

- Sodicity – the amount of exchangeable sodium (Na) cations relative to other cations in the soil and is expressed in terms of exchangeable sodium percentage (ESP). It is generally agreed that soils with an ESP of greater than 5 are at risk of showing adverse structural impacts associated with sodicity (DEC, 2004).
- Salinity – the amount of dissolved salts in the soil solution, determined by measuring the electrical conductivity of the soil. Effluent or the combined effect of effluent and fertilisers may raise soluble salt levels to the extent that they impede plant growth and/or create salt scalds and increasing the potential for soil erosion (DEC, 2004).
- pH – the concentration of hydrogen ions in the soil. pH is related to the availability of plant macro and micro nutrients, for most plants pH in the range of 6 and 7.5 maximises the availability of plant nutrients and the potential for plant growth.
- Cation exchange capacity (CEC) and exchangeable cations – the CEC of a soil is the total quantity of exchangeable cations it can retain on its adsorption complex at a given pH. Soils with a high CEC generally have good soil structure and are better at mitigating potential risks associated with pH, nutrient, sodium, salt or contaminant content of wastewater.
- Emerson Aggregate Test (EAT) – this is a test designed to measure the structural stability of a soil. Soils with an EAT of 1 have the least stable structure, whilst soils with an EAT of 8 are unable to be penetrated by plant roots.
- Phosphorus adsorption – Most Australian soils have the potential to immobilise phosphorus (P) in soil thereby making it unavailable for plant growth. This capacity can vary with depth.

As part of the assessment for the soil, investigations have been undertaken to determine the suitability of the soils within the existing irrigation areas based on the GHD LM geotechnical report investigation locations.

The results of this assessment are found in the monitoring bore logs prepared by GHD LM in 2005. The soils were moist light brown to brown sandy clays with an estimated hydraulic permeability tested to be within the range 1×10^{-10} to $8 \times 10^{-11} \text{ ms}^{-1}$.

With regard to the parameters above the assessment found that the soils are suitable for irrigation. The water table, at the time of drilling was at approximately 30 m below the ground surface near the proposed effluent discharge area.

5.2 Water Balance

For an effective wastewater irrigation system, the right amount of wastewater must be applied at the right times to meet the requirements of crops, while ensuring that increases in runoff and

percolation are minimised. The following factors can be taken into account in order to determine the maximum volume of wastewater that can be sustainably irrigated each year:

- Precipitation;
- Wastewater applied;
- Evapotranspiration;
- Percolation; and
- Runoff.

The water balance can be expressed as:

$$\text{Precipitation} + \text{wastewater applied} = \text{Evapotranspiration} + \text{Percolation} + \text{Runoff}$$

Significant amounts of percolation and runoff occur as a result of natural rainfall events. Runoff is not expected to increase significantly above rain fed conditions.

5.2.1 Calculating Land Area and Storage Requirements

The irrigation scheme proposed would fully use the wastewater so there is no other requirement for discharge. The area required has been determined by calculating the limiting land area using a water and nutrient balance. The limiting land area is the largest land area required to satisfy any single water, nutrient or contaminant balance to ensure a sustainable scheme. The size of wet weather storage required is calculated from the water balance using the calculated minimum land area and the allowable discharge frequency.

As required by DEC 2004, the criteria for the storage pond would be for high strength effluent (**Table 5**) and would require storage for a 90th percentile wet year (see **Section 4.2.3** above).

5.2.2 Climate Data

Rainfall data from for Mathoura and evaporation data from the Deniliquin BOM Station have been used in calculations for the Moira site. Calculations have been based on a 90th percentile wet year. A 90th percentile wet year means 90% of years would have rainfall at or below this amount, only 10% would have rainfall above the amount.

Monthly 90th percentile rainfall is taken as follows:

$$90^{\text{th}} \text{ percentile Monthly Rainfall} = \frac{90\% \text{ Yearly}}{\text{Total of monthly } 90\%} \times 90\% \text{ rainfall for that month.}$$

5.2.3 Evapotranspiration

Evapotranspiration varies throughout the year and is dependant upon temperature, humidity, solar radiation, wind, crop type and crop growth patterns. Evapotranspiration is calculated by multiplying the monthly evaporation values by the appropriate crop factor for the species of plant to be grown on the site.

The crop factor takes into account plant productivity, and the meteorological factors. The crop factor used for the calculations in **Table 7** was provided in DEC 2004 *Table 4.1* for lucerne. This crop factor was chosen for the following reasons:

- The crop factors in **Table 7** are for Wagga Wagga⁴. For example, yearly evaporation between Wagga and Moira is within 5%.

⁴ Meyers et al.(1999)

- The crop factor for lucerne was chosen because the yield for irrigated lucerne of 20 tonnes per hectare per year is the likely crop on the irrigation area.

The results of the water balance are shown in **Table 7**. As indicated, the five proposed irrigation areas, totalling 380 hectares, is sufficient to irrigate the 1,043ML/year of effluent water and includes an allowance for rotation spelling of irrigation areas. Figures have been based on data from Darling Downs Feedlot (Lott, 2005).

5.2.4 Tailwater and Stormwater Runoff Control

Irrigation tends to increase runoff due to the reduction in the amount of rain required to saturate soil to a point where runoff occurs. Runoff as a result of irrigation of wastewater has been set to zero in the water balance. However, some runoff would occur during prolonged or heavy rain.

Pollution from effluent runoff is an offence under the Protection of the Environment Operations Act 1997. Therefore, the effluent irrigation areas need to be suitably isolated from nearby waterways and catch drains and tailwater dams installed at the lowest point.

This would be managed with the installation suitably sized catch drains and tailwater drainage channels based on a volume of 12mm times the operating area in m² as required by DEC Effluent Irrigation Guidelines.

Table 6: Irrigation Tailwater Drainage Capacity

Irrigation Area	Area (Ha)	Terminal Tailwater Volume (ML)
1	79.9	9.6
2	102	12.2
3	140	16.8
4	33.7	4.0
5	23.6	2.8

5.2.5 Effluent Storage Capacity

The water balance as shown in Table 4 has calculated that for a 90th percentile wet year, 368 ML/year of storage is required. Capacity and type has been based on high strength wastewater. A new 500 ML capacity storage pond would be constructed on the site as shown in **Figure 1**.

It should be noted that the draft NSW effluent irrigation guidelines require that the design allows a spill from the holding pond of 1 in 10 years. Hence, 90% wet year (Decile 9) data are used for the calculation.

The data show that for a 90% wet year, an irrigation area of a minimum of 380 Ha and a storage pond of 368 ML are required.

Table 7– Water Balance 90%

Parameter / Month	Evaporation (mm)	Crop Factor	Evapo-Transpiration (mm)	Precipitation Decile 9 (mm)	Irrigation Required 380 Ha			Effluent * Produced ML	Excess ML
					Net mm	ML/Ha	ML		
January	301	0.95	286	51	235	2.35	893	89	
February	246	0.90	221	38	183	1.83	695	67	
March	202	0.85	172	48	124	1.24	471	84	
April	117	0.80	94	40	54	0.54	205	70	
May	62	0.70	43	56				98	98
June	39	0.55	21	41				72	170
July	40	0.55	22	50				88	258
August	62	0.65	40	52				91	349
September	99	0.75	74	54	20	0.20	76	95	368
October	164	0.85	139	64	75	0.75	285	112	195
November	225	0.95	214	48	166	1.66	631	84	
December	282	1.00	282	53	229	2.29	870	93	
				595		10.86		1043	

* Based on 1.754 ML/mm of rainfall – see Table 3

5.3 Organic Balance

If organic matter is applied to soil at a greater rate than the soils ability to assimilate it, then soil pores can become clogged and anaerobic odorous conditions can result. High organic loading requires an increased resting period between wastewater applications. An average loading rate of 1,500kg/ha/month is generally taken as the maximum organic loading for most soils (DEC, 2004).

The minimum irrigation area required based on organic loading is calculated as follows:

$$A = \frac{CQ}{1000 \times Lc}$$

Where:

A = Irrigation area (ha)

C = Concentration BOD₅ (mg/L) = 500 mg/L

Q = Average effluent flow rate (kL/month) = 87,000

Lc = critical loading rate of constituent = 1,500 kg/ha/month

$$A = \frac{500 \times 87,000}{1,000 \times 1,500}$$

$$= 29 \text{ ha}$$

Therefore a minimum area of 29 ha is required to absorb the organic material in the wastewater on a sustainable basis. The proposed irrigation area is 380 Ha, and therefore would sufficiently absorb organic material.

5.4 Salt Loading

The quantity of salt in wastewater is important to ensure irrigation does not result in soil degradation by increased soil salinity. The main requirement for salinity control in irrigation systems is to ensure there is adequate leaching to prevent salt accumulation in the soil.

As shown in **Table 4**, the average Electrical Conductivity (EC) of the proposed effluent irrigant is 4,500 µS/cm and SAR of 4.6. This equates to a Total Dissolved Solids of approximately 3,300 mg/L. The proposed crop for the irrigation area is lucerne and as grass generally has a moderate tolerance to salt (see DEC *Table 4.4*) at this concentration, it is likely that the salt content of the effluent would have an estimated 10% reduction in yeild impact on the irrigation crop because the plants are only moderately salt tolerant.

In relation to the impact on the soil, the DEC, Load Calculation Protocol 2005, is shown below (DEC, 2005) in **Table 8**. This table outlines the requirements to manage various levels of salinity. The EC of the wastewater is required to be less than 3,700 µS/cm to be sustainable.

To ensure that wastewater to be used in irrigation is less than 3,700 µS/cm, prior to any irrigation, the wastewater will be tested for salinity. Should it be above 3,700 µS/cm, fresh water will be added to bring it below this concentration. Note that SAR is below 8.

Table 8: Criteria for salt management (a) Pollutant management factor of 0 (full discount)

Salinity $\mu\text{S}/\text{cm}$	SAR ^a	Na* (mg/L)	Management conditions	Monitoring conditions
<300	Any	N/A	N/A	N/A
<735	<3	N/A	N/A	N/A
	>3	N/A	Apply gypsum (or equivalent in agricultural lime) every 5 years at 2 t/ha or whenever soil ESP ^b exceeds 5% within plant root zone	Only if SAR >6, in which case monitor Na in soil once per annum
<1470	>3	<200	As above. Application to cease if EC _{se} ^c exceeds 4 dS/m in plant root zone	Only if SAR >6, monitor once per annum for Na and EC _{se} in soil within and immediately below plant root zone
		>200	Apply gypsum (or equivalent in agricultural lime) whenever soil ESP exceeds 5%. Application to cease if EC _{se} exceeds 4 dS/m in plant root zone	Monitor once per annum for Na and EC _{se} in soil within and immediately above plant root zone
<2200	<8	<200	As above	As above plus monitor once per annum available P and N below plant root zone
	<10	<200	As above	As above plus monitor any important groundwater resource within 10m of the surface of the ground
<3700	>10	>300	As above	As above
Any	Any	Any	Effluent applied at rate of no more than 50 mm per year. EC _{se} in plant root zone not to exceed 4dS/m	Monitor Na and EC _{se} in soil and apply gypsum if Na levels in plant root zone exceed 5%. Monitor available P and N below plant root zone once per annum

Source: Table 9, DEC 2005

^aSAR – sodium adsorption ratio; ^bESP – exchangeable sodium percentage; ^cEC_{se} – electrical conductivity of saturated extracts of soil.

These management and monitoring measures would be undertaken to control salinity levels on the irrigation area.

5.5 Nutrient Balance

Loading rates of nitrogen and phosphorus can also place limits on the quantity of wastewater to be irrigated on an area.

5.5.1 Nitrogen

The behaviour of nitrogen in plant-soil systems is complex and includes additions and losses to the system as well as transformations of the forms of nitrogen. The capacity of an irrigation system to use nitrogen can be maintained and restored over time as the removal of nitrogen

from wastewater largely depends on biological processes. To calculate the nitrogen balance nitrogen inputs are compared with nitrogen losses (DEC, 2004).

For the calculation of nutrient balance, an average year is used, that is, a rainfall of 443 mm and a total runoff for the year of:

$$\text{Runoff (ML)} = 443 \times 1.754$$

$$= 777 \text{ ML}$$

Therefore using data from Table 2, total nutrients are as follows

$$\text{TN (Kg)} = 777 \times 148 \times \frac{10^6}{10^6}$$

$$= 114,996 \text{ Kg}$$

The Queensland Manual loading rate for TN is 560 Kg N/Ha/Year. As a result, the feedlot requires an area of 205 Ha to dispose of the TN by complete uptake in the plants of the irrigation area.

The nitrogen balance calculated for the irrigation area compares the total nitrogen usage of the crop with the amount of nitrogen available. This approach should ensure that the irrigation would be sustainable in the long term as the total nitrogen applied plus mineralisation would balance the nitrogen removed by the plants.

Using data from DEC 2004, the nitrogen calculation is as follows.

Amount of TN in irrigant	= 114,996 kg/year
Average crop yield*	= 20 tonnes /ha/year
Nitrogen content of crop*	= 3.5%
Total nitrogen in crop	= 700 kg/ha/year
TN in 380 ha of crop	= 266,000 kg/year

*These figures are taken from Table 4.2 DEC 2004 for lucerne.

The crop would remove 266,000 kg of nitrogen per year. The irrigation would add 114,996 kg nitrogen per year. Therefore the irrigation area is considered to be sustainable with respect to nitrogen as required by DEC 2004.

5.5.2 Phosphorus

Based on Table 4.3 of the NSW DEC 2004 *Environmental Guidelines - Use of Effluent by Irrigation*, for the South West area the soil parent material is alluvial sediments. The soil classification is red brown earth with Total P characteristics shown in Table 9.

Table 9: Phosphorous adsorption potential of NSW soils (1m depth)

Classification	Total P Sorption Capacity	P sorption capacity (critical)
Units	(kg/Ha)	(kg/Ha)
Range	6070-6830	2000-2300
Average	6450	2150

Phosphorus (P) is removed from the wastewater through biological, chemical and physical processes in the soil. The existing P sorption capacity of the soil and the P uptake by plants to be grown determines how much P can be introduced before the site is saturated. The phosphorus saturation point of most soils is reached between 0.25 and 0.5 of total sorption capacity (Kruger et al. 1995 in DEC, 2004). If the amount of P applied exceeds this threshold, runoff and leaching of phosphorus to surface and groundwater may occur (DEC, 2004).

As shown in **Table 4**, the average Total Phosphorus (TP) in the wastewater was 40mg/L. The data to be used for calculating the phosphorus balance are as follows:

Concentration TP in irrigant	= 40 mg/L (see Table 6)
Volume wastewater	= 777 ML/year
Amount of TP in irrigant	= 31,080 kg/year
Crop yield*	= 20 tonnes /ha/year
Phosphorus content of crop*	= 0.4%
Total phosphorus in crop	= 80 kg/ha/year
TP in 380 ha of crop	= 30,400 kg/year

The crop would remove 30,400 kg of phosphorus per year. The irrigation would add 31,080 kg of phosphorus per year. Within the order of accuracy of the data, the irrigation is sustainable with regard to phosphorus and the phosphorus sorption capacity of the soil will only be needed as a backup.

6 IRRIGATION SYSTEM

6.1 Methods

The proposed method for irrigation on the site would be for spray irrigation in the areas of the site as shown in **Figure 1**.

6.1.1 Proposed Effluent Irrigation Areas

The proposed effluent irrigation areas are outlined in the layout in **Figure 1** and areas detailed would be required for routine irrigation.

The land available for irrigation to the sides of the feedlot site is approximately 380ha. During normal years, the effluent areas will require surface tailwater dams and drainage of runoff. It is expected that the land will be irrigated in dry periods to maintain grass cover. This would ensure that bare areas are not exposed, which could result in wind blown dust. The spray irrigation method would be via a large scale irrigator similar to those currently used on the site for crop irrigation.

6.2 Control System

The control system for the irrigation would be designed to minimise risks of environmental pollution which may be caused by poor design, human error, weather conditions, or faulty equipment. The application of irrigation water would be controlled manually by the irrigation manager.

6.3 Reticulation System

New pipeline routes will be establish for reticulation of effluent water across parts of the proposed irrigation land from the pumphouse at the Effluent Storage Dam. Five separate pipelines would be required onto the Effluent Irrigation Areas.

The pipelines and mainlines would consist of 150mm, 100mm PVC Class 9 pipework and 150mm PVC Class 12 pipework. Wastewater to be irrigated would be drawn from the Storage Dam through a suction line by either or both of two electronically driven centrifugal pumps fitted with anti-siphon valves that prevent siphoning of the irrigant water on loss of pressure from the pumps.

6.4 Scheduling

Irrigation would occur only on suitable, selected areas in any year. Irrigation scheduling would be closely supervised by the irrigation manager. The irrigation schedule would be established to sustainably manage the irrigation. Effluent water would be irrigated primarily during the hotter months, with irrigation in the colder months being based on rainfall and regular observation of the irrigation area. More detailed irrigation scheduling would be included in the Effluent Irrigation Management Plan (EIMP) which would be prepared upon approval of the proposal. This would include monitoring of irrigation for salinity prior to irrigation. If necessary, the wastewater would be diluted to ensure appropriate salinity (see Section 5.4).

7 EFFLUENT IRRIGATION MANAGEMENT PLAN

A detailed Effluent Irrigation Management Plan (EIMP) would be prepared and implemented prior to the operation of the proposed development.

Irrigation management is an important factor in ensuring the sustainability of the operation. The operation would employ best management measures to ensure long term sustainability of the operation. The plan for irrigation management plan provided measures to identify potential environmental impacts from the operation and provides measures to minimise these impacts. The DEC guidelines state that an effective wastewater irrigation system should include:

- Efficient irrigation facilities for applying wastewater to the site;
- A control system to adjust the wastewater application rates or other factors to maintain optimum performance;
- Wet weather storage facilities where appropriate;
- Tailwater and stormwater controls where appropriate including a recovery system to capture and recycle any stormwater runoff;
- Wastewater transport facilities to convey water from the Effluent Dam to the site;
- A site specific management plan detailing the necessary procedures to maintain optimum performance of the irrigation system and satisfy statutory requirements; and
- A monitoring system to measure, record and identify any action to ensure the environmental performance of the system.

7.1 Runoff Control and Storage

Runoff would be controlled on site to ensure that ground and surface waters do not become contaminated by any flow from irrigation areas.

Runoff diversion bunds would be constructed to divert uncontaminated runoff away from the irrigation area. Run-off and tailwater from the irrigation area would be collected in tailwater dams. The *Environmental Guidelines Use of Effluent by Irrigation* (DEC, 2004) requires for high strength irrigant that stormwater run-off be controlled by construction of a tailwater system to contain a volume equivalent to 12mm of runoff. For the proposed 380ha irrigation area, this is equivalent to 46 ML of total storage.

A series of catch drains would direct tailwater and stormwater to a collection pond where it would be re-irrigated. The tailwater ponds would be of sufficient length and depth to allow some settlement of suspended solids.

The proposed tailwater dams and bunds proposed on the site will be at the lowest level in each irrigation area.

The following measures would be implemented to manage runoff:

- All uncontaminated stormwater would be prevented from entering the irrigation area by use of diversion banks;
- All irrigation tailwater and stormwater from the irrigation area would be directed to the tailwater dam;
- All bunds, supply channels and drains would be maintained in good condition, especially at the end of the wet season;
- All bunds, supply channels and drains would be inspected at least once per month;

- The dams and spillways would be maintained in good condition at all times, particularly at the start of winter; and
- Maximum freeboard would be maintained at all times. This means that the dams should be practically empty during summer, and during February, the dams would be emptied by irrigation.

7.2 Screening

A vegetative screen would be planted along the boundary of the site in the direction of prevailing winds to minimise any potential spray drift. The proposed location of plantings is to be developed.

7.3 Commissioning of Effluent Treatment System

Previous history at feedlots has shown that there is the potential for problems during commissioning and shutdown. To ensure that these are minimised during start up, the following measures would be taken:

- (i) An external wastewater treatment expert would advise the management of the feedlot during startup;
- (ii) Visual observations would be undertaken at least once per week to ensure that the systems are working correctly, for example, the settling, holding and sedimentation dams, the pumping equipment, the irrigators etc; and
- (iii) Measurements of wastewater quality would be undertaken at least three monthly until it can be demonstrated that the systems are operating correctly.

7.4 Treatment and Storage Management

The storage dams would be monitored and managed by the irrigation manager to ensure capacity to store wastewater during wet weather. The storage provided on site in storage dams would allow storage of 630 ML of wastewater. Settleable solids reduce the capacity of both the treatment ponds and storage ponds. The following measures would be undertaken to manage the treatment plant and storage ponds:

- Infrastructure such as banks and walls would be maintained and inspected at least once per month;
- Solids would be removed as much as practicable from the incoming wastewater; and
- Ponds would be desludged once the volume is reduced by 30%, sludge would be dried and removed for composting.

7.5 Effluent Irrigation Transport System

The effluent irrigation transport system would be monitored and managed by the irrigation manager to ensure it is well maintained and functioning effectively. The following measures would be undertaken to manage the wastewater transport system:

- Maintenance of the wastewater transfer system would be undertaken on an as needs basis; and
- Regular visual inspections would be undertaken to check for spills and leaks.

7.6 Crop Management

The preservation of biodiversity and maintenance of plant health is an important factor to manage in the use of wastewater for irrigation. Measures to manage crops would be undertaken as described below:

- Maximum crop removal by harvesting as many times as is practicable to ensure evapotranspiration and crop growth would be maximised; and
- Plant growth would be monitored on a regular basis.

7.7 Weed Management

The application of effluent to pastures also provides good conditions for weeds to flourish. Therefore weeds would be controlled by the application of herbicides or mechanical control measures.

7.8 Spray Irrigation Areas

The following measures would be undertaken to manage the spray irrigation area:

- Irrigated wastewater would not be allowed to escape to any water course;
- Uncontaminated run-off would be prevented from entering the irrigation area by the use of run-off diversion banks upslope of the irrigation area;
- Treated wastewater would not be applied to land if soil moisture conditions are such that surface run-off or ponding is likely to occur;
- Diversion banks, drains and holding dams would be regularly inspected and well maintained;
- Spray from irrigation to the land would be controlled to ensure no drift beyond the boundaries;
- The irrigation of treated wastewater to the land would not be carried out within 20 metres of any major watercourse;
- The irrigation area would be maintained in a proper and efficient condition so as to provide adequate assimilation, percolation, evaporation and transpiration of the irrigated wastewater.

7.9 Contingency Plans

Detailed contingency plans would be prepared as part of the environmental management plan for the operation of the irrigation system. These would be developed to manage emergencies such as:

- a failure of the wastewater treatment system where the plant does not meet the required performance to allow for irrigation;
- a flood event in which storage volume is compromised; or
- a pipeline breakage.

The detailed operational EMP would provide details of emergency systems in place, personnel responsible for implementing emergency procedures and details of training and monitoring.

The irrigation system would be established in such a way as to minimise potential risks due to the following:

- the irrigation system would be operated and managed by the irrigation manager who would manually switch on irrigators;
- the pipe system would have an automatic cut off in case of a breakage – loss of pressure would cause the system to switch off;
- regular visual inspections would be undertaken of the irrigation area and pipelines by the irrigation manager;
- diversion bunds and tailwater ponds would act as an emergency collection system to capture effluent from any spills should they occur; and
- operation of the irrigation system and impacts to the environment would be overseen by the site environmental officer.

8 MONITORING

The results of monitoring would assist in demonstrating due diligence in the protection of public health, agricultural resource and environmental risks.

Monitoring would be undertaken in accordance with the requirements outlined in DEC's Guideline 2004. These requirements are reproduced in the Tables below. It should be noted, however, that DEC would licence the activity and that monitoring requirements would be detailed in the licence.

8.1 Effluent Wastewater Monitoring

Table 10: Recommended Wastewater Sampling Frequency

Constituent ¹	Low strength	Medium strength	High strength
TSS	Quarterly	Quarterly	Monthly
Oil and grease	Biannually	Quarterly	Quarterly
Total P	Biannually	Quarterly	Quarterly
Total N	Biannually	Quarterly	Quarterly
BOD ₅	Quarterly	Quarterly	Monthly
PH	Quarterly	Quarterly	Monthly
EC dS/m;TDS	Quarterly	Quarterly	Monthly
Cations	Quarterly	Quarterly	Quarterly
SAR ($\sqrt{\text{meq/L}}$)	Quarterly	Quarterly	Quarterly
Metals	Yearly	Yearly ²	Yearly ²
Ocs	Yearly	Yearly ²	Yearly ²
Herbicides	Yearly	Yearly ²	Yearly ²
Thermotolerant coliforms (cfu/100ml)	Use specific ³	Use specific ³	Use specific ³
Other	Advice should be sought from the Department of Environment and Conservation or local council ⁴	Advice should be sought from the Department of Environment and Conservation or local council ⁴	Advice should be sought from the Department of Environment and Conservation or local council ⁴

Source: Table 5.1 (DEC 2004)

Notes: 1. Units are in mg/L unless otherwise stated

2. Higher frequencies would be required where these constituents are the constituents that determine the medium or high strength classification

3. See Appendix 1 in DEC 2004 for municipal sewage. Other effluents may not require monitoring for thermotolerant coliforms (see Section 3.10 in DEC 2004). Obtain advice from NSW Health and/or NSW Department of Primary Industries

4. Seek advice from the appropriate regulatory authority (see Section 6.1 in DEC 2004)

5. BOD₅ may be replaced by tests such as chemical oxygen demand provided the relationship between the two measurements is established.

8.2 Soil Monitoring

In accordance with DEC 2004, Table 7 below outlines a recommended soil monitoring strategy.

Table 4: Recommended soil monitoring strategy

Constituent ¹	Frequency of sampling	
	Surface soil	Soil profile at four depth increments
pH (no units)	Annually	Annually
Electrical conductivity (EC) (dS/m)	Annually	Annually
Nitrate –N	Annually	Annually
Total N	After 3 years	N/A
Available P	Annually	N/A
Total P	After 3 years	Every 3 years
Exchangeable sodium percentage	Annually	Every 3 years
P sorption capacity ² (kg/ha)	After 3 years (site specific)	Every 3 years (site specific)
Heavy metals and pesticides	After 10 years ³	N/A

Source: Table 5.2 DEC 2004

Notes: 1. mg/L unless otherwise stated

2. As recommended by an accredited laboratory or soil scientist

3. Or more frequently if any are identified/calculated as a particular risk factor in effluent

8.3 Groundwater Monitoring

Requirements for groundwater monitoring are detailed in the Preliminary Geotechnical Assessment undertaken by GDH LM for the proposal. It would be expected that the licence issued by DEC will contain groundwater monitoring requirements.

8.4 Crop Monitoring

Sampling of crops or pastures is not considered necessary at this stage. However, should unacceptable levels of trace contaminants be identified in the system, a crop monitoring program would be established.

9 REFERENCE MATERIAL

The reference material used in this report has included:

- Cadell Community's Land and Water Management Plan, 2001
- Draft Environmental Guideline. Use of Treated Effluent in Irrigation, NSW EPA 2000
- National Beef Cattle Feedlot Environmental Code of Practice, Australian Lot Feeders Association
- National Guidelines for Beef Cattle Feedlots, ARMCANZ
- The Draft New South Wales Feedlot Manual, NSW Agriculture, 2003
- The Establishment and Operation of Beef Cattle Feedlots in Queensland. Queensland Department of Primary Industry, 2000
- The New South Wales Feedlot Manual NSW Agriculture, 1997



Figures

- Site boundary
- Drainage pipeline
- - - - - Moira channel relocation



Proposed Site Layout
Agricultural Equity Investments Pty Ltd
 Moira Station Cattle Feedlot
 Environmental Impact Statement
 Mathoura NSW



Scale 1:20000

FIGURE
1

TOTAL AREA 1200Ha (Approx)
 IRRIGATION AREA 375.5Ha

Appendix A - Climate Averages for Australian Sites – Deniliquin (Wilkinson St) and Mathoura State Forest



What is the weather usually like?

- Climate Averages for Australian Sites -

Averages for DENILIQUIN (WILKINSON ST)

Make sure you understand [what the Climate Averages are all about](#) before you make use of the following information. A comma separated text file of these averages is also available for [download](#) which can be graphed in software such as a spreadsheet

074128	DENILIQUIN (WILKINSON ST)					Commenced: 1858				Last record: 2004				
Latitude:-35.5269 S		Longitude: 144.9520 E				Elevation: 93.0 m		State: NSW						
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	No. Yrs	%age comp
Mean Daily Max Temp (deg C)														
32.5	32.0	28.7	23.4	18.6	15.1	14.4	16.4	19.6	23.6	27.5	30.5	23.5	141.3	97
Mean no. Days, Max >= 40.0 deg C														
3.2	1.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.5	7.4	141.1	97
Mean no. Days, Max >= 35.0 deg C														
10.0	8.2	3.7	0.2	0.0	0.0	0.0	0.0	0.0	0.6	3.1	6.9	32.7	141.1	97
Mean no. Days, Max >= 30.0 deg C														
19.6	17.8	11.9	2.3	0.0	0.0	0.0	0.0	0.4	3.6	9.2	15.4	80.3	141.1	97
Highest Max Temp (deg C)														
49.6	47.2	45.0	41.7	31.1	25.6	25.9	32.2	35.0	40.8	44.2	47.8	49.6	141.6	97
Mean Daily Min Temp (deg C)														
15.5	15.5	13.1	9.3	6.3	4.2	3.1	4.1	6.0	8.5	11.3	13.7	9.2	140.6	97
Mean no. Days, Min <= 2.0 deg C														
0.1	0.0	0.1	0.6	3.3	7.3	11.0	7.7	3.7	1.3	0.4	0.3	35.7	140.4	97
Mean no. Days, Min <= 0.0 deg C														
0.0	0.0	0.0	0.2	1.0	3.1	5.4	3.2	1.3	0.5	0.2	0.2	15.2	140.4	97
Lowest Min Temp (deg C)														
-3.9	0.6	-1.1	-2.8	-7.8	-7.2	-10.0	-9.4	-9.4	-6.7	-7.2	-5.6	-10.0	141.2	97
Mean 9am Air Temp (deg C)														
22.8	22.0	19.3	14.8	10.4	7.5	6.5	8.6	12.2	16.2	19.5	21.8	15.1	138.8	95
Mean 9am Wet-bulb Temp (deg C)														
16.5	16.5	14.9	11.9	8.9	6.6	5.6	7.1	9.7	12.1	14.0	15.5	11.6	137.8	95
Mean 9am Dew Point Temp (deg C)														
11.4	12.2	11.1	9.1	7.2	5.4	4.3	5.3	6.9	7.9	8.9	10.0	8.3	137.8	95
Mean 9am Relative Humidity (%)														
51	56	61	70	82	88	86	81	71	60	53	50	68	137.8	95
Mean 9am Wind Speed (km/hr)														
10.6	9.6	9.2	8.2	6.8	7.0	7.1	8.4	10.5	11.8	11.7	11.0	9.3	130.2	89
Mean 3pm Air Temp (deg C)														
30.0	29.9	26.8	21.8	17.3	14.0	13.3	15.1	18.0	21.5	25.2	28.1	21.7	96.1	66
Mean 3pm Wet-bulb Temp (deg C)														
18.4	18.9	17.4	14.8	12.5	10.5	9.8	10.6	12.1	13.9	15.6	17.1	14.3	95.4	66
Mean 3pm Dew Point Temp (deg C)														
8.9	10.4	9.7	8.3	7.7	6.8	5.8	5.6	5.9	6.2	6.5	7.5	7.4	95.3	66
Mean 3pm Relative Humidity (%)														
30	33	37	44	55	63	62	55	48	40	34	30	44	95.3	66
Mean 3pm Wind Speed (km/hr)														
10.5	9.7	9.5	9.2	8.5	8.3	9.3	10.6	11.2	11.7	12.3	11.1	10.2	89.5	62
Mean Rainfall (mm)														
28.4	27.2	31.8	30.8	39.2	40.3	35.0	37.0	38.2	39.7	29.2	28.9	405.7	145.7	99
Median (Decile 5) Rainfall (mm)														
16.8	15.4	18.5	22.5	32.9	35.6	31.1	35.3	33.0	32.0	20.0	19.1	386.6	142	
Decile 9 Rainfall (mm)														
71.4	70.6	71.6	66.9	85.9	72.7	67.0	65.5	71.1	87.9	63.8	66.7	576.7	142	
Decile 1 Rainfall (mm)														
1.1	0.5	0.4	2.7	7.0	13.1	8.7	9.6	13.2	9.8	3.4	1.6	234.8	142	
Mean no. of Raindays														
3.8	3.5	4.1	5.1	7.5	9.2	9.5	9.5	8.6	7.5	5.2	4.5	78.0	144.3	99
Highest Monthly Rainfall (mm)														
253.9	187.7	225.5	111.1	123.5	128.2	112.9	124.8	141.6	124.7	133.7	167.8	145.7	99	
Lowest Monthly Rainfall (mm)														
0.0	0.0	0.0	0.0	0.0	2.3	1.2	1.6	4.3	0.3	0.0	0.0	145.7	99	
Highest Recorded Daily Rain (mm)														
76.2	99.1	153.4	59.7	53.8	55.6	46.0	52.1	65.3	87.9	57.2	67.3	153.4	144.3	99
Mean no. of Clear Days														
13.5	12.9	14.2	11.5	9.1	7.7	7.1	8.3	9.1	9.8	10.4	12.9	126.5	97.8	67
Mean no. of Cloudy Days														
4.4	4.3	4.4	5.3	9.1	10.5	10.8	9.0	7.3	7.6	6.8	5.4	84.8	97.8	67
Mean Daily Sunshine (hrs)														
11.1	11.2	8.8	6.0	...	5.2	4.8	6.7	9.1	10.6	8.3	10.9	8.4	0.9	92
Mean Daily Evaporation (mm)														
9.7	8.8	6.5	3.9	2.0	1.3	1.3	2.0	3.3	5.3	7.5	9.1	5.1	26.3	62



What is the weather usually like?

- Climate Averages for Australian Sites -

Averages for MATHOURA STATE FOREST

Make sure you understand what the [Climate Averages](#) are all about before you make use of the following information. A comma separated text file of these averages is also available for [download](#) which can be graphed in software such as a spreadsheet

074069	MATHOURA STATE FOREST					Commenced: 1949				Last record: 2004				
Latitude:-35.8115 S		Longitude: 144.9017 E		Elevation: 105.0 m				State: NSW						
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	No. Yrs	%age comp
Mean Daily Max Temp (deg C)														
31.4	30.3	27.5	22.1	16.9	14.1	13.0	14.9	18.1	21.7	25.4	28.6	22.0	20.3	98
Mean no. Days, Max >= 40.0 deg C														
2.1	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	3.9	12.9	99
Mean no. Days, Max >= 35.0 deg C														
8.9	6.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.7	4.5	24.4	12.9	99
Mean no. Days, Max >= 30.0 deg C														
19.0	14.0	10.7	1.6	0.0	0.0	0.0	0.0	0.3	3.0	8.0	12.1	68.7	12.9	99
Highest Max Temp (deg C)														
44.7	44.2	40.8	34.9	27.2	26.6	19.4	23.1	33.3	37.8	41.7	41.9	44.7	12.9	99
Mean Daily Min Temp (deg C)														
15.5	15.2	13.2	9.2	6.1	4.3	3.3	4.2	6.0	8.7	10.7	13.1	9.0	20.3	98
Mean no. Days, Min =< 2.0 deg C														
0.0	0.0	0.0	0.4	5.7	9.8	12.1	8.5	4.2	1.4	0.2	0.0	42.2	12.8	98
Mean no. Days, Min =< 0.0 deg C														
0.0	0.0	0.0	0.0	0.5	4.2	4.9	3.3	0.5	0.2	0.0	0.0	13.7	12.8	98
Lowest Min Temp (deg C)														
5.6	5.8	2.8	1.3	-1.1	-3.3	-3.8	-2.6	-1.4	-0.7	0.8	4.4	-3.8	12.9	96
Mean 9am Air Temp (deg C)														
23.8	22.4	20.0	15.6	10.7	8.0	7.0	9.0	12.4	16.1	19.3	21.6	15.5	17.2	99
Mean 9am Wet-bulb Temp (deg C)														
16.5	16.2	15.0	12.5	9.1	7.0	5.9	7.4	9.7	12.0	13.4	15.1	11.6	16.4	96
Mean 9am Dew Point Temp (deg C)														
10.3	10.4	10.4	9.1	7.2	5.9	4.6	5.8	6.6	7.9	7.4	8.9	7.9	12.2	94
Mean 9am Relative Humidity (%)														
45	50	56	68	80	85	85	80	68	60	49	47	64	16.5	96
Mean 9am Wind Speed (km/hr)														
10.4	10.7	8.7	6.6	6.1	5.0	5.3	6.2	7.8	9.2	10.5	9.2	7.9	12.8	98
Mean 3pm Air Temp (deg C)														
30.5	29.4	26.9	20.9	15.4	13.2	12.2	14.9	17.2	21.0	24.6	27.6	24.8	10.3	61
Mean 3pm Wet-bulb Temp (deg C)														
18.7	18.4	17.7	...	...	...	8.4	10.7	12.3	14.3	15.6	17.3	16.2	9.7	57
Mean 3pm Dew Point Temp (deg C)														
8.3	8.7	9.6	...	...	...	...	6.0	6.4	7.6	6.1	7.0	7.6	7.1	56
Mean 3pm Relative Humidity (%)														
29	31	37	...	...	...	...	56	52	45	35	33	38	9.6	57
Mean 3pm Wind Speed (km/hr)														
11.8	11.9	9.5	6.3	7.2	12.0	6.6	7.1	8.7	9.7	12.7	11.7	10.6	7.8	61
Mean Rainfall (mm)														
32.1	23.0	35.3	29.6	43.3	36.9	42.7	44.4	44.5	44.8	33.5	32.6	442.8	55.3	100
Median (Decile 5) Rainfall (mm)														
23.8	13.4	21.1	25.1	33.9	32.7	40.1	40.8	37.6	31.0	22.6	20.4	454.2	54	
Decile 9 Rainfall (mm)														
80.0	60.9	75.4	64.4	88.9	66.1	80.6	83.0	85.9	103.1	75.6	86.3	592.9	54	
Decile 1 Rainfall (mm)														
0.9	0.4	0.9	3.1	10.1	12.5	12.1	10.0	17.0	9.7	6.6	2.2	258.2	54	
Mean no. of Raindays														
3.8	3.6	4.3	5.4	8.5	9.1	10.8	10.9	9.5	8.4	6.2	5.0	85.4	53.7	97
Highest Monthly Rainfall (mm)														
222.9	99.4	184.9	99.8	125.7	106.2	105.7	148.3	112.3	145.5	105.2	133.1	55.3	100	
Lowest Monthly Rainfall (mm)														
0.0	0.0	0.0	0.2	2.4	0.2	1.0	2.8	5.4	0.0	1.8	0.4	55.3	100	
Highest Recorded Daily Rain (mm)														
62.7	45.7	98.0	58.2	53.3	32.4	42.4	53.6	55.9	68.2	59.0	81.0	98.0	55.0	99
Mean no. of Clear Days														
15.7	13.9	17.5	6.8	10.0	13.0	6.0	12.5	11.0	11.1	11.2	15.4	144.1	8.2	64
Mean no. of Cloudy Days														
4.5	5.3	3.7	2.4	9.0	6.0	10.0	9.5	7.5	8.3	7.1	7.5	80.7	8.2	64

Last modified 16 August 2004



What is the weather usually like?

- Climate Averages for Australian Sites -

Averages for DENILIQUIN (WILKINSON ST)

Make sure you understand what the Climate Averages are all about before you make use of the following information. A comma separated text file of these averages is also available for download which can be graphed in software such as a spreadsheet

074128	DENILIQUIN (WILKINSON ST)				Commenced: 1858				Last record: 2004					
Latitude:-35.5269 S		Longitude: 144.9520 E		Elevation: 93.0 m		State: NSW								
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	No. Yrs	%age comp
Mean Daily Max Temp (deg C)														
32.5	32.0	28.7	23.4	18.6	15.1	14.4	16.4	19.6	23.6	27.5	30.5	23.5	141.3	97
Mean no. Days, Max >= 40.0 deg C														
3.2	1.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.5	7.4	141.1	97
Mean no. Days, Max >= 35.0 deg C														
10.0	8.2	3.7	0.2	0.0	0.0	0.0	0.0	0.0	0.6	3.1	6.9	32.7	141.1	97
Mean no. Days, Max >= 30.0 deg C														
19.6	17.8	11.9	2.3	0.0	0.0	0.0	0.0	0.4	3.6	9.2	15.4	80.3	141.1	97
Highest Max Temp (deg C)														
49.6	47.2	45.0	41.7	31.1	25.6	25.9	32.2	35.0	40.8	44.2	47.8	49.6	141.6	97
Mean Daily Min Temp (deg C)														
15.5	15.5	13.1	9.3	6.3	4.2	3.1	4.1	6.0	8.5	11.3	13.7	9.2	140.6	97
Mean no. Days, Min =< 2.0 deg C														
0.1	0.0	0.1	0.6	3.3	7.3	11.0	7.7	3.7	1.3	0.4	0.3	35.7	140.4	97
Mean no. Days, Min =< 0.0 deg C														
0.0	0.0	0.0	0.2	1.0	3.1	5.4	3.2	1.3	0.5	0.2	0.2	15.2	140.4	97
Lowest Min Temp (deg C)														
-3.9	0.6	-1.1	-2.8	-7.8	-7.2	-10.0	-9.4	-9.4	-6.7	-7.2	-5.6	-10.0	141.2	97
Mean 9am Air Temp (deg C)														
22.8	22.0	19.3	14.8	10.4	7.5	6.5	8.6	12.2	16.2	19.5	21.8	15.1	138.8	95
Mean 9am Wet-bulb Temp (deg C)														
16.5	16.5	14.9	11.9	8.9	6.6	5.6	7.1	9.7	12.1	14.0	15.5	11.6	137.8	95
Mean 9am Dew Point Temp (deg C)														
11.4	12.2	11.1	9.1	7.2	5.4	4.3	5.3	6.9	7.9	8.9	10.0	8.3	137.8	95
Mean 9am Relative Humidity (%)														
51	56	61	70	82	88	86	81	71	60	53	50	68	137.8	95
Mean 9am Wind Speed (km/hr)														
10.6	9.6	9.2	8.2	6.8	7.0	7.1	8.4	10.5	11.8	11.7	11.0	9.3	130.2	89
Mean 3pm Air Temp (deg C)														
30.0	29.9	26.8	21.8	17.3	14.0	13.3	15.1	18.0	21.5	25.2	28.1	21.7	96.1	66
Mean 3pm Wet-bulb Temp (deg C)														
18.4	18.9	17.4	14.8	12.5	10.5	9.8	10.6	12.1	13.9	15.6	17.1	14.3	95.4	66
Mean 3pm Dew Point Temp (deg C)														
8.9	10.4	9.7	8.3	7.7	6.8	5.8	5.6	5.9	6.2	6.5	7.5	7.4	95.3	66
Mean 3pm Relative Humidity (%)														
30	33	37	44	55	63	62	55	48	40	34	30	44	95.3	66
Mean 3pm Wind Speed (km/hr)														
10.5	9.7	9.5	9.2	8.5	8.3	9.3	10.6	11.2	11.7	12.3	11.1	10.2	89.5	62
Mean Rainfall (mm)														
28.4	27.2	31.8	30.8	39.2	40.3	35.0	37.0	38.2	39.7	29.2	28.9	405.7	145.7	99
Median (Decile 5) Rainfall (mm)														
16.8	15.4	18.5	22.5	32.9	35.6	31.1	35.3	33.0	32.0	20.0	19.1	386.6	142	
Decile 9 Rainfall (mm)														
71.4	70.6	71.6	66.9	85.9	72.7	67.0	65.5	71.1	87.9	63.8	66.7	576.7	142	
Decile 1 Rainfall (mm)														
1.1	0.5	0.4	2.7	7.0	13.1	8.7	9.6	13.2	9.8	3.4	1.6	234.8	142	
Mean no. of Raindays														
3.8	3.5	4.1	5.1	7.5	9.2	9.5	9.5	8.6	7.5	5.2	4.5	78.0	144.3	99
Highest Monthly Rainfall (mm)														
253.9	187.7	225.5	111.1	123.5	128.2	112.9	124.8	141.6	124.7	133.7	167.8	145.7	99	
Lowest Monthly Rainfall (mm)														
0.0	0.0	0.0	0.0	0.0	2.3	1.2	1.6	4.3	0.3	0.0	0.0	145.7	99	
Highest Recorded Daily Rain (mm)														
76.2	99.1	153.4	59.7	53.8	55.6	46.0	52.1	65.3	87.9	57.2	67.3	153.4	144.3	99
Mean no. of Clear Days														
13.5	12.9	14.2	11.5	9.1	7.7	7.1	8.3	9.1	9.8	10.4	12.9	126.5	97.8	67
Mean no. of Cloudy Days														
4.4	4.3	4.4	5.3	9.1	10.5	10.8	9.0	7.3	7.6	6.8	5.4	84.8	97.8	67
Mean Daily Sunshine (hrs)														
11.1	11.2	8.8	6.0	...	5.2	4.8	6.7	9.1	10.6	8.3	10.9	8.4	0.9	92
Mean Daily Evaporation (mm)														
9.7	8.8	6.5	3.9	2.0	1.3	1.3	2.0	3.3	5.3	7.5	9.1	5.1	26.3	62



What is the weather usually like?

- Climate Averages for Australian Sites -

Averages for MATHOURA STATE FOREST

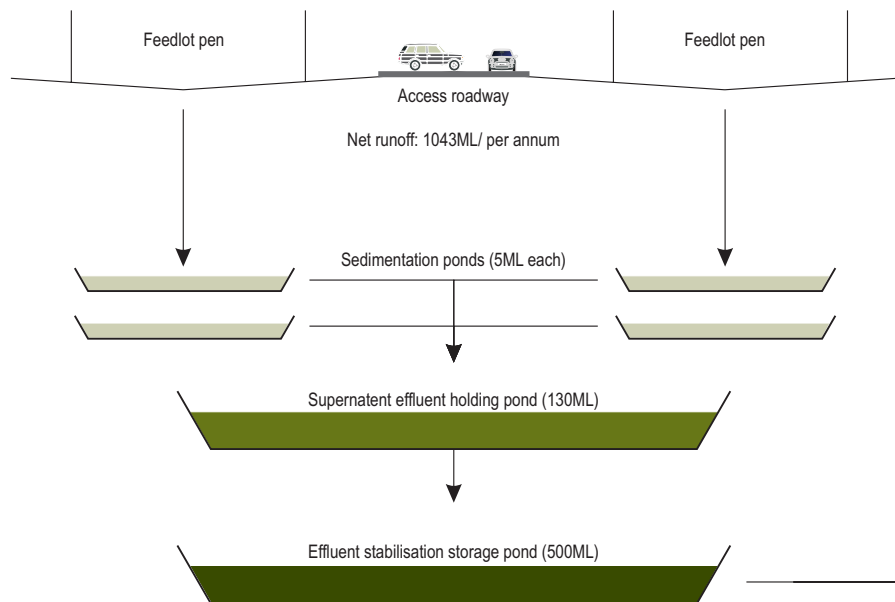
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074069 MATHOURA STATE FOREST		Commenced: 1949		Last record: 2004										
Latitude:-35.8115 S		Longitude: 144.9017 E		Elevation: 105.0 m										
				State: NSW										
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	No. Yrs	%age comp
Mean Daily Max Temp (deg C)														
31.4	30.3	27.5	22.1	16.9	14.1	13.0	14.9	18.1	21.7	25.4	28.6	22.0	20.3	98
Mean no. Days, Max >= 40.0 deg C														
2.1	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	3.9	12.9	99
Mean no. Days, Max >= 35.0 deg C														
8.9	6.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.7	4.5	24.4	12.9	99
Mean no. Days, Max >= 30.0 deg C														
19.0	14.0	10.7	1.6	0.0	0.0	0.0	0.0	0.3	3.0	8.0	12.1	68.7	12.9	99
Highest Max Temp (deg C)														
44.7	44.2	40.8	34.9	27.2	26.6	19.4	23.1	33.3	37.8	41.7	41.9	44.7	12.9	99
Mean Daily Min Temp (deg C)														
15.5	15.2	13.2	9.2	6.1	4.3	3.3	4.2	6.0	8.7	10.7	13.1	9.0	20.3	98
Mean no. Days, Min =< 2.0 deg C														
0.0	0.0	0.0	0.4	5.7	9.8	12.1	8.5	4.2	1.4	0.2	0.0	42.2	12.8	98
Mean no. Days, Min =< 0.0 deg C														
0.0	0.0	0.0	0.0	0.5	4.2	4.9	3.3	0.5	0.2	0.0	0.0	13.7	12.8	98
Lowest Min Temp (deg C)														
5.6	5.8	2.8	1.3	-1.1	-3.3	-3.8	-2.6	-1.4	-0.7	0.8	4.4	-3.8	12.9	96
Mean 9am Air Temp (deg C)														
23.8	22.4	20.0	15.6	10.7	8.0	7.0	9.0	12.4	16.1	19.3	21.6	15.5	17.2	99
Mean 9am Wet-bulb Temp (deg C)														
16.5	16.2	15.0	12.5	9.1	7.0	5.9	7.4	9.7	12.0	13.4	15.1	11.6	16.4	96
Mean 9am Dew Point Temp (deg C)														
10.3	10.4	10.4	9.1	7.2	5.9	4.6	5.8	6.6	7.9	7.4	8.9	7.9	12.2	94
Mean 9am Relative Humidity (%)														
45	50	56	68	80	85	85	80	68	60	49	47	64	16.5	96
Mean 9am Wind Speed (km/hr)														
10.4	10.7	8.7	6.6	6.1	5.0	5.3	6.2	7.8	9.2	10.5	9.2	7.9	12.8	98
Mean 3pm Air Temp (deg C)														
30.5	29.4	26.9	20.9	15.4	13.2	12.2	14.9	17.2	21.0	24.6	27.6	24.8	10.3	61
Mean 3pm Wet-bulb Temp (deg C)														
18.7	18.4	17.7	...	...	...	8.4	10.7	12.3	14.3	15.6	17.3	16.2	9.7	57
Mean 3pm Dew Point Temp (deg C)														
8.3	8.7	9.6	...	...	...	...	6.0	6.4	7.6	6.1	7.0	7.6	7.1	56
Mean 3pm Relative Humidity (%)														
29	31	37	...	...	...	...	56	52	45	35	33	38	9.6	57
Mean 3pm Wind Speed (km/hr)														
11.8	11.9	9.5	6.3	7.2	12.0	6.6	7.1	8.7	9.7	12.7	11.7	10.6	7.8	61
Mean Rainfall (mm)														
32.1	23.0	35.3	29.6	43.3	36.9	42.7	44.4	44.5	44.8	33.5	32.6	442.8	55.3	100
Median (Decile 5) Rainfall (mm)														
23.8	13.4	21.1	25.1	33.9	32.7	40.1	40.8	37.6	31.0	22.6	20.4	454.2	54	
Decile 9 Rainfall (mm)														
80.0	60.9	75.4	64.4	88.9	66.1	80.6	83.0	85.9	103.1	75.6	86.3	592.9	54	
Decile 1 Rainfall (mm)														
0.9	0.4	0.9	3.1	10.1	12.5	12.1	10.0	17.0	9.7	6.6	2.2	258.2	54	
Mean no. of Raindays														
3.8	3.6	4.3	5.4	8.5	9.1	10.8	10.9	9.5	8.4	6.2	5.0	85.4	53.7	97
Highest Monthly Rainfall (mm)														
222.9	99.4	184.9	99.8	125.7	106.2	105.7	148.3	112.3	145.5	105.2	133.1	55.3	100	
Lowest Monthly Rainfall (mm)														
0.0	0.0	0.0	0.2	2.4	0.2	1.0	2.8	5.4	0.0	1.8	0.4	55.3	100	
Highest Recorded Daily Rain (mm)														
62.7	45.7	98.0	58.2	53.3	32.4	42.4	53.6	55.9	68.2	59.0	81.0	98.0	55.0	99
Mean no. of Clear Days														
15.7	13.9	17.5	6.8	10.0	13.0	6.0	12.5	11.0	11.1	11.2	15.4	144.1	8.2	64
Mean no. of Cloudy Days														
4.5	5.3	3.7	2.4	9.0	6.0	10.0	9.5	7.5	8.3	7.1	7.5	80.7	8.2	64

Last modified 16 August 2004



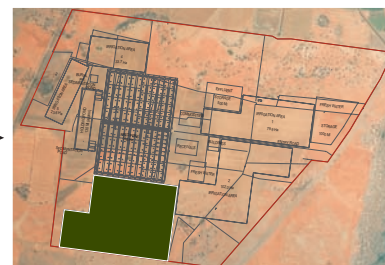
Appendix B - Effluent Treatment and Irrigation Schematic



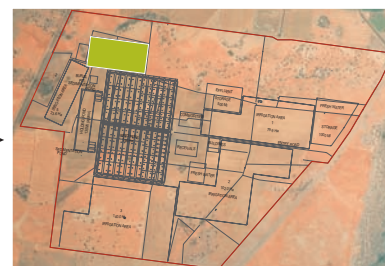
Irrigation area no. 1 (76.2ha)



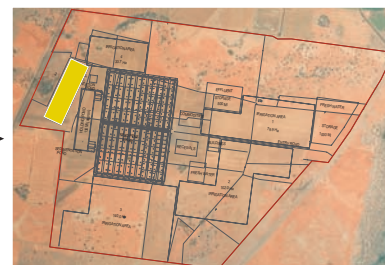
Irrigation area no. 2 (102ha)



Irrigation area no. 3 (140ha)



Irrigation area no. 4 (33.7ha)



Irrigation area no. 5 (23.6ha)

Total irrigation
area - 375.5ha

PROJECT-FILE NAME
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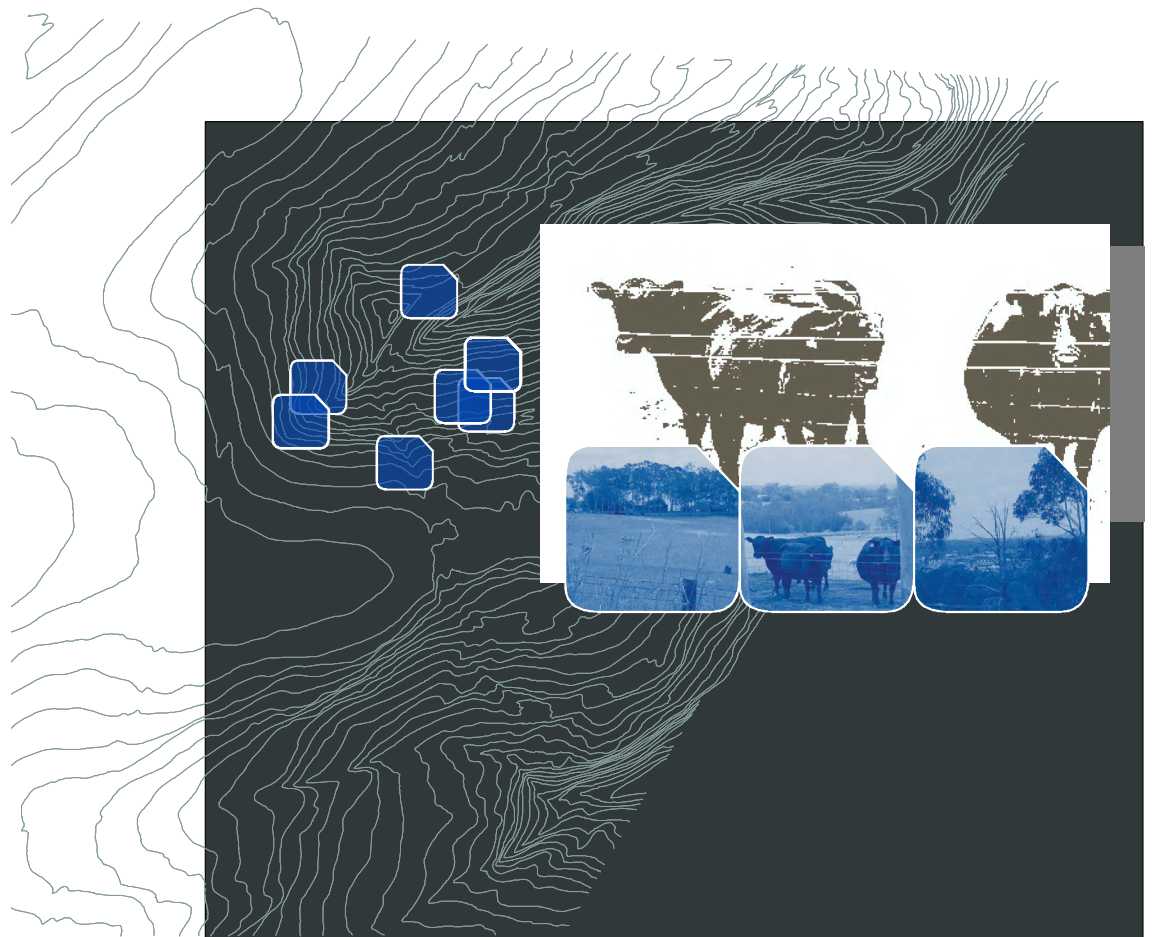
S60133
July 2005
TO

Effluent Treatment and Irrigation
Preliminary Concept Process Flows
Agricultural Equity Investments Pty Ltd
Moirra Station Cattle Feedlot
Environmental Impact Statement
Moirra NSW



APPENDIX

B



appendix f

flora & fauna assessment

Moira Station Cattle Feedlot Flora and Fauna Survey

Moira, New South Wales

18 November 2005

Prepared for:
Agricultural Equity Investments Pty Ltd
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Sydney NSW 2001

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HLA Ref: S6013306_FinalRpt_Nov05.doc

DISTRIBUTION

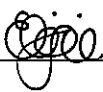
Moira Station Cattle Feedlot Flora and Fauna Survey
Moira, NSW
18 November 2005

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This document was prepared for the sole use of Agricultural Equity Investments Pty Ltd and the regulatory agencies that are directly involved in this project, the only intended beneficiaries of our work. No other party should rely on the information contained herein without the prior written consent of HLA-Envirosciences Pty Limited and Agricultural Equity Investments Pty Ltd.

By

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for Rochelle Lawson, Ecologist


for Neil McElhinney, Ecologist

Peer Review:

Date:

for

	18/11/05
Peter Wright, Principal Environmental Services	

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- Appendix A: EPBC Act Protected Matters Report
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1 INTRODUCTION

HLA-Envirosciences Pty Ltd has been commissioned by Agricultural Equity Investments Pty Ltd to undertake a Flora and Fauna Survey to identify the ecological issues associated with the proposed Moira Station cattle feedlot. The Flora and Fauna Survey has been prepared in accordance with the requirements of the Director General of Department of Infrastructure, Planning and Natural Resources (DIPNR) issued for preparation of the Environmental Impact Statement (EIS) for the proposal. The Director General's requirements include consideration of *Environmental Protection and Biodiversity Conservation Act 1999* matters. The requirements make specific reference to the need to assess the potential impacts of the proposed development upon flora and fauna on, in or adjacent to the site.

This report identifies potential impacts of the proposed development on the terrestrial vertebrate fauna and vascular flora of the proposed development site.

1.1 Proposed development

Agricultural Equity Investments Pty Ltd propose to develop an 80,000 head of cattle feedlot located on Moira Station, which is approximately 12km south of Mathoura in southwestern NSW (**Figure 1**). The total area of the property is 1,200ha and the proposed feedlot would occupy a footprint of approximately 600ha. Cattle weighing approximately 300kg would be transported to the feedlot and housed in pens. The cattle would be fed grain until they reach a certain weight (529kg) after which they would be transported from the site to an abattoir.

The proposed feedlot would include the following elements:

- feed pens;
- internal roadways;
- ancillary buildings;
- effluent storage;
- commodities;
- receivals;
- freshwater storage;
- holding pond; and
- irrigation area.

The site has been previously cleared for agriculture (grazing and irrigated and dryland cereal cropping) and there remains scattered remnant native vegetation on parts of the property (**Figure 2**). There is an extensive network of irrigation channels throughout the site, fed by the main Moira Irrigation Channel.

1.2 Scope of this report

The scope of this report is to:

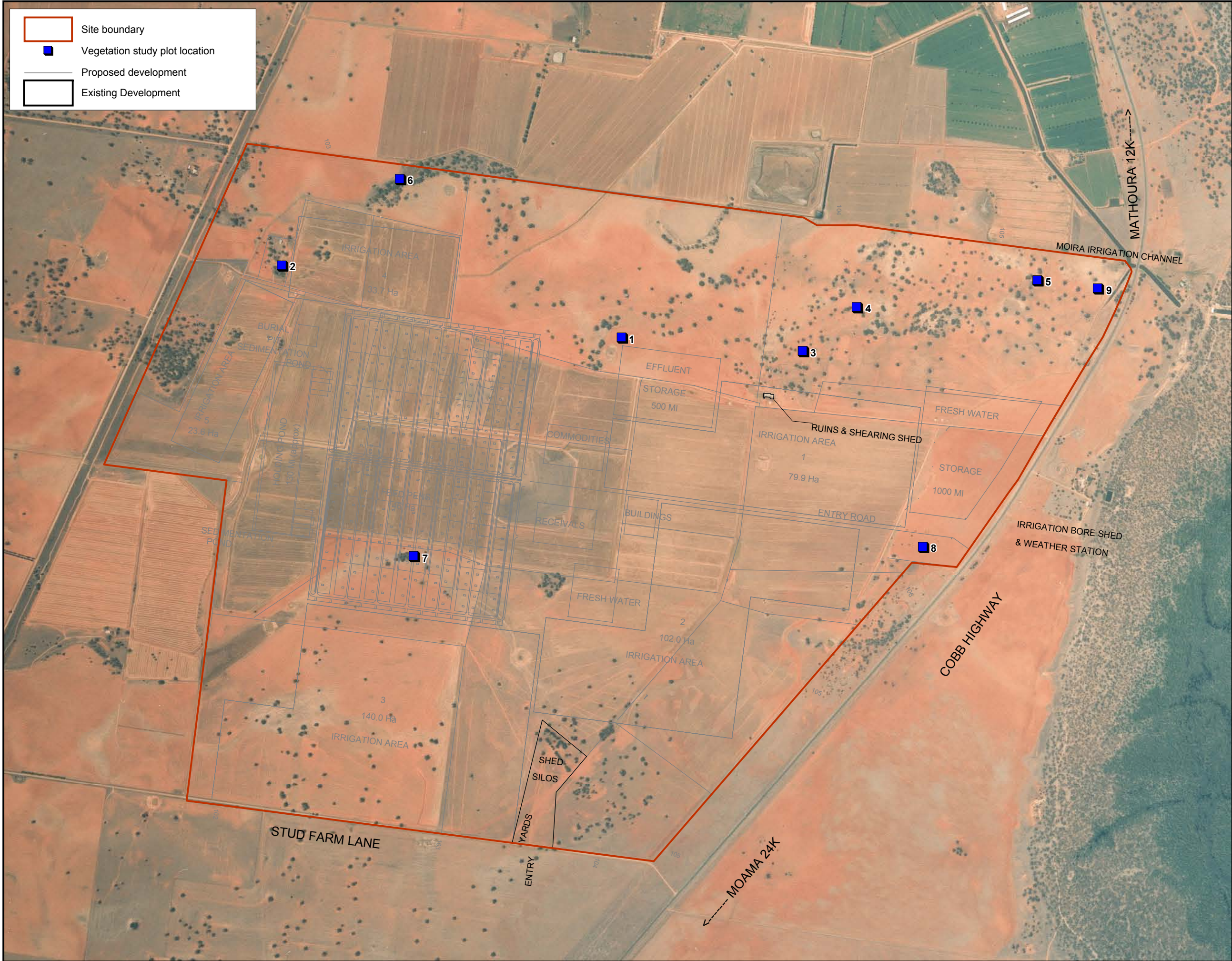
- conduct a baseline flora and fauna survey within the property;
- conduct a review of existing information on flora and fauna in the region;
- assess the impact of the proposed development in accordance with the *Threatened Species Conservation Act 1995* (with relevant amendments as per the *Threatened Species Conservation Amendment Act 2002*) and *Environment Protection and Biodiversity Conservation Act 1999* plus any relevant State Environment Planning Policies (e.g. SEPP No. 44 – Koala Habitat Protection);



Site Location
Moira Station Feedlot



1



PROJECT FILE NAME - S60133
DATE - April 2005
DRAWN - TO
APPROVED

0 300 600
Metres

Proposed Development and Aerial
Photograph of Existing Vegetation and
Study Plots
AEI Pty Ltd
Flora and Fauna Survey
Moira Cattle Station



Figure
2

- recommend measures to mitigate against potential impacts; and
- provide a report detailing the methodology, findings and recommendations of the flora and fauna survey.

1.3 Limitations of the study

The species lists presented in this report reflect what was observable in the days and evenings of the flora and fauna survey at the time of the survey (March 2005). Seasonal variation in plant form (i.e. presence or absence of seeds and flowers) and movement of fauna also should be taken into account.

2 INFORMATION REVIEW

2.1 Regional context

The Moira Station site is located in the Murray Fans subregion (RIV3) within the Riverina biogeographic region. The region is important for biodiversity:

- there are seventy wetlands listed in the Directory of Important Wetlands in Australia within this bioregion, providing a range of habitats and acting as major drought refuges for waterbirds;
- the red gum forests provide essential habitat for many woodland birds, including the vulnerable Superb Parrot; and
- ninety-two species of flora and fauna are listed as either endangered or vulnerable.

Over 60% of the bioregion has been cleared for agriculture; grazing on native pastures and irrigated cropping are the dominant landuses. Logging of the extensive River Red Gum forests has been ongoing over the last century. Connectivity between native vegetation remnants is low and relatively little of the native vegetation is managed with biodiversity conservation objectives in mind. Birds of the riparian corridors have largely been unaffected, but ground-feeding insectivores and grassland birds have been reported much less frequently, perhaps as a consequence (NLWRA 2002).

Within the bioregion there are endangered vulnerable flora and fauna species (NLWRA 2002). Broadscale clearing of vegetation, further fragmentation and loss of habitat, grazing pressure, feral animals and weeds remain the greatest general threat to these species.

Elevated areas within the region that very rarely or never flood contain a higher variety of tree species, including Grey Box (*Eucalyptus microcarpa*), Yellow Box (*Eucalyptus melliodora*), White Cypress Pine (*Callitris glaucophylla*), Murray Pine (*Callitris gracilis subsp. murrayensis*) and Bulloak (*Allocasuarina luehmannii*) (Leslie 2002).

The plains woodlands are assumed to be unimportant in terms of river health, as they do not form part of the floodplain. They are, however, highly significant in terms of providing refuge for terrestrial fauna during major floods, being representative of depleted or rare vegetation communities within the Riverina bioregion, and providing habitat for threatened woodland birds such as Gilberts Whistler (*Pachycephala inornata*) and Hooded Robin (*Melanodryas cucullata subsp. cucullata*) (NLWRA 2002).

2.2 Climate

During the past one to two years rainfall in the region has been average or above average (see **Figure 3**, from Bureau of Meteorology). The above average rainfall may explain the regional declines in several groupings that are more commonly associated with the arid zone such as Chats, Diamond Dove, Budgerigar and Zebra Finch (NLWRA 2002).

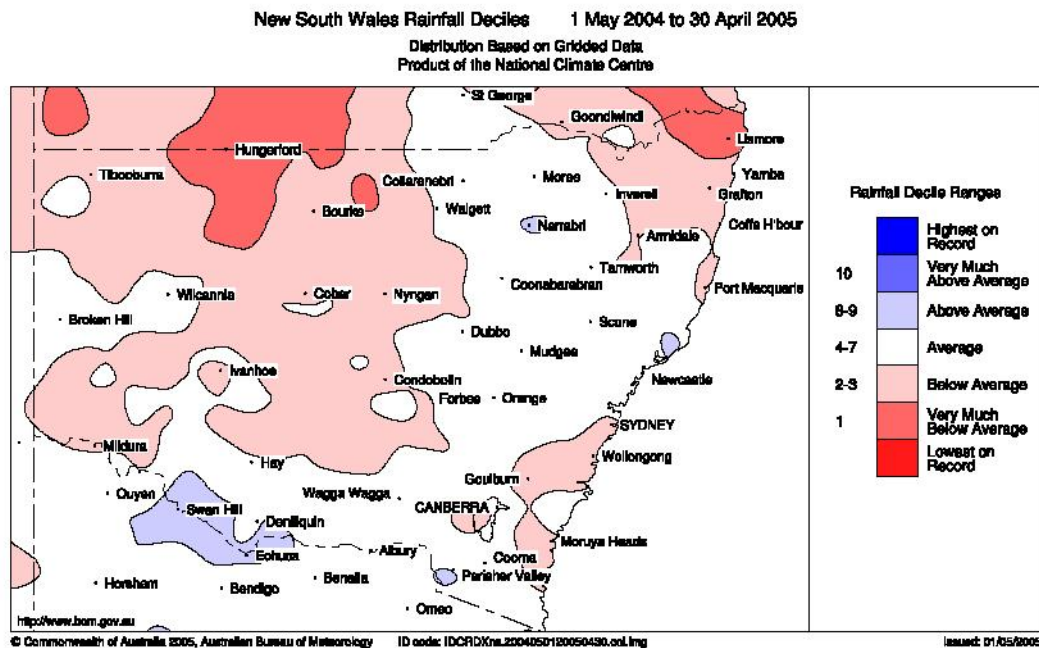


Figure 3: Rainfall Deciles for New South Wales in the past 12 months shows above average rainfall for the site.

2.3 General biodiversity

2.3.1 Birds

The general trends for the subregion are that bird species such as the Long-billed Corella, Little Corella and Common Myna are on the increase and ground-feeding insectivores and grassland birds are being reported much less frequently.

Species such as Emu, Australasian Bittern, Australian Bustard, Banded Lapwing, Superb Parrot, Blue Bonnet, Brown Treecreeper, Hooded Robin, Flame Robin, Jacky Winter, Grey-crowned Babbler, Varied Sittella, Crested Shrike-tit, Restless Flycatcher, and Diamond Firetail are considered indicator species, and their presence or absence giving insight into the condition of the habitat.

2.3.2 Mammals

There are 47 mammal species occurring within the Riverina bioregion (NLWRA 2002). Eleven of these are introduced exotic species.

2.3.3 Reptiles and amphibians

There is very little information available in the literature about the status of reptiles and amphibians in the Riverina bioregion. No threatened species have been recorded within the local area (NLWRA 2002).

2.3.4 Threatened species

The Department of Environment and Conservation (DEC) Wildlife Atlas (WA) was searched to identify threatened species that have been recorded within the area covered by the Echuca and Mathoura 1:100,000 map sheets. A search of ecological Protected Matters under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) was also undertaken and is provided in Appendix A.

The threatened flora species are listed in **Table 1**, which also indicates their status under the *Threatened Species Conservation Act 1995* (TSC) and EPBC Act.

Table 1: Threatened flora species recorded in the region

Scientific Name	Common Name	Status TSC	Status EPBC
<i>Lepidium monoplocoides</i>	Winged Peppercress	Endangered	-
<i>Swainsonia murrayana</i>	Slender Darling Pea	Vulnerable	Vulnerable
<i>Amphibromus fluitans</i>	River Swamp Wallaby Grass	Vulnerable	Vulnerable
<i>Sclerolaena napiformis</i>	Turnip Copperbur	Endangered	Endangered
<i>Brachyscome muelleroides</i>	Mueller Daisy	-	Vulnerable
<i>Cullen parvum</i>	Small Scurf-pea	-	Endangered
<i>Swainsona plagiotropis</i>	Red Darling Pea	-	Vulnerable

The search of the DEC WA identified 22 threatened fauna species that have been recorded within the Echuca and Mathoura 1:100,000 map sheets. An additional species, the Northern Hairy-nosed Wombat (*Lasiorninus krefftii*) has also been recorded, but is now considered to be extinct in NSW. A search for ecological Protected Matters under the EPBC Act identified eleven threatened fauna species as either occurring or potentially occurring in the local area. Species that occur or potentially occur within the local area, and are protected either by the provisions of the TSC Act or the EPBC Act, are listed in **Table 2**.

Table 2: Threatened fauna recorded in the region

Scientific Name	Common Name	Status TSC	Status EPBC
<i>Botaurus poiciloptilus</i>	Australasian Bittern	Vulnerable	-
<i>Burhinus grallarius</i>	Bush-stone-curlew	Endangered	-
<i>Climacteris picumnus</i>	Brown Treecreeper	Vulnerable	-
<i>Grantiella picta</i>	Painted Honeyeater	Vulnerable	-
<i>Grus rubicundus</i>	Brolga	Vulnerable	-
<i>Lathamus discolor</i>	Swift Parrot	Endangered	Endangered
<i>Lophoictinia isura</i>	Square-tailed Kite	Vulnerable	-
<i>Melanodryas cucullata</i>	Hooded Robin	Vulnerable	-
<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subsp.)	Vulnerable	-
<i>Neophema pulchella</i>	Turquoise Parrot	Vulnerable	-
<i>Ninox connivens</i>	Barking Owl	Vulnerable	-
<i>Pachycephala inornata</i>	Gilbert's Whistler	Vulnerable	-

Scientific Name	Common Name	Status TSC	Status EPBC
<i>Polytelis swainsonii</i>	Superb Parrot	Vulnerable	Vulnerable
<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler (eastern subsp.)	Vulnerable	-
<i>Rostratula benghalensis australis</i>	Painted Snipe (Australian subsp.)	Endangered	Vulnerable
<i>Stagonopleura guttata</i>	Diamond Firetail	Vulnerable	-
<i>Xanthomyza phrygia</i>	Regent Honeyeater	Endangered	Endangered
<i>Pedionomus torquatus</i>	Plains-wanderer	-	Vulnerable
<i>Antechinomys laniger</i>	Kultarr	Endangered	-
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	Vulnerable	-
<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	Endangered	-
<i>Phascolarctos cinereus</i>	Koala	Vulnerable	-
<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat (Eastern Long-eared Bat)	Vulnerable	Vulnerable
<i>Delma impar</i>	Striped Legless Lizard	-	Vulnerable
<i>Litoria raniformis</i>	Southern Bell Frog	-	Vulnerable
<i>Craterocephalus fluviatilis</i>	Murray Hardyhead	-	Vulnerable
<i>Maccullochella peelii peelii</i>	Murray Cod	-	Vulnerable
<i>Macquaria australasica</i>	Macquarie Perch	-	Vulnerable

3 SURVEY METHODS

3.1 Flora survey

The vascular flora of the study area was surveyed by establishing nine 20m x 20m quadrats and by conducting surveys along transects in between quadrats. The quadrats were located in areas of relatively natural vegetation and where it is proposed to clear remnant woodland for the development of the feedlot (**Figure 2**). Quadrats were generally not located in cropping areas due to the sustained history of disturbance. Photos of the first six quadrats are included as **Plates 1 through 6**.

In each quadrat, the following details were recorded:

- location, accurate to the nearest 6m;
- land use and disturbances;
- vegetation structure and dominant species;
- all vascular flora species that can be identified given seasonal and other constraints; and
- presence of significant species, for example, threatened or noxious species.

Vegetation community descriptions were defined by structure and dominant species present. These were then aligned with existing vegetation descriptions to allow comparisons of community significance to be made.

Species were identified in the field or off site using the taxonomic keys within Harden (1992), Harden (1993), Harden (2000), Harden (2002), aided by Cunningham *et al.* (1992) with naming conventions as per the Royal Botanic Gardens NSW, current as at June 2002.

3.2 Fauna survey

The fauna of the site was studied using a combination of systematic and opportunistic methodologies, including targeted survey points and incidental observations. The methodologies used are described below.

3.2.1 Birds

Dawn surveys of bird species present on the site were conducted between 15 - 17 March 2005. Locations were chosen based on the presence of water and nearby trees. Timed survey was conducted over a minimum of 30 minutes, with species identified by sight, behaviour or characteristic call with the aid of Simpson and Day (1999). Incidental sightings of birds throughout the day were also recorded. Nocturnal birds were surveyed by passive listening for half an hour, call playback and spotlighting. Call playback for the Masked Owl (*Tyto novaehollandiae*) was carried out using taped calls (Stewart 1999) broadcast with a Toa 15 W megaphone.

3.2.2 Mammals

Larger mammals were observed opportunistically during the day between 14-16 March 2005. Dusk and evening surveys of mammals were conducted on 14-16 March 2005. Insectivorous bats were surveyed using an Anabat II bat detector, set up in a different location each of the three evenings at dusk (2 dams and one remnant woodland area) (**Figure 2**). Bat echolocations were recorded for 30 minutes onto a tape recorder, with recording starting at the first bat detected. Bat echolocations were downloaded using Anabat V zero crossing analysis interface

module using Anabat V software and the echolocations compared to Penny *et al.* (2004). Spotlights were used to visually search the ground and tree canopy on three evenings. Trapping was not undertaken due to the limited vegetation cover of the site.

3.2.3 Reptiles and amphibians

Reptiles were caught and identified throughout the day as suitable habitat was encountered, such as fallen timber, debris and infrastructure ruins. Amphibians were surveyed by listening for characteristic calls near dams at dusk and evenings.

4 OBSERVATIONS

4.1 Flora

The site has been extensively cleared for agricultural uses, and has been impacted to varying degrees by weed invasion and overgrazing by stock and feral species. Weeds dominate the areas that are presently irrigated. Adjacent agricultural land has been substantially cleared and the remaining woodlands within the site generally have a disturbed understorey due to past livestock and rabbit grazing.

A total of 69 vascular plant species were identified within the site, of which 29 were not native to Australia, and two species were native to Australia but not the local area. The species identified at each of the nine vegetation quadrats are listed in **Appendix B**. The two native species that were not endemic were the Golden Wattle (*Acacia pycnantha*) and Sugar Gum (*Eucalyptus cladocalyx*). No threatened flora (see **Table 1**) were detected during the survey.

Aquatic / riparian herbaceous species associated with irrigation channels were not mapped separately. In addition to the common species found in the ground cover of the River Red Gum Community, *Juncus* sp., *Cyperus* sp. *Rumex* sp. and Knotweed (*Persicaria lapathifolia*) were present.

4.1.1 Vegetation communities

The vegetation communities present on the site (**Figure 4**) are:

- River Red Gum (*Eucalyptus camaldulensis*) Community;
- Black Box (*Eucalyptus largiflorens*) Community;
- Box Community with Exotic Understorey; and
- Cropped.

Table 3 shows the dominant species within each community.

Table 3: Dominant species and cover abundance within vegetation communities present on the site

Community	Dominant Species / cover *		
	Canopy	Shrub	Ground Cover
River Red Gum Community	<i>Eucalyptus camaldulensis</i>	-	<i>Eleocharis pusilla</i> / 3 <i>Marsilea drummond</i> / 3
Black Box Community	<i>Eucalyptus largiflorens</i> / 1	-	<i>Austrodanthonia caespitosa</i> / 3 <i>Austrostipa scabra</i> subsp. <i>Scabra</i> / 3 <i>Chenopodium murale</i> / 3 (under canopy)
Box Community with exotic understorey	<i>Eucalyptus largiflorens</i> / 1 <i>Eucalyptus microcarpa</i> / 1 <i>Eucalyptus melliodora</i> / 1	-	Crop - Crop Stubble / 3 <i>Polygonum aviculare</i> / 3 <i>Amsinckia intermedia</i> / 3

Community	Dominant Species / cover *		
	Canopy	Shrub	Ground Cover
Cropped	-	-	Crop - Crop Stubble / 5 <i>Polygonum aviculare</i> / 3 <i>Amsinckia intermedia</i> / 3

* Modified Braun Blanquet cover abundance scale

1. <5% cover and few individuals
2. <5% cover and many individuals
3. 5 - 25% cover
4. 25 - 50% cover
5. 50 - 75% cover
6. 75 - 100% cover

River Red Gum (*Eucalyptus camaldulensis*) Community

The River Red Gum Community was restricted to drainage depressions in the northern part of the site. The tree canopy was exclusively River Red Gum, and there was no shrub understorey. The ground cover varied, with the northeastern remnant having the greatest cover and diversity of native species. Dominant ground cover species included *Eleocharis pusilla* and Common Nardoo (*Marsilea drummondii*). No other species dominated; however, several species were restricted to this community, including *Goodenia gracilis* and *Lythrum hyssopifolia*.

The remainder of the community was significantly impacted by cattle sheltering or accessing water.

Black Box (*Eucalyptus largiflorens*) Community

The Black Box Community occurred in flood plains between the drainage depressions and higher areas and had the greatest diversity of all communities in terms of native species and spatial extent of a native dominated understorey. The dominant tree species was Black Box; however, other tree species were also present, including River Red Gum near small depressions, Yellow Box (*Eucalyptus melliodora*) and Grey Box (*Eucalyptus microcarpa*).

The community in the uncropped northern pastures had few shrub species, dominated mostly by scattered chenopods, especially Galvanised Burr (*Sclerolaena birchii*) and also *Maireana aphylla* being relatively common. The ground cover beneath the trees was dominated by exotic species, a result of shade, disturbance and increased nutriment from stock sheltering. Very common species included Nettle-leaf Goosefoot (*Chenopodium murale*), Common Fiddleneck (*Amsinckia intermedia*) and the noxious species African Boxthorn (*Lycium ferocissimum*). Native grass species, especially Ringed Wallaby Grass (*Austrodanthonia caespitosa*) and Speargrass (*Austrostipa scabra* subsp. *scabra*) dominated away from the cover of trees.

Box Community with Exotic Understorey

This community was mapped for areas where scattered remnants of the former woodland cover occurred in cropped areas. While Grey Box and Black Box were common in this community, other species also occurred. Exotic species comprised crop species and weeds such as Wireweed (*Polygonum aviculare*), Patersons curse (*Echium plantagineum*) and the noxious Bathurst Burr (*Xanthium spinosum*). As with the Black Box Community, the ground cover under tree canopies was dominated by Nettle-leaf Goosefoot and Common Fiddleneck.

Cropped

This community dominated in terms of spatial extent, and included areas that are irrigated. Species that are presently grown include *Sorghum* sp., while many other areas have been harvested with crops such as Wheat (*Triticum aestivum*) and Barley (*Hordeum* sp.). The ground cover in fallow areas was typically dominated by Wireweed and Fiddleneck with Bathurst Burr and Patersons Curse also occurring.

Previous vegetation mapping identifies the entire site as being cleared; however, nearby locations on elevated flats of the Murray River floodplain are mapped as having remnants of Grey Box (*Eucalyptus macrocarpa*) Woodland, dominated by Black Box (*E. largiflorens*) and Bulloak (*Allocasuarina luehmannii*) (Porteners 1993). The community occurs in the uppermost floodplain levels, and is dominated by Black Box, often mixed with Grey Box (*E. macrocarpa*) and Yellow Box (*E. melliodora*), the latter species becoming less frequent in the south. The ground cover may have Caustic Weed (*Chamaesyce drummondii*), *Atriplex semibaccata*, *Oxalis perennans* and *Alternanthera denticulata*. Black Box trees are susceptible to dieback in heavily irrigated areas. A major problem to the community is soil salinisation along the Edward River system causing dieback (Porteners 1993).

4.2 Fauna

4.2.1 Birds

There were 56 species of vertebrate fauna recorded during the field investigations, the majority of which were bird species. There were three threatened species of bird found on the Moira site during this survey: the Grey-crowned Babbler (*Pomatostomus temporalis temporalis*), the Brown Tree Creeper (*Climacteris picumnus*) and the Blue-billed Duck (*Oxyura australis*). The locations of these sightings and the Grey-crowned Babbler nests discovered on the site are shown on **Figure 4**. The remains of a Major Mitchell's Cockatoo (*Cacatua leadbeateri*) were found at study plot 2 and this species is listed as Vulnerable under the TSC Act.

4.2.2 Mammals

Eleven species of mammal were observed during the present survey, including three exotic species, seven species of bat and the Common Brushtail Possum. There were no threatened species observed. The species are listed in **Appendix C**.

4.2.3 Reptiles and amphibians

There are very few records of reptiles or amphibians recorded in the on-line DEC WA. These include six frog species, two snake species, a freshwater turtle and a gecko, however this is likely to be a reflection on past survey effort rather than a depauperate herpetofauna.

Three species of skink were found on the site under or near building and fence debris: *Cryptoblepharus carnabyi*, *Ctenotus taeniolatus*, and *Morethia boulengeri*. *Cryptoblepharus carnabyi* is a semi arboreal species, associated with trees, shrubs and rocky areas (Cogger 2000). Within the study area it was observed amongst timber piles and around the shearing quarters. The observation of the Copper-tailed Skink (*Ctenotus taeniolatus*) is west of the mapped distribution (Cogger 2000). The species was observed in timber piles near the shearing quarters. *Morethia boulengeri* was observed amongst fallen timber in the north of the study area.

Overall, there were very few observations of reptiles or amphibians despite the weather being relatively warm and humid during the field investigations. This is probably a result of past land management which has resulted in the simplification of terrestrial habitat and significant reduction in woodland habitat. In particular, there is a general lack of terrestrial refuge sites, such as fallen timber, whilst tilling of the soil and irrigation practices would have destroyed subterranean refuge locations. The increased predation potential that results from the reduced vegetation cover after harvesting is likely to further reduce the ability for herpetofauna to persist.

No threatened species were observed during the survey.

5 IMPACT ASSESSMENT

5.1 Existing impacts

The site is presently used for cropping, with a significant portion irrigated. Fallow cropped areas and paddocks in the north of the site are presently utilised for grazing. The ground cover under trees is dominated by weed species. Also present are many remains of sheep that either died through lack of water or starvation during a drought.

It is likely the remnant woodlands have a lower cover abundance than what is likely to have occurred prior to European settlement. The presence of the large shearing shed and substantial shearers quarters suggests the property previously supported a large number of sheep.

Other impacts include farm infrastructure, a cattle feedlot, irrigation channels, graded tracks and ploughing of cropped land.

Fauna is also likely to significantly impact the vegetation and native fauna communities, through the predation of terrestrial mammals, amphibians, reptiles and ground dwelling birds by foxes (*Vulpes vulpes*), grazing by rabbits (*Oryctolagus cuniculus*) and the spread of weeds such as African Boxthorn by birds and foxes.

5.2 Potential impacts

The proposed development will largely impact areas that are currently used for agricultural activities. A small remnant stand of trees will be removed for the cattle feedlot and isolated trees are likely to be removed during the construction of buildings, water storages and access roads. Other potential impacts may result from the raising of the water table and associated salinisation if there is a significant increase in the amount of water used for irrigation.

5.3 Impacts to Threatened Species

No threatened plant species were recorded within the site during the field investigations. Therefore the following considerations to impacts to threatened species are for fauna species only. The details of section 5A of the *Environmental Planning and Assessment Act (1979)* assessment (eight-part test) are in **Appendix D**.

5.3.1 Threatened Species Conservation Act 1995 considerations

Threatened fauna species under the TSC Act that have been recorded in the Mathoura and Echuca 1:100,000 map sheets and an indication of whether present or habitat was present on the site are listed in **Table 4**. There are no records of the Major Mitchell's Cockatoo or Blue-billed Duck in the search area, and therefore the species is not included in the table. However, the Major Mitchell's Cockatoo is listed as Vulnerable and the Blue-billed Duck is listed as Vulnerable and they are included in the eight-part test.

Table 4: Threatened fauna for the Mathoura and Echuca regions (DEC Atlas)

Scientific Name	Common Name	Status TSC	Species/ Habitat Present on site
<i>Botaurus poiciloptilus</i>	Australasian Bittern	Vulnerable	No habitat present

Scientific Name	Common Name	Status TSC	Species/ Habitat Present on site
<i>Burhinus grallarius</i>	Bush-stone-curlew	Endangered	Habitat present
<i>Climacteris picumnus</i>	Brown Treecreeper	Vulnerable	Yes - Observed
<i>Grantiella picta</i>	Painted Honeyeater	Vulnerable	Habitat present
<i>Grus rubicundus</i>	Brolga	Vulnerable	No habitat present
<i>Lathamus discolor</i>	Swift Parrot	Endangered	Habitat present
<i>Lophoictinia isura</i>	Square-tailed Kite	Vulnerable	Habitat present
<i>Melanodryas cucullata</i>	Hooded Robin	Vulnerable	Habitat present
<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subsp.)	Vulnerable	Habitat present
<i>Neophema pulchella</i>	Turquoise Parrot	Vulnerable	Habitat present
<i>Ninox connivens</i>	Barking Owl	Vulnerable	No habitat present
<i>Pachycephala inornata</i>	Gilbert's Whistler	Vulnerable	Habitat present
<i>Polytelis swainsonii</i>	Superb Parrot	Vulnerable	Habitat present
<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler (eastern subsp.)	Vulnerable	Yes - Observed
<i>Rostratula benghalensis australis</i>	Painted Snipe (Australian subsp.)	Endangered	Habitat present
<i>Stagonopleura guttata</i>	Diamond Firetail	Vulnerable	Habitat present
<i>Xanthomyza phrygia</i>	Regent Honeyeater	Endangered	Habitat present
<i>Antechinomys laniger</i>	Kultarr	Endangered	No habitat present
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	Vulnerable	Habitat present
<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	Endangered	No habitat present
<i>Phascolarctos cinereus</i>	Koala	Vulnerable	Habitat present
<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat	Vulnerable	Habitat present

5.3.2 Environment Protection and Biodiversity Conservation Act 1999 considerations

Threatened fauna species under the EPBC Act that have been recorded in the Moira region and an indication of whether present or habitat was present on the site are listed in **Table 5**.

Table 5: Threatened fauna recorded in the region (EPBC Act Protected Matters Report)

Scientific Name	Common Name	Status EPBC	Species/ Habitat Present on site
<i>Lathamus discolor</i>	Swift Parrot	Endangered	Habitat present
<i>Polytelis swainsonii</i>	Superb Parrot	Vulnerable	Habitat present
<i>Rostratula benghalensis australis</i>	Painted Snipe (Australian subsp.)	Vulnerable	Habitat present
<i>Xanthomyza phrygia</i>	Regent Honeyeater	Endangered	Habitat present
<i>Pedionomus torquatus</i>	Plains-wanderer	Vulnerable	No habitat present
<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat (Eastern Long-eared Bat)	Vulnerable	Habitat present
<i>Delma impar</i>	Striped Legless Lizard	Vulnerable	No habitat present
<i>Litoria raniformis</i>	Southern Bell Frog	Vulnerable	No habitat present
<i>Craterocephalus fluviatilis</i>	Murray Hardyhead	Vulnerable	No habitat present
<i>Maccullochella peelii peelii</i>	Murray Cod	Vulnerable	No habitat present
<i>Macquaria australasica</i>	Macquarie Perch	Vulnerable	No habitat present

Habitat for the woodland birds is present on the site, however it is unlikely to be of sufficient quality or size to support populations of these threatened species.

5.3.3 SEPP 44 considerations

The site occurs in the Murray Local Government Area, which is named in Schedule 1 of the State Environmental Planning Policy No 44 - Koala Habitat Protection.

Table 6 lists the preferred Koala feed tree species, only one of which is present on the site.

Table 6: Feed Tree species (Schedule 2 of SEPP 44)

Scientific Name	Common Name	Present on Site
<i>Eucalyptus tereticornis</i>	Forest red gum	No
<i>Eucalyptus microcorys</i>	Tallowwood	No
<i>Eucalyptus punctata</i>	Grey Gum	No

Scientific Name	Common Name	Present on Site
<i>Eucalyptus viminalis</i>	Ribbon or manna gum	No
<i>Eucalyptus camaldulensis</i>	River red gum	Yes
<i>Eucalyptus haemastoma</i>	Broad leaved scribbly gum	No
<i>Eucalyptus signata</i>	Scribbly gum	No
<i>Eucalyptus albens</i>	White box	No
<i>Eucalyptus populnea</i>	Bimble box or poplar box	No
<i>Eucalyptus robusta</i>	Swamp mahogany	No

Of the trees listed in Schedule 2 of SEPP No.44, the River Red Gum (*Eucalyptus camaldulensis*) is present within the site. The River Red Gum Community occurs outside of the development footprint and is unlikely to be significantly impacted.

The site is not considered 'Core Koala Habitat' and therefore SEPP44 does not apply. No breeding females were observed on the site.

5.4 Management Recommendations

From a regional perspective, the key management actions are to protect, enhance and link woodland fragments. This would involve preventing grazing in representative areas and the adoption of reduced, conservative grazing rates in key habitat across the bioregion. It is also important to maintain an on-going supply of hollows for fauna habitat (NLWRA 2002).

There is a history of plains woodland rehabilitation since 1992, which encourages tree and shrub regeneration in high conservation value woodlands adjoining the floodplain. Since that time, livestock grazing has been deferred from approximately 3,000 hectares, direct seeding using local provenance seed has occurred over 500 hectares and almost 6,000 tubestock seedlings have been planted. Low rabbit numbers are also being maintained through cooperative programs involving 1080 (sodium fluoroacetate) baiting, warren destruction, and release of myxomatosis (Type species *Myxoma virus*) and the rabbit calicivirus (Type species *Rabbit hemorrhagic disease virus*). A strategic livestock grazing program was also implemented in 2001 (Leslie 2002).

Specifically for this site, the protection of the northern belt of native woodland is paramount. This band of mature trees is key habitat for at least two threatened woodland bird species and would most likely act as a corridor or link to other woodland or riparian areas in the region.

The first management recommendation is to leave this area ungrazed or lightly grazed. It is assumed that the feedlot stock will be kept in pens and not allowed to graze the northern part of the property, however, if the area is used for grazing, it is recommended that over-stocking be avoided during times of drought and weeds are controlled. Stock should be excluded from sensitive moist habitats, for example the River Red Gum Community to the northwest of the development footprint, and stock should be excluded from parts of the woodland habitat that occurs in areas with predominantly native grass species.

The second management recommendation is to deposit tree snags and branches removed as part of the development in a random and scattered pattern in the northern woodland belt to enhance the habitat for reptiles and mammals. Care should be taken to avoid stockpiling the woody debris in such a way that encourages fox and rabbit sheltering, including soil material in the stockpile or heaping the woody debris in large piles.

The third management recommendation is to plant trees that are native to the local area (i.e. Black Box) along the property boundary, fence lines and drainage lines that have few trees present. This will ensure these tree root systems will develop under the changed hydrological regime that will result from the proposed development, and help to lower the water table. Otherwise, the risk is that if water-logging leads to the death of the present mature trees, the water table will rise too high. The new trees will also intercept nutrients in the groundwater and minimise eutrophication of water bodies external to the site. They will also provide shelter for stock. It is recommended irrigation does not occur in the northern Black Box woodland area, in keeping with the development plans.

5.5 Conclusion

An ecological impact assessment of the proposed development on the Moira Station site was undertaken. This investigation has identified an area of native woodland with a native grass understory located in the northern part of the property that potentially provides habitat for two threatened woodland bird species: Grey-crowned Babbler; and Brown Tree Creeper. Another threatened bird, the Blue-billed Duck, was observed in a farm dam in the southeastern part of the property. No threatened flora species were found.

Habitat for the majority of threatened fauna species under the TSC and EPBC Acts that potentially utilise the site will not be impacted by the proposed development because it is outside of the development footprint.

The assessment has provided details of management measures to incorporate into the operation of the proposed development, which will minimize and mitigate any environmental impacts associated with the proposal. These measures include:

- Protection of the northern belt of native woodland and grassland;
- Depositing tree snags and branches to be removed as part of the development in the northern belt of woodland to enhance habitat for reptiles and mammals;
- Planting of trees along the property boundary and drainage lines to help lower the water table.

Following implementation of the management measures, it is expected that the proposed cattle feedlot development would not create any significant ecological impacts.

6 REFERENCES

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PLATES



Plate 1

Vegetation plot # 1 in recently harvested barley crop paddock.



Plate 2

Vegetation plot # 2 in small paddock with shed and silos and dam in northwest corner of property



Plate 3

Vegetation plot #3 north of shearing shed ruins.



Plate 4

Vegetation plot #4 near a dam in the northern belt of trees.



Plate 5

Vegetation plot #5 in the northeastern part of the belt of trees.



Plate 6

Vegetation plot #6 in northeastern section of property.



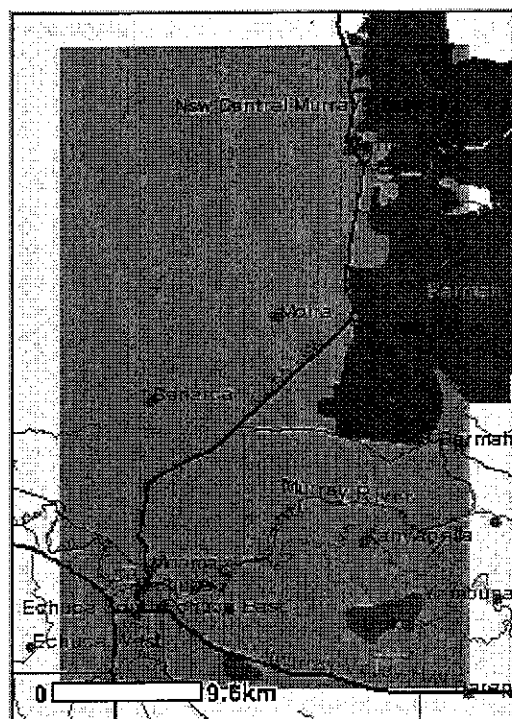
APPENDIX A: EPBC ACT PROTECTED MATTERS REPORT

You are here: [DEH Home](#) > [EPBC Act](#) > [Search](#)

EPBC Act Protected Matters Report

You may wish to print this report for reference before moving to other pages or websites.

The Australian Natural Resources Atlas at <http://www.environment.gov.au/atlas> may provide further environmental information relevant to your selected area. Information about the EPBC Act including significance guidelines, forms and application process details can be found at <http://www.deh.gov.au/epbc/assessmentsapprovals/index.html>



Search Type: Area

Buffer: 0 km

Coordinates: -35.7398,144.6932, -36.1967,144.6932, -36.1967,144.9821, -35.739,144.9821



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see <http://www.deh.gov.au/epbc/assessmentsapprovals/guidelines/index.html>.

World Heritage Properties:	None
National Heritage Places:	None
<u>Wetlands of International Significance:</u> (Ramsar Sites)	3
Commonwealth Marine Areas:	None
<u>Threatened Ecological Communities:</u>	1
<u>Threatened Species:</u>	20
<u>Migratory Species:</u>	5

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at <http://www.deh.gov.au/heritage/index.html>.

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species,

whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at <http://www.deh.gov.au/epbc/permits/index.html>.

Commonwealth Lands:	2
Commonwealth Heritage Places:	None
Places on the RNE:	6
Listed Marine Species:	9
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	3
Other Commonwealth Reserves:	None
Regional Forest Agreements:	None

Details

Matters of National Environmental Significance

Wetlands of International Significance [[Dataset Information](#)]
(Ramsar Sites)

BARMAH FOREST

GUNBOWER FOREST

Within same catchment as Ramsar site

NSW CENTRAL MURRAY STATE FORESTS

Threatened Ecological Communities [[Dataset Information](#)]

Status	Type of Presence
--------	------------------

Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions

Endangered

Threatened Species [[Dataset Information](#)]

Status	Type of Presence
--------	------------------

Birds

Lathamus discolor
Swift Parrot

Endangered	Species or species habitat may occur within area
------------	--

Pedionomus torquatus
Plains-wanderer

Vulnerable	Species or species habitat likely to occur within area
------------	--

Polytelis swainsonii
Superb Parrot

Vulnerable	Breeding likely to occur within area
------------	--------------------------------------

Rostratula australis
Australian Painted Snipe

Vulnerable	Species or species habitat may occur within area
------------	--

Xanthomyza phrygia

Endangered	Species or species habitat may
------------	--------------------------------

Regent Honeyeater		occur within area
Fishes		
<u>Craterocephalus fluviatilis</u> *	Vulnerable	Species or species habitat may occur within area
Murray Hardyhead		
<u>Maccullochella peelii peelii</u>	Vulnerable	Species or species habitat may occur within area
Murray Cod, Cod, Goodoo		
<u>Macquaria australasica</u> *	Endangered	Species or species habitat may occur within area
Macquarie Perch		
Frogs		
<u>Litoria raniformis</u> *	Vulnerable	Species or species habitat may occur within area
Southern Bell Frog, Growling Grass Frog, Warty Bell Frog, Green and Golden Frog		
Mammals		
<u>Dasyurus maculatus maculatus</u> (SE mainland population)	Endangered	Species or species habitat likely to occur within area
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population)		
<u>Nyctophilus timoriensis</u> (South-eastern form)	Vulnerable	Species or species habitat may occur within area
Eastern Long-eared Bat		
Reptiles		
<u>Delma impar</u> *	Vulnerable	Species or species habitat likely to occur within area
Striped Legless Lizard		
Plants		
<u>Amphibromus fluitans</u>	Vulnerable	Species or species habitat may occur within area
River Swamp Wallaby-grass		
<u>Brachyscome muelleroides</u>	Vulnerable	Species or species habitat likely to occur within area
Mueller Daisy		
<u>Callitriche cyclocarpa</u>	Vulnerable	Species or species habitat likely to occur within area
Western Water-starwort		
<u>Cullen parvum</u>	Endangered	Species or species habitat likely to occur within area
Small Scurf-pea		
<u>Myriophyllum porcatum</u>	Vulnerable	Species or species habitat likely to occur within area
Ridged Water-milfoil		
<u>Sclerolaena napiformis</u>	Endangered	Species or species habitat likely to occur within area
Turnip Copperbur		
<u>Swainsona murrayana</u>	Vulnerable	Species or species habitat likely to occur within area
Slender Darling-pea, Slender Swainson, Murray Swainson-pea		
<u>Swainsona plagiotropis</u>	Vulnerable	Species or species habitat likely to occur within area
Red Darling-pea, Red Swainson-pea		
Migratory Species [Dataset Information]	Status	Type of Presence
Migratory Terrestrial Species		
Birds		
<u>Haliaeetus leucogaster</u>	Migratory	Species or species habitat likely to occur within area
White-bellied Sea-Eagle		
<u>Hirundapus caudacutus</u>	Migratory	Species or species habitat may

White-throated Needletail

occur within area

Xanthomyza phrygia

Migratory

Species or species habitat may occur within area

Regent Honeyeater

Migratory Wetland Species

Birds

Gallinago hardwickii

Migratory

Species or species habitat may occur within area

Latham's Snipe, Japanese Snipe

Rostratula benghalensis s. lat.

Migratory

Species or species habitat may occur within area

Painted Snipe

Other Matters Protected by the EPBC Act

Listed Marine Species [[Dataset Information](#)]

Status

Type of Presence

Birds

Apus pacificus

Listed -
overfly
marine
area

Species or species habitat may occur within area

Fork-tailed Swift

Ardea alba

Listed -
overfly
marine
area

Breeding likely to occur within area

Great Egret, White Egret

Ardea ibis

Listed -
overfly
marine
area

Species or species habitat may occur within area

Cattle Egret

Gallinago hardwickii

Listed -
overfly
marine
area

Species or species habitat may occur within area

Latham's Snipe, Japanese Snipe

Haliaeetus leucogaster

Listed

Species or species habitat likely to occur within area

White-bellied Sea-Eagle

Hirundapus caudacutus

Listed -
overfly
marine
area

Species or species habitat may occur within area

White-throated Needletail

Lathamus discolor

Listed -
overfly
marine
area

Species or species habitat may occur within area

Swift Parrot

Merops ornatus

Listed -
overfly
marine
area

Species or species habitat may occur within area

Rainbow Bee-eater

Rostratula benghalensis s. lat.

Listed -
overfly
marine
area

Species or species habitat may occur within area

Painted Snipe

Commonwealth Lands [[Dataset Information](#)]

Communications, Information Technology and
the Arts - Telstra Corporation Limited

Defence

Places on the RNE [[Dataset Information](#)]

Note that not all Indigenous sites may be listed.

Historic

[Echuca Post Office VIC](#)

[Madowla Park VIC](#)

[Permewan Wright Building VIC](#)

[Shackells Bond Store \(former\) VIC](#)

Indigenous

[Cumerogunga Reserve / Maloga Mission Area NSW](#)

Natural

[Barnah and Millewa Forests NSW](#)

Extra Information

State and Territory Reserves [[Dataset Information](#)]

Barnah State Park, VIC

Goulburn River, Yambuna Bridge Natural Features Reserve - Streamside Reserve, VIC

River Murray Reserve Natural Features Reserve - River Murray Reserve, VIC

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the *Environment Protection and Biodiversity Conservation Act 1999*. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under "type of presence". For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the migratory and marine provisions of the Act have been mapped.

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgments

This database has been compiled from a range of data sources. Environment Australia acknowledges the following custodians who have contributed valuable data and advice:

- New South Wales National Parks and Wildlife Service
- Department of Sustainability and Environment, Victoria
- Department of Primary Industries, Water and Environment, Tasmania
- Department of Environment and Heritage, South Australia Planning SA
- Parks and Wildlife Commission of the Northern Territory
- Environmental Protection Agency, Queensland
- Birds Australia
- Australian Bird and Bat Banding Scheme
- Australian National Wildlife Collection
- Natural history museums of Australia
- Queensland Herbarium
- National Herbarium of NSW
- Royal Botanic Gardens and National Herbarium of Victoria
- Tasmanian Herbarium
- State Herbarium of South Australia
- Northern Territory Herbarium
- Western Australian Herbarium
- Australian National Herbarium, Atherton and Canberra
- University of New England
- Other groups and individuals

ANUCLIM Version 1.8, Centre for Resource and Environmental Studies, Australian National University was used extensively for the production of draft maps of species distribution.

Environment Australia is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Last updated:

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APPENDIX B: FLORA SPECIES LIST

APPENDIX B: FLORA SPECIES LIST

N – Native, I - Not native to area

NSW Status:

As per *National Parks and Wildlife Act 1975* and *Threatened Species Conservation Act 1995*

U - Unprotected

No Rare Or Threatened Australian Plant (ROTAP) species or species protected by provisions of the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999*.

Location Description: A – Additional; E – Entry; I - Irrigation channels; Numbers refer to plot #

Class: Coniferopsida

Scientific Name	Common Name	N/I	NSW Status	Location Description
Family: Cupressaceae				
<i>Callitris glaucophylla</i>	White Cypress Pine	N	U	A

Class: Filicopsida

Scientific Name	Common Name	N/I	NSW Status	Location Description
Family: Marsileaceae				
<i>Marsilea drummondii</i>	Common Nardoo	N	U	I,6

Class: Magnoliopsida (Liliidae)

Scientific Name	Common Name	N/I	NSW Status	Location Description
Family: Cyperaceae				
<i>Carex inversa</i>	Knob Sedge	N	U	6
<i>Cyperus difformis</i>	Dirty Dora	N	U	6
<i>Cyperus eragrostis</i>	Umbrella Sedge	I	U	I
<i>Eleocharis plana</i>		N	U	I,6
<i>Eleocharis pusilla</i>		N	U	6
Family: Juncaceae				
<i>Juncus continuus</i>		N	U	6
<i>Juncus semisolidus</i>		N	U	I
<i>Juncus subsecundus</i>		N	U	9
<i>Juncus usitatus</i>		N	U	I
Family: Poaceae				
<i>Austrodanthonia caespitosa</i>	Ringed Wallaby Grass	N	U	3,4,5,6,9
<i>Austrostipa scabra</i> subsp. <i>scabra</i>	Speargrass	N	U	3,4,9
<i>Avena</i> sp.	Oats	I	U	A
<i>Chloris truncata</i>	Windmill Grass	N	U	2,3,4,9
<i>Echinochloa colona</i>	Awnless Barnyard Grass	N	U	4
<i>Echinochloa crusgalli</i>	Barnyard Grass	I	U	3,4
<i>Eragrostis cilianensis</i>	Stinkgrass	N	U	E,5
<i>Lachnagrostis filiformis</i>		N	U	6
<i>Lolium rigidum</i>	Wimmera Ryegrass	I	U	6
<i>Panicum effusum</i>	Hairy Panic	N	U	1

<i>Paspalidium aversum</i>		N	U	6
<i>Poa sieberiana</i> var. <i>hirtella</i>		N	U	6
<i>Vulpia myuros</i>	Rat's Tail Fescue	I	U	4

Class: Magnoliopsida (Magnoliidae)

Scientific Name	Common Name	N/I	NSW Status	Location Description
Family: Amaranthaceae				
<i>Alternanthera denticulata</i>	Lesser Joyweed	N	U	6
Family: Asteraceae				
<i>Arctotheca calendula</i>	Capeweed, Cape Dandelion	I	U	1,3
<i>Calotis scapigera</i>				
<i>Centipeda minima</i> var. <i>minima</i>	Spreading Sneezeweed	N	U	6
<i>Cirsium vulgare</i>	Spear Thistle	I	U	A
<i>Hypochaeris glabra</i>	Smooth Catsear	I	U	6
<i>Xanthium spinosum</i>	Bathurst Burr	I	U	E,1
Family: Boraginaceae				
<i>Amsinckia intermedia</i>	Common Fiddleneck	I	U	E,1,2,3,4,7,9
<i>Echium plantagineum</i>	Paterson's Curse	I	U	E,1,2,7
Family: Brassicaceae				
<i>Lepidium pseudohyssopifolium</i>	Peppercress	N	U	A
<i>Sisymbrium irio</i>	London Rocket	N	U	4,5,7
Family: Caryophyllaceae				
<i>Silene gallica</i> var. <i>gallica</i>	French Catchfly	I	U	9
<i>Spergularia rubra</i>	Sandspurry	I	U	3,4,5
Family: Casuarinaceae				
<i>Allocasuarina luehmannii</i>	Bull Oak	N	U	A,E,7
Family: Chenopodiaceae				
<i>Atriplex semibaccata</i>	Creeping Saltbush	N	U	3
<i>Chenopodium murale</i>	Nettle-leaf Goosefoot	I	U	E,2,3,4,5,7
<i>Chenopodium pumilio</i>	Small Crubweed	N	U	9
<i>Enchylaena tomentosa</i>	Ruby Saltbush	N	U	4
<i>Maireana aphylla</i>	Cotton Bush	N	U	2,3
<i>Maireana microphylla</i>		N	U	A
<i>Sclerolaena birchii</i>	Galvanised Burr	N	U	2,3,4,5,9
Family: Convolvulaceae				
<i>Convolvulus erubescens</i>	Bindweed	N	U	9
Family: Cucurbitaceae				
<i>Citrullus lanatus</i> var. <i>lanatus</i>	Wild Melon	I	U	2,4,5,7
Family: Euphorbiaceae				
<i>Chamaesyce drummondii</i>	Caustic Weed	N	U	1,3,4
Family: Fabaceae (Mimosoideae)				
<i>Acacia pycnantha</i>	Golden Wattle	N	U	A
Family: Goodeniaceae				
<i>Goodenia gracilis</i>		N	U	6
Family: Lamiaceae				
<i>Marrubium vulgare</i>	Horehound	I	U	2,3
Family: Lobeliaceae				
<i>Pratia concolor</i>	Poison Pratia	N	U	I
Family: Loranthaceae				
<i>Amyema miquelii</i>	Box Mistletoe	N	U	5
<i>Lysiana exocarpi</i> subsp. <i>exocarpi</i>		N	U	A,E

Family: Lythraceae				
<i>Lythrum hyssopifolia</i>	Hyssop Loosestrife	N	U	6
Family: Malvaceae				
<i>Malva parviflora</i>	Small-flowered Mallow	I	U	2,4,7
<i>Sida corrugata</i>		N	U	2,3,4,5,9
Family: Myrtaceae				
<i>Eucalyptus camaldulensis</i>	River Red Gum	N	U	6
<i>Eucalyptus cladocalyx</i>	Sugar Gum	N	U	A
<i>Eucalyptus largiflorens</i>	Black Box	N	U	2,3,5,9
<i>Eucalyptus melliodora</i>	Yellow Box	N	U	2,3,5
<i>Eucalyptus moluccana</i>	Grey Box	N	U	A
Family: Oxalidaceae				
<i>Oxalis perennans</i>		N	U	3, 4, 5, 9
Family: Polygonaceae				
<i>Persicaria lapathifolia</i>	Pale Knotweed	N	U	I
<i>Polygonum aviculare</i>	Wireweed	I	U	E, 1, 5, 6, 9
<i>Rumex crispus</i>	Curled Dock	I	U	I, 5
<i>Rumex tenax</i>	Shiny Dock	N	U	4, 5, 6, 9
Family: Solanaceae				
<i>Lycium ferocissimum</i>	African Boxthorn	I	U	E, 3, 5, 7
<i>Solanum nigrum</i>	Black-berry Nightshade	I	U	3
Family: Zygophyllaceae				
<i>Tribulus terrestris</i>	Caltrop	I	U	E,2



APPENDIX C: FAUNA SPECIES LIST

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Status as per *Threatened Species Conservation Act 1995* and *National Parks and Wildlife Act 1975*

- U - Unprotected (feral)
- P - Protected (native, not threatened)
- E1 - Endangered (Listed Part 1, Schedule 1, TSC Act)
- V - Vulnerable (Listed Schedule 2, TSC Act)

Avian species on the Moira site

Scientific Name	Common Name	Status
<i>Anas castanea</i>	Chestnut Teal	P
<i>Anas gracilis</i>	Grey Teal	P
<i>Anhinga melanogaster</i>	Darter	P
<i>Anthus novaeseelandiae</i>	Richard's Pipit	P
<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	P
<i>Cacatua leadbeateri</i>	Major Mitchell Cockatoo	P
<i>Cacatua roseicapilla</i>	Galah	P
<i>Cacatua sanguinea</i>	Little Corella	P
<i>Chenonetta jubata</i>	Australian Wood Duck	P
<i>Climacteris picumnus</i>	Brown Treecreeper	V
<i>Colluricincla harmonica</i>	Grey Shrike-thrush	P
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	P
<i>Corcorax melanorhamphos</i>	White-winged Chough	P
<i>Corvus coronoides</i>	Australian Raven	P
<i>Cracticus nigrogularis</i>	Pied Butcherbird	P
<i>Egretta novaehollandiae</i>	White-faced Heron	P
<i>Elanus axillaris</i>	Black-shouldered Kite	P
<i>Erythronyx cinctus</i>	Red-kneed Dotterel	P
<i>Falco cenchroides</i>	Nankeen Kestrel	P
<i>Falco subniger</i>	Black Falcon	P
<i>Grallina cyanoleuca</i>	Magpie-lark	P
<i>Gymnorhina tibicen</i>	Australian Magpie	P
<i>Haliastur sphenurus</i>	Whistling Kite	P
<i>Hirundo neoxena</i>	Welcome Swallow	P
<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater	P
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck	P
<i>Manorina melanocephala</i>	Noisy Miner	P
<i>Milvus migrans</i>	Black Kite	P
<i>Ocyphaps lophotes</i>	Crested Pigeon	P

Scientific Name	Common Name	Status
<i>Oxyura australis</i>	Blue-billed Duck	V
<i>Pardalotus striatus</i>	Striated Pardalote	P
<i>Passer domesticus</i>	House Sparrow	U
<i>Phalacrocorax melanoleucos</i>	Little Pied Cormorant	P
<i>Platycercus eximius</i>	Eastern Rosella	P
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler	V
<i>Psephotus haematonotus</i>	Red-rumped Parrot	P
<i>Rhipidura leucophrys</i>	Willie Wagtail	P
<i>Sturnus vulgaris</i>	Common Starling	U
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe	P
<i>Threskiornis spinicollis</i>	Straw-necked Ibis	P
<i>Tyto alba</i>	Barn Owl	P
<i>Vanellus miles</i>	Masked Lapwing	P

Mammal species on the Moira site

Scientific Name	Common Name	Status
<i>Mormopterus sp.4</i>	Southwestern Freetail Bat	P
<i>Nyctinomus australis</i>	White-striped Mastiff-bat	P
<i>Chalinolobus morio</i>	Chocolate Wattled Bat	P
<i>Nyctophilus sp.</i>	Long-eared Bat	P
<i>Vespadelus regulus</i>	King River Eptesicus	P
<i>Vespadelus sp.</i>	Eptesicus	P
<i>Vespadelus vulturnus</i>	Little Forest Eptesicus	P
<i>Trichosurus vulpecula</i>	Common Brushtail Possum	P
<i>Vulpes vulpes</i>	Fox	U
<i>Oryctolagus cuniculus</i>	Rabbit	U
<i>Mus musculus</i>	House Mouse	U

Reptile species on the Moira site

Scientific Name	Common Name	Status
<i>Cryptoblepharus carnabyi</i>	Carnaby's Wall Skink	P
<i>Ctenotus taeniolatus</i>	Copper-tailed Skink	P
<i>Morethia boulengeri</i>	Boulenger's Skink	P



APPENDIX D: DETAILED SECTION 5A OF EP & A ACT ASSESSMENT

APPENDIX D: DETAILED SECTION 5A OF EP & A ACT ASSESSMENT

Environmental Planning and Assessment Act (1979) – Section 5A Considerations.

Significant effect on threatened species, populations or ecological communities, or their habitats.

Section 5A of the *EP&A Act* consists of eight factors that must be taken into account in deciding whether a proposed development or activity is likely to have a significant effect on threatened species, populations or ecological communities, or their habitats. In the case where suitable habitat for a threatened species occurs, it will be assumed the species potentially will utilise the habitat unless it can be demonstrated otherwise, in accordance with the uncertainty principle of ecological sustainable development. Populations will be considered viable or part of a viable population, in accordance with NSW Department of Environment and Conservation guidelines.

Species that were either observed or have potential habitat present within the site are assessed.

1. *In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

Name	Assessment
Bush-stone-curlew <i>Burhinus grallarius</i>	Although the field investigations did not take place during the breeding season, between August and January (Frith 1982), when the species is likely to be sedentary, it is unlikely the species utilises the site as territorial calls were not heard during the night. Nesting occurs on the ground, often near dead timber and the species also roosts on the ground (Marchant and Higgins 1993). This may place the species at risk from predation by foxes, observed during the field investigations, and cats. The woodland habitat with a ground cover dominated by native grasses will not be significantly impacted by the proposed development. The life cycle of the Bush Stone-curlew is unlikely to be disrupted such that a viable local population is likely to be placed at risk of extinction.
Brown Tree Creeper <i>Climacteris picumnus</i>	Three individuals were observed in the northwest part of the site in woodland in the vicinity of a stock dam, indicating there is a viable population of the species in this area. The woodland remnant is outside of the area that will be cleared for the proposed feedlot and proposed effluent irrigation areas. The life cycle of the Brown Treecreeper is not likely to be disrupted such that a viable local population is likely to be placed at risk of extinction.
Painted Honeyeater <i>Grantiella picta</i>	The species is rarely recorded in the region, usually in summer (Barrett <i>et al.</i> 2003). Foraging resources are limited in the study area. It is unlikely that there is a significant foraging resource, in terms of quantity, for the species. Tree clearing will be limited to a small area of Black Box (<i>Eucalyptus largiflorens</i>) that does not contain a significant mistletoe resource. The proposed development will not disrupt the life cycle of a viable local population, placing it at the risk of extinction.
Swift Parrot <i>Lathamus discolor</i>	The Swift Parrot breeds in Tasmania and migrates to the mainland, arriving in the region mainly by April, but also as early as January. The species returns for the breeding season

Name	Assessment
	starting in spring (Higgins 1999). In the region it is reliant on winter flowering tree species. The proposed development will not impact the species breeding habitat and an insignificant amount of potential foraging habitat will be impacted. It is unlikely that the life-cycle of the species will be disrupted such that a viable local population will be placed at the risk of extinction.
Square-tailed Kite <i>Lophoictinia isura</i>	The species was not observed in the study area and the study area does not contain preferred habitat. It is highly unlikely the species is dependant on habitats within the study area. It is unlikely that a viable local population will be placed at the risk of extinction as a result of the proposed development.
Hooded Robin <i>Melanodryas cucullata</i>	The Hooded Robin was not observed within the study area. Habitat within the study area is limited, of marginal value and will not be significantly impacted by the proposed development. A viable local population is not expected to be placed at the risk of extinction as a result of the proposed development.
Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i>	The Black-chinned Honeyeater was not observed during the field investigations and the area of potential habitat proposed to be removed is relatively isolated and is not of a significant spatial extent. It is unlikely that the life-cycle of the species will be disrupted such that a viable local population will be placed at the risk of extinction.
Turquoise Parrot <i>Neophema pulchella</i>	There is limited breeding habitat and foraging resources within the site, all present in the northern remnant woodland areas. These will not be significantly impacted by the proposed development. It is highly unlikely there is a viable local population of the Turquoise Parrot that would significantly utilise the habitats impacted by the proposed development.
Blue-billed Duck <i>Oxyura australis</i>	One individual was observed on a small stock dam in the east of the site, however the habitat is not regarded as preferred habitat. There is no significant aquatic habitat within the site. It is highly unlikely that there will be a significant impact to a viable local population of the species such that it will be placed at the risk of extinction.
Gilbert's Whistler <i>Pachycephala inornata</i>	This species was not observed during the field investigations. Typical habitat is absent from the site and breeding has not been recorded for the local area (Higgins and Peters 2002). The life cycle of the Gilbert's Whistler is unlikely to be disrupted such that a viable local population is likely to be placed at risk of extinction.
Superb Parrot <i>Polytelis swainsonii</i>	Breeding occurs in the southwest slopes and Riverina districts in three main areas. These are an area bounded by Cowra, Rye Park, Yass, Colac Cootamundra and Young; along the Murrumbidgee River between Wagga Wagga and Toganmain Station near Bringagee; and along the Murray River and Edwards River east of Barmah to Taylors Bridge (Higgins 1999). The timing of breeding is between September and January in a hollow limb or trunk, usually in a large tree near water. Independence by young is attained in approximately 60 days from laying (Higgins 1999). The species was not recorded

Name	Assessment
	in the study area and potential habitat is outside of the development footprint. It is unlikely a viable local population of the species will be impacted such that it will be placed at the risk of extinction.
Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i>	The species and nests were observed in the northern woodland. There are at least two, possibly three, family groups ranging in size from 2-7 individuals. The woodland areas where the species was observed are not within the development footprint. It is unlikely that there will be a significant impact to a viable local population of the Grey-crowned Babbler such that it will be placed at the risk of extinction.
Painted Snipe (Australian subsp.) <i>Rostratula benghalensis australis</i>	The species usually breeds between August and February in response to flooding of swamps where the nest is constructed within tall grass or reed beds often on low islands within the aquatic environment (Marchant and Higgins 1993). While marginal habitat may occur in the vicinity of the north western River Red Gum community that has an understorey dominated by rushes, no significant impact is expected to occur as a result of the proposed development as only cropped area and small remnants of dry woodland will be disturbed. Extensive and better quality habitat associated with the Wetland of International Significance ('Ramsar Wetland') to the east exists. It is highly unlikely that there will be a significant impact to a viable local population of the species such that it will be placed at the risk of extinction.
Diamond Firetail <i>Stagonopleura guttata</i>	The Diamond Firetail was not observed within the site. It is unlikely that the Diamond Firetail is dependent on the habitats that will be modified by the proposed development, as better quality habitat is present to the north of the proposed development. The life cycle of the Diamond Firetail is not likely to be disrupted such that a viable local population is likely to be placed at risk of extinction.
Regent Honeyeater <i>Xanthomyza phrygia</i>	The species is rarely recorded in the region, likely in autumn, possibly when usual foraging areas are poor in resources (Higgins <i>et al.</i> 2001). It is unlikely that there is a significant foraging resource for the species during the time that the species is present in the local area. The proposed development will not disrupt the life cycle of a viable local population, placing it at the risk of extinction.
Major Mitchell's Cockatoo (<i>Cacatua leadbeateri</i>)	Remains of a Major Mitchell Cockatoo were identified in a small area of remnant woodland to the north west of site. The species is rarely recorded in the region and breeding was not observed in the region as part of targeted avifauna surveys (Barrett <i>et al</i> 2003). There are few suitable nesting opportunities within the site and the present land use of cropping is unlikely to provide a significant foraging resource. The life cycle of the Major Mitchell's Cockatoo is unlikely to be disrupted such that a viable local population is likely to be placed at risk of extinction.
Brush-tailed Phascogale	There are few denning opportunities within the site, and none within the woodland to be cleared. It is unlikely that the

Name	Assessment
<i>Phascogale tapoatafa</i>	proposed clearing will place a viable population of <i>Phascogale tapoatafa</i> at risk of extinction as a result of the disruption in the life cycle of the species.
Koala <i>Phascolarctos cinereus</i>	A viable population of Koala is assumed to occur to the east of the proposed development in the Barmah State Forest. No habitat suitable for Koala will be removed and it is highly unlikely the proposed development will impede the movement of Koalas. The life cycle of the Koala is unlikely to be disrupted such that a viable local population is likely to be placed at risk of extinction.
Greater Long-eared Bat <i>Nyctophilus timoriensis</i>	While some trees with small hollows will be removed as part of the proposed development, no <i>Nyctophilus</i> sp. were recorded utilising the woodland remnant, to be removed, within half an hour of dusk. It is unlikely the species significantly utilises the woodland remnant. Similar woodland in terms of hollow development, occurs in the north of the site, and will not be impacted by the proposed development. The life cycle of the Greater Long-eared Bat is unlikely to be disrupted such that a viable local population is likely to be placed at risk of extinction.

2. In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

There are no endangered populations protected in accordance with the provisions of Part 2 of Schedule 1 of the TSC Act that will be impacted by the proposed development.

3. In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Name	Assessment
Bush-stone-curlew <i>Burhinus grallarius</i>	The Bush Stone-curlew inhabits lightly timbered open forest and woodland with a ground cover of short sparse grass, or leaf litter where the species forages for grasshoppers and other arthropods. It also will occupy farmland where remnant vegetation is present. Preferred habitat does not include wooded areas with a dense shrub understorey, rain forest and wet sclerophyll forest, unless these are adjacent to cleared areas. The woodland habitat with a ground cover dominated by native grasses will not be significantly impacted by the proposed development. In relation to the regional distribution of the habitat of the Bush Stone-curlew, a significant area of known habitat will not be modified or removed.
Brown Tree Creeper <i>Climacteris picumnus</i>	The species is known to utilise woodlands and forests dominated by <i>Eucalyptus</i> spp., especially rough barked species, usually in communities with a sparse but grassy understorey, but not with a dense woody understorey (Higgins <i>et al.</i> 2001). Fallen timber and leaf litter may be of importance as habitat for insect prey (pers. obs.). The majority of the

Name	Assessment
	wooded habitats has had fallen timber removed, however the species was observed foraging on the rough barked trunks of Yellow Box and Black Box trees. Similar woodland habitat to the northeast will not be impacted. The proposed development will not result in the removal of potential habitat. A significant area of known habitat will not be modified or removed in relation to the regional distribution of the habitat of <i>Climacteris picumnus</i> .
Painted Honeyeater <i>Grantiella picta</i>	The Painted Honeyeater is said to be present when fruiting mistletoes are abundant and occasionally consumes nectar or insects. The habitat of the species includes open dry woodlands and forests including those dominated by Yellow Box (<i>Eucalyptus melliodora</i>) and Black Box (<i>E. largiflorens</i>), and riparian forests of River Red Gum (<i>E. camaudulensis</i>), River Oak (<i>Casuarina cunninghamiana</i>) with parasitic Mistletoe (<i>Amyena sp.</i>) (Higgins <i>et al.</i> 2001). Mistletoes were absent and flowering resources are limited in the woodland that will be impacted by the proposed development. The proposed clearing will remove approximately 1.5 ha of Black Box woodland habitat with degraded understorey. In relation to the regional distribution of the habitat of <i>Grantiella picta</i> , a significant area of known habitat will not be modified or removed.
Swift Parrot <i>Lathamus discolor</i>	In NSW it inhabits dry open eucalypt woodlands, especially Ironbark and Box associations. In the region it is known to inhabit Box-Ironbark woodlands, including those dominated by Grey Box (<i>Eucalyptus microcarpa</i>) and River Red Gum (<i>E. camaudulensis</i>), feeding mostly on nectar, also consuming sugar-exuding insects and sometimes seed (Higgins 1999). The species has tendencies to site fidelity (pers comm. Deborah Saunders, DEC Threatened Species Officer/ Swift Parrot Recovery Team 28/11/03) and the small area of Eucalypts do not constitute a significant foraging resource. The proposed development will not result in the significant reduction of habitat as the clearing will remove approximately 1.5 ha of woodland.
Square-tailed Kite <i>Lophoictinia isura</i>	This species is associated mainly with coastal tropical and temperate Australia, particularly open and forests and woodlands occurring on fertile soils. In NSW the habitats are typically ridge and gully habitats dominated by <i>Eucalyptus longifolia</i> , <i>Corymbia maculata</i> , <i>E. elata</i> and <i>E. smithii</i> with a shrubby understorey. They feed on passerines, foliage insects and small terrestrial vertebrates in open woodland (Marchant and Higgins 1993). Given the probable absence of the species from the site, due to the likely absence of a significant foraging resource and riparian habitat, it is unlikely that a significant area of habitat for the species will be removed by the proposed development.
Hooded Robin <i>Melanodryas cucullata</i>	Generally speaking, the Hooded Robin occurs in lightly timbered habitats, dominated by Acacia sp. and Eucalyptus sp., including Box-Ironbark associations, often in or near clearings (Higgins and Peter 2003). The species seems to favour a sparse shrub understorey containing fallen timber (Fitri and

Name	Assessment
	Ford 1997). Dead timber is an important habitat component Reid (1999). Home ranges for Hooded Robins are on average around 18 ha (Fitri and Ford 1999). Preferred nesting habitat includes many eucalypts with forked branches less than 2 m above the ground (Higgins and Peter 2003). Areas containing dead timber, fallen or standing, is limited, occurring mainly in the northern woodland area that will not be significantly impacted by the proposed development.
Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i>	The Black-chinned Honeyeater inhabits the upper canopy of eucalypt woodlands and open forests. Preferred vegetation communities are Box-Ironbark associations with species such as White Box (<i>Eucalyptus albens</i>), Grey Box (<i>E. moluccana</i>), Western Grey Box (<i>E. microcarpa</i>) and Grey Ironbarks (<i>E. siderophylla</i> and <i>E. paniculata</i>) (Higgins <i>et al.</i> 2001). The area of potential foraging habitat that may be removed is not significant. In relation to the regional distribution of habitat for the Black-chinned Honeyeater a significant area of known habitat will not be modified or removed.
Turquoise Parrot <i>Neophema pulchella</i>	This species is usually associated with the foothills of the Great Dividing Range, inhabiting grassy woodland and open forest communities with dominant Eucalyptus trees species in assemblages often including <i>Callitris</i> sp. with White Box (<i>E. albens</i>), Red Stringy Barks (<i>E. macrohyncha</i>), Blakely's Red Gum (<i>E. blakelyi</i>), Red Box (<i>E. polyanthemus</i>), Yellow Box (<i>E. melliodora</i>), Mugga Ironbark (<i>E. sideroxylon</i>) and Bimble Box (<i>E. populifolia</i>). It is sometimes recorded in <i>Eucalyptus</i> spp. and <i>Angophora</i> spp. dominated communities in the Sydney biogeographical region and rarely in rainforest margins and salt marsh. It nests in trees hollows of both living and dead trees, often low to the ground (Higgins 1999). The Turquoise Parrot feeds usually beneath trees on seeding grasses and weeds (Slater <i>et al.</i> 1989). There are few hollows within trees or fallen timber, and potential foraging habitat is limited to a sparse cover of native grasses in the northern parts of the site, which will not be significantly impacted by the proposed development. The removal of approximately 1.5 ha of Black Box woodland with a ground cover dominated by exotic species will not result in a significant loss of potential habitat. A significant area of known habitat will not be modified or removed by the proposed development.
Blue-billed Duck <i>Oxyura australis</i>	This species is associated with aquatic habitats throughout the year, preferring permanent deeper water in large wetlands (Marchant and Higgins 1990a). In NSW the species is more commonly associated with the Murray-Darling Basin. Large flocks congregate during winter. Foraging has been recorded in water up to three metres deep, the Blue-billed Duck rarely utilises terrestrial habitats. The decline of this species is thought to be a result of modified drainage regimes, increased salinity, clearing, water extraction and grazing (Marchant and Higgins 1990). The study area has no preferred habitat and the

Name	Assessment
	proposed development will not result in the modification either directly or indirectly to the stock dam where the species was observed or to the preferred aquatic habitat to the east of the site. In relation to the regional distribution of the habitat of the Blue-billed Duck, a significant area of known habitat will not be modified or removed.
Gilbert's Whistler <i>Pachycephala inornata</i>	Gilbert's Whistler inhabits semi-arid mallee and acacia shrublands that have a shrubby understorey containing species such as <i>Cassia</i> sp., <i>Dodonaea</i> sp. and <i>Eremophila</i> sp. with a ground cover of grasses or chenopods (Higgins and Peters 2002). In relation to the regional distribution of the habitat of Gilbert's Whistler, a significant area of known habitat will not be modified or removed.
Superb Parrot <i>Polytelis swainsonii</i>	Typical habitats are riparian corridors dominated by River Redgum (<i>Eucalyptus camaldulensis</i>) or woodlands dominated by Box species such as Yellow Box (<i>E. melliodora</i>), Black Box (<i>E. largiflorens</i>), Western Grey Box (<i>E. microcarpa</i>) and Red Box (<i>E. polyanthemos</i>). The species feeds on grass seeds, herbaceous plants, berries, nectar, flowers and occasionally insects (Higgins 1999). Potential habitat does exist in the site, however these are restricted to the northern part that will not be significantly impacted by the proposed development. In relation to the regional distribution of the habitat of the Superb Parrot, a significant area of known habitat will not be modified or removed.
Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i>	In the region the species occupies dry open forests and woodlands on fertile soils, large eucalypt trees (including Black Box, Yellow Box and Grey Box), saplings and shrubs and a ground cover containing an abundance of leaf litter and woody debris (Higgins and Peters 2002). The species forages partly on the ground and in trees, preferring trees and shrubs with peeling bark (Davison and Robinson 1992). The woodland habitats where the species occurs is not within the development footprint. The main threat to the habitat is over grazing limiting regeneration and loss of trees, however use of the woodland is assumed to remain the same post development of the proposed cattle feedlot. In relation to the regional distribution of the habitat of the Grey-crowned Babbler, a significant area of known habitat will not be modified or removed.
Painted Snipe (Australian subsp.) <i>Rostratula benghalensis australis</i>	The species inhabits shallow aquatic environments such as freshwater swamps, including modified environments, with dense emergent or shore vegetation for refuge. It feeds in the shallow margins on a broad range of food items, including molluscs, insects and vegetation (Marchant and Higgins 1993). Potential habitat is limited to small areas around stock dams, irrigation channels and drainage depressions. These are likely to be marginal habitat due to size and predation risk from Foxes. Extensive potential habitat exists to the east in the Barmah Forest Wetland of International Significance. The proposed development will not result in the significant modification either directly or indirectly to potential habitat.

Name	Assessment
Diamond Firetail <i>Stagonopleura guttata</i>	The habitat of this species is described as open grassland with scattered timber near water, where it feeds on grass seeds and occasionally insects (Frith 1982). The Final Determination for the species states that it is unable to persist in remnant habitats of less than 200 ha. The woodlands that will be removed have a sparse understorey dominated by exotic herbaceous species. The woodland habitat to the northeast that occurs in an area of native grass species is a better habitat in terms of structure and species composition. In relation to the regional distribution of the habitat for the Diamond Firetail a significant area of known habitat will not be modified or removed.
Regent Honeyeater <i>Xanthomyza phrygia</i>	The main habitat types for <i>Xanthomyza phrygia</i> include dry eucalypt forests and woodlands dominated by box and ironbark species along creek lines of the inland slopes, particularly those associated with broad valley floors and lower slopes, with tree associations including Yellow Box, Grey Box and River Red Gum (Higgins <i>et al.</i> 2001). The majority of woodland will not be impacted by the development of the proposed cattle feedlot. In relation to the regional distribution of the habitat of <i>Xanthomyza phrygia</i> , a significant area of known habitat will not be modified or removed.
Major Mitchell's Cockatoo (<i>Cacatua leadbeateri</i>)	Habitat for this species is described as mainly arid and semi-arid rangelands and also River Red Gum riparian vegetation and Black Box (Higgins 1999). The species is omnivorous, feeding on the seeds of native grasses, roots, bulbs, insect larvae and also spilt grain and seeds from weeds, however cereal mono cultures do not provide an adequate variety of food types for the species and also reduce suitable breeding habitat which is usually a large hollow in a tree (Higgins 1999). There are few suitable nesting opportunities within the site and the present land use of cropping is unlikely to provide a significant foraging resource. In relation to the regional distribution of the habitat of Major Mitchell's Cockatoo a significant area of known habitat will not be modified or removed.
Brush-tailed Phascogale <i>Phascogale tapoatafa</i>	The Brush-tailed Phascogale is mainly arboreal, feeding on nectar, insects, spiders, small vertebrates and ants in large trees. Mating and the raising of young take place in a tree hollow. Males die after the mating season, which takes place from May to July. The species will utilise tree hollows, stumps and even globular bird nests during the day. Female home range is between 20 and 70 hectares and do not overlap (Soderquist 1998). No trees with suitable hollow development will be removed as a result of the proposed development. Woodland in the north of the site will not be impacted by the proposed development. In relation to the regional distribution of <i>Phascogale tapoatafa</i> habitat, a significant area of potential habitat will not be modified or removed.
Koala <i>Phascolarctos cinereus</i>	Trees utilised by the Koala for foraging within the site is limited to River Red Gum (<i>E. camaldulensis</i>) (Schedule 2, SEPP 44). No River Red Gum will be removed as a result of the proposed

Name	Assessment
	development. A significant area of known Koala habitat will not be modified or removed by the proposed development.
Greater Long-eared Bat <i>Nyctophilus timoriensis</i>	Known habitat for the species includes tall eucalypt forest, open savanna and Black Box woodland, with a preference for semi-arid areas, roosting in hollows or under loose bark, however, little is known of the species specific habitat requirements (Churchill 1998, Parnaby 1998). While some potential roosting habitat for the species will be removed or modified by the proposed development, the majority of woodland within the site will not be impacted. An area of known habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat for the Greater Long-eared Bat.

4. Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Name	Assessment
Bush-stone-curlew <i>Burhinus grallarius</i>	The woodland habitat with a ground cover dominated by native grasses will not be significantly impacted by the proposed development. An area of known habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat for the Bush Stone-curlew.
Brown Tree Creeper <i>Climacteris picumnus</i>	The proposed feedlot will remove a small isolated remnant of box woodland, however the remnant in which the species was observed will not be impacted. An area of known habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat for the Brown Treecreeper.
Painted Honeyeater <i>Grantiella picta</i>	The proposed clearing will result in the removal of approximately 1.5 ha of woodland. The woodland to be removed is a relatively isolated remnant of a larger woodland unit to the north of the study area. It is highly unlikely that the woodlands will be fragmented to the point where a migratory species such as <i>Grantiella picta</i> cannot utilise remaining habitats. An area of habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat for <i>Grantiella picta</i> .
Swift Parrot <i>Lathamus discolor</i>	The proposed clearing will result in the removal of approximately 1.5 ha of woodland. The woodland to be removed are relatively isolated remnants of a larger woodland unit similar to the north of the study area. It is highly unlikely that the woodlands will be fragmented to the point where a migratory species such as <i>Lathamus discolor</i> cannot utilise remaining habitats. An area of habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat for <i>Lathamus discolor</i> .
Square-tailed Kite <i>Lophoictinia isura</i>	As the species is unlikely to significantly utilise the study area or adjacent woodlands, and that the majority of woodland habitat will not be impacted by the proposed development, it is unlikely that the proposed development will result in the

Name	Assessment
	isolation of currently interconnecting or proximate habitat for the species.
Hooded Robin <i>Melanodryas cucullata</i>	The habitats utilised by the Hooded Robin will not be isolated from similar habitats, as the woodland habitat will not be significantly impacted.
Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i>	The area of potential habitat proposed to be removed is relatively isolated and is not of a significant spatial extent. An area of habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat for <i>Melithreptus gularis</i> .
Turquoise Parrot <i>Neophema pulchella</i>	The movement or habitat utilisation in the local area is unlikely to be significantly impacted by the removal of woodland that is relatively isolated. An area of known habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat for the Turquoise Parrot.
Blue-billed Duck <i>Oxyura australis</i>	Known habitat in the area will not be isolated by the clearing of woodland that will occur as part of the proposed development. The species is known to move short distances between breeding swamps and over-wintering lakes and can complete long distance dispersal (Marchant and Higgins 1990). The habitat for the Blue-billed Duck will not become isolated from currently interconnecting or proximate areas of habitat.
Gilbert's Whistler <i>Pachycephala inornata</i>	An area of known habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat for the Gilbert's Whistler as there is no habitat that will be impacted by the proposed development.
Superb Parrot <i>Polytelis swainsonii</i>	A significant area of potential habitat will not be removed by the proposed development. The habitat for the Superb Parrot will therefore not become isolated from currently interconnecting or proximate areas of habitat.
Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i>	The potential habitat is not present within the footprint of the proposed development. The proposed development will not result in the isolation of habitat for the Grey-crowned Babbler.
Painted Snipe (Australian subsp.) <i>Rostratula benghalensis australis</i>	Little is known of the movements of Painted Snipe, but it is thought to be capable of dispersal over large distances, probably as a response to local influences such as flooding or drought (Marchant and Higgins 1993). Known habitat in the area will not be isolated by the limited clearing of woodland that will occur as part of the proposed development will not result in the hindrance of movement by the species.
Diamond Firetail <i>Stagonopleura guttata</i>	It is unlikely that the movement of a potential Diamond Firetail population will be significantly impeded by the clearing associated with the proposed cattle feedlot, as it is a small isolated remnant within an area that is cropped and grazed. The woodland habitat in the north of the site will not be significantly impacted. An area of potential habitat is unlikely to become isolated from currently interconnecting or proximate areas of habitat for the Diamond Firetail.
Regent Honeyeater	The proposed clearing will result in the removal of approximately 1.5 ha of woodland that is presently relatively

Name	Assessment
<i>Xanthomyza phrygia</i>	isolated and unlikely to be utilised by the species. It is highly unlikely that the woodlands will be fragmented to the point where a migratory species such as <i>Xanthomyza phrygia</i> cannot utilise remaining habitats. An area of habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat.
Major Mitchell's Cockatoo (<i>Cacatua leadbeateri</i>)	A significant area of woodland, in terms of spatial extent and connectivity to similar habitats, will not be removed as part of the proposed development. An area of known habitat is not likely to become isolated from currently interconnecting or proximate areas of habitat for the Major Mitchell's Cockatoo.
Brush-tailed Phascogale <i>Phascogale tapoatafa</i>	The woodland that will be removed as part of the proposed development is isolated with regard to arboreal mammal movement. The proposed clearing will not further isolate habitat for the Brush-tailed Phascogale.
Koala <i>Phascolarctos cinereus</i>	Koalas are capable of moving long distances, regularly travelling more than two kilometres moving through fragmented rural landscapes (White 1999). The proposed development is highly unlikely to impede the movement of Koalas in the local area.
Greater Long-eared Bat <i>Nyctophilus timoriensis</i>	The Greater Long-eared Bat is likely to be highly mobile and not reliant on an isolated remnant. The woodland in the northern part of the site is relatively continuous in comparison and forms a more significant corridor in terms of movement. The woodland in the northern part of the site will not be impacted by the proposed development. An area of known habitat will not be isolated.

5. Whether critical habitat will be affected.

No critical habitat has been declared for the site or habitats that occur in the site.

6. Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are only six conservation reserves in the Riverina biogeographical region, reserving approximately 0.32 per cent of the region.

Name	Assessment
Bush-stone-curlew <i>Burhinus grallarius</i>	Has not been recorded within the reserve system of the region
Brown Tree Creeper <i>Climacteris picumnus</i>	The Brown Treecreeper (<i>Climacteris picumnus</i>) has been recorded in the Goonawarra Nature Reserve, Kemendok Nature Reserve, Lake Urana Nature Reserve, Nombinnie Nature Reserve and Willandra National Park.
Painted Honeyeater <i>Grantiella picta</i>	Has not been recorded within the reserve system of the region

Name	Assessment
Swift Parrot <i>Lathamus discolor</i>	Has not been recorded within the reserve system of the region
Square-tailed Kite <i>Lophoictinia isura</i>	The Square-tailed Kite has not been recorded with the reserve system of the Riverina Biogeographical Region (DEC On-line Wildlife Atlas 16/03/05). It is highly unlikely the habitats for the species is adequately reserved in the biogeographical region.
Hooded Robin <i>Melanodryas cucullata</i>	This species has been recorded in the Benambra National Park within the Riverina biogeographical region (DEC On-line Wildlife Atlas 16/03/05). It is unlikely given the species recent listing, and preference for woodlands that have been preferentially cleared for agriculture, that the species is adequately reserved.
Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i>	Has not been recorded within the reserve system of the region
Turquoise Parrot <i>Neophema pulchella</i>	Has not been recorded within the reserve system of the region
Blue-billed Duck <i>Oxyura australis</i>	The Blue-billed Duck (<i>Oxyura australis</i>) has been recorded in the Morrisons Lake Nature Reserve and Willandra National Park.
Gilbert's Whistler <i>Pachycephala inornata</i>	There are only six conservation reserves in the Riverina biogeographical region, reserving approximately 0.32 per cent of the region. The Gilbert's Whistler (<i>Pachycephala inornata</i>) has been recorded in the Kemendok Nature Reserve, however as the species is still threatened and favour woodland habitats that have been a long history of modification for agricultural development, it is unlikely that the species is adequately reserved in the region.
Superb Parrot <i>Polytelis swainsonii</i>	Has not been recorded within the reserve system of the region
Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i>	The Grey-crowned Babbler has been recorded within the Lake Urana Nature Reserve, Morrisons Lake Nature Reserve, Nombinnie Nature Reserve, Willandra National Park and Yanga Nature Reserve.
Painted Snipe (Australian subsp.) <i>Rostratula benghalensis australis</i>	The Painted Snipe has been recorded in the Morrisons Lake Nature Reserve and Willandra National Park.
Diamond Firetail <i>Stagonopleura guttata</i>	The Diamond Firetail has been recorded in the Lake Urana Nature Reserve and Willandra National.
Regent Honeyeater <i>Xanthomyza phrygia</i>	Has not been recorded within the reserve system of the region
Major Mitchell's Cockatoo (<i>Cacatua leadbeateri</i>)	The Major Mitchell's Cockatoo has been recorded within the Morrisons Lake Nature Reserve, Nombinnie Nature Reserve and Willandra National Park.
Brush-tailed Phascogale <i>Phascogale tapoatafa</i>	Brush-tailed Phascogale have not been recorded within the reserve system of the region.

Name	Assessment
Koala <i>Phascolarctos cinereus</i>	Has not been recorded within the reserve system of the region
Greater Long-eared Bat <i>Nyctophilus timoriensis</i>	Has not been recorded within the reserve system of the region

As these species are still threatened and favour woodland habitats that have been a long history of modification for agricultural development, it is unlikely that any of the species are adequately reserved in the region.

7. Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The 'Clearing of native vegetation' is a Key Threatening Process under Schedule 3 of the TSC Act. The Brown Treecreeper (*Climacteris picumnus*), Grey-crowned Babbler (*Pomatostomus temporalis*), Painted Honeyeater (*Grantiella picta*) Major Mitchell's Cockatoo (*Cacatua leadbeateri*), Swift Parrot (*Lathamus discolor*) are listed as species that could become threatened by this process. Tree clearing impacts these species by many mechanisms, including the reduction in nest sites, particularly tree hollows, reduction in food resources, for example loss of nectar producing trees and mistletoes, loss of woody debris that provide habitat for invertebrates and small terrestrial vertebrates and loss of grass seed. Fragmentation also allows aggressive species, both native and exotic to compete for food and nest sites.

The draft recovery plan for the Bush Stone-curlew lists Fox predation as a significant cause of the species decline. Fox predation is a Key Threatening Process under the TSC Act.

The proposed development will result in clearing of native vegetation, a threatening process under the provisions of the TSC Act, however the woodland to be removed is unlikely to be utilised significantly by any species as it lacks a native grass understorey and other important habitat features such as fallen timber and tree hollows. Woodland within the site with these characteristics will not be impacted by the proposed cattle feedlot. The proposed development, whilst clearing native vegetation, will not result in threatened species being further threatened.

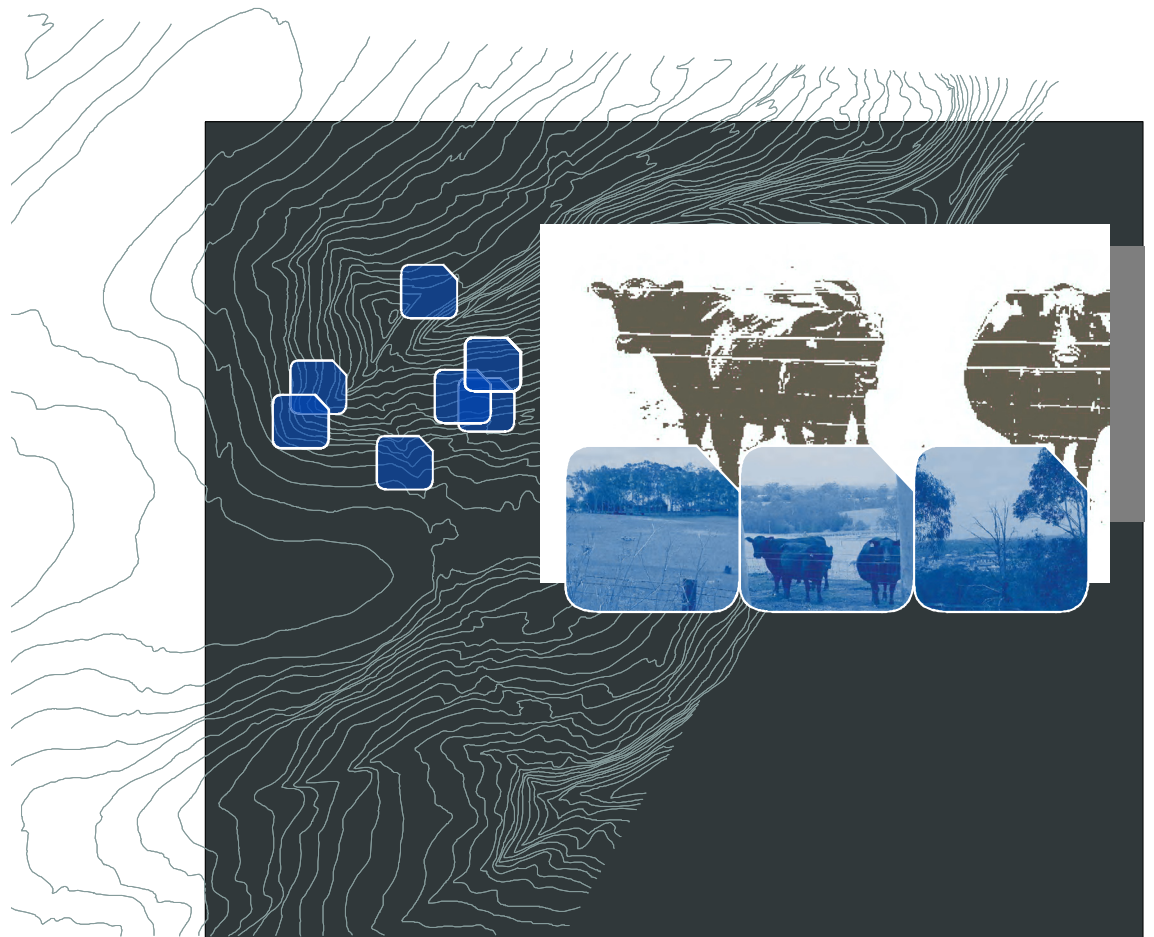
8. Whether any threatened species, population or ecological community is at the limit of its known distribution.

Name	Assessment
Bush-stone-curlew <i>Burhinus grallarius</i>	The species has been recorded in States and Territories, with the exception of Tasmania and the ACT (Barrett <i>et al.</i> 2003). In NSW, it is rare east of the Great Dividing Range, and more common on the western slopes (Marchant and Higgins 1993). In the region it is rarely recorded, mostly in summer and autumn, however breeding hasn't been recorded (Barrett <i>et al.</i> 2003). The species is not at the limits of its distribution.
Brown Tree Creeper <i>Climacteris picumnus</i>	The sub-species of the Brown Treecreeper that occurs in the local area was known to occur from Queensland to South Australia, however has declined in range (primarily as a result of agricultural clearing) and is threatened in Victoria and the

Name	Assessment
	ACT. The species is not at the limit of its known distribution in the Moira local area.
Painted Honeyeater <i>Grantiella picta</i>	The species is known to occur mainly in areas west of the Great Dividing Range from central Victoria to central Queensland, with few records east of the Great Dividing Range in the north of NSW to western Sydney. The species has not been recorded in the Sydney biogeographical region since 1993 (Higgins <i>et al.</i> 2001, DEC On-line Wildlife Atlas 16/02/04). The local area is historically significant as it is near the southern coastal limit (in NSW) for the species.
Swift Parrot <i>Lathamus discolor</i>	The Swift Parrot is said to be a vagrant north of the Hunter Valley (Higgins 1999), however the species is commonly observed in far northern NSW (pers comm. Deborah Saunders, DEC Threatened Species Officer/ Swift Parrot Recovery Team 28/11/03). The observations of the Swift Parrot in the local area are not close to the species distributional limits.
Square-tailed Kite <i>Lophoictinia isura</i>	The distribution for Square-tailed Kite is associated mainly with coastal tropical and temperate Australia, but has been recorded regularly on the south coast south of the Sydney district. With the exception of the far north coast, the species distribution in NSW is primarily the western slopes, north of the upper Hunter Valley, joining the Sydney district through the Blue Mountains (Marchant and Higgins 1993), with a patchy distribution through the southwestern slopes through to Victoria and South Australia (Simpson and Day 1999). The study area is not within the distributional limits of the species.
Hooded Robin <i>Melanodryas cucullata</i>	The sub species of the Hooded Robin that occurs in the local area is known from eastern South Australia to southeastern Queensland. It is known to be declining from the western slopes and is also threatened in Victoria. The species is not at the limit of its known distribution in the local area
Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i>	The subspecies of the Black-chinned Honeyeater that occurs in the local area is known to occur from coastal, montane and western slope regions from the tropics in Queensland to South Australia (Simpson and Day 1999), however in NSW it is rarely seen east of the Great Dividing Range, with the exception of between the Richmond River and Grafton (Higgins and Peter 2003). The species is not at its latitudinal distributional limits in the local area.
Turquoise Parrot <i>Neophema pulchella</i>	The Turquoise Parrot has a limited distribution, mainly within the sheep belt of NSW extending to Queensland, and Sydney region via the Hunter Valley, with an isolated population in Victoria. The species is near its historical south western distributional limit in the wider local area.
Blue-billed Duck <i>Oxyura australis</i>	The Blue-billed Duck is known to occur throughout NSW, Victoria, South Australia Western Australia, Queensland, Tasmania and Victoria (Barrett <i>et al.</i> 2003), and is more common in the Murray-Darling Basin (Marchant and Higgins 1990). The observations of the Blue-billed Duck in the local area are not at the species distributional limits.
Gilbert's Whistler <i>Pachycephala inornata</i>	Gilbert's Whistler has a discontinuous distribution from the south-western slopes of the Great Dividing Range, central and

Name	Assessment
	north-western Victoria, south-eastern South Australia, and inland south-western Western Australia (Higgins and Peters 2002). The species is not at its distributional limits in the local area.
Superb Parrot <i>Polytelis swainsonii</i>	The Superb Parrot occurs mainly in the Riverina district of southern NSW and Victoria, along the Murray, Murrumbidgee and Lachlan Rivers. The species is very occasionally seen on the NSW coast, and in areas such as Lightning Ridge and Bourke (Higgins 1999). The species is at its south western limit in the local area.
Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i>	The Grey-crowned Babbler is historically known to have occurred from South Australia to Queensland. The species is now extinct in South Australia (Higgins and Peters 2002), and is rarely recorded in Victoria and the Riverina biogeographical region, although the species hasn't shown a significant decline over the previous 20 years (Barrett <i>et al.</i> 2003).
Painted Snipe (Australian subsp.) <i>Rostratula benghalensis australis</i>	The observations of the Painted Snipe in the local area are not close to the species distributional limits. The species is nomadic and has been observed mostly in the Murray Darling Basin and coastal plains of NSW, with the exception of the south coast (Marchant and Higgins 1993), however recent survey recorded the species in widely scattered locations in NSW, Victoria, Queensland, Western Australia and South Australia (Barrett <i>et al.</i> 2003). This may be a response to range contraction as a result of the recent drought. It is unlikely that the species is at its distributional limits in the local area.
Diamond Firetail <i>Stagonopleura guttata</i>	The species is known to occupy drier habitats including the western slopes and tropical savannas, from Queensland to South Australia (Barrett <i>et al.</i> 2003). The species is threatened in Victoria and South Australia but not in Queensland. The species is not at the limits of the known distribution at the present study area.
Regent Honeyeater <i>Xanthomyza phrygia</i>	The Regent Honeyeater is historically known to have occurred from south of Rockhampton, Queensland to South Australia, where it is found west of the Great Dividing Range from the NSW/Queensland boarder to Victoria (Frith 1982). Most records in NSW are scattered west of the Great Divide, with regular recordings of the species near Canberra, Capertee Valley, Warrumbungle National Park and Barraba. The species is apparently extinct in South Australia (Higgins <i>et al.</i> 2001) and recent survey did not record the species along the Murray River west of Albury (Barrett <i>et al.</i> 2003). The species is probably at the limit of its distribution in the local area.
Major Mitchell's Cockatoo (<i>Cacatua leadbeateri</i>)	The Major Mitchell Cockatoo has experienced a greater than 20 per cent decrease in number of reported sightings between 1980 and 2003 (Barrett <i>et al.</i> 2003). The species is however known to occur from north western Victoria, South Australia, Western Australia, Northern Territory, Queensland and NSW west of the Great Dividing Range (Barrett <i>et al.</i> 2003). In the local area the species is rarely observed in spring, and incidentally at other times of the year. The species is close to

Name	Assessment
	the southern distributional limits in the local area.
Brush-tailed Phascogale <i>Phascogale tapoatafa</i>	The sub-species of the Brush-tailed Phascogale that occurs in the local area had a historic distribution from coastal districts and ranges from Rockhampton, Queensland to around Adelaide, South Australia. This has since fragmented with two populations that are between Hervey Bay, Queensland to the Sydney district and from the far south coast of NSW to the ranges of western Victoria. The species in the local area is likely to be close to the southern limit of its distribution.
Koala <i>Phascolarctos cinereus</i>	The species presently has a fragmented distribution including coastal plain, montane and western slope districts from the tropics of Queensland to South Australia. The species is not at its distributional limits in the local area.
Greater Long-eared Bat <i>Nyctophilus timoriensis</i>	The subspecies of Greater Long-eared Bat is known to occur from near Rockhampton in Queensland to South Australia (Churchill 1998). The species is unlikely to be at the limit of its regional distribution.



appendix g

aboriginal heritage assessment

Aboriginal Heritage Assessment of the Proposed 80,000 Head Cattle Feedlot at Moira Station, Mathoura, NSW

18 November 2005

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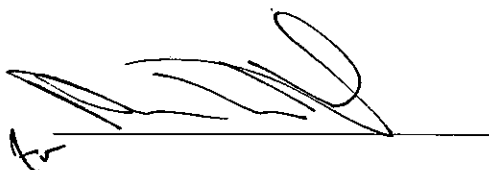
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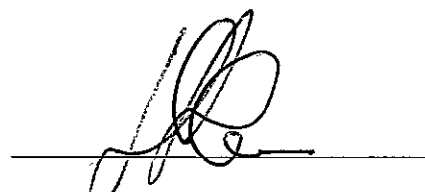
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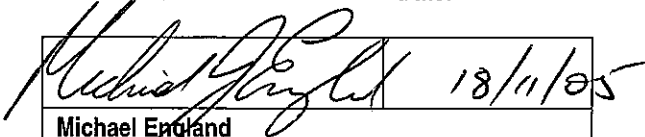
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APPENDICES

- Appendix A: Consultation Log, Native Title Information and Community statements
- Appendix B: Aboriginal Sites Search information and Site Cards
- Appendix C: Geotechnical Report (GHD).

1 INTRODUCTION

HLA-Envirosciences (henceforth HLA) was commissioned by Agricultural Equity Investments Pty Ltd (AEI) to undertake an Aboriginal Heritage Assessment for a proposed 80,000 head cattle feedlot in southern NSW at Moira Station, approximately 12 km south of Mathoura. The feedlot is to be developed in an area designated Zone 1(a) General Rural in the Murray Shire Local Environmental Plan. This zoning states that feedlot development is permissible with consent.

Due to the size of the proposed development and the employment opportunities expected to be created, the project will be designated a State Significant Development under State Environmental Planning Policy (SEPP) 34 – (Major Employment Generating Industrial Development). The consent authority for the development of a cattle feedlot that employs more than 20 people or has a capital investment of more than \$20 million is the NSW Minister for Planning. The assessment is carried out by the Department of Infrastructure, Planning and Natural Resources (DIPNR).

Under the EP&A Act 1979, this development is listed in Schedule 3 of the (Environment Planning and Assessment Regulation 1994) and is therefore a Designated Development. For Designated Development, it is required that a development application (DA) be accompanied by an Environmental Impact statement (EIS). Part of the legislative requirements for an EIS is an Aboriginal Heritage Assessment. Therefore AEI commissioned HLA Envirosciences Pty Ltd (HLA) in February 2005 to undertake an Indigenous Heritage assessment of the area. The aim of this assessment is to identify the archaeological sensitivity of the site, through identification of known Aboriginal sites, areas of archaeological potential and the subsequent development impacts upon them. Management strategies and mitigation measures are then provided to minimise potential impacts.

This report clarifies the activities within the study area and their potential impact to the Aboriginal archaeology. In summary, work undertaken in the preparation of this report involved the following:

- An Aboriginal Sites Search of the Department of Environment & Conservation (DEC) AHIMS register.
- Site survey with professional archaeologists to identify any archaeology and its potential impact.
- Identification and provision of management measures on future heritage issues within the study area.

The scope of works is based on the professional standards outlined by the DEC (formerly NSW National Parks and Wildlife Service) *Aboriginal Cultural Heritage Standards and Guidelines Kit* (1997) and *Interim Community Consultation Guidelines for Applicants* (2005).

Following recent Department of Environment and Conservation (DEC) consultation guidelines, an extensive consultation process was undertaken for this project to ensure appropriate Aboriginal stakeholders were informed and included.

1.1 Study Area

The study area is located off the Cobb Highway, 13 km south of Mathoura (**Figure 1**). It is bounded to the west by the Deniliquin-Bendigo railway, with the Cobb Highway traversing the eastern part of the study area in a north-south direction. The property consists of 1200 ha.

The current owner of the property is Mr. Noel Griffen. The property is currently used for irrigation and grazing.

1.2 Project Team

The Indigenous component of this report has been authored by archaeologists Jakub Czastka and Emma Harrison. Michael England was responsible for QA/review, and support services were provided by Kim Wilkinson and Tim Osborne.

1.3 Report Structure

The report structure relates the sections of the report and their contribution to the study.

Section 2.0 of this report outlines the Aboriginal community consultation and involvement undertaken for the project. **Section 3.0** summarises the regional archaeological and environmental context for the assessment of the study area. This review specifically targets known sites within the area, past reports and landscape evolution. **Section 4.0** outlines the methods and results of the archaeological survey and assessment of the study area. **Section 5.0** will combine the results of the background research and site survey and provide a predictive model of archaeological sensitivity for the site. **Section 6.0** discusses the sensitivity model and provides recommendations and management options, based on the statutory controls relevant to the project. This management strategy also identifies any additional concerns raised by Aboriginal community group representatives, and incorporates these concerns where possible.

A summary of the statutory requirements regarding Aboriginal heritage is provided in **Section 6.2**. This is based on experience with the heritage system in NSW and does not purport to be legal advice. It should be noted that legislation, regulations and guidelines change over time and users of the report should satisfy themselves that the statutory requirements have not changed since the report was written.

1.4 Limitations

This assessment is based on the existing environmental and archaeological knowledge of the study area, within the larger context of the Murray River floodplain. If previously recorded surface archaeological materials are found within the immediate locality, they are identified and discussed. This discussion has been based on the reports prepared by others (as cited in this report) and HLA has relied on these reports and has not sought to independently verify the results and interpretations in these reports.

Predictions have been made about the probability of subsurface archaeological materials occurring within the study area. It is possible that materials may occur in any landscape context, and the assessment of subsurface materials refers to the likelihood of occurrence based on surface indications and environmental context.

HLA has undertaken a search of the Aboriginal Heritage Information Management System (AHIMS) held within the Department of Environment and Conservation (DEC). The search results are provided in **Appendix B**.

As stated in the qualifying letter from the Acting AHIMS Administrator, Register searches are constrained by the amount of data in the register and the quality of that data (for example grid references can be inaccurate). Large areas of NSW may not have been systematically searched and may contain Aboriginal objects and other heritage values not recorded on AHIMS.

Additionally, the AHIMS reports database can only be searched by the title of the report, which may not indicate the geographical location of the area covered. This means that it is possible that some known sites and some reports may have been omitted from this study. Sites and reports are added and removed from AHIMS and therefore the accuracy of information provided from AHIMS is only valid on the day the register is searched and to the nature of the search.

A summary of the statutory requirements regarding Aboriginal heritage is provided in **Section 6**. This is provided based on experience with the heritage system in NSW and does not purport to be legal advice. It should be noted that legislation, regulations and guidelines change over time, and users of the report should satisfy themselves that the statutory requirements have not changed since the report was written.

1.5 Acknowledgements

HLA would like to thank Catherine Franklin (Moama LALC administrator), Richard Kerr (Aboriginal Sites Officer to Moama LALC), and Rebecca Atkinson (Aboriginal Sites Officer to Cummeragunja LALC) and Kevin Atkinson for making us feel welcome in their country and for sharing their considerable knowledge of the local area. Chris Kelly provided us with an overview of the study area with a well versed tour which proved invaluable. Tony Camphin's (AEI) facilitation of the project is also acknowledged, as is his sensitivity to Aboriginal cultural heritage. Richard Chandler, the author of the GHD geotechnical report is gratefully acknowledged for providing comments and research material.

2 COMMUNITY CONSULTATION

In response to two recent Land and Environment Court (LEC) rulings (*Carriage v Stockland Development Pty Ltd* (No 4) [2004] NSWLEC 3553 and *Williams v The Director General of the Department of Environment and Conservation v Ors* [2004] NSWLEC 613) the Department of Environment & Conservation (DEC) has developed the *Interim Community Consultation Requirements for Applicants* (DEC, 1 January 2005). These new requirements have expanded developed on the current guidelines (*Aboriginal Cultural Heritage Standards and Guidelines*, DEC 1997), making the consultation process longer and more thorough.

For this reason HLA undertook the following steps with regard to this project:

- Contacted MS Teresa Gay, Executive Director of Operations at DEC, to identify relevant Aboriginal stakeholders.
- Contacted the Moama LALC to identify their interest in the project, and to identify other Aboriginal groups in the area.
- Searched the Native Title Tribunal to identify possible Native Title holders.
- Searched the Office or Registrar of Aboriginal Corporations.
- Advertised in the *Yarrawonga Chronicle* (local newspaper circulated weekly) on Wednesday 2nd March 2005.

Information on the Native Title Search and the public advertisement are attached in **Appendix A**. No responses were received from the newspaper advertisement.

After determining from a variety of sources that the Moama LALC was the relevant Aboriginal Land Council in the area, HLA contacted them to identify their interest and invite them to participate in the survey. As the study area is situated close to the boundary of two Local Aboriginal Land Councils (LALC), HLA also inquired whether the second LALC were interested in cultural heritage issues of the study area.

After clarification was received from the Moama LALC, the Cummeragunja LALC was confirmed as a further group for which the study area holds significance. HLA directly received an expression of this group's interest via the Moama LALC. Thereafter it was agreed between all parties that the Moama LALC would pass on further correspondence from HLA concerning the survey to the Cummeragunja LALC.

After discussions with Catherine Franklin (Moama LALC administrator), Richard Kerr (Aboriginal Sites Officer to Moama LALC), and Rebecca Atkinson (Aboriginal Sites Officer to Cummeragunja LALC) were both assigned to the survey and participated in all future stages of the project.

Rebecca Atkinson and Richard Kerr joined HLA archaeologists on the physical survey conducted at Moira Feedlot from Monday the 4th to Friday the 8th April 2005.

Details of community consultation can be found in **Appendix A**.

3 BACKGROUND RESEARCH

Background research into the environment forms the basis for assessing the regional archaeological context and predictions for site distribution in the study area. It is generally assumed by archaeologists that Aboriginal settlement patterns are related to the environment and that areas of similar environment will have similar site distribution. Thus, understanding the environment of a study area assists comparative analyses.

Secondly, understanding something of the environmental background also assists in assessing the conditions for site preservation or destruction. This is important in interpreting the results of archaeological surveys and in developing management strategies for protection of sites.

This section has been split into the following areas: environmental context, geology, soils, vegetation, landforms, historical overview, previously recorded sites, geotechnical context and regional archaeological context.

3.1 Environmental Context

The environment, broadly speaking, refers to the landscape – vegetation, soils, geology, fauna, and geomorphology - incorporating climatic (temperature and precipitation) and increasingly human (agriculture, infrastructure etc) influences. Whereas certain sets of conditions are, literally, set in stone (like geological structures and bedrock influencing geomorphology), others are continually changing at various rates (e.g. night / day temperature range; seasonal precipitation). Therefore, a perspective appreciating that landscapes are not static features is a useful observation to consider when reviewing environmental factors. Furthermore, an assessment of the environmental context provides a framework from which to view past and present natural and human processes as they affect the landscape, and consequently the archaeological resource.

One of the key goals of describing the environmental context is to provide a sound framework from which to make predictive statements. When considered alongside the regional and local archaeological contexts, predictive models that also consider proxy environmental data (e.g. past soil formation) can offer a useful assessment of both surface and subsurface conditions.

3.1.1 Geology

Identification of the underlying geological formations of the landscape is important in order to understand the natural resources within the study area. Resource availability influences the nature and intensity of human activity throughout the landscape. In particular, the procurement of raw material for flaked stone artefact manufacture is a major influence on the distribution of Aboriginal sites. Regional geology can also point to areas that have potential for subsurface archaeological remains. Finally, 'bedrock' geology (both consolidated and unconsolidated) is the interface at which weathering occurs to form soils, the nature of which is ultimately dictated by the available parent material.

The geological sheet that covers the study area is the Deniliquin 1:250 000 (SI 55-13). The geology of the study area is a combination of Holocene and Pleistocene alluvial and fluvial deposits identified as the Coonambidgal and Shepparton Formations respectively. The Coonambidgal Formation also has a lacustrine component in its deposits. The older Shepparton Formation is composed of silt, sand and minor gravel deposits, whilst the Coonambidgal Formation includes clay, sand and sandy clay. The range in texture classes between the Shepparton and Coonambidgal Formation indicates that the former represents a faster flow regime.

3.1.2 Soils

Soils form through a variety of processes, predominantly diagenesis (the breakdown of bedrock into soil) and pedogenesis (the development of diagenetic material into soils), but can be highly diverse due to varying conditions such as climate, topography, parent material, organisms and time. The natural chemical and physical constitution of the soil is also impacted by the underlying rock, with grain size, clay minerals, plant nutrients, and the retention capacity of the soil affected. Soil characteristics such as depth and erodibility, as well as the natural processes that affect these features, impact upon the detection of archaeological evidence within the landscape.

Soil analysis has important ramifications for archaeological research through the potential impact of different soils on human activity (such as agricultural exploitation) and the impact of the soils on archaeological evidence (such as post-depositional movement). The soils known to occur throughout the study area are identified here in order to delineate their nature and impact on the survival and location of archaeological material.

Deniliquin, some 40 kilometres north of the current study area, indicates a typical depositional sequence for the Riverina Plain area. Deniliquin reveals at least three groundsurfaces (K Cycle after Butler (1967): the K₂ surface (ubiquitous groundsurface) of red-brown earths to grey soils of heavy texture; the K₃ groundsurface is found only as a buried soil, most commonly a grey soil of heavy texture, where on elevated ground it occurs as a red-brown earth; and, the K₄ groundsurface occasionally found beneath K₃ in isolated patches. These three deposits are composed of both windblown and alluvial elements subsequently weathered into soils.

The soils of the study area are identified at a very coarse scale in the 1:500 000 *Geomorphic Map of the Riverine Plain of South Eastern Australia* (Butler et al; 1973). This maps the surface deposits as alluvial plains with scalds. An unconfined stream trace is also found at the southern side of the property, with a confined stream trace located at the south western corner of the property, greater than 650 m wide (ibid.). The Geotechnical study of the Moira property indicates that the surface material is a light brown to brown sandy clay with fine grained sand (loam) representing a disturbed topsoil and varying in depth from 0.10 m to 27 m (GHD, 6th May 2005). Only one location (TP25; pers.com Richard Chandler) indicated remnant topsoil, which had been truncated with only 0.1 m remaining of a dark grey clayey sand with fine grained sand (loam) identified as alluvial in origin¹. Subsurface conditions reflect a series of alluvial deposits: a red brown clay with traces of fine grained sand follows the disturbed surface layer to a depth of between 0.60 m and 1.0 m. Most test pits below this level revealed clay alluvium with traces of fine grained sand of various colours. A red brown clay, typically 0.50 m in depth, sometimes preceded a grey brown clay, with subsequent levels revealing clays – again alluvial - a combination of these colours, sometimes with yellow brown and grey, and all mottled. TP 25 – 27 and 32 also identified white sand at between 2.0 to 4 m and TP 29 located sandy silt with fine grained sand traces between 2.3 and 3.2 m. A clayey sand was also encountered in TP 26 between 3.0 m and 4.3 m. All these subsurface deposits represent alluvial formation processes. A single borehole taken in the south western part of the study area revealed clays to a depth of 7.0 m, followed by a series of alternating sand and clay deposits to 12 m, identifies the fact that this alluvial sequence.

Only one location (TP 15) indicated a slight anomaly in the grey with grey brown mottled clay (between 1.6 and 4 m) in the form of a calcite trace (evidence of illuviation?). Although no definite palaeosols (soils formed under different climatic conditions than today's) can be identified from the Geotechnical study, the potential for them to be present within the study area exists. Alluvial plain deposition can be extremely varied and soil formation does occur under favourable aerobic conditions.

¹ Transect 6 indicated traces of a similar soil.

3.1.3 Vegetation

The distribution of vegetation and water resources within the local landscape are important factors influencing patterns of Aboriginal land use and occupation. Additionally, the effectiveness of the archaeological survey is directly impacted by visibility conditions, of which vegetative cover is an important feature.

The site has been extensively cleared for agricultural uses, and has been impacted to varying degrees by weed invasion and overgrazing by stock and feral species. Weeds dominate the areas that are presently irrigated. Adjacent agricultural land has been substantially cleared and the remaining woodlands within the site generally have a disturbed understorey due to past livestock and rabbit grazing.

The site could be classified into four areas of ecological community:

River Red Gum (*Eucalyptus camaldulensis*) Community

The River Red Gum Community was restricted to drainage depressions in the northern part of the site. The tree canopy was exclusively River Red Gum, and there was no shrub understorey. The ground cover varied, with the northeastern remnant having the greatest cover and diversity of native species. Dominant ground cover species included *Eleocharis pusilla* and Common Nardoo (*Marsilea drummondii*). No other species dominated; however, several species were restricted to this community, including *Goodenia gracilis* and *Lythrum hyssopifolia*.

The remainder of the community was significantly impacted by cattle sheltering or accessing water.

Black Box (*Eucalyptus largiflorens*) Community

The Black Box Community occurred in flood plains between the drainage depressions and higher areas and had the greatest diversity of all communities in terms of native species and spatial extent of a native dominated understorey. The dominant tree species was Black Box; however, other tree species were also present, including River Red Gum near small depressions, Yellow Box (*Eucalyptus melliodora*) and Grey Box (*Eucalyptus microcarpa*).

The community in the uncropped northern pastures had few shrub species, dominated mostly by scattered chenopods, especially Galvanised Burr (*Sclerolaena birchii*) and also *Maireana aphylla* being relatively common. The ground cover beneath the trees was dominated by exotic species, a result of shade, disturbance and increased nutriment from stock sheltering. Very common species included Nettle-leaf Goosefoot (*Chenopodium murale*), Common Fiddleneck (*Amsinckia intermedia*) and the noxious species African Boxthorn (*Lycium ferocissimum*). Native grass species, especially Ringed Wallaby Grass (*Austrodanthonia caespitosa*) and Speargrass (*Austrostipa scabra* subsp. *scabra*) dominated away from the cover of trees.

Box Community with Exotic Understorey

This community was mapped for areas where scattered remnants of the former woodland cover occurred in cropped areas. While Grey Box and Black Box were common in this community, other species also occurred. Exotic species comprised crop species and weeds such as Wireweed (*Polygonum aviculare*), Patersons curse (*Echium plantagineum*) and the noxious Bathurst Burr (*Xanthium spinosum*). As with the Black Box Community, the ground cover under tree canopies was dominated by Nettle-leaf Goosefoot and Common Fiddleneck.

Cropped

This community dominated in terms of spatial extent, and included areas that are irrigated. Species that are presently grown include *Sorghum* sp., while many other areas have been harvested with crops such as Wheat (*Triticum aestivum*) and Barley (*Hordeum* sp.). The ground

cover in fallow areas was typically dominated by Wireweed and Fiddleneck with Bathurst Burr and Patersons Curse also occurring.

Previous vegetation mapping identifies the entire site as being cleared; however, nearby locations on elevated flats of the Murray River floodplain are mapped as having remnants of Grey Box (*Eucalyptus macrocarpa*) Woodland, dominated by Black Box (*E. largiflorens*) and Bulloak (*Allocasuarina luehmannii*) (Porteners 1993). The community occurs in the uppermost floodplain levels, and is dominated by Black Box, often mixed with Grey Box (*E. macrocarpa*) and Yellow Box (*E. melliodora*), the latter species becoming less frequent in the south. The ground cover may have Caustic Weed (*Chamaesyce drummondii*), *Atriplex semibaccata*, *Oxalis perennans* and *Alternanthera denticulata*. Black Box trees are susceptible to dieback in heavily irrigated areas.

3.1.4 Landform

Landscape analysis is an important part of an archaeological survey. The topographic features of the study area are discussed to identify features directly relevant to occupation and land use across the landscape. It is assumed that Aboriginal groups will have used various landforms differently in the past; therefore a background understanding of these landforms within a study area is necessary for the development of predictive models detailing site location and site types.

As part of the assessment process a division of landforms was designed to identify landform units within each transect or previously identified boundary (e.g. hill, flat). This was in order to provide a landscape framework within which any archaeological material or areas of significance could be placed. The landform units were based on McDonald *et al.* (1998), which is a standard guide for describing landform divisions.

The categories defined in McDonald *et al.* (1998) are designed for a variety of land division purposes, being a two-layered technique that involves treating the landscape as a series of 'mosaics'. The tiles of the mosaics are described in two distinct sizes - the larger categories are referred to as landform patterns with the smaller being *landform elements* within these patterns. Landform patterns are large-scale landscape units more than 600 m in width, while landform elements are the individual features contained within these broader landscape patterns and only measure about 40 m in width. There are around 40 of the larger landform pattern units described with over 70 landform elements. However, of all the landform elements there are 10 morphological types. These are relevant to archaeological survey for they divide the landscape into standardised elements that can be used for comparative analyses. These divisions have generally been adopted by archaeologists and allow comparison of site location. These elements are: *Crest*, *Hillock*, *Ridge*, *Simple slope*, *Upper slope*, *Mid-slope*, *Lower-slope*, *Flat*, *Open depression* and *Closed depression*.

In addition, streams within the area were classified with reference to Strahler's (1952) stream order classification. Eight landform units were defined based on the morphological type, slope, dimensions and geomorphological agents of landform elements throughout the study area. The level of detail outlined by McDonald *et al.* (1998) is generally beyond what is required for archaeological analysis, and the eight landform units defined for this report are based in the generalised landform elements outlined above. No division was made between upper and lower hillslope units within the study area, as they did not exhibit sufficient differences in morphology, slope class and visibility.

The western slopes / Murray River valley region are part of a continuously sloping surface which ends abruptly in the east by the Great Dividing Range. The terrain of the western slopes generally has low to moderate relief and palaeo-landforms are often well preserved (Walker, 1986: 41). The Murray-Darling Basin encompasses a large area of inland alluvial plain with

climate ranging from humid to subhumid and vegetation corresponds accordingly from eucalypt forest to Eucalypt woodland (Walker, 1986: 44). Gradational to strong textural differentiation within sodic and calcareous subsoils are a common feature of the subhumid areas (op.cit).

The Riverine Plain represents the gently sloping area west of the Great Dividing Range. The Riverine Plain has been formed by the deposition of vast alluvial fans by the precursors of the present rivers – Murrumbidgee, Murray and Goulburn – which flow across it from the east and from the south. It is flanked on the north, south and east by the low foothills of the main mountain zones from where the rivers rise and by mallee (a characteristic aeolian landscape) on the west and in pockets to the north (Butler, 1967: 243).

3.2 Historical Overview

Although the Aboriginal history of the Murray floodplain in the relevant area is scarce in the literature, a summary of the general area has been provided here from Lance (1985:3-5) in his report *An Archaeological Investigation of the Algeboia Shell Midden in the Moira State Forest, Murray Valley, NSW*. This information has been supplemented with that produced by Craib (1991) in his report entitled *Archaeological Survey in the Moira-Millewa State Forests*.

3.2.1 Aboriginal History

Much of this history is based on European observations, therefore little is known about Aboriginal occupation of the area before 1788, although the archaeological record (see **Section 3.2.2**) does provide some information in this regard.

Some idea of the way of life of the Aborigines on the Murray River, before the arrival of Europeans, can be seen in the written records made by early explorers and white settlers. Although there are problems and biases in these records, they do allow some appreciation of Aboriginal society at the time of European contact. Recorded observations of Aboriginal life made by early settlers along the Murray River were selective and not all aspects of economic life were recorded.

The observations made of Aboriginal subsistence activities have been used to interpret the archaeological materials left by prehistoric peoples. As Aboriginal society was changing at the time of the first European settlement, and probably had been changing before this time, the observations made may not be an accurate reflection of Aboriginal society at the time prehistoric archaeological sites were being used. In any case severe changes to Aboriginal society had already taken place as the result of introduced disease (see also Craib 1991: 46).

Disease was introduced from the east coast and was transported by social contact between Aboriginal groups living along the river systems. Smallpox and influenza epidemics, which occurred in the Central Murray in the 1830's and 1840's (Bickford 1966: 154-5; Coulson 1979: 9; Butlin 1983), resulted in severe loss of life in Aboriginal populations with no natural resistance to the diseases. The impact of disease may have proved severe amongst the riverine Aboriginal communities of this particular region because of a higher population density and more sedentary lifestyle, which facilitated easier transmission of diseases (Mulvaney and Kamminga 1999: 68) In 1829-30 the number of Aborigines living on the lower Goulburn River was estimated by Sturt to be in the order of 1200 people (Sturt 1833). When Hawdon visited the area in 1838 this population had decreased dramatically to approximately 200 individuals (Buchan 1980: 31).

Therefore, observations made by even the earliest European explorers present an overall picture of depopulation amongst Aboriginal communities in the region due to epidemics. Such dramatic events would have significantly altered Aboriginal lifestyles.

European settlement of the Central Murray region from the 1840's onwards caused the displacement from traditional lands of those remaining Aborigines who had survived the disease epidemics. Bushby (1980: 52) states that local Aborigines particularly resented European intrusion into the areas at the junction of the Edward and Murray Rivers (now Picnic Point) as well as the Moira/Barmah Lakes area. "Feuds" continued until about 1848.

Early European explorers in the Central Murray Valley in the 1830's indicate that the Aboriginal population size was larger than that along other major rivers in New South Wales (Buchan 1980: 27). This larger population would have been sustained by the permanent, plentiful water supply and an abundance of animal and plant foods, particularly in lake and swampland areas.

At the time of European contact the most important foods eaten by Aborigines living in this region were fish, shellfish, crayfish and waterfowl. Seasonal fluctuation of river water levels would have restricted the availability of some animal resources exploited for food to certain seasons (Beveridge 1889 II: 250).

In spring, river levels rose and billabongs and the river flats were flooded. During this season fish and freshwater crayfish would have been an important source of food (Mulvaney 1975: 66). Netting of the river would have allowed the gathering of large quantities of fish, sufficient to feed the gatherings of people observed during this season (Lawrence 1969: 97). As the river levels began to fall, fish weirs were built across channels to catch fish returning from swamps to the main river channels. In addition to such seasonal labour intensive fishing methods, individuals would have been using multi-pronged fish spears throughout the year.

Freshwater mussels would have been important in the local Aboriginal diet, particularly in the summer months when low water levels would have made the collection of shellfish from streambeds and lake shores an easier task.

Kangaroos, possums and rats were also hunted for food and clothing materials. Kangaroos were scarce when Europeans first visited the Central Murray Region and they may not have been an important food resource, considering the abundance of other foods available from the river (Buchan 1980: 28).

Several methods were used by Aborigines in south-eastern Australia for the preparation of plant and animal foods. The most common cooking technique observed by the early European settlers was the use of earth ovens. In areas where stone was readily available, several cobbles were placed on a fire that had been lit within a 60-90cm deep pit. Once the stones were heated, damp grass was used to cover the hearth, onto which the food (animal or vegetable) had been placed. The food was covered with further layers of grass and soil and allowed to cook for several hours (Angas 1847 I: 89; Parker 1905; Buchan 1980: 29). As there is little stone on the alluvial plains of the Murray Valley pieces of clay were used instead.

The ash and clay was removed from the pits, which could then be re-used. This led to the formation of mounds of clay, ash and food refuse.

3.3 Archaeological Context

The archaeological context has been split into two parts, the regional context, which is general information on archaeology in the Riverine Plain region and more specific archaeology related to the areas surrounding Moira.

3.3.1 Regional Archaeological Context

The settlement of the Murray-Darling Basin region by Aboriginal people is represented by a series of sites located to the north (Willandra Lakes region) and west (Kow Swamp) of the Riverine Plain dating back to the Late Pleistocene and Holocene. These sites indicate that during periods of wetter climatic conditions than today, the increased rainfall fed both river systems and now extinct lakes (e.g. Lake Mungo), providing optimum conditions for Aboriginal people to settle the region. Based on current evidence and models, Aboriginal sites were concentrated around rivers, lakes and creek lines – i.e. the necessity for water as both a resource and as an environment attractive to game, water fowl and obviously fish. The active Murray floodplain is also an excellent environment for exposing Aboriginal sites.

Willandra Lakes (containing Mungo) is a series of 13 interconnecting dry lake basins in southwestern NSW. With the discovery of human remains at Lake Mungo in 1968 by Jim Bowler, the Willandra Lakes region is one of the best studied and most significant archaeological resources in Australia (Johnston & Clark 1998). The cremated human remains, labelled Mungo I, were dated to 26,000 years BP making it the earliest cremation in the world (Bowler et al. 1976). Subsequent findings of additional human remains, specifically Mungo III that has been recently re-dated using Optical Stimulated Luminescence (OSL) dating to between 38,000 to 42,000 years ago (Bowler et al 2003), has led to substantial environmental and geomorphological studies of the region.

Studies reveal that the Walls of China surrounding Lake Mungo, consists of three sediment units, Mungo, Arumpo, Zanci, overlaying a red clay layer (the Golgol unit) dated to some 140,000 years ago (Bowler 1998). Above the Golgol Unit is the Mungo unit dates to around 32 to 50,000 years ago, which contain Mungo I and III. Above the Mungo Unit is the Arumpo Unit (35 to 22, 000 years ago), Zanci Unit (22 to 19, 000 years ago) and the Mulurulu Unit (19 to 17, 500 years ago), the latter being the surface layer evident today. These studies, which reveal a complex climatic regime of droughts (indicated by the deposits of windblown dunes described above) and floods intermingled with human interaction (artefacts have been found as far back as 50,000 years), indicate that the general area retains high potential for deep stratigraphic deposits extending back to the last Interglacial (ibid.).

Kow Swamp has never been published in detail, however Alan Thorne undertook a series of excavations in the late 1960's and early 1970's and found a number of skeletons. 22 individuals were located dating from the Lateglacial (skeleton KF 5 dated to approx 15,000 calibrated years ago) to mid Holocene (KS16 at 6,500 years ago) (Thorne 1975 and 1976; Thorne & Macumber 1972). OSL dates by Cupper & Stone (2003) put these dates back to the Last Glacial Maximum (LGM), some 22 to 15, 000 years ago. Since few of the individuals were dated *in situ*, arguments surround their dates placing them between the LGM and the mid Holocene. However, similar to Lake Mungo, there is clear evidence in this location for sediments (and in this case buried land surfaces) to survive over the last 20,000 years or so.

3.3.2 Local Archaeological Context

The knowledge of archaeological sites in the local context is relatively poor. Archaeological assessments have been undertaken in the Moira State Forest in the Murray floodplain immediately to the east of the study area, as well Barmah, Gulpa Island and Millewa forests to the northeast, east and south east.

As will be seen in the following section, the local archaeological context reveals a suite of sites that are clustered around the Murray River. The Murray has soft sediments in which to dig graves (sandy deposits), Eucalypt trees from which to make canoes, shields etc (as well as proximity to waterways), plenty of food (shellfish, game and waterfowl) discarded to create

middens, exposures of raw materials such as ochre, as well as plenty of water and hence campsites which lead to the creation of oven mounds for cooking. Processes such as sand mining, logging and flooding all serve to expose areas not normally visible and are often the main cause, either directly through impacts or indirectly through Aboriginal heritage assessments, of identifying Aboriginal sites.

The artefactual assemblage produced and used by the Aborigines in the study area is poorly known. Most of the items produced in the forests were made from local resources, primarily fibres, wood, and bark. Local stone sources were absent; the presence of chipped, and in particular, ground stone axes, reflects the presence of the extensive exchange system in which the people of the Barmah-Millewa forests participated (Craib 1991: 59-60).

3.3.3 Previously Recorded Sites.

HLA undertook a site search of the study area and its surrounds (the search area being 20 km north-south by 7 km east-west) using the Department of Environment and Conservation's Aboriginal Heritage Information System (AHIMS) on the 29 June 2005. The AHIMS search revealed 26 Aboriginal objects and places in proximity to the study area, a summary of which is presented in **Table 1** and **Figure 1**.

Table 1: List of known Aboriginal sites recorded in AHIMS as being within 7 x 20km of the study area.

DEC AHIMS identification number	Site Name	Site type	Easting	Northing
54-4-0030	Ochre mine	Ochre Quarry	310200	6019100
54-4-0032	Shield tree & Colomans	Scarred Tree	310700	6016800
54-4-0034	Dora oven mounds	Mound (Oven)	310750	6016800
54-5-0053	Mathoura; Moira State Forest	Burial/s, Midden	311902	6029794
54-5-0054	Moira	Burial/s	310636	6019540
54-5-0055	Algeboia	Aboriginal Place	310500	6017500
54-5-0063	Site 11 Shell Scatter	Midden; Scarred Tree	312800	6016680
54-5-0064	Site 12 A Algebonia	Scarred Tree	310800	6017950
54-5-0065	Site 12 C Scarred Tree	Mound (Oven); Scarred Tree	310750	6017850
54-5-0066	Site 12 C Scarred Tree	Burial/s; Mound (oven); Scarred Tree	310750	6017850
54-5-0067	Site 13 Scarred Tree	Burial/s; Midden; Mound (Oven); Ochre Quarry; Scarred Tree	310300	6019000
54-5-0069	Site 19 Scarred Tree	Midden; Mound (Oven); Scarred Tree	313350	6014570
54-5-0070	Site 20 Shell Midden	Midden; Scarred Tree	313250	6015800
54-5-0071	Site 21 Shell Midden	Midden; Scarred Tree	313200	6015850
54-5-0072	Site 22 Shell Midden	Midden; Scarred Tree	312800	6016350
54-5-0073	Site 23 Shell Midden	Midden; Scarred Tree	312600	6015450
54-5-0074	Site 24 Shell Midden	Midden; Mound (Oven); Scarred Tree	312950	6016900
54-5-0152	Site 100 Cemetery	Burial/s; Mound (Oven); Scarred Tree	311520	6031500
54-5-0153	Site 101 Scarred Tree	Scarred Tree	311200	6030950
54-5-0154	Site 102 Scarred Tree	Scarred Tree	310900	6030950
54-5-0155	Site 103 Mound	Burial/s; Mound (Oven); Scarred Tree	312800	6027450

DEC AHIMS identification number	Site Name	Site type	Easting	Northing
54-5-0156	Site 104 Burial	Burial/s; Mound (Oven) Scarred Tree	310150	6018400
54-5-0160	Site 112 Scarred Tree	Scarred Tree	311250	6029750
54-5-0174	Site 144	Midden; Mound (Oven); Scarred Tree	311400	6029600
59-2-0036	Site 17 Shell Midden	Midden; Scarred Tree	313700	6014050
59-2-0037	Site 18 Scarred Tree	Midden; Mound (Oven); Scarred Tree	313420	6014420

As demonstrated in **Table 1** and **Figure 1**, 21 of the sites identified in AHIMS are scarred trees, which constitute the bulk of sites in this area. The other two main categories of site in the vicinity are shell middens and oven mounds, which occur in almost equal numbers: 12 shell midden sites are listed, followed by 11 recorded oven mounds. Burials make up a lesser, although significant, number of sites, with 7 recorded in the area. The remaining 3 sites are split between ochre mine locations (2) and Aboriginal places (1).

In almost all cases, the sites (50) are located within the Moira-Millewa State Forest, on the margins of Dora Creek and the Murray River. Other sites (4) are located on private property directly adjacent (west) to the Moira-Millewa State Forest boundary. This is to be expected since riverine resources were clearly important and heavily utilised by traditional Aboriginal peoples in this area, and because widespread land-clearing has meant that many sites outside of the forest have not survived.

All recorded burials in the region, and indeed within the wider Murray River corridor, are located within the local riverine sand deposits. These soft Murray River sands are characteristic of the alluvial floodplain in this region and make a very suitable environment for interment, due to the soft nature of the deposits. There are many large-scale prehistoric cemeteries known from within this river corridor (see Mulvaney and Kamminga 1999: 36, 305-6).

Typically middens are only going to be found in the vicinity of the resource, which consists of the Murray River and its tributaries. Oven mounds are characteristic of the Murray River region and are frequently found in association with burials. The oldest of these in the Murray Valley region is dated to around 3000 years (Mulvaney and Kamminga 1999: 25).

With regard to the proposed cattle feedlot, there are two Aboriginal sites recorded in the immediate area. This would largely be the result of agricultural practices over time, considering the landscape of the study area has been part of the Moira cattle station since the 1840's (Craib 1991: 47). These two sites are: the Algeboia freshwater shell midden, and the nearby ochre mines. Both sites are located within some 3km southeast of the proposed feedlot.

Algeboia shell midden is located in the sand body bordering the Murray River floodplain, and has been disturbed in the past by sand extraction activities. An archaeological investigation of the site carried out by Lance (1985) confirmed the antiquity of the site and pointed to the presence of several skeletal remains. Although a boundary fence has been erected by NPWS, it seems that further recent disturbances have occurred at the site due to clandestine sand quarrying at the site.

The ochre mines are located in the land adjacent to the Moira-Millewa State Forest. While there is little written material available concerning the ochre mines, it is clear that they are of cultural significance. According to the local Aboriginal groups, the use of the deposits is ongoing with ochre being still quarried here on a small scale for ceremonial purposes to the present day.

4 ARCHAEOLOGICAL SURVEY & ASSESSMENT

This section details the field methodology employed and the results of the survey and analysis.

4.1 Survey and Terrain Mapping Methodology

The aim of the field survey was to identify the archaeological sensitivity of the study area. This assessment was determined by the criteria outlined below in **Section 4.2**.

The archaeological survey team for the project consisted of Mr. Jakub Czastka and Ms. Emma Harrison of HLA, Mr. Richard Kerr of Moama LALC, and Ms Rebecca Atkinson of Cumeragunja LALC.

The presence or absence of archaeological materials and the terrain features and integrity of sites were documented using a specifically designed recording form (see **Table 3**). A range of environmental attributes affects the detection of archaeological material during site surveys. Some of these features are vegetation cover, soil type and presence of naturally occurring surface rock. Ground surface visibility is also a major influence of artefact detection. The nature (i.e. size, colour, material type) of the archaeological material also affects the effectiveness of the field survey. To assess the reliability of the survey results the following features were recorded for the site:

- Landform unit;
- Environmental setting within landform unit;
- Fall of slope along transect;
- Type of vegetation cover;
- Visibility levels measured as percentage of soil surface visible per transect;
- Type of ground exposure i.e. erosion or disturbance from mining activities;
- Frequency of exposures i.e. number in each transect;
- Size of exposures;
- Depth of soil erosion;
- Soil type and profile level exposed;
- Evidence of downslope movement of soil and rock particles;
- Presence of naturally occurring rock suitable for artefact production; and
- Presence of archaeological material.

The range of attributes relating to each of these environmental features across the site is reproduced in Table 2. Terminology for all landscape descriptions was obtained from McDonald *et al* (1990).

Photography was also used to document the environmental and archaeological features of the survey area.

Table 3: Terrain recording form

Survey Area									
AMG Reference	Start.....					End.....			
Landform Unit	Crest		Ridge			Hillock			
	Simple Slope		Upper Slope			Mid Slope			
	Lower Slope		Flat			Open Depression			
	Closed Depression		Stream	1 st	2 nd	3 rd	4 th		
Slope	Level		Very Gently Inclined			Gently Inclined			
	Moderately Inclined		Steep			Very Steep			
Exposure	Eroded		Aggraded			Human Action			
Geomorphological Agent	<i>Gravity:</i>		Collapse			Particle Fall			
	<i>Precipitation:</i>		Soil Creep			Mass Movement		Sheet Wash	
	<i>Stream Flow:</i>		Overbank			Channelled	Flood	Watertable	
	<i>Biological</i>		Human			Animal			
Human Action:	Road	Residential	Earthworks			Industrial	Pastoral		
	Other.....								
Level of Disturbance	1	2	3	4	5	6	7	8	
Exposure	No. of exposures.....					Exposure area.....			
Soil Type	I								
Soil Profile Exposed	Exposed:	A	A2	B	C	Vertical Profile:	Yes	No	
Geology									
Locally Available Material	Silcrete	Mudstone	Quartz	Tuff	Quartzite				
	Chert	FGS	Pet Wood	Sandstone					
Vegetation	Tall = trees>10m		Mid= shrubs+trees<10m			Low= grasses			
Groundcover	Dense= 70%		Mid-dense=30-70%			Sparse=10-30%			
	Very sparse= 10%		None						
Stone Artefacts	Absent	Present	Number.....						
Raw Materials Used	Silcrete	Mudstone	Quartz	Tuff	Quartzite				
	Chert	FGS	Pet Wood	Sandstone					

Most of the categories on the recording sheet are self-explanatory with the exception of levels of disturbance and fall of slope, which require a key to the rating system. Levels of disturbance and fall of slope were classified according to the criteria listed below. This key along with the following guide to the soils in the local landscapes was printed on the reverse of each recording form to assist with consistency in the identification of these features.

Level of disturbance criteria

- 0) No effective disturbance
- 1) No effective disturbance except for hoofed animals
- 2) Limited clearing
- 3) Extensive clearing
- 4) Complete clearing: pasture but not cultivated
- 5) Complete clearing: pasture cultivated at some stage
- 6) Cultivation, rain fed
- 7) Cultivation, irrigated
- 8) Highly disturbed, eg. mining, urban development, road

Fall of slope criteria

A guide to the slope classes covered by the landform units present in the study area can be obtained from McDonald *et al* (1990:37).

- Moderately inclined slopes = 10% to 32% range
- Gently inclined slopes = 3% to 10% range
- Very gently inclined slopes = 1% to 3% range
- Level <1%

Summary

The aim of the survey and recording methodology was to divide the surveyed site into landscape zones and areas of land use that reflect the potential for archaeological material to exist in these sections. This data would then be able to be assessed against the background information on the site and used to produce archaeological sensitivity areas for the site (see **Section 5**).

4.2 Assessment of Archaeological Sensitivity

The archaeological sensitivity of the study area was assessed on four criteria: the presence of known surface archaeological materials, the probability of undetected surface archaeological materials, the probability of subsurface archaeological materials, and the terrain integrity of each transect area. The presence or absence of surface archaeological materials and the level of effective ground surface visibility were documented during the field survey. The probability of additional surface artefacts occurring was based on these attributes. The assessment of the subsurface archaeological potential of the study area was based on the known patterning of archaeological materials in the Morisset area and field observations of the environmental characteristics and terrain integrity. These characteristics included the availability of stone materials, proximity to water resources, soil depth and landform unit.

A summary of the data recorded for each transect is presented using the following categories:

- variability of landscape (low, medium or high);
- visibility levels (low, medium or high);
- conditions for artefact detection (low, medium or high);
- effectiveness of surface survey (low, medium or high);
- availability of raw materials (present/absent);
- degree of ground disturbance from human activities (low, medium or high);
- presence of flaked stone artefacts (present/absent); and
- potential for subsurface artefacts (low, medium or high).

Comparison of these categories enables an analysis of the features exhibited within each transect, facilitating an assessment of the overall archaeological integrity and potential of each area.

Based on the results of this analysis of environmental and archaeological features a rating of low, moderate or high archaeological sensitivity was assigned to each portion of the site. The definition of these categories is as follows:

<i>Low Archaeological Sensitivity:</i>	Areas where archaeological materials are not likely to occur, as a result of removal or disturbance from land use history. Some indication of the natural soil profile or natural terrain remains, but is limited and not likely to contain archaeological materials.
<i>Moderate Archaeological Sensitivity:</i>	Areas where archaeological materials may occur. Some indication of the natural soil profile or natural terrain remains, but where high site or artefact density is unlikely to occur.
<i>High Archaeological Sensitivity:</i>	Areas known or likely to contain surface or subsurface archaeological materials. The natural soil profile or natural terrain is evident, and sites and artefacts are known to occur in this context.

4.3 Survey Results

The archaeological field survey of Moira Station cattle feedlot was conducted between Monday the 4th April and Friday the 8th of April 2005. The survey was undertaken by: Jakub Czastka and Emma Harrison (HLA), Richard Kerr (Moama LALC), and Rebecca Atkinson (Cummeragunja LALC).

A systematic survey was undertaken, which covered transects across all sections of the study area. The route of the physical inspection paid particular attention to areas potentially impacted directly by surface and subsurface earthworks (i.e. for infrastructure). A diminutive section of the irrigation areas were not covered, as they were either inundated at the time due to irrigation, and/or were deemed by HLA and the Aboriginal Sites Officers to be highly unlikely to contain heritage material - the latter based on direct experience gained from the Moira study area. Such areas were omitted on the basis that they were akin to a larger number of areas already surveyed at the site, these having withstood a high level of human and animal impact on the landscape. These practices are ultimately detrimental to the surface visibility of most

archaeologically and culturally significant materials. The site survey results themselves show that no such areas surveyed at the site were found to contain heritage material.

The greatest influence on the landscape of the study area and hence the potential to detect archaeological sites is the irrigation, ploughing and laser levelling of the majority of the study area. The only area that were not obviously (recently?) impacted by these farming practices was the north eastern block (the area between the 'ruins and shearing shed' and 'Moira irrigation channel' on **Figure 11** covering approximately 1470 m by 1000 m). Hence, although the visibility of the surface was excellent, a continuous process of sedimentation through irrigation and truncating surfaces through laser levelling of the landscape within much of the study area has affected any potential archaeological deposits on or near the surface.

All information was recorded on a survey recording sheet as described in **Section 4.1** and on base maps of the site provided by AEI. The results are presented in **Table 4**.

A total of 24 transects were walked across the study area, although the survey emphasis was on areas to be directly impacted by the proposed works (**Figure 4**). Transects are ideally separated on the basis of landscape features and landform type, but since the study area represents a large alluvial plain, largely featureless, man-made features such as irrigation channels and fencing usually demarcated transects. Each transect was individually described for potential surface and subsurface archaeology. The start, end and any other relevant features were located with GPS, while multiple photographs across each transect were undertaken.

Transects were undertaken with a spacing of approximately 20 m between each person; therefore, with four people participating in the survey transects were up to 100 m wide. The effective field of vision (for detecting surface finds) was between 5 to 10 m (depending on vegetation) either side of each participant, giving a range for width of approximately 10 to 20 m for the surface area 'effectively' covered in any individuals transect. If we take a conservative value of 10 m as the area effectively covered by each person, this translates to coverage of approximately 40 % of any given 100 m wide transect.

All transects were across what is identified as alluvial plain influenced by wind (scalding) erosion. The landform is essentially flat, relief across the study area being a maximum of 107 AHD and a minimum of 101 m AHD, the average relief across the study area being 103 – 104 m AHD. Gentle rises were present in the north east (to 107m AHD) and south west (to 105 m AHD) corners of the study area, with a slight depression in the south west (101m AHD). Overall the study area slopes from east to west – the product of uplift as a result of the Cadell faultline running immediately east of the study area boundary. All references in the ensuing discussion of transects to features such as the proposed 'feeding pens' or 'sedimentation pond' are clearly marked on **Figure 11**.

Table 4: Survey Result Summary

Transect	1	2	3	4	5	6
Start AMG Co-ordinate	E144.89590 S35.93588	E144.89143 S35.93650	E144.85272 S35.93568	E144.85782 S35.93507	E144.86025 S35.93532	E144.86315 S35.93530
End AMG Co-ordinate	E144.89589 S35.93595	E144.89057 S35.93546	E144.85682 S35.93619	E144.86001 S35.93532	E144.86317 S35.93570	E144.86498 S35.93247
Approximate Transect Area	189750m ²	238950m ²	257895m ²	40664m ²	54280m ²	96710m ²
Geological Unit	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation
Soil Landscape	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain
Terrain Unit	Plain	Flat	Flat	Flat	Flat	Flat
Slope	Very gently inclined to level	Level	Level	Level	Level	Level
Geo. Agent	Human, animal	Human, animal	Human, animal	Human, animal	Human, animal	Human, animal
Human Action	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)
Erosion Action	Wind	Wind	Wind	Wind	Wind	Wind
Level of Disturbance	7	7	7	7	7	7
Exposure Area	132825m ²	95,580m ²	77,369m ²	2,033m ²	2,714m ²	96,710m ²
% of Transect Exposed	70	40	30	5	5	100
Visibility %	90	70	30	30	30	100
Soil Profile	Mixed A and B	Mixed A and B	Mixed A and B	Mixed A and B	Mixed A and B	Mixed A and B
Vertical Profile	Yes	Yes	Yes	Yes	Yes	No
Vegetation	Low = weeds, stubble	Low = weeds, stubble	Low = grasses	Low = loosen	Low = loosen	None = ploughed field
Groundcover	Very sparse	Mid-dense	Mid-dense	Very Dense	Very Dense	Very sparse
Artefacts/Sites	Absent	Absent	Absent	Absent	Absent	Absent

Table 3: Survey Result Summary

Transect	7	8	9	10	11	12
Start AMG Co-ordinate	E144.86815 S35.93117	E144.86295 S35.93068	E144.86273 S35.93086	E144.86510 S35.93564	E144.85509 S35.94026	E144.85216 S35.93872
End AMG Co-ordinate	E144.86813 S35.93131	E144.86273 S35.93086	E144.86481 S35.93544	E144.86776 S35.93229	E144.85533 S35.93901	E144.85445 S35.93604
Approximate Transect Area	148289m ²	29842m ²	29842m ²	71179m ²	21387m ²	57621m ²
Geological Unit	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation
Soil Landscape	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain
Terrain Unit	Plain	Plain	Plain	Plain	Plain	Plain
Slope	Level	Level	Level	Level	Level	Level
Geo. Agent	Human, animal	Human, animal	Human, animal	Human, animal	Human, animal	Human, animal
Human Action	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)
Erosion Action	Wind	Wind	Wind	Wind	Wind	Wind
Level of Disturbance	7	7	7	7	7	7
Exposure Area	44,487m ²	20,889m ²	20,889m ²	56,943m ²	1,069m ²	2,881m ²
% of Transect Exposed	30	70	70	80	5	5
Visibility	80	80	70	40	70	40
Soil Profile	Mixed A and B	Mixed A and B	Mixed A and B	Mixed A and B	Mixed A and B	Mixed A and B
Vertical Profile	No	No	No	No	No	No
Vegetation	Low = weeds, stubble	Low = weeds, stubble	Low = weeds, stubble	Low = weeds, stubble	Low = weeds, stubble	Low = weeds, stubble
Groundcover	Dense	Sparse	Sparse	Dense	Very Dense	Very Dense
Artefacts/Sites	Absent	Absent	Absent	Absent	Absent	Absent

Table 4: Survey Result Summary

Transect	13	14	15	16	17	18
Start AMG Co-ordinate	E144.85495 S35.94307	E144.86513 S35.94167	E144.88143 S35.93372	E144.88083 S35.92877	E144.86375 S35.92402	E144.87228 S35.94249
End AMG Co-ordinate	E144.85592 S35.94054	E144.86610 S35.94186	E144.89862 S35.93066	E144.88086 S35.92882	E144.86380 S35.92664	E144.87230 S35.94246
Approximate Transect Area	245000m ²	16928m ²	767660m ²	431973m ²	133074m ²	52279m ²
Geological Unit	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation
Soil Landscape	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain
Terrain Unit	Plain	Plain	Plain	Plain	Plain	Plain
Slope	Level	Level	Level	Level	Level	Level
Geo. Agent	Human, animal	Human, animal	Human, animal	Human, animal	Human, animal	Human, animal
Human Action	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)
Erosion Action	Wind	Wind	Wind	Wind	Wind	Wind
Level of Disturbance	7	7	7	7	7	7
Exposure Area	73,500m ²	11,850m ²	76,766m ²	259,184m ²	13,307m ²	49,665m ²
% of Transect Exposed	30	70	10	60	10	95
Visibility	70	70	90	60	70	100
Soil Profile	Mixed A and B	Mixed A and B	Mixed A and B	A?	Mixed A and B	Mixed A and B
Vertical Profile	No	No	Yes	No	No	No
Vegetation	Low = weeds, stubble	Low = weeds, grasses	Low = grasses, tall = trees >10m,	Low = grasses, tall = trees >10m	Low = grasses, tall = trees >10m	None
Groundcover	Mid-dense	Mid-dense	Mid-dense	Mid-dense	Dense	None
Artefacts/Sites	Absent	Absent	MF1 - 3	Absent	Absent	Absent

Table 4: Survey Result Summary

Transect	19	20	21	22	23	24
Start AMG Co-ordinate	E144.87290 S35.93853	E144.87301 S35.93855	E144.86719 S35.95060	E144.86101 S35.94920	E144.85573 S35.94828	E144.84926 S35.94724
End AMG Co-ordinate	E144.87301 S35.93856	E144.86719 S35.95060	E144.86351 S35.94824	E144.86094 S35.94918	E144.85573 S35.94828	E144.84963 S35.94745
Approximate Transect Area	37284m ²	155916m ²	115316m ²	38684m ²	64400m ²	6779m ²
Geological Unit	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation	Coonambidgal Formation
Soil Landscape	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain	Alluvial Plain
Terrain Unit	Plain	Plain	Plain	Plain	Plain	Plain
Slope	Level	Level	Level	Level	Level	Level
Geo. Agent	Human, animal	Human, animal	Human, animal	Human, animal	Human, animal	Human, animal
Human Action	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)	Ploughing, levelling, channels (irrigation)
Erosion Action	Wind	Wind	Wind	Wind	Wind	Wind
Level of Disturbance	7	7	7	7	7	7
Exposure Area	3,728m ²	155,916m ²	57,628m ²	15,474m ²	19,320m ²	2,034m ²
% of Transect Exposed	10	100	50	40	30	30
Visibility	80	100	60	40	40	40
Soil Profile	Mixed A and B	Mixed A and B	Mixed A and B	A?	Mixed A and B	Mixed A and B
Vertical Profile	Yes	No	No	Yes	No	No
Vegetation	Low = grasses	None	Low = crop	Low = grasses	Low = grasses, tall = trees >10m	Low = grasses, Tall = trees >10m
Groundcover	Dense	None	Mid-dense	Mid-dense	Mid-dense	Dense
Artefacts/Sites	Absent	Absent	Absent	Absent	Present	Absent

Following guidelines for site surveys as required by DEC, **Table 5** has been presented to show the available exposure and detection of the survey.

Table 5: Survey Coverage of the study area.

Transect no.	Landform unit.	Total Area of LF unit (m ²)	Exposure (%)	Area of Exposure (m ²)	Visibility %	Area available for detection (m ²)	% of landform available for site detection
1	Plain	189,750	70	132,825	90	119,543	63
2	Plain	238,950	40	95,580	70	66,906	28
3	Plain	257,895	30	77,369	30	23,211	9
4	Plain	40,664	5	2,033	30	610	2
5	Plain	54,280	5	2,714	30	814	2
6	Plain	96,710	100	96,710	100	96,710	100
7	Plain	148,289	30	44,487	80	35,589	24
8	Plain	29,842	70	20,889	80	16,712	56
9	Plain	29,842	70	20,889	70	14,623	49
10	Plain	71,179	80	56,943	40	22,777	32
11	Plain	21,387	5	1,069	20	214	1
12	Plain	57,621	5	2,881	20	576	1
13	Plain	245,000	30	73,500	70	51,450	21
14	Plain	16,928	70	11,850	70	8,295	49
15	Plain	767,660	10	76,766	90	69,089	9
16	Plain	431,973	60	259,184	60	155,510	36
17	Plain	133,074	10	13,307	70	9,315	7
18	Plain	52,279	95	49,665	100	49,665	95
19	Plain	37,284	10	3,728	80	2,983	8
20	Plain	155,916	100	155,916	100	155,916	100
21	Plain	115,316	50	57,658	60	34,595	30
22	Plain	38,684	40	15,474	40	6,189	16
23	Plain	64,400	30	19,320	40	7,728	12
24	Plain	6,779	30	2,034	40	813	12
AVERAGE		137,571	44	53,866	62	39,576	32
TOTAL		3,301,702		1,292,791		949,833	

In general the site was comprehensively covered due to these high numbers of personnel and time allocated for the survey. As can be seen in **Table 5**, over 32% of the total area surveyed (330 hectares - equivalent to 3,301,702 m²) had good visibility and was available for archaeological detection, an area of some 95 hectares (equivalent to 949,833 m²).

Transect 1 was located in a section to the west of the Cobb Highway and east of the ruins and shearing sheds. The transect was demarcated by fence lines on the north, south, and west and by an irrigation channel to the west. An east west track connecting the property with the Cobb Highway was immediately north of the southern boundary. The transect has a barely perceptible fall of 3 to 4 m from east to west and is one of the highest points of the study area. The area has been subject to ploughing and irrigation (**Plate 1**). Groundcover was sparse – around 30 % -

and limited to straw and weeds. Soils were a red brown clay to fine sandy clay, a disturbed topsoil mixed with subsurface alluvial clays. No Aboriginal sites were located.

Transect 2 was located in the field immediately south of transect 1. The transect was demarcated by fence lines to the north, east and west, the east side abutting the Cobb Highway, the southern side being the start of transect 3. An irrigation channel also traversed the northern and eastern boundaries just inside the fence lines (**Plate 2**). Again, this area has been subject to flood irrigation, ploughing and laser levelling, although grass cover has been reestablished. Vegetation consisted of grass and weeds, obscuring approximately 60 % of the ground surface (**Plate 3**). A vertical profile was visible across a large section of the study area because of the irrigation channel. Deposits were a red brown clay to fine sandy clay, a disturbed topsoil mixed with subsurface alluvial clays. No Aboriginal sites were located.

Transects 1 and 2 were located in the area demarcated for the fresh water storage pond (1000 l).

Transect 3 was located across the areas marked as the burial pit, sedimentation pond and holding pond (northern half), the transect being located in the section immediately west of the feed pens (**Plate 4**). The transect was bounded by fence lines on all sides. The area was a flat landform, with the main surface deposit being red brown clayey silt, representing disturbed topsoil. Irrigation channels were present on the north and south boundaries. Vegetation consisted of low grasses and weeds and covered approximately 70 % of the ground surface. No Aboriginal sites were located.

Transect 4 was located east of transect 3 within the proposed feed pen area – the north east quarter. The transect was located within a series of fields currently under irrigation and growing loosen (**Plate 5**). The area was a flat landform, with the main surface deposit being red brown clayey silt to silty loam, representing disturbed topsoil. Due to the loosen, vegetation covered approximately 95 % of the ground surface. No Aboriginal sites were located.

Transect 5 was located immediately east of transect 4, within the north eastern section of the proposed feed pen. The transect was again located within a series of fields currently under irrigation and growing loosen. The area was a flat landform, with the main surface deposit being red brown clayey silt to silty loam, representing disturbed topsoil. Due to the loosen, vegetation covered approximately 95 % of the ground surface. No Aboriginal sites were located.

Transect 6 was across a ploughed field demarcating the north west corner of the proposed feed lot. The boundaries of the transect were fence lines on all cardinal points. A heavy red clayey loam to grey brown loam² were present as a disturbed topsoil. The red soils were broadly confined to north west and south west corners of the paddock, the remainder being mainly the grey brown loamy material. Vegetation on the surface was absent apart from some thistles on the western edge of the ploughed field, meaning visibility was > 95 % of the ground surface. No Aboriginal sites were located.

Transect 7 (**Plate 6**) was situated within a ploughed field in the north east corner of the proposed feedlot pens. The boundaries of the transect were fence lines on all cardinal points. A red brown clayey loam to clay was present on the plain as disturbed topsoil. Vegetation on the surface was thistles and straw, meaning visibility was around 30 % of the ground surface. No Aboriginal sites were located.

Transect 8 was located in the north west quarter of the proposed feeding pens (**Plate 7**, the area being a ploughed field. A red brown clayey loam to clay was present as disturbed topsoil.

² This may be traces of the remnant topsoil identified by Richard Chandler (GHD) in TP25 immediately south of the area demarcated as 'receivals' in the centre of the study area. Transect 6 is located approximately 850 m to the north west of TP25.

The landform is a continuation of the alluvial plain. Vegetation on the surface was thistles and straw stubble, although visibility of the ground surface was around 70 %. No Aboriginal sites were located.

Transect 9 was located to the east of the proposed feed pen, again the landform a continuation of the alluvial plain. The area has been left fallow for some time, although vegetation was sparse and a combination of thistles and occasional grass and other weeds. Ground surface visibility was around 70 %, showing a brown clayey loam deposit, again disturbed topsoil. No Aboriginal sites were located.

Transect 10 was located to the south of transect 9 in the north central section of the study area. The alluvial plain here indicated a fallow cultivation area with dense regrowth (weeds and grasses) of approximately 80 % covering the ground surface. A red brown clayey loam to clay was present as disturbed topsoil. No Aboriginal sites were located.

Transect 11 was located across the areas marked as two sedimentation ponds immediately west of the southern half of the proposed feed pen. Grass cover was very dense here (95 %), the area obviously lying fallow from cultivation (probably seeded) for some time (**Plate 8**). Where visible, the ground surface indicated a brownish red clay / clayey loam, representing a disturbed topsoil. No Aboriginal sites were located.

Transect 12 traversed the south west corner of the feed pen immediately east / south east of the sedimentation ponds. Similar to transect 11, grass cover was very dense here (95 %) – again, the result of the area obviously lying fallow from cultivation (and probably seeded) for some time. Where visible, the ground surface indicated a brownish red clay / clayey loam, representing a disturbed topsoil. No Aboriginal sites were located.

Transect 13 (**Plate 9**) was located within the south west corner of the area earmarked for the proposed feeding pens. Vegetation cover within this part of the study area was around 70 %, the visible ground surface indicating that the soil was a disturbed brown loam topsoil. No Aboriginal sites were located.

Transect 14 was located within to the east of transect 13 over the area near the south eastern corner of the proposed feeding pens (**Plate 10**). Vegetation cover within this part of the study area was around 70 %, the visible ground surface indicating that the soil was a disturbed brown loam topsoil. No Aboriginal sites were located.

Transect 15, from near the historic ruins to the Cobb Highway, is flat and level. (**Plate 11**). The route follows the southernmost tree line of the northern wooded area, and contains a dam with exposed soils present at the northeast corner of the transect. Further to this there are some dry earthworks located in the southwest of the transect. Both earthworks display exposed A / B horizon – a red brown loam. Approximately 10% of the total transect area was exposed in places to 90% visibility due to erosion scouring. Exposure in the area is middling, with visibility hindered by coverage of grasses and some low weeds. The area is scattered with pockets of tall trees and sapling regrowth. A total of three archaeological sites were recorded in this transect, which was the total number of sites recorded in the study area as a whole. This is not surprising considering that this area has the least impacted landscape at the site, and has not been as intensively cleared, irrigated and tilled – at least in the recent past.

Transect 16 runs to the northwest of the previous transect, and is located in the central northern area of the site (**Plate 12**). The route followed forms a wide loop of coverage, with the end of the transect being at the same point as the start. The overall area is less densely wooded than the prior transect, although much of the area should still be classified as an open woodland with established tall trees and some regrowth present. The majority of this transect is vegetated with low grasses and thick infestations of Bathurst Burr, particularly to the west, making visibility

middling – some 30 % of the ground surface was exposed. The landscape is flat and level, and shows evidence of relatively recent ploughing and irrigation practices. Irrigation channels are present in the north and west of the area. There is also evidence of animal impact in the form of fox dens and rabbit burrows, and the usual sheep/cattle interference. Ground surfaces revealed a disturbed topsoil horizon. No Aboriginal sites were located.

Transect 17 surveyed the most northwest point of the site, within the proposed irrigation area in that section (**Plate 13**). This transect covers the central and southern portion of this area (see **Figure 4**, with coverage finishing approximately 400m from the point of origin. The transect crosses a flat, level landscape with a dam located in the northeast corner of the paddock and a dry irrigation channel present. Ground cover is low grasses and weeds, which make for dense ground vegetation (approximately 90 %), with some tall trees present to the north and west. Topsoil indicates a red brown loam – again, most probably a disturbed topsoil. No Aboriginal sites were located.

Transect 18 was located in the south central portion of the study area covering the area proposed for fresh water storage (see **Figures 4 and 11**). The area revealed fairly wet surface conditions, the result of irrigation. Ground exposure was however at 95 %, straw stubble making up the remainder. The ground surface indicated a disturbed topsoil – a red brown loam. No Aboriginal sites were located (**Plate 14**).

Transect 19 encompassed the proposed footprint of the buildings central southern portion of the study area (see **Figures 4 and 11**). Surface deposits indicated a disturbed topsoil, being a grey brown loam, where vegetation cover left approximately 10 % of the ground surface visible (**Plate 15**). Vegetation was limited to low grasses and weeds. No Aboriginal sites were located.

Transect 20 was located in a paddock midway along the southern boundary of the study area abutting Stud Farm Lane. An irrigation channel delineated the eastern boundary of this transect. There was no vegetation cover, visibility being a 100 % (**Plate 16**), revealing a disturbed topsoil – a red brown loam – still subject to irrigation. No Aboriginal sites were located.

Transect 21 was located within the same field parameters as transect 20 except for the fact it was immediately north. Again an irrigation channel delineated the eastern boundary of this transect, however vegetation cover indicated a visibility of around 50 % (**Plate 17**), revealing a disturbed topsoil – a red brown loam – still subject to irrigation. No Aboriginal sites were located.

Transect 22, as for transects 23 and 24, were all located within the south west corner of the study area within fields obviously used for irrigation, immediately west of transects 21 and 22 (see **Figure 4**). Surface cover was low grasses and weeds with occasional trees, exposures being approximately 40 % (**Plate 18**). Topsoil was a disturbed deposit showing a red brown loam. At least five irrigation channels running east west were noted during the course of this transect. No Aboriginal sites were located.

Transect 23 was located west of transect 22 and traversed a north south route. Surface deposits indicated a disturbed topsoil of red brown to grey brown loam, with a medium density vegetation cover of around 70 %. Both transects 23 and 24 were bounded on the north side by a dam (**Plate 19**). No Aboriginal sites were located.

Transect 24 was the final transect traversed across the study area. As for the previous transect, surface deposits indicated a disturbed topsoil of red brown to grey brown loam, with a medium density vegetation cover of around 70 %. No Aboriginal sites were located.

4.4 Sites identified

Three evident Aboriginal sites were identified within the study area. All identified sites are located within Transect 15 of the survey, in an area that is not under direct impact from the proposed feedlot, and is relatively less disturbed than the surrounding landscape. All archaeological sites have been identified as areas of high sensitivity in **Figure 5**.

The first Aboriginal site discovered was a scarred tree, identified as MF1. (**Plates 20 and 21**). This scarred tree was found in the northern irrigation area, within a pocket of box tree and bull oak and associated sapling regrowth approximately 1 km west of the Cobb Highway. The area is adjacent to the northern extremity fence that runs in an east-west direction over the property. The site consists of a grey box tree (*Eucalyptus microcarpa*) of around 10 metres in height with at least 8 carved toeholds ascending up the central trunk of the tree. The substantial natural regrowth over these toeholds is indicative of the considerable age of the carvings. It is estimated that the tree itself is at least 150-200 years old. The carved tree will not be directly impacted by the proposed development, it being located around 1km to the north of the area of impact.

Two further archaeological sites were identified. MF2 was identified as a hearth mound (**Plate 22**), located in the area adjacent to the northern extremity fence, approximately 800m west of the Cobb Highway. The mound consists of an area raised approximately 30cm above the surrounding flat, is approximately 9 metres in diameter from north to south, and is comprised of dark grey ashy deposits (**Plate 23**) and large clumps of burnt clay. Such "oven mounds" are sites common to the Murray River Valley region.

The remaining site is an isolated artefact identified as MF3 (**Plate 24**). Again situated in the area adjacent to the northern extremity fence, the site is approximately 480 meters west of the Cobb Highway. The site consists of a core fashioned from the base and lower walls of a bottle, indicating post-contact use of local Aboriginal stone tool technology (**Plate 25**). The core displays three clear flakes that have been struck off in a downward motion (towards the bottle base). Some microflaking may indicate earlier intentional flaking of the core. Stylistic traits of the bottle itself, such as the thick nature of the glass base and walls, the dark opaque colouring of the glass, and imperfections in the moulding of the base, show the considerable (historical) age of the glass medium.

4.5 Interpretive Framework

One of the greatest drawbacks in consultancy-based archaeology is that the level of interpretation provided for individual development-driven projects is limited. This is due to the obvious constraints imposed by time and finances on most projects, but also the absence of rigorous regional or local archaeological studies funded by government bodies, which would act as research frameworks archaeologists could work within. The result is a distinct lack of cohesion or connectedness across archaeological studies, where interpretations are often 'isolated' in their relevance to a particular study area only. The following section makes an attempt to address this issue. It does so by providing a model of regional archaeological structure based on a model developed by Foley (1981a; 1981b), at the same time providing further interpretive resolution by assessing site formation models. Although by no means the last word on the subject, it at least provides a framework in which to attempt the interpretation of archaeological versus natural patterning for the study area itself, as well as addressing the nature of the original archaeological patterning. The authors will seek to develop this 'model' approach in subsequent studies and the ensuing section should be viewed with this in mind.

4.5.1 Site Formation and Integrity

Observations during the survey and available published data were used to create a geomorphological model of the landscape in order to better understand the age and formation processes identified in the survey and their potential to retain archaeological deposits. In particular, a series of processes are identified that have served to alter, bury or erode soils with the potential to contain archaeological deposits

The changes that occur through time, which effect stream valleys are caused by various fluvial, alluvial and slope controlled processes. The magnitudes of these processes are controlled by several factors, specifically climate, topography, vegetation, hydrology (including those associated with sea level changes) and geology. In essence there are few changes caused by any one process that do not have ramifications or knock-on effects for other processes. Landscapes, of which slopes and stream valleys are a component, are dynamic and therefore continuously changing and evolving. A summary of these basic micro-depositional environments is given below in **Table 6**.

Table 6: Survey Coverage of the study area. Geoarchaeological Classification of Select Micro-depositional Environments (Modified from Butzer, 1982; 57: Table 4.4).

Type	Erosion	Transfer	Bedding, texture	Sorting	Archaeological Prospects
Fluvial Delta	Little local erosion, with sediment carried in from watershed, channel migration	Hydrodynamic mobilisation of suspended and solute sediment;	Characteristically extensive, massive beds, dominantly, some sedimentary structures; clayey/silty, with some sands and precipitates	Mainly moderate to good	Suitability for settlement or exploitation varies according to season and microenvironments; prone to flooding on lower slopes, includes drainage problems; subject to periodic deposition
Flood Plain	Channel cutting; surface denundation; localised but pervasive small-scale scour	Hydrodynamic mobilisation of suspended and bed-load sediments at variable energy thresholds	Complex vertical and lateral facies sequences, commonly lenticular, partly cross-bedded, ranging from clays to cobble gravels	Moderate to good	Suitability for settlement or exploitation varies according to season and microenvironments; preservation of intact sites threatened by periodic erosion and repeated geomorphic activity

Type	Erosion	Transfer	Bedding, texture	Sorting	Archaeological Prospects
Slope	Slow or rapid stripping of upland, crest slope, or mid-slope (soil or rock waste)	Complex range of dry, gravity, plastic, and hydrodynamic transfers, often in combination with frost	Thin to massive bedding, poorly stratified, with mixed facies common; sometimes contorted or festooned; loamy to rubbly textures	Generally poor	Sedimentation in swales or on footslopes may preserve parts of surface sites, but secondary palimpsests are more common, due to multiple reworking

The Riverine Plain has been subject to alluvial and fluvial and aeolian influences, largely dependent on the prevailing climatic conditions of previous geological epochs. The study area would have been subject to episodic alluvial deposition, almost certainly with soil formation in certain places. Alternatively, drier climatic periods moving away from climatic 'optimums' resulted in aeolian erosion and deposition and soil formation would probably have suffered due to the absence of sufficient water to promote pedogenesis (see **Figure 10** for summary various climatic regimes over the last 40 000 years or so). At a very basic level, the consideration of the study areas evolution needs to consider time transgressive stratigraphic sequences with both historical overlap (as in what happens within a pro-grading alluvial plain, i.e. deposits overlap as they extend horizontally) and without historical overlap (which occurs when deposits build up vertically). An appreciation of the fact that both wind and water would have eroded soils as well as deposited them is also necessary, as is the fact that the current surface deposits has been altered substantially from their natural state (see **Figure 9** for different alluvial formation models based on stream flow).

A set of criteria is examined during the course of assessing whether a deposit has the potential to contain archaeological features or objects. At a very basic level, potential archaeological deposits with in situ or relatively undisturbed contexts³ require conditions that reflect a relatively level land surface - usually well-drained or at least seasonally dry soils - with increasing potential being awarded to factors like proximity to resources such as water or stone, with nominal post-depositional alteration. Other types of contexts likely to contain archaeological objects but within secondary contexts are river gravels or slopes (see also **Table 6** above).

Many of the concepts and methods described above are not strictly speaking 'archaeological.' They are for the most part developed by earth scientists to investigate the natural processes that occur across and beneath the earth's surface. However, at the most fundamental level, the identification of landsurfaces, their relation to natural features such as rivers, shorelines and hills and their long-term evolution, provides essential contextual data that is necessary for the correct interpretation of archaeological features and objects. Geoarchaeologists apply these criteria to specifically 'archaeological' scenarios, where the resolution, spatial parameters and paradigms are very distinct from purely 'geological' approaches. Such 'landscape' data influences not only the survival of archaeology, but also the identification (or not) of it's potential existence within the landscape.

³ For the purpose of this study, in situ and bioturbated soils that reflect no or minimal spatial patterning disintegration are termed 'primary' contexts, and deposits that reflect depositional environments such as river gravels, slopes or beaches, are described as secondary contexts.

The potential for establishing chronosequences⁴ across and within landscapes is a necessary prerequisite if we are to identify and understand local and regional archaeological patterns.

4.5.2 Archaeological Models

Models represent simplified representations of a more complex reality (Shaw and Jameson, 1999: 403). They can be used to tackle 'tactical' issues such as the break-up of stone artefacts, to larger 'strategic' problems such as the spread of microlith industries across Australia. Further, the model known as the 'statistical cycle' (after Orton, 1980) is an expression of the way that archaeologists interact with their material in a research (or consultancy) setting. This sees the relationship between theory and data as mediated through models, which vary in their complexity and expression. The distinct advantage of this approach is that it does not confine the archaeologist to any particular paradigm of research.

As indicated in **Section 4.3**, the basic model that will be utilised here to look at 'archaeological structure' (simply the way that artefacts are distributed across the landscape) is based on the work of Foley (1981a; 1981b). At a simplistic level, **Figure 7** (left image) graphically expresses what is considered to be a fair representation of the distribution of activities within a home range (the area in which resources are exploited), whilst **Figure 7** (right image) graphically expresses the subsequent pattern of artefacts. This model is based on the concept that archaeological data relates primarily to long term, gross behavioural characteristics (Foley, 1981a: 1). The 'home range' is not tied in to any precepts concerning the short, medium, or long-term 'settlement' of a particular area. The home range concept can also be likened to 'site catchment analysis', a phrase first explicitly coined by Higgs in the 1970s (Vita-Finzi and Higgs, 1970), which refers to the evaluation of the natural resources within an easily exploitable distance of a given settlement or site. The limits of the model are (after Foley, 1981a: 1) "(a) that it applies primarily to small scale, mobile societies, principally hunter-gatherers; (b) that it is predominantly useful for populations using a lithic technology, and treats lithic artefacts only; and (c) that it is most appropriate in stable or degrading, moderately uniform landscapes with good surface visibility."

The basic hypothesis outlined by Foley (1981a:2) was that the archaeological record is spatially continuous and the nature of the distribution should be viewed in terms of a variable artefact density across the landscape (what he called the "regional archaeological structure"). From the authors' general experience within NSW, it is **rare** that any given location within the landscape does not contain some evidence of Aboriginal archaeology – and only then because it has been disturbed or deposits removed or destroyed.

Foley (1981a:2) considered that spatial continuity resulted from the operation of three processes: behaviour and discard (i.e. human activities such as making tools or gathering food-stuffs); accumulation (i.e. the archaeological record usually reflects repeated events 'superimposed' over one another such as a knapping location); and post-deposition (i.e. processes that occur after a site has been abandoned such as burial, slope wash or ploughing). This is the theoretical basis of Foley's now famous (to archaeologists) "off-site" archaeological model. For the purposes of this study, post-depositional processes form the focus of assessment, since for many of the landforms present (particularly slopes and to a lesser degree alluvial terraces/flats), natural and post-Contact man-made processes have either created or exaggerated 'archaeological' patterning.

With the arrival of Europeans in Australia and the introduction of farming and the development of urban centres and associated infrastructure, the Australian landscape was (and continues to be) put under a variety of processes detrimental to the stability of landsurfaces, particularly

⁴ A Chronosequence can be defined as a genetically related suite of soils, in which vegetation, topography and climate are similar (Harden, 1982; quoted in Gerrard, 1992:5).

soils. In effect, a landscape that was *relatively* stable (except at times of climatically introduced stress - e.g. the absence of vegetation due to smaller water budgets during the Last Glacial Maximum between c.27,000 – 17,000 years Before Present (BP) or, localised cycles of erosion/deposition and soil formation within particular catchments) for long periods of time has, in the space of a just over 200 years, been subject to problems of slope instability and the subsequent erosion of soil mantles. These processes serve to alter the archaeological patterning of objects and sites, which includes processes that alter horizontal and vertical site integrity, in addition to removing and/or destroying Aboriginal sites. From the perspective of *archaeological* significance (cultural significance is different because Aboriginal people consider all Aboriginal objects and sites, regardless of condition, as significant), the study area has been markedly affected by laser levelling, ploughing and irrigation, as well as the construction of roads and dams etc. Except for the north eastern section of the study area, the condition of the landscape indicated that the likelihood of finding in situ archaeological material on the current surface is extremely low. Subsurface indications were largely confined to the upper sections of the soil profile exposed in irrigation channels. Unfortunately, repeated wetting and drying through irrigation, weathering and stock damage rendered all of these exposures as virtually useless for the purposes of soil descriptions, although the geotechnical investigation only revealed a single area with a remnant truncated natural topsoil (TP 25; pers.com R. Chandler; May 2005). However, the main point in regards to the study area is its identification as an area with two previous creek channels running in a east to west direction, dated by the geological series map (**Figure 2**) as part of the Holocene. These channels are part of the Coonambidgal Formation, which overlies the Shepparton Formation (Pleistocene) on the study area. Both of these deposits reflect the gently sloping nature of the alluvial plain that makes up the Riverine Plain. The most notable and widespread geomorphic features of the Riverine Plain are therefore fluvial in character with associated alluvial plains. These processes will have had a direct influence on the nature, extent, survival and detectability of Aboriginal archaeological sites resident within the Riverine Plain. Most notably, identifying whether the study area has subsurface potential will be dependent upon the absence or presence of palaeosols (old land surface / soils formed under different climatic conditions to today). The secondary identification of geomorphological processes that create either time transgressive sequences with or without historical overlap is also of paramount importance as it would help identify the potential for lateral or vertical sequences. In developing any model for the formation of archaeological sites in the Riverine Plain, **Figures 8 and 9** would be essential to understand and predict these processes.

Figures 8 and 9 illustrate fluvial and alluvial processes in 'schematic' form. These two figures illustrate the features and types of floodplains created by differing fluvial regimes. Although the possibility exists that in situ buried archaeological deposits may be present within the context of the Riverine Plain, there is also a high likelihood of discovering sites that are in secondary contexts. There are techniques (largely borrowed and adapted from sedimentology and geomorphology by archaeologists) to ascertain the main post-depositional processes that may have affected sites and artefacts. These range from specific archaeological techniques like the refitting of artefacts, to plotting 'rose' diagrams using orientation and dip data taken on artefacts.

4.5.3 Discussion

The study area falls within the catchment of Murray-Darling Basin, more specifically the Riverine Plain. The study area is limited to an extensive alluvial floodplain with a very slight rise in the north eastern section.

With our current understanding of general Aboriginal settlement patterns within the Riverine Plain, the local archaeological context reveals a suite of sites that are clustered around the Murray River. The Murray has soft sediments in which to dig graves (sandy deposits), Eucalypt trees from which to make canoes, shields etc (as well as proximity to waterways), plenty of food (shellfish, game and waterfowl) discarded to create middens, exposures of raw materials such

as ochre, as well as plenty of water and hence campsites which lead to the creation of oven mounds for cooking. Processes such as sand mining, logging and flooding all serve to expose areas not normally visible and are often the main cause, either directly through impacts or indirectly through Aboriginal heritage assessments, of identifying Aboriginal sites.

Firstly, it can be concluded that not all landforms surveyed have provided evidence of Aboriginal sites, with sites concentrated around the floodplains of the modern-day Murray and in exceptional circumstances, around palaeochannels of the Murray River. Furthermore, specific depositional environments around dunes and relict lakes across the general region have also revealed exceptionally significant Aboriginal sites – namely Lake Mungo to the north (and associated lakes within the Willandra Lakes World Heritage Area) and Kow Swamp to the west. Furthermore, with the concentration of hunter-gatherer-fisher activities around active drainages – with the density of sites falling the further one moves away from available water – the likelihood of locating Aboriginal sites away from modern or palaeodrainages would be dependent largely upon the presence of truncated or exposed lake-side, dune or alluvial soils. Unsurprisingly therefore, this archaeological picture is somewhat biased towards archaeological sites adjacent to creeklines or lakes (and their associated dunes) and the time of year and density of vegetation cover encountered at the time of the archaeological surveys (affecting visibility and hence detectability of archaeological sites). Furthermore, because of these issues of detectability, Aboriginal sites are usually most visible in areas experiencing erosion. It is true to say that the ability to detect Aboriginal sites is largely influenced by this fact, in the absence of subsurface testing programs. The density of Aboriginal sites, however, varies according to landform. Taking into account Foley's model outlined above (see also **Figure 7**), this is to be expected.

In terms of general archaeological patterning (regional structure), the continuous exploitation of an area over time by hunter-gatherers leads to an increase in the absolute density of artefacts and the effects of blurring are seen ('accumulation' process described above). Hunter-gatherer people set up camps (be they short, medium or long-term) based on the habitat context (Foley, 1981b: 159), rather than the exact location of any particular settlement (for example, pastoralists re-using huts in upland pastures grazed only during the summer months). This is true of creeklines in general, where repeated visitation over very long periods of time can create a very dense archaeological pattern of stone artefacts (although the erosion and deposition of artefact concentrations by fluvial processes have to be considered and 'filtered' out). Conversely, sites on slopes, breaks of slope and footslopes are often the result of slope processes (water, gravity) and concentrate artefactual material to resemble sites (discussed in **Section 4.5.1** above). Finally, the more recent human actions (such as drainage excavations, dam construction etc) can expose sites. Other detrimental processes such as salt scalding that cause and intensify the erosion of soil mantles, are also present within the survey area.

5 ASSESSMENT OF ARCHAEOLOGICAL SENSITIVITY

The assessment of the archaeological sensitivity of each survey unit is based on the following three criteria (following the discussion in **Section 5.2**):

Criterion 1 The presence of known surface archaeological materials.

The known locations of previously recorded archaeological sites within the study area have been plotted on the topographic map of the region (**Figure 1**). A review of archaeological work in the region and the AHIMS site cards, as well as the archaeological survey and assessment have identified that a number of previously recorded sites are near the study area.

Three new sites were identified, all within the low impact zone at the northern extremity of the study area: MF1, MF2 and MF3. MF1 is an Aboriginal carved tree; MF2 is a possible hearth mound, whilst MF3 is a glass core fashioned from a bottle base.

Criterion 2 The probability of undetected surface archaeological materials.

The probability of undetected surface materials occurring within the study area is assessed on a number of characteristics. These include:

- The analysis of effective ground surface visibility within the study area.
- The terrain context and integrity of areas.

Ground surface visibility is the most common obstacle in the detection of archaeological material. Low, dense vegetation limits effective survey coverage to a low, or moderately low level. The likelihood of detecting surface archaeological materials in these densely vegetated areas is low. Therefore, this assessment relies on the terrain context and the level of landscape integrity within each transect.

The terrain integrity within the study area has been documented to identify whether archaeological material could still be found in those areas, or whether they would have been removed as a result of past disturbance. The probability (classified as low, moderate or high) of surface archaeological materials occurring within specific landscape contexts may then be considered.

The surface deposits of the study area revealed a highly disturbed landscape. Surface soils typically represented a mixed A and B horizon of loam. The post-war development of an irrigation system across the study area, with subsequent laser levelling, ploughing and irrigation (bringing in silts and clays to inundate and mix with surface deposits), in addition to around a 150 years of pastoral use of the study area means that it has been impacted to such a high degree that the probability of the survey having missed surface archaeological materials is extremely low.

Criterion 3 The probability of subsurface archaeological materials.

The assessment of the subsurface archaeological potential of the survey area is based on a number of criteria, including:

- The known patterning of surface and subsurface archaeological materials throughout the local region.
- The terrain characteristics of known archaeological (surface and subsurface) sites.

The field survey examined terrain contexts where subsurface archaeological materials may have occurred in currently uncleared land, such as in upturned tree bowls or exposed sections,

but failed to find any evidence. This information allows the probability (classified as low, moderate or high) of subsurface archaeological materials occurring within specific landscape contexts to be established.

Existing levels of terrain integrity and the demonstrated patterns of the surface and subsurface distribution of archaeological materials in the study area were used as the main evidence in the following evaluation. As there is no evidence of buried archaeological material in the immediate area, this evaluation is based upon the potential for intact natural soils to exist. Following geomorphological models (see **Section 4.5.1**), no areas were highlighted to have the potential to contain potential archaeological deposits. The alluvial floodplain represented by the study area has the potential to contain subsurface archaeological deposits wherever palaeosols are encountered dating to anywhere in the past 40-50 000 years. However, this point needs to be clarified in the context of the current study. No evidence of buried alluvial soils was observed during the course of the current survey (although subsurface exposures were limited in number and value), nor did the geotechnical investigations identify any potential palaeosols. The last point should be made with the proviso that the geotechnical investigations were limited to the engineering qualities of the study areas soils rather than their origin and chronosequence. Although the regional picture identifies a long history of landuse by Aboriginal people, these sites represent the exception rather than the rule. Therefore, the probability of subsurface archaeological materials within the study area is low.

5.1 Sensitivity Rating

Zones of archaeological sensitivity can be delineated on the basis of this assessment of the probability of additional archaeological material occurring in the study area. This assessment relates to the probability of material occurring and does not address scientific significance or the cultural significance of the material to Aboriginal community members.

Low or Nil Archaeological Sensitivity

The areas indicated on **Figure 5** that are impacted by laser levelling, ploughing, irrigation services, and/or roads are assessed to be of low or nil archaeological sensitivity where archaeological material is unlikely to occur as the terrain has been significantly altered.

Moderate Archaeological Sensitivity

Areas of 'relatively' undisturbed terrain outside the area impacted by laser levelling, ploughing, irrigation services, and/or roads, or that are considered to retain natural deposits are shown on **Figure 5** and assessed to be of moderate archaeological sensitivity where archaeological material may occur, as the terrain has not been significantly altered. There is some evidence of surface material but the presence of potential subsurface deposits indicates a potential for archaeological material.

High Archaeological Sensitivity

Areas that have known or recently discovered Aboriginal sites have been identified as being of high sensitivity and are shown in **Figure 5**. In this study, the only areas that have been identified as highly sensitive are sites MF1 to 3 inclusive. These sites are all located within the north eastern portion of the study area away from any direct impacts from the proposed feedlot and associated infrastructure.

5.2 Summary of Results

The archaeological survey and assessment divided the survey area into areas of low, moderate or high archaeological sensitivity. This assessment was based on three criteria: the presence of

known surface archaeological materials, the probability of undetected surface archaeological materials, and the probability of subsurface archaeological materials. This assessment was therefore based on the results of the field survey, within the broader framework of the archaeological understanding of site distribution within this region.

In summary, there is a low to nil potential for archaeological material to occur in the areas currently affected by laser levelling, ploughing, irrigation services, and/or roads. This encompasses the vast majority of the study area (see **Figure 5**).

Only one area has been assigned as moderate sensitivity due to its 'relatively' (in comparison with the remaining areas) undisturbed condition. It is located within the north eastern section of the study area and is outside the area of impact.

Three Aboriginal sites were identified: a scarred tree (MF1), a potential oven mound (MF2) and a glass bottle base reused as a core (MF3). All three locations have been identified as high sensitivity due to the presence of Aboriginal objects protected under the NPW act 1974 (as amended).

Table 6 lists the archaeological sensitivity of all transects recorded and areas examined and **Figure 5** illustrates these locations.

Table 6. Archaeological sensitivity of areas examined.

Low or Nil Archaeological Sensitivity	Moderate Archaeological Sensitivity	High Archaeological Sensitivity
All existing areas used for irrigation, ploughing and laser levelling, including roads and agricultural infrastructure – silos, sheds, irrigation channels	North eastern section of the study area	Areas containing known Aboriginal sites specifically MF1 to MF3.

6 MITIGATION MEASURES

This section discusses the proposed development, the statutory controls relating to Aboriginal heritage and outlines a management strategy including appropriate mitigation measures for implementation.

6.1 Proposed Development

The proposed development is an 80,000 head of cattle feedlot located at Moira Station, which is approximately 12km south of Mathoura in southwestern NSW. The proposed feedlot would occupy a footprint of approximately 600 hectares (**Figure 11**). Cattle weighing 300kg would be transported to the feedlot and housed in pens. The cattle would be fed grain until they reach a designated weight (529kg) whereby they would be transported from the site to an abattoir.

6.1.1 Project Elements

The proposal comprises the following elements:

- Feed pens;

Ninety six (96) pens measuring 61m by 168m would be established to contain the cattle on site. The feed pens will slope from east to west. The relative levels of the pens have been designed to provide an approximate balance of cut and fill on the site. Material excavated from the holding pond will be used as fill under the pens.

Pavement material for a 300mm thick layer under the pens will be extracted from a separate borrow pit off site. The highest point on the pen area will be 1.35m above existing ground level. The feedlot pens would have a slope of 3% which fall to lateral drains with a slope of 0.2%. The lateral drains would run between the cattle alleyways.

Four lateral move irrigators would be installed and used during the summer months. These irrigators would extract water from a concrete channel east and west of the pens and be used for cooling, dust control and maintaining pad moisture.

- Internal roadways;

Feed and cattle lanes would be established between each of the pens. These roads would be 4m wide to enable vehicles to deliver feed to the feed banks of the pens. Additionally, an 8m wide roadway between the site receivals area and the Cobb Highway would be established. This roadway would be sealed and cater for vehicles, including B-Doubles, delivering and transporting feed, cattle and compost. Pavement material for a 300mm thick layer under the roads will be extracted from a separate borrow pit off site.

- Ancillary buildings;

Ancillary buildings for the purpose of feedlot administration would be established.

- Effluent storage;

Water from the holding pond would be pumped up into the irrigation storage, and fresh water supplied to the storage via the freshwater storage located on the eastern section of the site. Water from the effluent storage, consisting of a mixture of freshwater, runoff, and waste water would be directed into irrigation channels to flood irrigate the fields adjacent to the feed pens. The storage will be capable of holding all wastewater and runoff during the wet winter months when irrigation will not be taking place. The storage area would have a capacity of 500ML.

- Receivals area;

Cattle would be delivered in the receivals area, which would be connected to the Cobb Highway by an internal access road.

- Freshwater storage;

A freshwater storage of 2,000ML capacity would be constructed in the northeastern corner of the site.

- Sedimentation and Holding ponds;

Runoff from the feedlot will be directed into two sets of twin sedimentation ponds. Each sedimentation pond would measure 95m by 46m at the floor and have depths from 0.37m to 0.75m. A channel with an approximate slope of 7% will connect the sedimentation basins to a holding basin, via concrete box culverts measuring 1500mm x 900mm and 16m in length. The holding basin would measure 870m by 181m at the top with side slopes of 1V:3H. The floor would be 6.2m below ground level and water depths in the sedimentation and holding ponds would not exceed 1.5m and 3m respectively. Material excavated from the holding pond will be used as fill under the pens.

- Irrigation area;

The irrigated area will cover 379ha, comprising 300ha of liquid waste irrigated crop and the remainder made up of drains, roads and channels.

- Diversion of Moira Irrigation Channel.

Some existing channels of the Moira Irrigation Channel will be re-directed around the footprint of the proposed development.

A series of recommendations to mitigate against the potential impacts to these areas has been formulated. These are based on the statutory controls affecting the management of archaeological materials. These controls, and the recommendations developed, are outlined below.

6.2 Statutory Controls

Sites of cultural heritage significance are protected or controlled by a number of varying levels of statutory control that vary according to Authority and site type. The nature and levels of controls on the project area are set out below.

6.2.1 Commonwealth

Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation (EPBC Act) Act, 1999* requires the approval of the Commonwealth Minister for the Environment and Heritage for actions that may have a significant impact on matters of National Environmental Significance (NES).

As of 1 January 2004 the EPBC Act also provides for the identification, conservation and protection of places of national heritage significance as a matter of NES. In addition the EPBC Act provides for the management of Commonwealth heritage places and establishes the Australian Heritage Council.

Aboriginal and Torres Strait Islander Heritage Protection Act 1984

The Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Heritage Protection Act) is the principal Commonwealth legislation protecting Indigenous heritage. The Act complements state/territory legislation and is intended to support state/territory laws and processes.

Under the Heritage Protection Act the responsible Minister can make temporary or long-term declarations to protect areas and objects of significance under threat of injury or desecration. The Heritage Protection Act also encourages heritage protection through mediated negotiation and agreement between land users, developers and Indigenous people.

Since the passage of this legislation:

- around 200 applications have been lodged under the Act
- eight declarations have been made protecting objects of significance to Indigenous people
- emergency (i.e. temporary) declarations have protected five significant places, and
- two long-term declarations remain in place, one protecting women's sites under threat from a dam near Alice Springs and the other (with effect from July 2000) protecting Boobera Lagoon in northern New South Wales.

On 17 December 1998 responsibility for administration of the Heritage Protection Act was transferred by Administrative Arrangement Orders from ATSIC to the Environment and Heritage portfolio and the Heritage Protection Act is now administered by the Department of Environment and Heritage (DEH).

6.2.2 New South Wales

National Parks and Wildlife Act (1974)

The *National Parks and Wildlife Act* (1974) was amended in 2001 and some of the terms relating to Aboriginal archaeology have changed and the provisions have been tightened.

Under the provisions of the *National Parks and Wildlife Act* 1974, Aboriginal archaeological sites are defined as Aboriginal objects (formerly called relics). Aboriginal object "means any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises New South Wales, being habitation before or concurrent with (or both) the occupation of that area by persons of non-Aboriginal extraction, and includes Aboriginal remains".

It should be noted that this definition technically would seem to exclude PADs as they are clearly not deposits, objects or material evidence; rather they are potential aboriginal objects.

The most relevant section of the legislation is section 90, which deals with the destruction of Aboriginal objects and is reproduced below.

Section 90 Destruction etc of Aboriginal objects or Aboriginal places

(1) A person must not destroy, deface, damage or desecrate, or cause or permit the destruction, defacement, damage or desecration of, an Aboriginal object or Aboriginal place.

Maximum penalty: 50 penalty units or imprisonment for 6 months, or both (or 200 penalty units in the case of a corporation).

(1A) Subsection (1) does not apply with respect to an Aboriginal object that is dealt with in accordance with Aboriginal tradition pursuant to section 85A.

(1B) Subsection (1) does not apply with respect to an Aboriginal object or Aboriginal place that is dealt with in accordance with a heritage impact permit issued by the Director-General.

(1C) It is a defence to a prosecution for an offence against subsection (1) if the defendant shows that:

- (a) he or she took reasonable precautions and exercised due diligence to determine whether the action constituting the alleged offence would, or would be likely to, impact on the Aboriginal object or Aboriginal place concerned, and
- (b) the person reasonably believed that the action would not destroy, deface, damage or desecrate the Aboriginal object or Aboriginal place.

(2) The Director-General may issue a heritage impact permit subject to such conditions and restrictions as are specified therein.

(2A) The Director-General may take action under subsection (2) in relation to an Aboriginal object or Aboriginal place listed on the State Heritage Register (within the meaning of the [Heritage Act 1977](#)) only after consulting the Director of the Heritage Office

(3) A person whose application for a heritage impact permit is refused, or who is dissatisfied with any condition or restriction subject to which the a heritage impact permit is given, may appeal to the Minister.

(4) The Minister:

- (a) may refuse to grant the appeal, or
- (b) may grant the appeal wholly or in part, and may give such directions in the matter as seem proper.

(5) The decision of the Minister on the appeal is final and is binding on the Director-General and the appellant, and shall be carried into effect accordingly.

(6) Where the regulations prescribe:

- (a) the manner in which an appeal is to be made under this section—the appeal shall be made in that manner, or
- (b) the period within which an appeal is to be made under this section—the appeal shall be made within that period.

(7) Where the Director-General fails to grant an application (other than an application for approval in respect of integrated development within the meaning of section 91 of the [Environmental Planning and Assessment Act 1979](#)) for a heritage impact permit, the application shall, for the purposes of this section, be deemed to be refused upon the expiration of:

- (a) subject to paragraph (b)—7 days after the application was received by the Director-General, or
- (b) where the regulations prescribe some other period—that other period.

(8) If a court finds a person guilty of an offence under subsection (1), the court may, in addition to or in substitution for any pecuniary penalty for the offence, direct the person to take any action to mitigate the damage to, or to restore, the Aboriginal object or Aboriginal place concerned or to take such other action in relation to the Aboriginal object or Aboriginal place as the court considers appropriate in the circumstances.

(9) The court may specify the actions to be taken to mitigate the damage or to restore the Aboriginal object or Aboriginal place under subsection (8) and may order the person to provide security for the performance of any obligation imposed under that subsection.

It should be noted that section 90 applies to all Aboriginal objects irrespective of whether they are considered to be disturbed or not. The issue is whether reasonable precautions and due diligence was exercised to determine whether an Aboriginal object or place was going to be destroyed, defaced, damaged or desecrated or not. Thus if an area was identified as having archaeological potential and was disturbed or destroyed the defence of reasonable precautions and due diligence would not be available.

Section 87 of the Act covers permits to allow certain actions under section 86. This includes disturbing or excavating any land, or causing any land to be disturbed or excavated, for the purpose of discovering an Aboriginal object.

Environmental Planning and Assessment Act (1979)

The *Environmental Planning and Assessment Act* (EP&A Act) requires that consideration be given to environmental impacts as part of the land use planning process. In NSW environmental impacts are interpreted as including cultural heritage impact. Three parts of the EP&A Act are most relevant to Heritage. Part 3 relates to planning instruments including those at local and regional levels, Part 4 controls development assessment processes and Part 5 refers to approvals by determining authorities.

Under the EP&A Act, Environmental Planning Instruments (EPIs) typically have provisions that protect items of environmental heritage. The relevant EPIs have not been reviewed by HLA as the project already has a development consent and is therefore subject to the conditions of consent.

Murray Shire Local Environmental Plan 1989 (LEP 1989)

LEP 1989 requires that Aboriginal heritage assessments be conducted prior to the submission of development applications (part 3, clause 1d). The Council will not consent to an application to carry out development on land unless the potential impact on places and buildings of archaeological or heritage significance, including Aboriginal relics and places, has been assessed. Council expects that the relevant steps (eg: permit applications as necessary) be taken prior to awarding development consent.

6.3 Management Strategy

The study area is part of the Murray-Darling Basin, specifically the Riverine Plain. The Quaternary Epoch has seen substantial changes in climatic conditions, particularly those associated with the glacial and interglacial cycles, the knock-on effects for areas like the Riverine Plain being the onset of wet or dry conditions and obviously dictating whether fluvial / alluvial or Aeolian processes dominated depositional environments.

The level of human impact, through irrigation, laser levelling and ploughing has substantially affected the study area. For this reason it seems highly unlikely that surface sites survive within the study area *in situ* and therefore these areas have been identified as of low sensitivity. Areas that have been identified as of low sensitivity do not require any further archaeological action.

However, regional studies (such as Kow Swamp and Lake Mungo) reveal that deep soil profiles, particularly spanning the last 50,000 years, are evident in the general area. No evidence of these sequences were found during the survey, but this is unsurprising due to the lack of sections within the study area and the normal location of these deposits relatively deep beneath the surface (which itself is often composed of modern European agricultural and grazing deposits).

No evidence of these deep soil profiles were located by the geotechnical personnel on site, however geological and quaternary maps do reveal palaeochannels (old river channels) within the general study area region. Typically geotechnical investigations do not observe or record the types of deposits that would be of archaeological interest.

Since, there is only a small potential for significant Pleistocene soil sequences in the study area, (HLA recommends that some form of targeted monitoring be undertaken during the excavations), a method often contrary to DEC guidelines. However, it is completely unfeasible to undertake substantial deep archaeological excavations preceding this development based on the current information, but since there is a potential for sequences, ongoing targeted monitoring should be undertaken by the Moama LALC to ensure any specific areas of interest or archaeological sites uncovered (specifically buried) are suitably managed.

In addition, instructions would be given by a suitable qualified geoarchaeologist (which HLA can provide if necessary) to both the Moama LALC personnel and geotechnical personnel on site prior to monitoring to improve their identification of buried land surfaces and sub surface archaeological deposits. (This instruction could be undertaken in a variety of ways, although some form of public lecture may also improve locals support as well as teach the required archaeological and geomorphological information).

Should substantial soil sequences be uncovered, the Moama LALC would be provided the opportunity to thoroughly investigate the deposits for archaeological material. The Moama LALC may wish to bring in specialist help, since significant existing archaeological material in this region is considered internationally and nationally significant. HLA would be willing to participate and facilitate in any subsurface monitoring and/or additional excavations that may be required following a discovery.

If potential archaeological remains are discovered during the monitoring phase, a section 87 "Preliminary Research Permit" should be obtained from DEC prior to any further excavations occurring. Further archaeological investigations followed by an application for a section 90 "Consent to Destroy" may be required dependent on the findings of any section 87 "Preliminary Research Permit" works.

As shown in **Figure X** the areas of high and moderate sensitivity located within the study area would not be impacted by the proposed development and there are therefore no further archaeological requirements. Any future proposed impacts should be preceded by detailed archaeological investigation. Management of these areas, at this stage, will not require any form of archaeological permit.

Prior to any development, all contractors on site should be advised of the potential for buried archaeological deposits, specifically burials, and the protocols that should be undertaken following their discovery.

If skeletal remains are identified during the works, then all works must stop and contact with the NSW Police, Department of Environment & Conservation and the NSW Coroners Office must be made immediately. Aboriginal objects are protected under the *National Parks & Wildlife Act 1974* (as amended) as discussed in **Section 6.2**, therefore any Aboriginal objects identified would require work to cease and the appropriate permits to be sought.

6.4 General Management Measures

- Aboriginal objects are protected under the NPW Act (as amended), regardless of location. Should any objects be identified during the course of site works, all works must cease and the DEC (South Western Branch, Environment Protection and Regulation

Division, Regional Archaeologist) contacted in regard to appropriate permit requirements before any further impact is undertaken.

- Should **suspected** skeletal material be uncovered during the course of site works, all works must cease and the DEC, the NSW Police and the NSW Coroners office contacted immediately, **regardless** of any existing DEC permits for the proposed development.

6.5 Specific Management Measures

- The Moama LALC would be invited to undertake targeted monitoring of the excavations on site.
- Geotechnical personnel and Moama LALC working within the study area should be provided brief instruction by a qualified geoarchaeologist in identifying significant soil sequences and buried archaeological deposits. This may take place in a public forum to provide additional interest to the local community.
- If buried archaeological deposits are identified, work would stop and a section 87 "Preliminary Research Permit" from the Department of Environment & Conservation would be obtained.
- No further surface archaeological work is required in areas of low sensitivity.
- All contractors would be made aware of the General Recommendations prior to commencing site works.
- All contractors who work within the confines of the study area would be made aware of the NPW Act 1974 (as amended) and the fact that it is an offence to move, disturb or destroy Aboriginal objects without the written permission of the Director General of the DEC.

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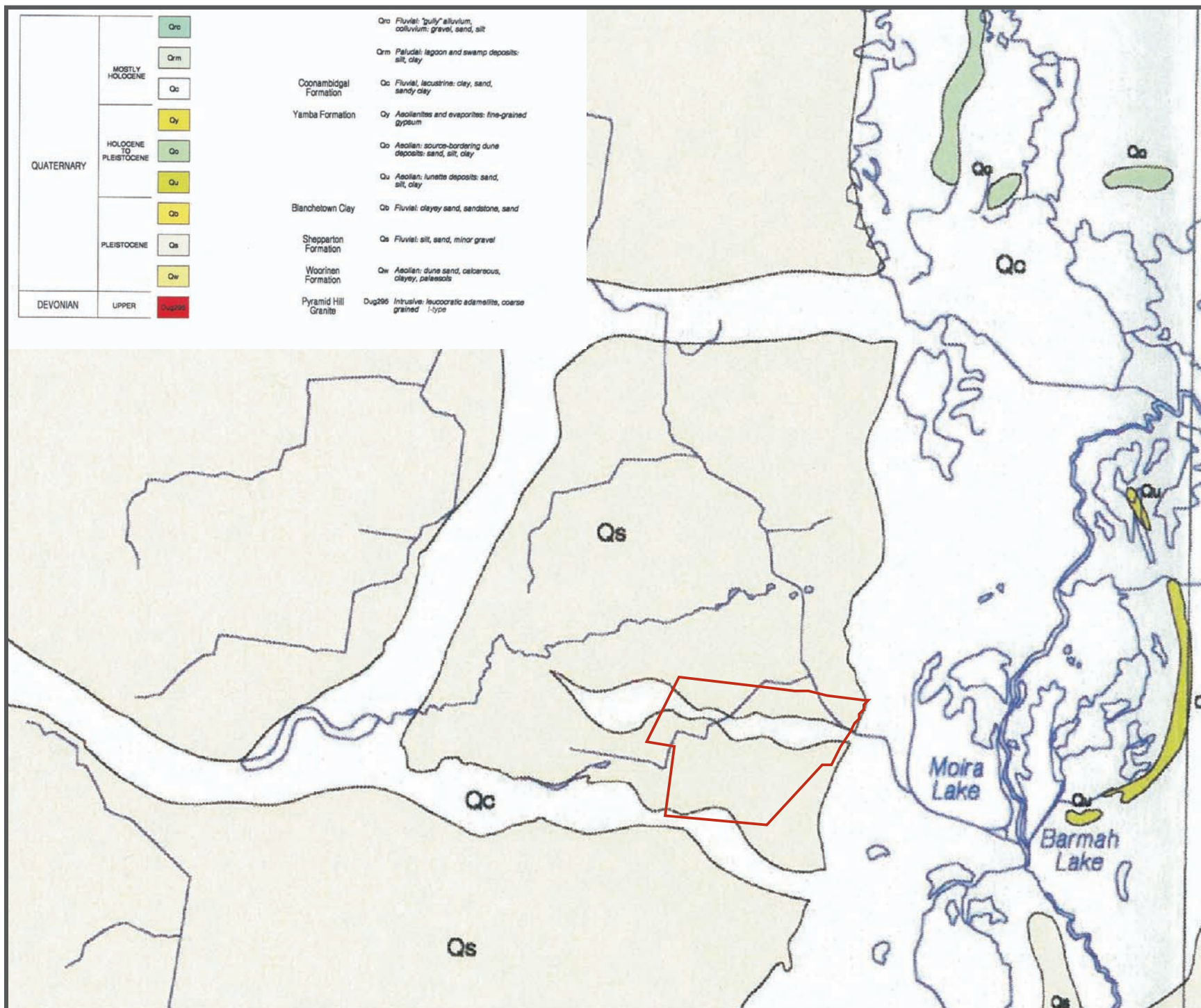
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Figures



PROJECT-FILE NAME S60133
DATE June 2005
DRAWN TO
APPROVED

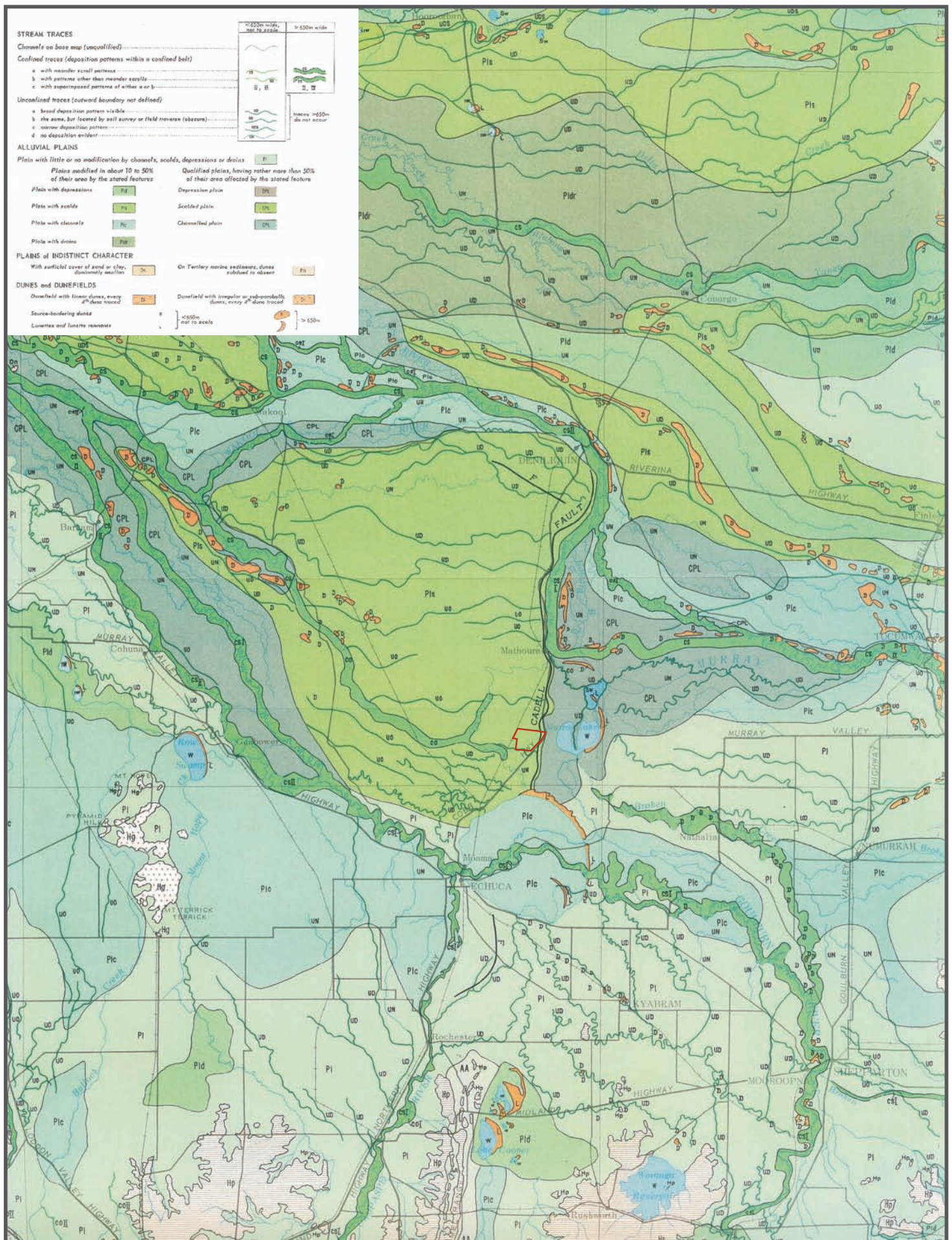
 Site boundary

Quaternary Geology of the Study Area
Agricultural Equity Investments
Aboriginal Heritage Assessment of the Proposed 80,000 Head Cattle Feedlot at Moira Station
Mathoura, NSW



FIGURE

2

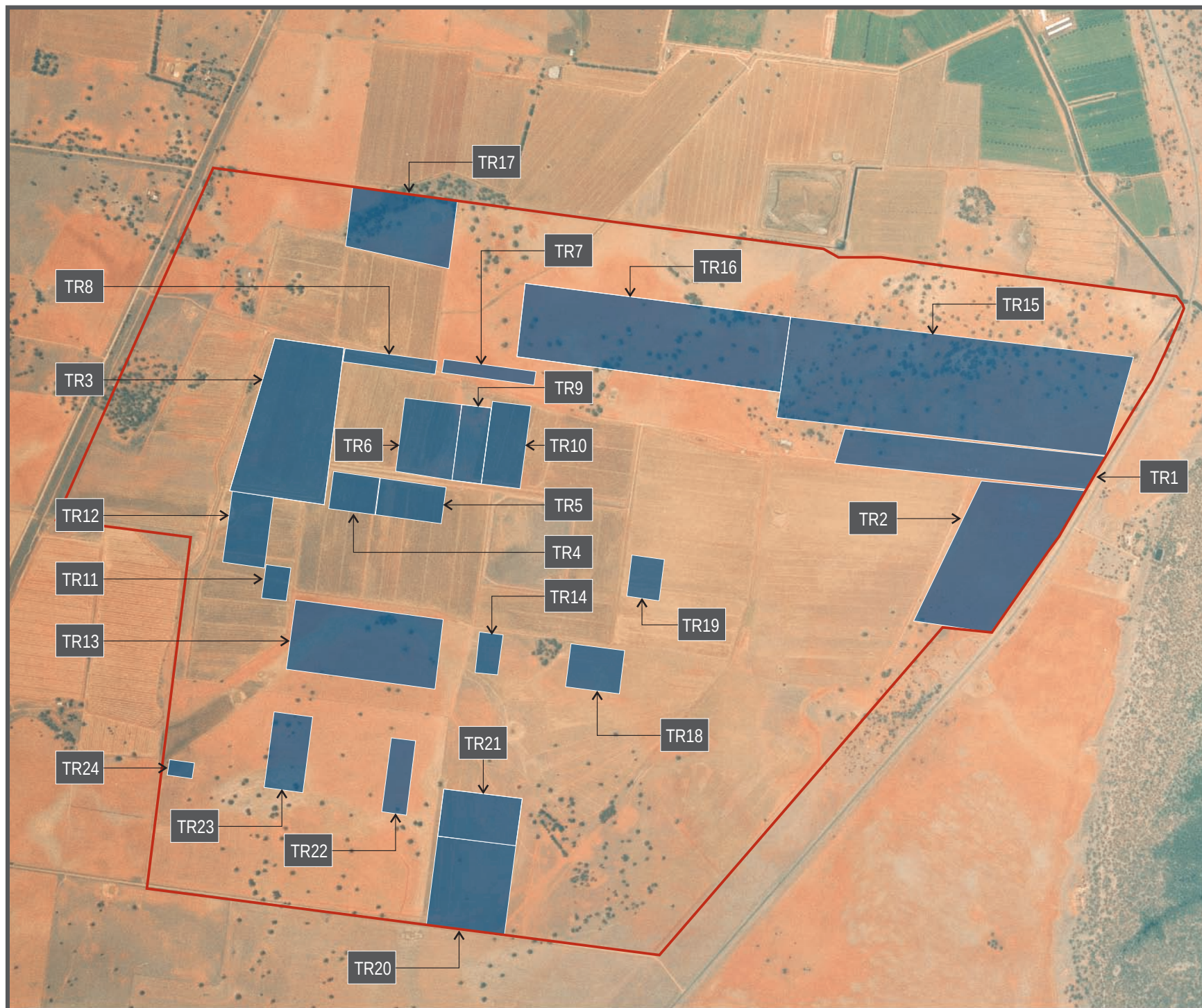


Geomorphic Map of the Study Area
Agricultural Equity Investments Pty Ltd
Aboriginal Heritage Assessment of the Proposed 80,000
Head Cattle Feedlot at Moira Station
Mathoura, NSW

Site boundary



FIGURE
3



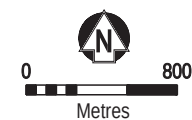
Site boundary
Transect location



Survey Transect Locations
Agricultural Equity Investments
Pty Ltd
Aboriginal Heritage Assessment of the
Proposed 80,000 Head Cattle Feedlot
at Moira Station Mathoura, NSW



-  Site boundary
-  High sensitivity
-  Medium sensitivity
-  Low sensitivity



Archaeological Sensitivity of the
Study Area
Agricultural Equity Investments
Pty Ltd
Aboriginal Heritage Assessment of the
Proposed 80,000 Head Cattle Feedlot
at Moira Station Mathoura, NSW





Location of Geotechnical Test Pit and Borehole Locations (After GHD) Agricultural Equity Investments Aboriginal Heritage Assessment of the Proposed 80,000 Head Cattle Feedlot at Moira Station Mathoura, NSW



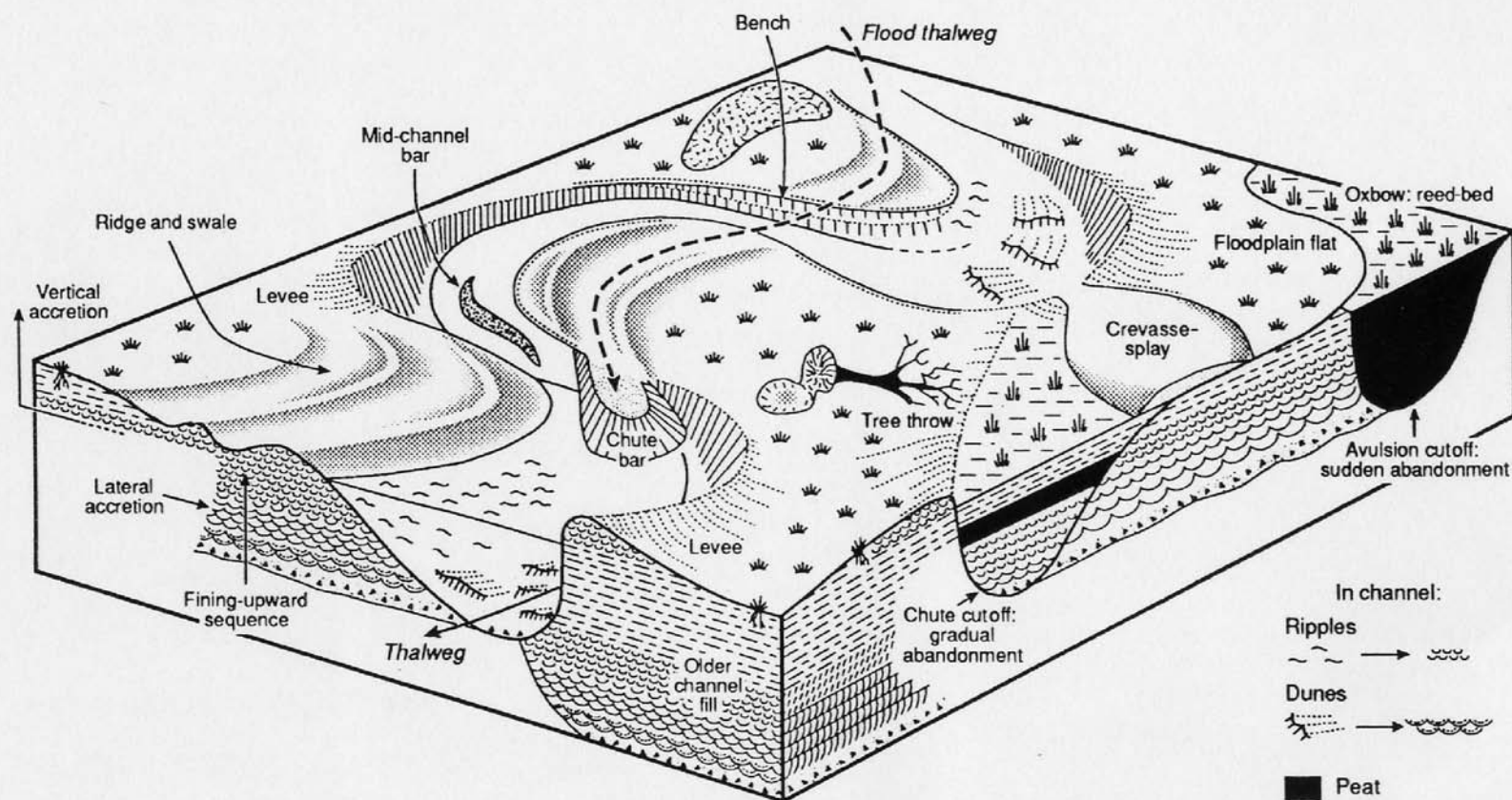


Modelled Distribution of Activities within Home Range (Left)
and Consequent Patterning of Artefacts (right) (after Foley, 1981a)
Agricultural Equity Investments Pty Ltd
Aboriginal Heritage Assessment of the Proposed 80,000
Head Cattle Feedlot at Moira Station
Mathoura, NSW

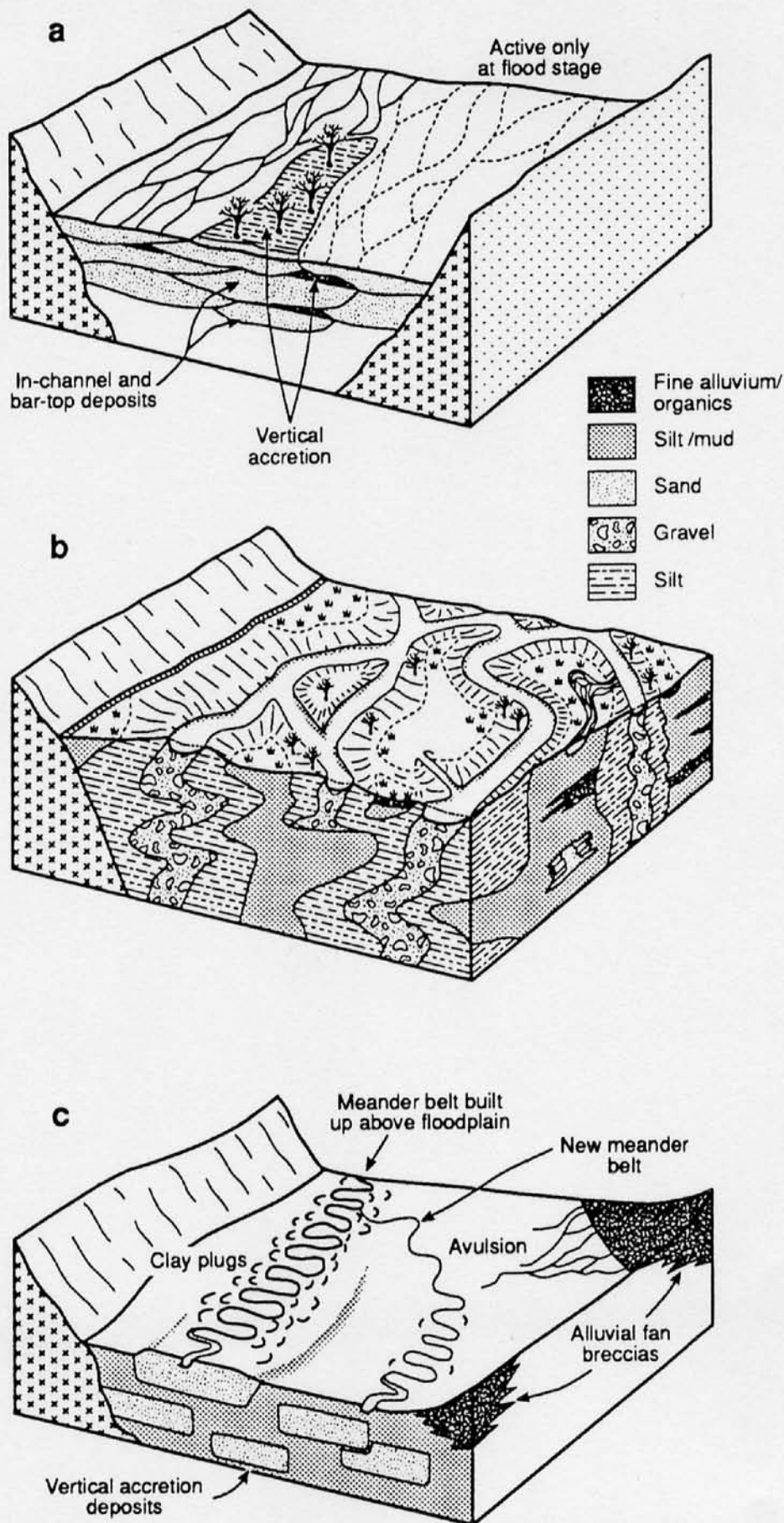
-  Temporary camps
-  Lithic source
-  Animal migration
-  Swamp

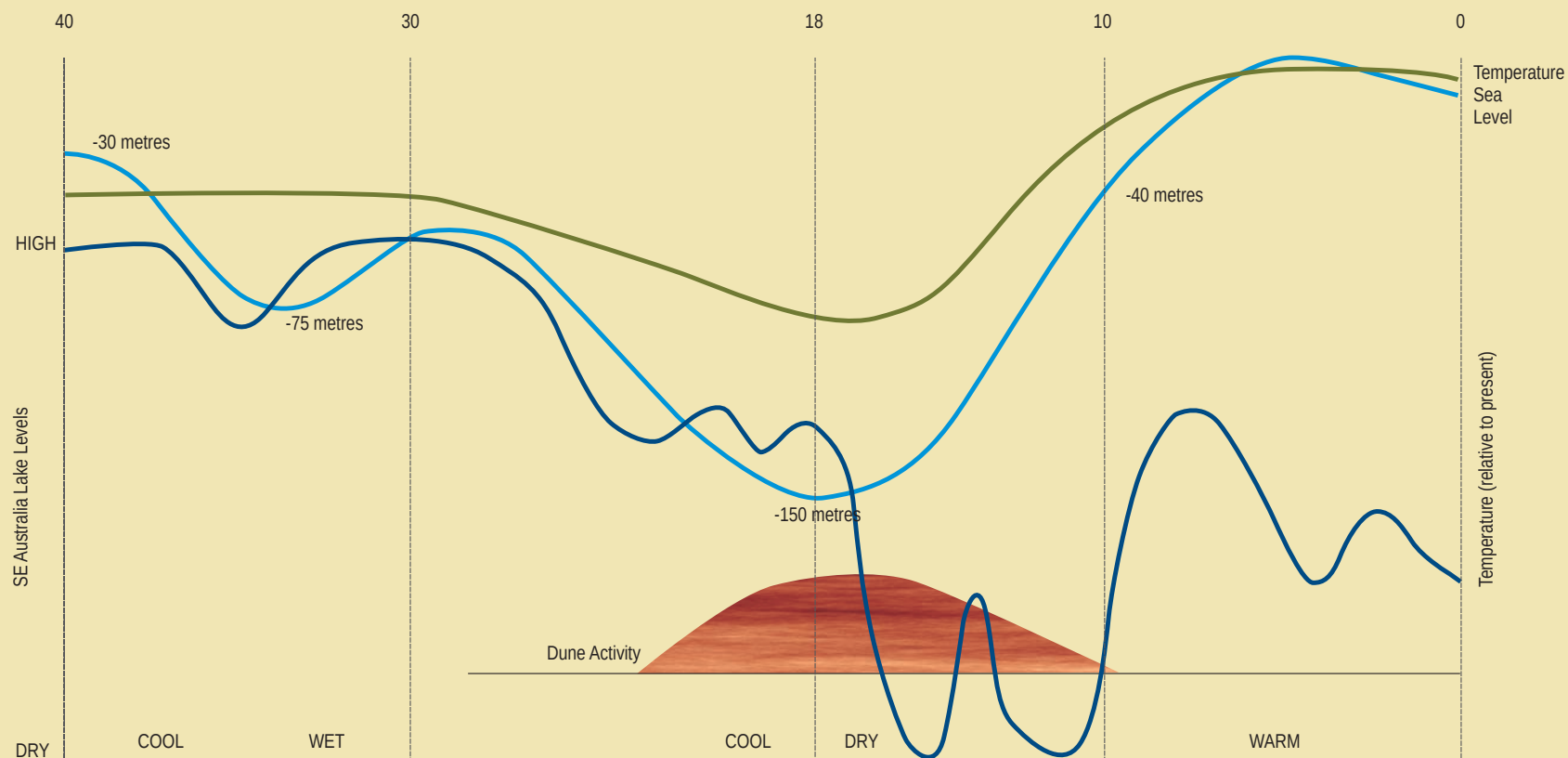
FIGURE

7



Block Diagram of Landforms
Associated with a Meandering River
and its Floodplain (taken from Brown)
Agricultural Equity Investments
Aboriginal Heritage Assessment of the
Proposed 80,000 Head Cattle Feedlot
at Moira Station
Mathoura, NSW





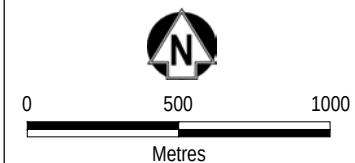
- Lake levels in South East Australia from high to dry
- Sea level relative to today
- Temperature relevant to present
- Dune building

Lake Levels, Sea Level, Temperature and Dune Building in the last 40,000 years
 Agricultural Equity Investments
 Aboriginal Heritage Assessment of the
 Proposed 80,000 Head Cattle Feedlot
 at Moira Station
 Mathoura, NSW



PROJECT FILE NAME - S60133
DATE - June 2005
DRAWN - TO
APPROVED

 Site boundary



Site Layout
Agricultural Equity Investments Pty Ltd
Aboriginal Heritage Assessment of the
Proposed 80,000 Head Cattle Feedlot
at Moira Station Mathoura, NSW



FIGURE
11



Plates



PLATE 1

Transect 1 looking west. Note organic surface litter



PLATE 2

Transect 2 looking south east towards the Cobb Highway with an irrigation channel in the centre of the photo. Note the uniform colour of the deposits, except where moisture levels differ.



PLATE 3

Transect 2 looking westwards. Note the low grass cover. Transect 2 is visible beyond the fence line to the right



PLATE 4

Transect 3 looking north. Note the vegetation cover, particularly the thistles (Bathurst Bir) ubiquitous across the study area



PLATE 5

Transect 4 looking north across a loosen paddock. Note the heavy surface cover of loosen



PLATE 6

Transect 7 looking north across the alluvial plain. Note the parallel lines indicating ploughing



PLATE 7
Transect 8 looking westwards



PLATE 8
Transect 11 looking westwards – note the dense grass cover



PLATE 9

Transect 13 looking east. Note the plough lines and weeds



PLATE 10

Transect 14 looking south. Note the irrigation channel is flooded



PLATE 11
Transect 15 looking west



PLATE 12
Transect 16 looking west



PLATE 13
Transect 17 looking westwards



PLATE 14
General shot indicating ground conditions across transect 17 looking west



PLATE 15
General view eastwards across Transect 17



PLATE 16
Transect 20 looking southwards. Note the absence of vegetation and the large clods



PLATE 17

Transect 21 looking west. Note the vegetation cover in contrast to Plate 16 – the transect immediately south of this one



PLATE 18

Transect 22 looking southwards. Note Bathurst burr weeds, low grass and occasional tree



PLATE 19

Transect 23 looking northwards towards the dam bordering this transect and transect 24



PLATE 20

General shot of site MF1 looking north. Note the cut footholds located in the central trunk



PLATE 21

Close-up of MF1 footholds. Scale is in centimetres



PLATE 22

Oven Mound MF2 looking westwards. The three people are standing at the western, northern and southern boundaries of the mound



PLATE 23

Close up of the surface of MF2: reveals an ashy dark grey loam



PLATE 24
MF3 within it's landscape context



PLATE 25
Close up of glass bottle base core – MF3



Appendix A

Client: .. Agricultural Equity Investments Pty Ltd Project No.: S6013305 Site.: Moira Station Cattle Feedlot

GROUP	REPRESENTATIVE CONTACTED	DATE	COMMENTS	HLA REPRESENTATIVE
DEC	Teresa Grey, Executive Director of Operations	18.2.05	Contacted Teresa by letter in order to obtain information regarding relevant Aboriginal stakeholders for Moira.	Alan Williams and Chaz
National Native Title Tribunal	General addressee	18.2.05	Contacted the Tribunal by fax in order to place a search of the Tribunal Register	Alan Williams
Office of the Registrar	General addressee	18.2.05	Contacted the Office by fax to request a search of the Aboriginal Land Claims Register for lands within the study area.	Alan Williams
DEC	Kelly-Anne Sheargold	23.2.05	Contacted the DECb by fax in order to request an AHIMS search listed in the register in relation to the study area.	Emma Harrison
Deniliquin LALC; Moama LALC	General addressee	24.2.05	Contacted the LALC's in order to seek advice of any Aboriginal stakeholders known in regards to the study area, including themselves. Also sought an expression of interest from both groups, and advised of tentative timeframes for the fieldwork.	Alan Williams
Moama LALC	Catherine Franklin	25.2.05	Called and spoke to Catherine regarding clarification of her groups management over the relevant study area, which was confirmed. Spoke generally about the project and sought their interest, as well as clarifying matters in regards to other groups managing over the area. Catherine requested a copy of the DEC Interim Guidelines. I Advised that the Guidelines and specific job details would be forwarded by fax shortly.	Emma Harrison
Yarrawonga Chronicle	Gemma, Accounts Dep't	28.2.05	Contacted the <i>Yarrawonga Chronicle</i> by phone and email in order to place a public notice in the classifieds regarding the upcoming fieldwork for the project.	Emma Harrison
Moama LALC	Catherine Franklin	28.2.05	Faxed a copy of the Interim Guidelines to the LALC as requested, as well as attaching a copy of HLA's Standard Terms of Engagement (STE), and confirming general survey timeframes.	Emma Harrison

Moama LALC	Catherine Franklin	1.3.05	Sent a copy of the survey methodology by fax, giving a 21-day period for comment/endorsement. Advised that comments were due by 22.3.05	Emma Harrison
Moama LALC	Catherine Franklin	1.3.05	Spoke to Catherine regarding general survey details and discussed the methodology and STE. Catherine advised that another relevant group, Cummeragunja LALC, were interested in participating in the survey but this was to be determined.	Alan Williams
Moama LALC	Catherine Franklin and Richard Kerr	1.3.05	Sent a detailed location map to the LALC with the site marked, and asked if they could advise HLA as to whether or not the Cummeragunja LALC would also be participating.	Alan Williams
Moama LALC	Catherine Franklin	9.3.05	Received a fax from Catherine with a copy of Moama LALC's site protocols.	Alan Williams
Moama LALC	Catherine Franklin	10.3.05	Received a fax from Moama LALC confirming Cummeragunja LALC's upcoming participation in the survey.	Alan Williams
Moama LALC	Catherine Franklin	10.3.05	Called Catherine to advise of the tentative survey dates and to request a copy of the Moama and Cummeragunja LALC's fee structure(s) in writing.	Emma Harrison
Moama LALC	Catherine Franklin	10.3.05	Received a fax from Catherine advising of the costs for both LALC representatives, and invoice details.	Emma Harrison
Moama LALC	Catherine Franklin	11.3.05	Called Catherine in order to confirm the dates for the physical inspection (4.4.05-8.4.05) and to arrange a convenient meeting place on the morning of the first day of the survey. These arrangements were made; I then followed up this conversation with a fax sent to the LALC confirming these details.	Emma Harrison



Appendix B



List of Sites (List - Short)

Moirra Cattle Feedlot

Grid Reference Type = AGD (Australian Geodetic Datum) Zone = 56 Easting From = 295000 Easting to = 302000 Northing From = 6010000 Northing to = 6030000 Requestor = HLA Envirosiences Pty Ltd (551) Service ID = 12206 Feature Search Type = AHIMS Features

<u>Site ID</u>	<u>Site Name</u>	<u>Datum</u>	<u>Zone</u>	<u>Easting</u>	<u>Northing</u>	<u>Site Features</u>	<u>Site Types</u>	<u>Recording</u>	<u>Reports</u>
----------------	------------------	--------------	-------------	----------------	-----------------	----------------------	-------------------	------------------	----------------

NO SITES
RECORDED

List of Reports

Moira

Criteria : Title like %moira%%

<u>Cat. Num.</u>	<u>Published Date</u>	<u>Report Title</u>	<u>Report Type</u>
------------------	-----------------------	---------------------	--------------------

969	08/01/1985	An archaeological investigation of the Algeboia shell midden in the Moira State Forest, Murray Valley, NSW.	Total Survey
-----	------------	---	--------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Lance, A	☒

2205	12/01/1991	Archaeological survey in the Moira - Millewa State Forests.	Synthetic Review
------	------------	---	------------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Craib, J	☒

List of Reports

Millewa

Criteria : Title like %millewa%%

<u>Cat. Num.</u>	<u>Published Date</u>	<u>Report Title</u>	<u>Report Type</u>
------------------	-----------------------	---------------------	--------------------

1328	02/01/1988	Aboriginal sites in the Deniliquin district, in forests of the Millewa group, the Weraí group, the Koondrook group and surrounding areas.	Synthetic Review
------	------------	---	------------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Lyons,C	☒

2205	12/01/1991	Archaeological survey in the Moira - Millewa State Forests.	Synthetic Review
------	------------	---	------------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Craib,J	☒

List of Reports

Moama

Criteria : Title like %moama%%

<u>Cat. Num.</u>	<u>Published Date</u>	<u>Report Title</u>	<u>Report Type</u>
------------------	-----------------------	---------------------	--------------------

882	07/01/1985	An archaeological investigation of a sand dune on the MurrayRiver at Moama, NSW.	Literature Survey
-----	------------	--	-------------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Lance,A	☒
Webb,S	☐

1852	05/01/1990	An archaeological survey of the proposed Echuca -Moama RSL & Citizens Club site, Moama, NSW.	Total Survey
------	------------	--	--------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
L...nonds,V	☒

2723	11/01/1993	Pasadena Sand Quarry Site, Moama	Special Investigation (Detailed)
------	------------	----------------------------------	----------------------------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Littleton,J	☒
Johnston,H	☐

2874	09/01/1993	Archaeological Survey of Proposed Moama Sewerage treatment Works. Moama, NSW	Investigation
------	------------	--	---------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Lloyd,A	☒

3275	01/01/1993	Pasadena Sand Quarry Site, Moama	Special Investigation (Detailed)
------	------------	----------------------------------	----------------------------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Littleton,J	☒

3996	11/01/1997	Report on an Aboriginal Burial at Moama NSW	Investigation
------	------------	---	---------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Johnston,H	☒

98190	01/06/1999	An Archaeological Survey of the Corridor of a Proposed Levee Bank Near Moama, NSW	
-------	------------	---	--

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Stone,T	☒

List of Reports

Murray River

Criteria : Title like %murray river%%

<u>Cat. Num.</u>	<u>Published Date</u>	<u>Report Title</u>	<u>Report Type</u>
------------------	-----------------------	---------------------	--------------------

330	00/00/0000	Geology and geomorphology of the Murray River valley.	Excavation
-----	------------	---	------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Gill, E.D	☒

798	03/01/1983	Archaeological investigation of a threatened Aboriginal site near Robinvale, on the Murray River, Victoria.	Rock Art Recording
-----	------------	---	--------------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Cydler, S	☒

1896	07/01/1990	A survey for Aboriginal archaeological sites in proposed sand extraction lease extensions on the Murray River at Dareton and Monak (Bowen Park) NSW	Total Survey
------	------------	---	--------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Dowling, P	☒

3657	01/06/1996	An Archaeological Investigation of the Bridge Over the Murray River at Robinville and its Approaches in Northwest Victoria and Southwest NSW	Sample Survey
------	------------	--	---------------

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Edmonds, V	☒

97616	01/08/2000	An archaeological investigation of a proposed bridge over the Murray River at Cobram/Barooga, N.S.W.	
-------	------------	--	--

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Johnston, D	☒

97836	01/07/1999	An archaeological study of the proposed main road 86 new bridge over the Murray River, between Corowa and Wahgunyah.	
-------	------------	--	--

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Central West Archaeological and Heritage Ser	☒

97837	00/00/0000	An archaeological study of the proposed Main Road 86 New Bridge over the Murray River, between Corowa and Wahgunyah	
-------	------------	---	--

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Central West Archaeological and Heritage Ser	☒

List of Reports

Murray River

Criteria : Title like %murray river%%

<u>Cat. Num.</u>	<u>Published Date</u>	<u>Report Title</u>	<u>Report Type</u>
97850	01/07/1999	An archaeological study of the proposed Main Road 86, New Bridge over the Murray River, between Corowa and Wahgunyah.	

Report Author(s)

<u>Name</u>	<u>Primary Author?</u>
Central West Archaeological and Heritage Ser	☒



Appendix C



Agricultural Equity Investments Pty
Ltd

**Proposed 80,000 Head Feedlot at
"Moir Station", Mathoura**

Preliminary Geotechnical Investigation

Report



July 2005



GHD LongMac
Consulting geotechnical engineers and geologists

12 July 2005

Agricultural Investments Pty Ltd
Suite 22B The Lindfield Centre, 12 Tyron Road
LINDFIELD NSW 2070

Our ref: 21/13507//AW095 Rev 2.doc

Attn: Mr Tony Camphin

Dear Tony

**Proposed 80,000 Head Feedlot at "Moir Station", Mathoura
Preliminary Geotechnical Investigation**

We are pleased to present herein an update of our report on the above geotechnical investigation. This report includes a summary of our previously reported discussion and recommendations (Rev 0, dated 6 May 2005) and minor changes from the Rev 1 report issued 26 June 2005.

The factual results of the field investigation and laboratory testing are presented, together with comments and recommendations in relation to expected excavation characteristics, effluent and fresh water-retaining structures, groundwater levels, and discussion of subsurface conditions with respect to design and construction issues.

We trust that this report is satisfactory for your needs. Please contact either of the undersigned should you have any questions in regard to this report or require further assistance with this project.

Yours faithfully
GHD-LongMac

Prepared by

Reviewed by

Richard Chandler
Senior Geotechnical Engineer

Tony Colenbrander
Operations Manager



Controlled Document No. 1

PRELIMINARY GEOTECHNICAL INVESTIGATION

for

PROPOSED 80,000 HEAD FEEDLOT AT "MOIRA STATION", MATHOURA

for

AGRICULTURAL EQUITY INVESTMENTS PTY LTD

REF: 21/13507/

DATE: 12 July 2005

Rev No. 2



**CONTROLLED DOCUMENT
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Document History

Revision No.	Revision Date	Description
0	6/05/05	Initial Issue
1	26/06/05	Minor Revisions
2	12/07/05	Minor Revisions

Issued by:

Date:

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Figure

Figure 1 Test Location Plan



Standard Sheets

General Notes
Glossary of Symbols
Soil Description
Rock Description
Laboratory Testing

Appendices

- A Profile Logs (TP01 to TP32 and BH01)
- B Geotechnical Laboratory Test Results
- C Agricultural Laboratory Test Results

1. Introduction

This report presents the results of geotechnical investigation conducted for the proposed 80,000 head cattle feedlot located at "Moir Station", Mathoura, southern NSW. Mr Tony Camphin of Agricultural Equity Investments Pty Ltd (AEI) commissioned the investigation on the basis of our proposal dated 20 January 2005 (GHD-LongMac reference AV952).

We understand that as part of the approvals process for the proposed development, an Environment Impact Statement (EIS) is required. We understand that HLA Envirosiences Pty Ltd will prepare the EIS and that this report will be included as an appendix to the EIS document.

The objectives of the geotechnical investigation were to

- ▶ Assess geotechnical issues for water-retaining structures (freshwater and effluent storage dams, sedimentation and holding ponds/basins, compacted earthworks embankments), feedlot pens, commodities and receivals areas.
- ▶ Provide a general discussion on groundwater issues.
- ▶ Undertake a limited assessment of soil issues for the proposed effluent/ wastewater irrigation areas.

Mr Chris Kelly of Frank Rennick and Co. provided GHD-LongMac with preliminary layout drawings prepared prior to the commencement of the field investigation, showing the main components of the proposed development. These drawings were subsequently updated on 21 February 2005 and have been used for the geotechnical assessment and presentation of information. Frank Rennick and Co provided information on the proposed depths of excavation and embankment heights for the various dams and ponds proposed for the site.

This report should be read in conjunction with the attached General Notes.

2. Proposed 80,000 Head Cattle Feedlot

The proposed project involves the establishment of a cattle feedlot with the following main components:

- ▶ Feedlot Pens for 80,000 head of cattle covering an area of approximately 145 hectares;
- ▶ A Freshwater Storage Dam of 1000 MI capacity involving site excavation to a depth of 2 metres (approximately 700 metres x 450 metres);
- ▶ A Receivals and Commodity area covering approximately 12 hectares;
- ▶ Two Freshwater Basins involving site excavation to a depth of 3.5 metres (each approximately 120 metres x 190 metres);
- ▶ An Effluent Storage Dam (wastewater/irrigation storage dam) of approximately 800 MI involving site excavation to a depth of 2 metres (approximately 850 metres x 400 metres);
- ▶ A Holding Pond involving site excavation to a depth of 6.4 metres (approximately 170 metres x 860 metres);
- ▶ Four Sedimentation Ponds (located near the holding pond) involving site excavation to a depth of 4.6 metres (each approximately 60 metres x 100 metres);
- ▶ A Burial Pit located near the Feedlot Pens and the Holding Pond; and
- ▶ A number of Effluent (wastewater) Irrigation Areas covering a total of approximately 380 hectares. These irrigation areas have been identified by Frank Rennick and Co. as Irrigation Areas 1 to 5, with individual areas ranging from 23.6 hectares (No. 5) to 140.0 hectares (No. 3). With the exception of most of Irrigation Area 3, the irrigation areas proposed for the development are currently developed for flood irrigation.

The layout of the proposed development based is shown on Figure 1.

3. Method of Investigation

3.1 Preliminaries

Prior to commencement of the fieldwork the following was undertaken:

- ▶ Discussions with Murray Irrigation with regard to background/groundwater information for the area.
- ▶ Collation of geological and topographic information covering the area.
- ▶ On site discussions with the “Moira Station” farm manager, Mr Brian Salmon, regarding the position of any underground services on the property.

3.2 Summary of Geotechnical Factors

The geotechnical assessment was undertaken to provide information on the following:

- ▶ General subsurface conditions in the feedlot pen, pond, dam, basin, and receivals and commodities areas.
- ▶ Excavation conditions in the Effluent Storage Dam (wastewater/irrigation storage dam), Freshwater Storage Dam, Sedimentation Pond, Holding Pond and Freshwater Basin areas.
- ▶ Suitability of the proposed excavated material for use as compacted earthworks.
- ▶ Batter angles for compacted earthwork embankments and cut slopes.
- ▶ Foundation preparation for proposed fill areas.
- ▶ Permeability of excavated material proposed for compacted earthworks.
- ▶ Soil compaction requirements.

3.3 Summary of Agricultural Issues

The investigation in the proposed effluent disposal/irrigation area was undertaken to provide factual information on the following:

- ▶ General subsurface conditions.
- ▶ Insitu permeability of the near surface soils.
- ▶ Chemical composition of the near surface soils for agricultural purposes (selected analytes).
- ▶ Near surface groundwater conditions.

3.4 Fieldwork

A series of test pits, numbered (TP01 to TP32), were excavated between 16 and 21 February 2005 under the full time supervision of a geotechnical engineer from GHD Long-Mac. The test pit locations were distributed over the entire proposed development area. The depth of excavation at each test pit location was determined on the basis of type of facility and depth of excavation (if any) proposed at the investigation location. The depth of the test pit excavations ranged from 2.0 metres at TP07 (Irrigation Area) to 5.5 metres at TP01 (Holding

Pond). A 20 tonne Komatsu excavator (PC 200 LC) provided by "Moir Station" was used to excavate the test pits.

A borehole (BH01) was drilled in the vicinity of the proposed Holding Pond at the western end of the site to a depth of 12.0 metres. A standpipe piezometer was installed at this location to about the maximum depth of the borehole.

The borehole was advanced through the soil profile by auger drilling using solid flight augers fitted with a V bit. Standard Penetration Tests (SPT) were undertaken at 2 metres intervals commencing at a depth of 2 metres to assess the strength (consistency) of the soils encountered by the borehole.

Percolation tests were undertaken at three locations within the proposed irrigation area (test pits TP07, TP23 and TP30) to assess the permeability of the near surface soils. These tests were mainly undertaken in the sandy clay topsoil/disturbed horizon and the immediately underlying high plasticity clay. The percolation tests involved the drilling of a 100 mm diameter hand auger borehole to the underside of the topsoil layer, "saturation" with water, and monitoring water levels over time.

The location of the test pits and the borehole are shown on the attached Figure 1. The test pits and borehole were located in the field by GPS measurements, with reference to the corner peg for each of the proposed facilities (placed by Mr Chris Kelley of Frank Rennick and Co.) and nearby site features such as fences and irrigation channels. The co-ordinates shown of the test pit and borehole log sheets are the GPS co-ordinates obtained in the field, and are therefore approximate.

The surface levels shown on the log sheets were interpolated from the contour levels shown on the Frank Rennick and Co. drawings; with reference to the plotted location based on the GPS co-ordinates. The surface levels shown on the log sheets are therefore approximate.

The borehole and test pit logs are contained in Appendix A. These should be read in conjunction with the attached Standard Sheets which explain the terms, abbreviations and symbols used together with an explanation of the logging procedures and their limitations.

3.5 Groundwater Monitoring

A standpipe piezometer was installed at borehole BH01 to monitor near surface ground water conditions in the vicinity of the proposed Holding Pond. The screened section at this location was placed over the base three metres of the borehole (about 9m to 12m deep). This standpipe was constructed with a fine gravel surround over the screened section and with clay cuttings above it.

On 22nd February 2005 groundwater readings were taken at two bores that were installed at some time prior to the current geotechnical investigation. These bores are identified as follows:

- ▶ A Department of Land and Water Conservation (DLWC) Bore No. 473, located near the north eastern corner of the property in the Cobb Highway road reserve.
- ▶ An "Unnamed Bore" (125 mm diameter PVC casing) located immediately south of the disused shearing shed/ruins and adjacent to a gravel access road within the property. Installation details for this bore are not known, except that it extends to a maximum

depth of 29.2 metres below the top of the casing identified by GHD-LongMac during the geotechnical investigation. The top of casing was 0.15 metres above adjacent ground level.

Groundwater was not encountered at any test pit or at borehole BH01 at the time of the field investigation. All the groundwater readings obtained during the investigation are contained in Table 1 in Section 5.2.

3.6 Geotechnical Laboratory Testing

A selection of soil samples was recovered from the test pits and borehole, and returned to our NATA accredited laboratory for testing. A programme of soil classification tests was conducted on the soil samples as a basis for confirming the tactile field soil classifications and providing information for design and construction. This testing comprised the following:

- Particle Size Distribution.
- Hydrometer testing for fine particle size distribution.
- Atterberg Limits and Linear Shrinkage.
- Emerson Crumb (dispersion) Tests.
- Field Moisture Content.
- Standard Compaction.
- Compacted permeability.

The geotechnical laboratory results are presented in Appendix B.

3.7 Agricultural Laboratory Testing

A number of soil samples were collected from shallow test pits excavated in the existing and proposed irrigation areas and were dispatched to a specialist laboratory for testing of agricultural characteristics.

These “agricultural” soil samples generally comprised topsoil (typically 0 – 0.1m depth) and samples of the underlying clay soils. The maximum “agricultural” soil sample depth was 1.3 metres.

This testing comprised the following:

- Cation Exchange Capacity (CEC) including exchangeable Sodium (Na), Potassium (K), Magnesium (Mg), Aluminium (Al) and Calcium (Ca).
- pH.
- Conductivity.
- Total Kjeldahl Nitrogen (TKN).
- Bray Phosphorus.
- P-Sorp.
- Organic Matter.

The agricultural laboratory results are presented in Appendix C.

4. Site Conditions and Regional Geology

4.1 Site Description

“Moira Station” is located between Mathoura and Moama/Echuca in southern NSW and occupies an area of approximately 1,200 hectares. The Cobb Highway is located along the eastern property boundary, with Stud Farm Lane to the south and the Moira Irrigation channel to the north. Other agricultural properties and small rural landholdings are located to the west. The property is located approximately 12 km south of Mathoura and approximately 24 km north of Moama/Echuca.

At the time of the field investigation, the property was used for agricultural purposes. This involved flood irrigation, cropping, cattle and sheep grazing. Extensive areas of the property had been laser levelled for flood irrigation. A relatively undisturbed area of the property located south west of the proposed feed pens area and west of Irrigation Area 3, was “swampy” at the time of the field investigation.

4.2 Regional Geology and Soils

Examination of the 1:500,000 Geological Series Sheet for the area (Urana, reference SI 55-13-14, First Edition, 1972) indicates the area is underlain by Quaternary Alluvium comprising sand, silt, clay and gravel. A geomorphic map (1:500,000 Geomorphic Map of the Riverine Plain of South Eastern Australia, 1973), details the nature and position of the alluvial deposits in the area such as Stream Traces. Stream Traces are features identified by aerial photography as indicative of ancient stream flow. The following type of alluvial deposits were identified on the Geomorphic Map at the site:

- ▶ A Plain with Scalds (wind erosion of the surface soils) over the majority of the property.
- ▶ A Confined Stream Trace, greater than 650 metres wide, at the south western corner of the property.
- ▶ An Unconfined Stream Trace along the southern side of the property.

Available information indicates (McNally, 1997), that in engineering terms, the “Stream Trace” materials are typically well-graded, rounded quartz sand, with a small portion of fine gravel. The fines within the “Stream Trace” materials are typically aggregated clay particles, which are dispersive.

4.3 Regional Groundwater

Information on regional groundwater level was obtained from the Cadell Community’s Land and Water Management Plan publication (January 2001) prepared by the Cadell Land and Water Management Plan Working Group. The document was obtained from Murray Irrigation located in Deniliquin.

Figure 2.11b of the plan indicates that groundwater at the site is in the vicinity of 20 metres to 22 metres below the surface.

5. Subsurface Conditions

5.1 Field Investigation

5.1.1 Test Pits and Borehole

Reference should be made to the test pit and borehole logs attached in Appendix A for a detailed description of the subsurface strata encountered at the individual test pit and borehole sites.

In general terms, the investigation confirmed the presence of an alluvial soil profile as indicated by the Geological and Geomorphic sheets. A generalised description of the various strata encountered at the site is given below.

Surface Topsoil/Disturbed Layer

Apart from the topsoil encountered by test pit TP25, the surface layer encountered typically comprised brown, low plasticity sandy clay to a depth of about 0.1 metres. At most of the test locations this surface layer had been formed during construction of the irrigation areas (laser levelling) and with subsequent disturbance by ploughing.

At test pit TP25 the surrounding area appeared relatively undisturbed with a number of large trees in the vicinity. At this location the topsoil comprised dark grey, medium grained clayey sand. The underlying material at test pit TP25, to a depth of 0.3 metres, comprised brown, low plasticity sandy clay, similar in texture to the topsoil encountered over the majority of the site.

Alluvial Clayey Soils

Clayey alluvial soils were encountered at all test pit locations below the topsoil layer. These soils generally comprised high plasticity clay underlain by medium plasticity clay, with layers of sandy clay at some locations. These units are described below:

- ▶ Moist, red-brown or brown, stiff, high plasticity clay containing a trace of fine-grained sand. This material was encountered typically from a depth of 0.1 metres, extending to depths of between 0.7 metres to 1.3 metres. This unit is underlain by:
- ▶ Moist becoming slightly moist at depth, mottled in colour, very stiff, medium plasticity clay containing a trace of fine-grained sand. These materials comprised a mixture of colours including grey brown, red-brown, yellow brown, light grey brown and grey.
- ▶ At a number of locations sandy clay soils were encountered. The layer thickness was not determined at all test pit locations as some test pits were terminated upon the depth capacity of the excavator. The encountered layer thickness ranged from 0.8 metres to greater than 2.5 metres. These materials were typically low or medium plasticity and very stiff. These materials were mottled and comprised a mixture of colours including grey brown, yellow brown, light grey brown, grey, and brown.

At borehole BH01 (Holding Pond Area) clay soils were encountered to a depth of 7.0 metres. These clay soils were consistent with the clay soils encountered by the adjacent test pits.

Alluvial Sandy Soils

Sandy soils were encountered in test pits TP25 (below 2.9 metres), TP26 (between 3.0 metres and 4.3 metres), TP27 (below 2.0 metres), and TP32 (below 2.3 metres). Interbedded sand and clay layers were encountered by borehole BH01 below a depth of 7.0 metres. The sandy soils typically comprised light grey and yellow brown, fine to medium grained sand. Clayey sand material was encountered in test pit TP26 (between 3.0 metres and 4.3 metres) and borehole BH01 (between 9.8 metres and 10.0 metres).

Alluvial Silty Soils

Sandy silt soils were encountered in test pit TP29 between the depths of 2.3 metres and 3.2 metres. The materials above and below this layer were medium plasticity clay.

5.1.2 Percolation Tests

The percolation tests indicate that ploughing and land forming have disturbed the surface sandy clay topsoil layer, and that the permeability of the immediately underlying material is consistent with high plasticity clay soils.

5.2 Groundwater

The groundwater levels noted during the geotechnical investigation are summarised in the following table.

Table 1 Recorded Groundwater Levels Below Ground Level

Borehole Number	Maximum Borehole Depth (m)	Groundwater Depth After Drilling (m)	Groundwater Depth on 21 February 2005 (m)	Groundwater Depth on 22 March 2005 (m)
BH01	12.0	Not encountered	-	Not encountered (advised by AEI following a site visit on 22 March 2005)
DLWC Bore No. 473	DLWC record	-	24.70	-
Shearing shed/ruins Bore	29.05	-	19.05	-

5.3 Geotechnical Laboratory Results

The laboratory results are presented in Appendix B and summarised in the following table.

Table 2. Summary of Geotechnical Laboratory Results

Test Pit	Sample Depth (m)	Description	FMC (%)	LL (%)	PI (%)	LS (%)	ECN	SMDD (t/m ³)	SOMC (%)	<2µm (%)	k (m/s)
TP01	0.27 - 0.4	High plasticity, red brown, Clay.	24.7	52	33	13.0	1	-	-	66	-
TP02	5.0 - 5.4	Medium plasticity, grey with yellow brown, Clay.	16.1	36	22	10.5	1	1.79	16.9	47	6x10 ⁻¹¹
TP09	2.0 - 2.5	High plasticity, grey brown, Clay.	21.8	56	37	13.5	1	1.66	22.1	63	8x10 ⁻¹¹
TP13	0.3 - 0.5	High plasticity, red brown, Clay.	26.6	54	33	13.5	1	-	-	68	-
TP16	2.8 - 3.1	High plasticity, grey brown and yellow brown, Clay.	19.4	58	39	14.5	1	-	-	61	-
TP17	1.0 - 1.5	High plasticity, grey brown, Clay.	25.2	59	39	15.0	1	1.61	23.9	58	1x10 ⁻¹⁰
TP19	1.0 - 1.2	High plasticity, grey brown, Clay.	19.8	60	39	18.5	2(M)	1.67	21.5	52	-
TP21	0.5 - 0.6	Medium to high plasticity, red brown, Clay.	22.9	48	28	12.0	1	-	-	38	-
TP21	1.5 - 2.0	Medium to high plasticity, red brown and grey brown, fine grained sand, sandy Clay.	16.9	48	27	14.5	2(M)	1.65	19.7	35	9x10 ⁻¹¹
TP26	3.5 - 4.0	Fine to medium grained, light grey and orange, Sand, with clay.	11.7	-	-	--	-	-	-	10	-
TP28	0.3 - 0.5	High plasticity, red brown, Clay	27.5	61	40	18	1	-	-	59	-
TP28	2.5 - 3.0	High plasticity, grey brown mottled yellow brown, Clay	26.0	66	44	18.5	1	1.59	24.8	58	-

Where: - = not determined PL = plastic limit SMDD = standard max dry density
FMC = field moisture content PI = plasticity index SOMC = standard optimum moisture content
LL = liquid limit PI = LL-PL k = remoulded/compacted permeability
ECN Emerson Class Number LS = linear shrinkage <2µm = % clay

The geotechnical laboratory results are discussed in the following sections.

5.3.1 Dispersive Soils

The ECN test results generally were Class 1 with two Class 2(M) samples. These results show that the clay soils at the site are dispersive. Dispersive soils are a known cause of “piping failures” of water-retaining earth embankments, such as dams and ponds. Various methods (both design and construction) need to be adopted to mitigate the impact of dispersive soils. These aspects are discussed in Section 6 of this report.

5.3.2 Clay Soil Permeability

Both laboratory permeability tests (falling head) of remoulded soil samples, and particle size distribution tests were undertaken as part of the permeability assessment of the clay soils proposed for compacted earthworks embankments and clay liners. The falling head permeability tests results (four tests undertaken) were in the range of 1×10^{-10} m/sec to 9×10^{-11} m/sec with the samples tested described as medium plasticity clay, high plasticity clay, and medium to high plasticity sandy clay soils. The result for the sandy clay soil sample (test pit TP21, 1.5 to 2.0 metres) was 9×10^{-11} m/sec. It is noted that a value of 1×10^{-9} m/sec is generally considered the maximum value in situations where environmental concerns may be an issue. The falling head permeability test samples were remoulded to a nominal 98% SMDD prior to test.

The percentage of soil particles less than $2\mu\text{m}$ (that is, the “clay” fraction) may be used as an indicator of soil permeability. The results obtained were in the range of 35% to 68%, with most results above approximately 50%. These soil samples were described as medium plasticity or high plasticity clays, with the exception of a medium plasticity sandy clay sample from the Freshwater Dam area (test pit TP21, 1.5 to 2.0 metres). This sandy clay soil has a clay fraction of 34% and approximately 30% sand ($75\mu\text{m}$ to 2.36mm), with the remainder being silt and gravel.

5.3.3 Atterberg Limits and Soil Plasticity

Atterberg Limit (Liquid Limit, Plastic Limit and Plasticity Index) and Linear Shrinkage tests were undertaken to assess the plasticity and shrinkage potential of the clay soils at the site. A total of 11 Atterberg Limit and 11 Linear Shrinkage tests were undertaken. The Liquid Limit results were in the range of 36% to 66%, indicating that the clay soils at the site vary from medium plasticity to high plasticity. The red brown clay soils encountered nearer the surface tended to be high plasticity.

The Linear Shrinkage results were in the range of 10.5% to 18.5% with most results above 13%. The higher results (in the range of 15% to 18.5%) were of samples taken from the Freshwater Storage Dam, Effluent Storage Dam and Freshwater Basin areas. The Linear Shrinkage results indicate the clay soils at the site are susceptible to cracking and shrink/swell movements with variations in moisture content. Various methods (both design and construction) may be adopted to mitigate the impact of cracking soils. These aspects are discussed in Section 6 of this report.

5.3.4 Soil Compaction and Field Moisture Content

Compaction tests (maximum dry density and optimum moisture content) and field (in-situ) moisture tests were undertaken as part of the assessment of the clay soils proposed for bulk earthworks. The difference between field moisture content and optimum moisture content can be used as an indication of the amount of moisture conditioning that would be required during construction (and undertaken by the earthworks contractor). It is noted that the in-situ moisture of the soils at the site will vary with rainfall and irrigation practices.

Standard compaction tests were performed on six clay soil samples taken from the Freshwater Storage Dam, Effluent Storage Dam, Holding Pond and Freshwater Basin areas. The standard maximum dry density (SMDD) results ranged from 1.59 t/m³ to 1.79 t/m³ and the optimum moisture content (SOMC) from 16.9% to 24.8%. These results are typical of clayey soils.

A total of 12 Field Moisture tests were undertaken, comprising 11 clay soil samples and one sand soil sample. Of the clay soil samples, the results were in the range of 16.1% to 27.5% indicating generally moist soil conditions at the time of the investigation. It is noted that most of the samples were taken from areas that had been developed for flood irrigation, and it is therefore likely these results are affected by irrigation practices at the site.

5.4 Agricultural Laboratory Results

The agricultural laboratory results are presented in Appendix C and summarised in the following table.

Table 3. Summary of Agricultural Laboratory Results

Test Pit	Depth (m)	Description	CE C (%)	ESP (%)	pH (1:5)	EC (µS/cm)	TKN (mg/kg)	Bray P (mg/kg)	P-Sorp (mg/kg)	OM (%)
TP06	0 – 0.1	Low plasticity, brown, sandy Clay (topsoil)	9.8	1.7	6.0	220	1500	3.9	420	2.5
TP06	0.1 – 0.3	High plasticity, red brown, Clay	9.1	0.7	8.6	1020	630	1.5	480	0.61
TP07	0 – 0.17	Medium plasticity, sandy Clay (topsoil)	14.3	9.8	6.5	210	1600	8.5	450	2.8
TP07	0.2 – 0.4	High plasticity, red brown, Clay	20.3	20.2	8.3	830	700	1.0	430	0.62
TP07	1.1 – 1.3	Medium plasticity, grey brown, Clay	37.5	4.3	7.4	4130	390	2.5	420	0.15
TP23	0 – 0.1	Low plasticity, brown, sandy Clay (topsoil)	8.5	8.5	5.6	210	1700	9.0	440	2.9

Test Pit	Depth (m)	Description	CE C (%)	ESP (%)	pH (1:5)	EC (μS/cm)	TKN (mg/kg)	Bray P (mg/kg)	P-Sorp (mg/kg)	OM (%)
TP23	0.3 – 0.5	High plasticity, red brown, Clay	20.7	18.1	8.0	470	1000	1.0	480	1.5
TP31	0 – 0.13	Low plasticity, brown, sandy Clay (topsoil)	7.8	4.1	5.9	250	1600	15	360	3.3
TP31	0.2 – 0.4	High plasticity, red brown, Clay	18.9	13.3	8.4	190	750	<0.5	500	0.86
TP31	0.8 – 1.0	High plasticity, grey brown and light grey, Clay	16.8	23.8	8.9	390	480	1.5	340	0.2

Where: nt = not determined EC = electrical conductivity P-Sorp = phosphorus soption
 CEC = cation exchange capacity TKN = total Kjeldahl nitrogen OM = organic matter
 ESP = exchangeable sodium % Bray P =Bray phosphorus

We understand that the assessment of the above results will undertake by others.

6. Geotechnical Discussion

6.1 Geotechnical Issues

6.1.1 General

The nature of the proposed development and the investigation undertaken by GHD-LongMac has identified a number of geotechnical issues that need to be considered for the site. These include the following:

- Treatment of dispersive soils.
- Variable subsurface conditions (clayey and sandy soils) and potentially undetected “Stream Traces” within the subsurface profile.
- Clay soil plasticity and cracking potential.
- Soil permeability.
- Stability of compacted earthworks embankments for effluent and water-retaining structures.
- Stability of excavated slopes within effluent and water-retaining structures.
- Compaction and moisture content requirements for bulk earthworks.

Each of these issues is addressed below. In assessing the site, reference should be made to the test pit and borehole logs attached in Appendix A for a detailed description of the encountered subsurface conditions at each test location, and the summary tables contained in this report for information on groundwater levels and laboratory results.

In summary, the investigation typically encountered clayey soils, with some underlying sandy layers at depth of 2.0 metres (TP27) to 7.0 metres (BH01). The clayey soils were assessed as alluvial in nature, consistent with the information shown on the Geological Series Sheet for the area (Urana) and the geomorphic map (Riverine Plain of South Eastern Australia) as detailed in Section 4.2 of this report. The sandy layers were assessed as alluvial deposits known as “Stream Traces” and were contained within the generally clayey subsurface profile. The encountered “Stream Traces” tended to be concentrated near the central part of the site (test pits TP25, TP26, TP27). It is noted that borehole BH01 encountered sand layers below the termination depth of the test pit investigations (due to excavator depth limitations).

The strengths of the alluvial clayey soils are typically in the range stiff to hard, and the sandy soils were typically loose, resulting in frequent sidewall collapse within the test pits within this material. The moisture content of the clay soils was typically moist and likely to have been influenced by irrigation practices at the site.

6.1.2 Dispersive Soils and Sand Layers

The soils at the site are dispersive and are therefore not appropriate for construction of the proposed effluent and water-retaining structures, unless modified or replaced with suitable material. Dispersive soils have been successfully used for construction of water-retaining structures using the following techniques:

- ▶ The addition of an appropriate percentage of gypsum (calcium sulphate) to the clay soil during construction.
- ▶ Stipulation of an appropriate construction specification for bulk earthworks with respect to both compaction and moisture content.
- ▶ Controls and verification during construction to ensure the adopted construction specification and design is followed.

Due to the confirmed presence of sand layers within and below the predominately clay (dispersive) subsurface profile, the presence of sand layers near and within the “cut” area of the reservoirs will need to be further assessed to verify the design and the layout of the facilitates. A “piping failure” through insitu clay material to an adjacent sand layer may be possible if an insufficient depth/distance of clay material separates these material types. At this stage it can be confirmed that sand layers are present in the vicinity of the proposed Holding Pond and Freshwater Basins. The sand layers could also adversely impact on the ability of the dams, ponds and basins to retain water.

For these reasons, and as part of a comprehensive investigation that will be required prior to development, it is recommended that additional geotechnical investigation/survey is undertaken to further assess sand layers and their impact within and adjacent the proposed reservoir areas. This additional work may include:

- ▶ An “electromagnetic” survey to establish the position of sand layers and “Stream Traces”.
- ▶ Drilling of a sufficient number of additional boreholes (to be grouted on completion).

Alternatively, all the dams and ponds could be lined on the assumption that underlying adverse sand layers are present.

Provided appropriate design and construction measures are undertaken, together with any required additional site investigation, the presence of dispersive soils is not expected to be a significant constraint to the proposed development.

6.1.3 Soil Cracking and Plasticity

The clay soils encountered by the investigation typically ranged from medium to high plasticity. The Linear Shrinkage results indicate the clay soils at the site are susceptible to cracking and shrink/swell movements with variations in moisture content. Methods that may be adopted to mitigate the impact of cracking soils include:

- ▶ Maintaining water in the reservoirs at all times to prevent drying out of the clay.
- ▶ Modifying the plasticity and shrinkage characteristics of the clay by adding an appropriate percentage of lime or gypsum.
- ▶ Encapsulating higher plasticity material within the placed earthworks.
- ▶ Topsoiling with less plastic material.

Provided appropriate design and construction measures are undertaken, the presence of potentially cracking soils is not expected to be a significant constraint to the proposed development.

6.1.4 Soil Permeability

The permeability and particle size distribution tests undertaken have confirmed the presence of suitable, relatively impermeable, clay soils at the site. The textural and physical characteristics of the tested clay samples indicate that these relatively impermeable clay soils are uniformly distributed across the site.

At the Holding Pond site it has been confirmed (borehole BH01) that a clay liner (or appropriate alternative) is required at the base of the reservoir.

6.1.5 Excavation

Excavation of the ponds, basins and dams to the proposed invert depths is expected to be in predominantly clay soils. Excavation of these materials is expected to be achievable using conventional earthmoving equipment such as excavators, backhoes and scrapers.

6.1.6 Stability of Compacted Earthworks Embankments

Provided the earthworks structures are constructed to an appropriate specification, the following batter slopes are recommended for preliminary design:

- ▶ Fill batters located on the external side of the embankment to be constructed at a slope of 2:1 (Horizontal: Vertical).
- ▶ Fill batters located on the interior side of the embankment (water retaining) to be constructed at a slope of 3:1 (Horizontal: Vertical).

6.1.7 Stability of Excavated Slopes

The following batter slopes are recommended for preliminary design:

- ▶ Cut batters located within the reservoir area to be constructed at a slope of 3:1 (Horizontal: Vertical).

6.1.8 Compaction and Moisture Content for Bulk Earthworks

It is recommended that earthworks is undertaken to an engineering specification prepared for the project. The following is recommended for preliminary design:

- ▶ Compacted earthworks embankments to be placed at a minimum of 95% Standard dry density ratio and at a moisture content between 3% dry and 1% wet of Standard optimum moisture content.
- ▶ Compacted clay liners to be placed at a minimum of 98% Standard dry density ratio and at a moisture content between 3% dry and 1% wet of Standard optimum moisture content.

6.2 Groundwater

Groundwater is expected to underlie the site at a depth of approximately 20 metres to 22 metres and is therefore not expected to be a development constraint.

Reference should be made to Table 1 for the summary of the groundwater levels that were encountered during the investigation. We note that groundwater levels are also subject to seasonal variations and are therefore expected to vary from the levels encountered during the investigation.

6.3 Construction Issues

It is recommended that placed earthworks is tested by a NATA registered soil laboratory at a test frequency appropriate to the development. AS 3798-Guidelines on Earthworks for Commercial and Residential Developments, provide recommendations for test frequencies and compaction levels for various types of developments.

It is recommended that the effluent and water-retaining structures be constructed under the full time presence of a geotechnical engineer/geotechnician on site. This would enable:

- ▶ Inspection and approval of stripped areas prepared by the earthworks contractor for the placement of fill.
- ▶ Confirmation that the earthworks construction techniques are in accordance with specification.
- ▶ Inspection of the reservoir area excavations for sand layers and bands, and input into any design changes that may be subsequently required.

6.4 Further Investigation

Following submission of the EIS document we understand that additional geotechnical investigations will be undertaken as part of the detailed design process.

It is expected that the final layout and design of the facilities will be modified from the preliminary layout (as used by this assessment), to account for sand layers/"Stream Traces" and any other unfavourable subsurface conditions. It is recommended that the additional geotechnical investigation recommended above is to be undertaken at this stage so that appropriate geotechnical design input is proved into the detailed design process.

7. Summary and Conclusions

Based on the results of the preliminary geotechnical investigation undertaken by GHD-LongMac, the following generalised site conditions were encountered. Reference should be made to the relevant sections of the report and appendices for a detailed appreciation of site conditions.

- ▶ Alluvial soils were predominantly encountered by the investigation and these typically comprised clay materials. The clay soils are dispersive and typically of medium plasticity or medium to high plasticity. The test results indicate that the clay soils encountered have a permeability less than 1×10^{-9} m/sec.
- ▶ "Stream Traces" of typically fine to medium grained sandy soils were encountered at a number of test locations. These layers of sandy soil are located within the generally clayey subsurface profile.
- ▶ Alluvial materials were referenced by the geomorphic map and geological sheet for the area.
- ▶ Groundwater is expected to underlie the site at a depth of approximately 20 metres to 22 metres.

Based on the provided preliminary layout drawings and the advised excavation depths and embankment heights, we conclude that the site can be developed for the proposed 80,000 head cattle feedlot provided appropriate design, further geotechnical investigation as required, construction control and verification is undertaken. The development issues are mainly related to effluent and water-retaining structures. These aspects are summarised below. However, reference should be made to the relevant sections of the report for details.

- ▶ The impact of dispersive soils can be mitigated by well-accepted engineering design and control methods. These measures include the modification of clay liners and embankment earthworks with gypsum and adoption of an appropriate construction specification for engineered fill.
- ▶ The impact of sandy soils in the proposed development area can be mitigated by appropriate design, further geotechnical investigation as required, and appropriate construction control and verification. Design measures include the provision of compacted clay liners to seal the effluent and water-retaining structures where "Stream Traces" are present.
- ▶ The impact of potentially cracking clay soils can be mitigated by a number of measures. These include maintaining water or effluent in the reservoirs to prevent drying out of the clay, encapsulating higher plasticity material within the placed earthworks, and/or modifying the plasticity and shrinkage characteristics of the clay by adding an appropriate percentage of lime or gypsum.
- ▶ Groundwater is not expected to be a development constraint.

We conclude from the preliminary geotechnical investigation undertaken that conventional engineering solutions can be adopted to address the geotechnical constraints identified at the site to enable construction of an 80,000 head cattle feedlot.

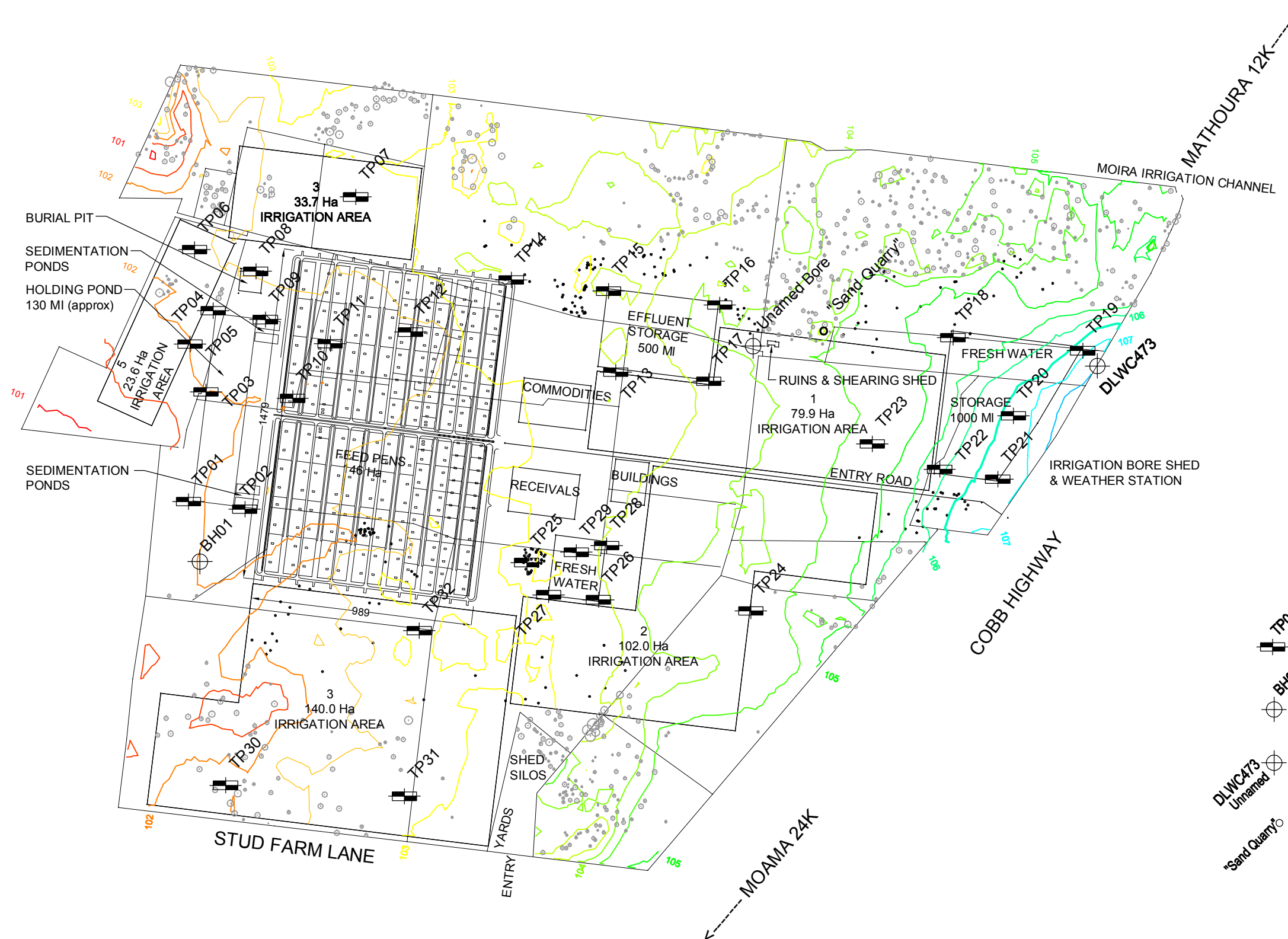
GHD-LONGMAC PTY LTD



Figure

Figure 1

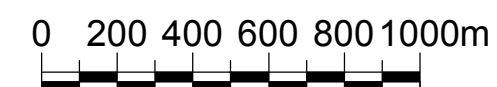
Test Location Plan



LEGEND

-  TP01 TEST PIT (BY GHD-LM)
-  BH01 BOREHOLE (BY GHD-LM)
-  DLWC473 BOREHOLE (BY OTHERS)
-  "Sand Quarry" LOCALITY

NOTE: PLOTTED LOCATIONS ARE FROM GPS CO-ORDINATES AND ARE THEREFORE APPROXIMATE.



SCALE IN METRES (1:20000 BEFORE REDUCTION)

REFERENCE: BASE PLAN PROVIDED BY FRANK RENNIK & COMPANY PTY. LIMITED, PLAN 3315-3A.DWG 05/02/2005.

NOTE: AMG (AGD66) ZONE 55

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"MOIRA STATION" COBB HIGHWAY, MATHOURA PROPOSED 80,000 HEAD CATTLE FEEDLOT TEST LOCATION PLAN

Designed:	RAC
Drawn:	RM
Checked:	Date: 26/4/05
File name:	2113507_F01.DWG

Figure No:	1
Job No:	21/13507
Scale:	AS SHOWN



Standard Sheets

General Notes

Glossary of Symbols

Soil Description

Rock Description

Laboratory Testing

GENERAL NOTES



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The report contains the results of a geotechnical investigation conducted for a specific purpose and client. The results should not be used by other parties, or for other purposes, as they may contain neither adequate nor appropriate information. In particular, the investigation does not cover contamination issues unless specifically required to do so by the client.

TEST HOLE LOGGING

The information on the test hole logs (boreholes, test pits, exposures etc.) is based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results). The test hole logs include both factual data and inferred information. Reference should be made to the relevant sheets for the explanation of logging procedures (Soil and Rock Descriptions, Core Log Sheet Notes etc.).

GROUNDWATER

Unless otherwise indicated, the water levels presented on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level depending on material permeabilities (i.e. depending on response time of the measuring instrument). Further, variations of this level could occur with time due to such effects as seasonal, environmental and tidal fluctuations or construction activities. Confirmation of groundwater levels, phreatic surfaces or piezometric pressures can only be made by appropriate instrumentation techniques and monitoring programmes.

INTERPRETATION OF RESULTS

The discussion or recommendations contained within this report normally are based on a site evaluation from discrete test hole data. Generalised, idealised or inferred subsurface conditions (including any geotechnical cross-sections) have been assumed or prepared by interpolation and/or extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions do occur in the natural environment, particularly between discrete test hole locations. Additionally, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site. Furthermore, conditions may change at the site from those encountered at the time of the geotechnical investigation through construction activities and constantly changing natural forces.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed or reported should be referred to this firm for appropriate assessment and comment.

GEOTECHNICAL VERIFICATION

Verification of the geotechnical assumptions and/or model is an integral part of the design process - investigation, construction verification, and performance monitoring. Variability is a feature of the natural environment and, in many instances, verification of soil or rock quality, or foundation levels, is required. There may be a requirement to extend foundation depths, to modify a foundation system or to conduct monitoring as a result of this natural variability. Allowance for verification by geotechnical personnel accordingly should be recognised and programmed during construction.

FOUNDATIONS

Where referred to in the report, the soil or rock quality, or the recommended depth of any foundation (piles, caissons, footings etc.) is an engineering estimate. The estimate is influenced, and perhaps limited, by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The material quality and/or foundation depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications should provide for variations in the final depth, depending upon the ground conditions at each point of support, and allow for geotechnical verification.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in our geotechnical report, or other technical information, for the inclusion in contract documents or engineering specification of the subject development, such reproductions should include at least all of the relevant test hole and test data, together with the appropriate standard description sheets and remarks made in the written report of a factual or descriptive nature.

Reports are the subject of copyright and shall not be reproduced either totally or in part without the express permission of this firm.

GLOSSARY OF SYMBOLS

This standard sheet should be read in conjunction with all test hole log sheets and any idealised geological sections prepared for the investigation report.

GENERAL

Symbol	Description	Symbol	Description
D	Disturbed Sample	PZ	Piezometer Installation
U	Undisturbed Sampled (suffixed by sample size or tube diameter in mm if applicable)	R	Rising Head Permeability Test
C	Core Sample (suffixed by diameter in mm)	F	Falling Head Permeability Test
SV	Shear Vane Test (suffixed by value in kPa)	PBT	Plate Bearing Test
SPT	Standard Penetration Test (with blows per 0.15m)	→	Water Inflow (make)
N	SPT Value	←	Water Outflow (loss)
PK	Packer Test	▽	Temporary Water Level
PM	Pressuremeter Test	▼	Final Water Level
PP	Pocket Penetrometer (suffixed by value in kPa)	●	Point Load Test (axial)
IMP	Impression Device Test	○	Point Load Test (diametric)
HB	SPT hammer bouncing		

SOIL SYMBOLS

Main Components

	SAND		CLAY		SILT
	GRAVEL		FILL		TOPSOIL

Minor Components

	sandy		clayey		silty
	gravelly		vegetation, roots		

Note: Natural soils are generally a combination of constituents, e.g.

	sandy CLAY
--	------------

ROCK SYMBOLS

Sedimentary

	SANDSTONE		SHALE
	CLAYSTONE		CONGLOMERATE
	SILTSTONE		COAL

Igneous

	GRANITE
	IGNEOUS DYKE

Note: Additional rock symbols may be allocated for a particular project.

NATURAL FRACTURES (Coding)

Fracture Type	Orientation	Shape	Roughness	Others
JT Joint	For vertical non-oriented core ... "Dip" angle (eg. 5°) measured relative to horizontal	PLN Planar	POL Polished	DIS Discontinuous
BP Bedding Plane Parting	For inclined non-oriented core ... "Angle" measured relative to core axis.	CU Curved	SLK Slickensided	TI Tight
SM Seam	For inclined oriented core ... "Dip" angle and "Dip Direction" angle (eg. 45°/225° mag.)	UN Undulating	SO Smooth	OP Open
FZ Fragmented Zone	VT Vertical	ST Stepped	RF Rough	
SZ Shear Zone	HZ or 0° Horizontal	IR Irregular	VR Very Rough	
VN Vein	d degrees			
Infilling or Coating				
CN Clean				
X Carbonaceous				
CLAY Clay				
KT Chlorite				
CA Calcite				
FE Iron Oxide				
MI Micaceous				
QZ Quartz				

SOIL DESCRIPTION



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This procedure involves the description of a soil in terms of its visual and tactile properties, and relates to both laboratory samples and field exposures as applicable. A detailed soil profile description, in association with local geology and experience, will facilitate the initial (and often complete) site assessment for engineering purposes.

The method involves an evaluation of each of the items listed below and is in general agreement with both Australian Standard AS 1726 (the Site Investigation Code) and ASTM D2487 and D2488.

MOISTURE

The moisture condition of the soil is most applicable for cohesive soils as a precursor to the assessment of consistency and workability. The moisture condition is described as:-

Dry (dusty, dry to the touch) **Slightly Moist** **Moist** (damp, no visible water) **Very Moist** or **Wet** (visible free water, saturated condition)

In addition, the presence of any seepage or free water is noted on the testhole logs.

COLOUR

Colour is important for correlation of data between testholes and during subsequent excavation operations. The prominent colour is noted, followed by (spotted, mottled, streaked etc.) then secondary colours as applicable. Colour is usually described at as-received moisture condition, though both wet and dry colours may also be appropriate.

CONSISTENCY/RELATIVE DENSITY

This assessment is based on the effort required to penetrate and/or mould the soil, and is an indicator of shear strength.

Granular soils are generally described in terms of density index as listed in AS 1726. These soils are inherently difficult to assess and normally a penetration test procedure (SPT, DCP or CPT) is used in conjunction with published correlations. Alternatively, in-situ density tests can be conducted in association with minimum and maximum densities performed in the laboratory.

Cohesive soils can be assessed by direct measurement (shear vane), or estimated approximately by tactile means and/or the aid of a geological pick as given on the following table. It is emphasised that a “design shear strength” must take cognisance of the in-situ moisture content and the possible variations of moisture with time.

Term	Tactile Properties	Unconfined Compressive Strength q_u (kPa)
Very Soft	Extrudes from fingers when squeezed	<25
Soft	Easily penetrated by thumb about 30-40 mm. Pick head can be pushed in up to shaft. Moulded by light finger pressure.	25-50
Firm	Penetrated by thumb 20-30 mm with moderate effort. Sharp end of pick pushed in 30-40 mm. Moulded by strong finger pressure.	50-100
Stiff	Indented by thumb about 5 mm with moderate effort. Pick pushed in up to 10 mm. Cannot be moulded in fingers.	100-200
Very Stiff	Readily indented by thumb nail. Slight indentation produced by pushing pick into soil.	200-400
Hard	Difficult to indent with thumb nail. Requires power tools for excavation.	>400

STRUCTURE/OTHER FEATURES

The soil structure is generally applicable to cohesive soils and refers to the presence or absence of joints and layering. Typical terms use are intact (no joints), fissured (closed joints), shattered (open joints), slickensided (polished joints indicative of movement), and stratified/laminated. In addition, the presence of other features (ferricrete nodules, timber inclusions) should also be noted as applicable.

For granular soils, an assessment of grading (well, uniform or poor), particle size (fine, medium etc.) and angularity and shape may also be given.

SOIL TYPE

The soil is described in terms of its estimated grain size composition and the tactile behaviour (plasticity of any fines (less than *0.06 mm)). This system does not differentiate on grading below 0.06 mm, in accordance with the Unified Soil Classification (USC) procedure.

Furthermore, as most natural soils frequently are combinations of various constituents, the primary soil is described and modified by minor components. In brief, the system is as follows:-

Coarse Grained Soils		Fine Grained Soils	
% Fines	Modifier	% Coarse	Modifier
5	omit, or use “trace”	15	omit, or use “trace”
5-12	describe as “with clay/silt” as applicable	15-30	described as “with sand/gravel” as applicable
>12	prefix soil as “silty/clayey” as applicable	>30	prefix soil as “sandy/gravelly” as applicable

(*The 200# sieve (0.075 mm) is commonly used in practice to differentiate between fine and coarse grained soils).

Note: For soils containing both sand and gravel the minor coarse fraction is omitted if less than 15%, or described as “with sand/gravel” as applicable when greater than 15%.

The appropriate USC symbol may also be given after the soil type description in accordance with ASTM D2487 and D2488.

ORIGIN

An attempt is made, where possible, to assess origin (transported, residual, pedogenic, or fill etc.) since this assists in the judgement of probable engineering behaviour. This assessment is generally restricted to field logging activities. An interpretation of landform is a useful guide to the origin of transported soils (e.g. colluvium, talus, slide debris, slope wash, alluvium, lacustrine, estuarine, aeolian and littoral deposits) while local geology and remnant fabric will assist identification of residual soils.

ROCK DESCRIPTION



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This method is based on Australian Standard AS 1726 and is orientated to the field logging of diamond drill core, but may be used for the profiling of natural exposures and cuttings, as applicable. The procedure involves a visual and tactile assessment of the rock mass and the nature of defects within it in order to facilitate a prediction of engineering behaviour.

DESCRIPTION: Rock Type is described on the basis of origin (sedimentary, metamorphic and igneous) with the common types listed below:-

Sedimentary				Metamorphic	Igneous				
Clastic	Non clastic (chemical)	Non clastic (organic)	Pyroclastic	Slate Phyllite Schist Quartzite Gneiss	Extrusive	Acid	Intermediate		Basic
Conglomerate Sandstone Siltstone Shale Claystone	Limestone Chert Gypsum Salt	Coal Some Limestone	Tuff Agglomerate Volcanic Breccia			Rhyolite	Trachyte	Andesite	Basalt
					Intrusive (medium grained)	Quartz Porphyry	Porphyry	Porphyry	Dolerite
					(coarse grained)	Granite	Syenite	Diorite	Gabbro

Colour is given to assist in rock identification and the interpolation of field data. Colour is usually described at as-received moisture condition, though both wet and dry colours may also be appropriate.

Texture refers to the degree of crystallinity and granularity (grain size) and the fabric relationship between the constituents of a rock. Often only grain size is given for simplified descriptions of certain sedimentary rocks.

Structure and texture are commonly used synonymously in describing rocks since there is no clear delineation between terms. In general, structure refers to large-scale features recognisable in the field (banding, lineation, massive, porphyritic, schistose etc.). For sedimentary rocks in particular, the thickness of sedimentary layering (bedding) is described as:-

Thinly laminated	<6mm	very thinly bedded	20-60mm	medium bedded	0.2-0.6m	very thickly bedded	>2m
Laminated	6-20mm	thinly bedded	60-200mm	thickly bedded	0.6-2m		

In addition, mineral composition, hardness, alteration, cementation is given as applicable.

WEATHERING: The assignment of weathering is somewhat subjective. Weathering assists identification and does not imply engineering behaviour. No distinction is drawn between chemical weathering and alteration for most engineering purposes. These procedures are collectively described as “weathering” using the following terms which do not describe the related strength change. This system is general, and in this format may not apply to all rock types. Carbonate rocks generally do not conform to this classification.

Term	Symbol	Definition
Completely Weathered	CW	Residual soil with rock fabric not visible.
Extremely Weathered	EW	The rock exhibits soil-like properties though the texture of the original rock is still evident.
Highly Weathered	HW	Limonite staining or colour change affects the whole of the rock mass and other signs of chemical or physical decomposition are evident.
Moderately Weathered	MW	Staining extends throughout the whole of the rock mass and the original colour is no longer recognisable.
Slightly Weathered	SW	Partial staining or discolouration of the rock mass, usually by limonite, has taken place.
Fresh	FR	Rock mass unaffected by weathering.

ESTIMATED STRENGTH: This refers to the strength of the rock substance and not that of the rock mass. The strength of the rock substance is estimated by the Point Load Strength Index $I_s(50)$ and refers to the strength measured in the direction normal to the bedding for sedimentary rocks. A field guide is given below:-

Term	Symbol	$I_s(50)$ MPa	Field Guide (The core refers to a 150mm long x 50mm dia. sample)
Extremely Weak	EW	<0.03	Remoulded by hand to a material with soil properties.
Very Weak	VW	0.03-0.1	May be crumbled in the hand. Sandstone is “sugary” and friable.
Weak	W	0.1-0.3	The core may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
Medium Strong	MS	0.3-1.0	The core may be broken by hand with considerable difficulty. Readily scored with knife.
Strong	S	1-3	The core cannot be broken by unaided hands, can be slightly scratched or scored with knife.
Very Strong	VS	3-10	The core may be broken readily with hand held hammer. Cannot be scratched with knife.
Extremely Strong	ES	>10	The core is difficult to break with hand held hammer. Rings when struck with a hammer.

DEFECTS: This important feature can control the overall engineering behaviour of a rock mass. All types of natural fractures across which the core is discontinuous are noted. These fractures include bedding plane partings, joints and other defects but exclude artificial fractures such as drilling breaks. The nature of the defects (joints, bedding partings, seams, zones and veins) is also noted with description, orientation, infilling or coating, shape, roughness, thickness, etc. given generally in accordance with AS 1726. The spacing of natural fractures excludes bedding partings unless there is evidence that they were separated prior to drilling. This notwithstanding, bedding partings maybe considered as planes of weakness in an engineering assessment.

LABORATORY TESTING



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GENERAL

Samples extracted during the fieldwork stage of a site investigation may be “disturbed” or “undisturbed” (as generally indicated on the trial hole logs) depending upon the nature and purpose of the sample as well as the method of extraction, transportation, extrusion and testing. This aspect should be taken into account when assessing test results, which must of necessity reflect the effects of such disturbance.

All soil properties (as measured by laboratory testing) exhibit inherent variability and thus a certain statistical number of tests is required in order to predict an average property with any degree of confidence. The site variability of soil strata, future changes in moisture and other conditions and the discrete sampling positions must also be considered when assessing the representative nature of the laboratory programme.

Certain laboratory test results provide interpreted soil properties as derived by conventional mathematical procedures. The applicability of such properties to engineering design must be assessed with due regard to the site, sample condition, procedure and project in hand.

TESTING

Laboratory testing is normally carried out in accordance with Australian Standard AS 1289 as amended, or RTA Standards when specified. The routine Australian Standard tests are as follows:-

Moisture Content	Test 2.1.1	
Liquid Limit	Test 3.1.1	)
Plastic Limit	Test 3.2.1	) collectively known as Atterberg Limits
Plasticity Index	Test 3.3.1	)
Linear Shrinkage	Test 3.4.1	
Particle Density	Test 3.5.1	
Particle Size Distribution	Tests 3.6.1, 3.6.2 and 3.6.3	
Emerson Class Number	Test 3.8.1	)
Percent Dispersion	Test 3.8.2	) collectively, Dispersive Classification
Pinhole Dispersion Classification	Test 3.8.3	)
Organic Matter	Test 4.1.1	
Sulphate Content	Test 4.2.1	
pH Value	Test 4.3.1	
Resistivity	Test 4.4.1	
Standard Compaction	Test 5.1.1	
Modified Compaction	Test 5.2.1	
Dry Density Ratio	Test 5.4.1	
Minimum Density	Test 5.5.1	
Density Index	Test 5.6.1	
California Bearing Ratio	Tests 6.1.1 and 6.1.2	
Shear Box	Test 6.2.2	
Undrained Triaxial Shear	Test 6.4.1	
One Dimensional Consolidation	Test 6.6.1	
Constant Head Permeability	Akroyd	

Where tests are used which are not covered by appropriate standard procedures, details are given in the report.

LABORATORY

Our laboratory is a Registered Laboratory in the terms of registration with the National Association of Testing Authorities (NATA) for the listed tests.

The oedometer, triaxial and shear box equipment are fully automated for continuous operation using computer controlled data acquisition, processing and plotting systems.



Appendix A

Profile Logs (TP01 to TP32 and BH01)

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP01

SHEET 1 OF 1

Position: 306117E, 6020401N

Surface RL: 101.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 16/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		Slightly moist, light brown, firm, sandy CLAY, fine grained sand (disturbed/topsoil).	
D	0.27		Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).	
	0.40m		as above, but brown MC>PL.	
D	0.75		Moist, grey brown with red brown mottle, very stiff, medium plasticity, CLAY [MC=PL], trace fine grained sand (alluvium).	
	1.30m		as above, but light grey brown and yellow brown mottled.	
D	2.00		Slightly moist, grey brown and yellow brown, very stiff, medium plasticity, CLAY [MC=PL], trace fine grained sand (alluvium).	
	3			
	4			
	4.50		Slightly moist, grey and light grey brown, very stiff, low plasticity, sandy CLAY [MC=PL], sand is fine grained (alluvium).	
D	5.50		End of hole at 5.5 metres. Depth limit of excavator.	
			No groundwater encountered.	
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

See standard sheets for
details of abbreviations
& basis of descriptions



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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP02

SHEET 1 OF 1

Position: 306368E, 6020367N

Surface RL: 102.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 16/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION
			Moisture, colour, consistency, structure, SOIL TYPE (origin)
	0		
	0.20		Slightly moist, light brown, firm, sandy CLAY, fine grained sand (disturbed/topsoil).
			Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).
	1		
	1.00		Moist, grey brown, very stiff, friable, medium plasticity, sandy CLAY [MC>PL], sand is fine grained (alluvium).
	2		
	2.20		Moist, light grey brown and yellow brown mottled, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			
	3		
	4		
	4.50		Moist, grey with yellow brown mottle, stiff, medium plasticity, CLAY [MC>PL], with fine grained sand (alluvium).
B			
	5		
	5.40		End of hole at 5.4 metres. No refusal to excavator bucket. No groundwater encountered.
	6		

PROFILE 2113507.GPJ GHD.GDT 18/05/05

See standard sheets for details of abbreviations & basis of descriptions



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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP03

SHEET 1 OF 1

Position: 306195E, 6020890N

Surface RL: 102.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 16/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION
			Moisture, colour, consistency, structure, SOIL TYPE (origin)
	0		
	0.20		Dry, brown, stiff, medium plasticity, sandy CLAY, [MC<PL], fine grained sand (disturbed/topsoil).
			Very moist, brown, very stiff, high plasticity, CLAY [MC>>PL] (alluvium).
	1		
	1.30		Moist, grey brown with slight light grey mottle, hard, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
	2		
	3		
	3.00		Moist, light grey brown and yellow brown mottled, hard, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
	4		
	5		
	5.30		End of hole at 5.3 metres. Depth limit of excavator. No groundwater encountered.
	6		

PROFILE 2113507.GPJ GHD.GDT 18/05/05

See standard sheets for
details of abbreviations
& basis of descriptions



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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP04

SHEET 1 OF 1

Position: 306256E, 6021259N

Surface RL: 102.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 16/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, light brown, firm, sandy CLAY, fine grained sand (disturbed/topsoil). Very moist, brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).	
	1			
	1.30		Moist, grey brown with slight red brown mottle, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	2			
D				
	3			
D				
	3.00		Moist, grey brown, yellow brown and light grey mottled, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	4			
	4.50		Moist, light grey brown and yellow brown mottled, very stiff, medium plasticity, CLAY [MC = PL], trace fine grained sand (alluvium).	
	5			
D				
	5.50		End of hole at 5.5 metres. Depth limit of excavator. No refusal to excavator bucket. No groundwater encountered.	
	6			

PROFILE 2113507 GPJ GHD.GDT 18/05/05

See standard sheets for
details of abbreviations
& basis of descriptions



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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP05

SHEET 1 OF 1

Position: 306124E, 6021104N

Surface RL: 102.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, [MC<PL], fine grained sand (disturbed/topsoil).
D				Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).
			0.75	Moist, grey brown mottled, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D	1			
	2		2.40	End of hole at 2.4 metres. No refusal to excavator bucket. No groundwater encountered.
	3			
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

See standard sheets for
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GHD LONGMAC



Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP06

SHEET 1 OF 1

Position: 306144E, 6021525N

Surface RL: 102.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, low plasticity, sandy CLAY MC<PL], fine grained sand (disturbed/topsoil).
D				Moist, red brown, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
			0.60	Moist, grey brown mottled, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D	1			
			2.20	End of hole at 2.2 metres. No refusal to excavator bucket. No groundwater encountered.
	2			
	3			
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP07

SHEET 1 OF 1

Position: 306863E, 6021760N

Surface RL: 102.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.17	Slightly moist, brown, stiff, medium plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil).
D				Moist, red brown, very stiff, high plasticity, CLAY, fine grained sand (alluvium).
			0.70	Moist, grey brown with red brown mottle, medium plasticity, CLAY, trace fine grained sand (alluvium).
D	1			1.1m, as above, but grey brown mottled.
			2.00	End of hole at 2.0 metres. No refusal to excavator bucket. No groundwater encountered.
	2			
	3			
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP08

SHEET 1 OF 1

Position: 306417E, 6021428N

Surface RL: 102.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).	
	0.70		Moist, grey brown with slight red brown and yellow brown mottle, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	1			
	2			
D				
	3			
	3.20		Moist, yellow brown and grey mottled, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	3.60		Moist, yellow brown and grey mottled, stiff, medium plasticity, sandy CLAY [MC>PL], fine grained sand (alluvium).	
D				
	4			
	4.80		End of hole at 4.8 metres. No refusal to excavator bucket. No groundwater encountered.	
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP09

SHEET 1 OF 1

Position: 306460E, 6021213N

Surface RL: 102.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
B	0		0.12	Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL] (alluvium).
	1		0.90	Moist, grey brown, stiff, high plasticity, CLAY [MC>PL], (alluvium).
	2			
	3		3.00	Moist, grey brown with yellow brown mottle, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	4			
	5			4.7m, sand content increasing with depth.
	5.20			End of hole at 5.2 metres. Depth of limit of excavator. No refusal to excavator bucket. No groundwater encountered.
	6			

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP10

SHEET 1 OF 1

Position: 306582E, 6020861N

Surface RL: 102.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 17/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Moist, dark brown, stiff, medium plasticity, sandy CLAY [MC>PL], fine grained sand (alluvium).
	1		1.10	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D	2		1.90	Moist, yellow brown and grey brown, low plasticity, sandy CLAY [MC=PL] (alluvium).
	3		3.50	Moist, grey brown and yellow brown mottled, medium plasticity, CLAY [MC=PL], trace fine grained sand (alluvium).
	4		4.50	End of hole at 4.5 metres. No refusal to excavator bucket. No groundwater encountered.
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP11

SHEET 1 OF 1

Position: 306749E, 6021105N

Surface RL: 102.30m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 4m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, dark brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).
D				
	1		1.00	Moist, grey brown with slight red brown mottle, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D				
	2			
D				
	3		3.00	Grey brown mottled and friable at depth. End of hole at 3.0 metres. No refusal to excavator bucket. No groundwater encountered.
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP12

SHEET 1 OF 1

Position: 307108E, 6021157N

Surface RL: 102.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, dark brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).
	0.80		0.80	Moist, grey brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	2.50		2.50	End of hole at 2.5 metres. No refusal to excavator bucket. No groundwater encountered.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP13

SHEET 1 OF 1

Position: 308023E, 6020978N

Surface RL: 103.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	0.80			Moist, brown and yellow brown, stiff, medium plasticity, CLAY [MC>PL], some fine grained sand (alluvium).
B	1.50			Moist, grey brown and grey, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	2.6m			2.6m, as above, greater proportion of grey.
	4.00			End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP14

SHEET 1 OF 1

Position: 307557E, 6021390N

Surface RL: 103.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 4m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY [MC<PL], fine grained sand (disturbed/topsoil). Moist, red brown, stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	0.80		Moist, grey and grey brown, stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).	
	2.00		Moist, grey brown and yellow brown, stiff, medium plasticity, sandy CLAY [MC≈PL], fine grained sand (alluvium).	
	3.0		3.0m, as above, but low plasticity, increasing sand content.	
	3.80		End of hole at 3.8 metres. No refusal to excavator bucket. No groundwater encountered.	
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP15

SHEET 1 OF 1

Position: 307991E, 6021340N

Surface RL: 103.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).
	0.80		0.80	Moist, grey brown with red brown mottle, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
B	1.60		1.60	Moist, grey with grey brown mottle, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand, trace calcite (alluvium).
	4.00		4.00	End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP16

SHEET 1 OF 1

Position: 308487E, 6021278N

Surface RL: 104.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Very moist, red brown, stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	0.60		Moist, grey brown mottled, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
B	1.20		Moist, grey mottled, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	2.30		Moist, grey brown and yellow brown mottled, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
D	3.60		Moist, brown, very stiff, medium plasticity, sandy CLAY [MC≈PL], fine to coarse grained sand, trace medium gravel (alluvium).	
D	4.40		End of hole at 4.4 metres. No refusal to excavator bucket. No groundwater encountered.	
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP17

SHEET 1 OF 1

Position: 308438E, 6020938N

Surface RL: 103.60m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
B	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Slightly moist, dark brown, hard, high plasticity, CLAY [MC<PL] (alluvium).
	0.80		0.80	Moist, grey brown, very stiff, high plasticity, CLAY [MC>PL], trace fine to medium grained sand (alluvium).
	1.50		1.50	Moist, light brown, medium plasticity, CLAY [MC>PL], some fine grained sand (alluvium).
	2.80		2.80	Moist, yellow brown, grey brown and grey mottled, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
B	4.00		4.00	End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP18

SHEET 1 OF 1

Position: 309528E, 6021133N

Surface RL: 105.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 18/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>>PL trace], some fine grained sand (alluvium).
D				
	0.80		0.80	Moist, light brown, very stiff, medium plasticity, sandy CLAY [MC≈PL], fine grained sand (alluvium).
D				
	1.60		1.60	Moist, grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
D				
	2.90		2.90	Becoming Moist, lighter grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
	4.30		4.30	End of hole at 4.3 metres. No refusal to excavator bucket. No groundwater encountered.
	5			
	6			

PROFILE 2113507 GPJ GHD GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP19

SHEET 1 OF 1

Position: 310107E, 6021074N

Surface RL: 106.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL] (alluvium).
	0.60		0.60	Moist, grey brown, very stiff, high plasticity, CLAY [MC≈PL], trace fine to medium grained sand (alluvium).
B	1			
	2		2.20	Moist, brown and grey brown mottled, very stiff, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
D				
	3		3.20	Slightly moist, light grey brown mottled, hard, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
	4		4.20	End of hole at 4.2 metres. No refusal to excavator bucket. No groundwater encountered.
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP20

SHEET 1 OF 1

Position: 309798E, 6020784N

Surface RL: 106.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
B	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], fine grained sand (alluvium).
	0.60		0.60	Moist, brown, very stiff, medium plasticity, CLAY [MC ≈ PL], trace fine grained sand (alluvium).
	1.60		1.60	Moist, grey brown and red brown mottled, very stiff, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
D	3		3.10	Slightly moist, grey and grey brown with slight yellow brown and red brown mottle, hard, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
	4		4.00	End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.

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& basis of descriptions



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57 Herbert Street, Artarmon NSW 2064
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GHD LONGMAC



Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP21

SHEET 1 OF 1

Position: 309728E, 6020501N

Surface RL: 106.60m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, medium to high plasticity, CLAY [MC>PL], trace fine to medium grained sand (alluvium).	
D	0.60		Moist, grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).	
	1			
B	1.50		Slightly moist, red brown and grey brown mottled, very stiff, medium plasticity, sandy CLAY [MC<PL], fine to medium grained sand, trace medium to coarse white semi-rounded gravel (alluvium).	
	2			
	2.80		Slightly moist, yellow brown, grey and red brown mottled, hard, medium plasticity, sandy CLAY [MC<PL], fine to medium grained sand (alluvium).	
D	3			
	4			
	4.20		End of hole at 4.2 metres. No refusal to excavator bucket. No groundwater encountered.	
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP22

SHEET 1 OF 1

Position: 309731E, 6020500N

Surface RL: 105.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	0.60		0.60	Moist, grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
	1.60		1.60	Slightly moist, red brown and grey brown, very stiff, medium plasticity, sandy CLAY, fine grained sand, trace medium to coarse white semi-rounded gravel (alluvium).
	3.20		3.20	Slightly moist, grey, grey brown and red brown with black staining, hard, low plasticity, sandy CLAY [MC<PL], fine to medium grained sand (alluvium), (vesicular).
	4.10		4.10	End of hole at 4.1 metres. No refusal to excavator bucket. No groundwater encountered.

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21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP23

SHEET 1 OF 1

Position: 309452E, 6020525N

Surface RL: 104.70m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			0.60	Slightly moist, grey brown with red brown mottled, medium plasticity, CLAY [MC<PL], trace fine grained sand (alluvium).
D			1.60	Moist, grey brown and red brown mottled, very stiff, medium plasticity, CLAY [MC<PL], trace fine grained sand, trace medium to coarse gravel (alluvium).
	2		2.20	End of hole at 2.2 metres. No refusal to excavator bucket. No groundwater encountered.
	3			
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

See standard sheets for
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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP24

SHEET 1 OF 1

Position: 308626E, 6019913N

Surface RL: 104.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.13	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			0.70	Moist, grey brown, very stiff, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
D	1		2.50	Moist, grey brown, red brown and yellow brown mottled, medium plasticity, CLAY [MC≈PL], trace fine grained sand (alluvium).
			2.90	End of hole at 2.9 metres. No refusal to excavator bucket. No groundwater encountered.

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP25

SHEET 1 OF 1

Position: 307626E, 6020129N

Surface RL: 103.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 15/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Slightly moist, dark grey, loose, clayey SAND, medium grained sand, low plasticity fines (topsoil).	
	0.30		Moist, brown, very stiff, low plasticity, sandy CLAY, fine grained sand (alluvium).	
			Moist, brown, very stiff, high plasticity, CLAY, trace fine grained sand (alluvium).	
	1			
	1.20		Moist, light grey brown mottled yellow brown, very stiff, low plasticity, CLAY, fine to medium grained sand (alluvium).	
	2			
D			Very sandy, vesicular.	
	2.90			
D	3		Dry, white and yellow brown mottled, inferred medium dense, medium grained, SAND (alluvium).	
	4			
	4.00		End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.	
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

21/13507

PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP26

SHEET 1 OF 1

Position: 307946E, 6019963N

Surface RL: 103.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			0.70	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	1			
	2			
	3		3.00	Slightly moist, light grey and orange, fine to medium grained, SAND, with clay (layers to 400mm) interbedded with clayey sand (alluvium).
D	4		4.30	Slightly moist, yellow brown and light grey, medium plasticity, sandy CLAY [MC<PL] (alluvium).
	5		5.10	End of hole at 5.1 metres. No refusal to excavator bucket. No groundwater encountered.
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP27

SHEET 1 OF 1

Position: 307724E, 6019985N

Surface RL: 103.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
B	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	0.70		0.70	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	2		2.00	Slightly moist, light grey and yellow brown, inferred loose, fine to medium grained, SAND (alluvium).
	4		4.00	End of hole at 4.0 metres. No refusal to excavator bucket. No groundwater encountered.
	5			Test pit sidewall collapse in sand from 2.0 to 4.0m
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP28

SHEET 1 OF 1

Position: 307983E, 6020204N

Surface RL: 103.50m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.10	Dry, dark brown, very stiff, high plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, stiff, high plasticity, CLAY [MC>PL], trace sand (alluvium).
D			0.60	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
	1			
			1.80	Moist, grey brown mottled yellow brown, high plasticity, CLAY [MC>PL], with fine to medium grained sand (alluvium).
	2			
B				
	3			
	4			
			4.80	End of hole at 4.8 metres. No refusal to excavator bucket. No groundwater encountered.
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP29

SHEET 1 OF 1

Position: 307847E, 6020175N

Surface RL: 103.40m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 5m

Checked:

Date: 19/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0			
	0.10		Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).	
	0.60		Moist, light grey, very stiff, medium plasticity, CLAY [MC=PL], trace fine grained sand (alluvium).	
	1			
	2		grading to.	
	2.30		Moist, light grey brown with yellow brown mottle, low plasticity, sandy SILT, fine grained sand (alluvium).	
	3			
	3.20		Moist, grey brown, very stiff, medium plasticity, CLAY, trace fine grained sand (alluvium).	
	4			
	4.80		End of hole at 4.8 metres. No refusal to excavator bucket. No groundwater encountered.	
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP30

SHEET 1 OF 1

Position: 306282E, 6019135N

Surface RL: 102.20m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 21/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.12	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			0.60	Moist, grey brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			1.20	Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL] (alluvium).
			2.50	End of hole at 2.5 metres. No refusal to excavator bucket. No groundwater encountered.

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP31

SHEET 1 OF 1

Position: 307080E, 6019086N

Surface RL: 102.80m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 3m

Checked:

Date: 21/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
D	0		0.13	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (disturbed/topsoil).
D				Moist, red brown, very stiff, high plasticity, CLAY [MC>PL] (alluvium).
			0.60	
				Dry, grey brown and light grey, hard, high plasticity, CLAY, trace fine grained sand (alluvium).
D	1			
			1.70	
				Dry, grey brown, light grey and brown mottled, hard, medium plasticity, sandy CLAY, fine grained sand (alluvium).
	2			
			2.40	
				End of hole at 2.4 metres. No refusal to excavator bucket. No groundwater encountered.
	3			
	4			
	5			
	6			

PROFILE 2113507 GPJ GHD GDT 18/05/05

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Job No.

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PROFILE SHEET

Client: AGRICULTURAL EQUITY INVESTMENTS PTY LTD

Project: PROPOSED 80,000 HEAD FEEDLOT

Location: "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. TP32

SHEET 1 OF 1

Position: 307146E, 6019825N

Surface RL: 103.00m approx (AHD)

Processed: HW

Method of Exploration: 20t Komatsu Excavator PC 200LC

Hole Size: 1.1m x 4m

Checked:

Date: 21/02/05

Logged by: RAC

Date:

SAMPLES & TESTS	Depth (metres)	Strata	DESCRIPTION	
			Moisture, colour, consistency, structure, SOIL TYPE (origin)	
	0		0.10	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (topsoil). Moist, red brown, very stiff, high plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).
D			0.60	Dry, light grey brown with slight yellow brown mottle, hard, medium plasticity, CLAY, trace fine grained sand (alluvium).
D			1.5m	as above, but low plasticity.
D			2.30	Dry, white, loose, fine to medium grained, SAND, with coarse grained sand (alluvium).
	3		3.30	End of hole at 3.3 metres. No refusal to excavator bucket. No groundwater encountered.
	4			
	5			
	6			

PROFILE 2113507.GPJ GHD.GDT 18/05/05

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Job No.

21/13507

BOREHOLE LOG SHEET WITH STANDPIPE PIEZOMETER

Client : AGRICULTURAL EQUITY INVESTMENTS PTY LTD
Project : PROPOSED 80,000 HEAD FEEDLOT
Location : "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. BH01**SHEET 1 OF 2**

Position : 306320E, 6020374N **Surface RL:** 102.00m approx (AH) **Angle from Horiz. :** 90° **Processed :** HW
Rig Type : Angove **Mounting :** Trailer **Contractor :** Lloyd Angove Drilling **Driller :** Lloyd Angove **Checked :**
Date Started : 22/02/05 **Date Completed :** 22/02/05 **Logged by :** RAC **Date :**

DRILLING					BOREHOLE DESCRIPTION			PIEZOMETER	
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS	PIEZOMETER LOG COMPONENTS
V-bit auger	Nil	Nil		0.10		CL/CH	Dry, brown, stiff, low plasticity, sandy CLAY, fine grained sand (topsoil).	SPT hammer bouncing	
				0.60		CL/CH	Very moist, red brown, high plasticity, CLAY [MC>>PL], trace fine grained sand (alluvium).		
							Moist, grey brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).		
			SPT 5/8/15 N=23	2.50		CL/CH	Moist, light grey brown and grey with slight yellow brown mottle, stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).		
			SPT 2/4/10 N=14	5.00		CL/CH	Moist, light grey and yellow brown, very stiff, medium plasticity, CLAY [MC>PL], trace fine grained sand (alluvium).		
						CL	5.5m, as above, but [MC ≈ PL].		
			SPT 6/12/16 N=28	7.00		SP	Slightly moist, light brown, fine to medium grained, SAND, trace coarse grained sand (alluvium).		
			D	7.80		CL	Slightly moist, light grey, low plasticity, sandy CLAY, medium grained sand (alluvium).		
			SPT 16/40 for 150mm HB N=ref	8.00		CL/CH	Slightly moist, yellow brown and light grey, hard, medium plasticity, CLAY [MC<PL], trace fine grained sand, isolated fine size rounded gravel (alluvium).		
			D	9.30		SP	Dry, white, inferred loose, fine grained, SAND (alluvium).		3m slotted PVC
			D	9.80			grading to.		
			D	10.00		CL	Dry, white and yellow brown, low		

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COREHOLE 2113507 GPI GHD GDT 18/05/05

HOLE No. BH01

SHEET 1 OF

	Processed : HW
--	----------------

Checked :

Date :

Date Logged :

[illegible]

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21/13507

COREHOLE 2113507.GPJ GHD.GDT 18/05/05

CORE LOG SHEET WITH STANDPIPE PIEZOMETER

Client : AGRICULTURAL EQUITY INVESTMENTS PTY LTD
Project : PROPOSED 80,000 HEAD FEEDLOT
Location : "MOIRA STATION" COBB HIGHWAY, MATHOURA

HOLE No. BH01

SHEET 2 OF

Position : 306320E, 6020374N Surface RL: 102.00m approx (AH) Angle from Horiz. : 90°
Rig Type : Angove Mounting : Trailor Contractor : Lloyd Angove Drilling Driller : Lloyd Angove
Casing Dia. : Barrel (m) : Bit : Bit Condition :
Date Started : 22/02/05 Date Completed : 22/02/05 Logged by : RAC Date Logged :

progress		DRILLING & CASING	WATER	Drill Depth	(Core loss / run %)	SAMPLES & TESTS	DEPTH metres	STRATA	DESCRIPTION	WEATHERING	Estimated Strength		NATURAL FRACTURES		ADDITIONAL DATA (joints, partings, seams, fracture or shear zones and veins)	PIEZOMETER LOG	COMPONENTS
											Is ₍₅₀₎ MPa	Spacing (mm)					
10									ROCK TYPE, colour, grain size, structure (texture, mineral composition, hardness, alteration, cementation, etc. as applicable) and moisture, colour, consistency, structure, SOIL TYPE (origin)		EW 0.03 VM 0.1 WL 0.3 MS 1 S 3 VS 10 FS 10	20 40 100 300 1000					
11	V-bit auger					SPT 10/16/20 N=36 D			plasticity, clayey SAND, fine grained sand (alluvium). Dry, light grey and yellow brown banded, dense, fine grained, SAND, some clay (alluvium). 11.0m, becoming fine to medium grained, trace coarse grained sand.								3m slotted PVC End of piezo@11.50m
12							12.00		End of hole at 12.0 metres. No groundwater encountered.								
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	

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Job No.
21/13507



Appendix B

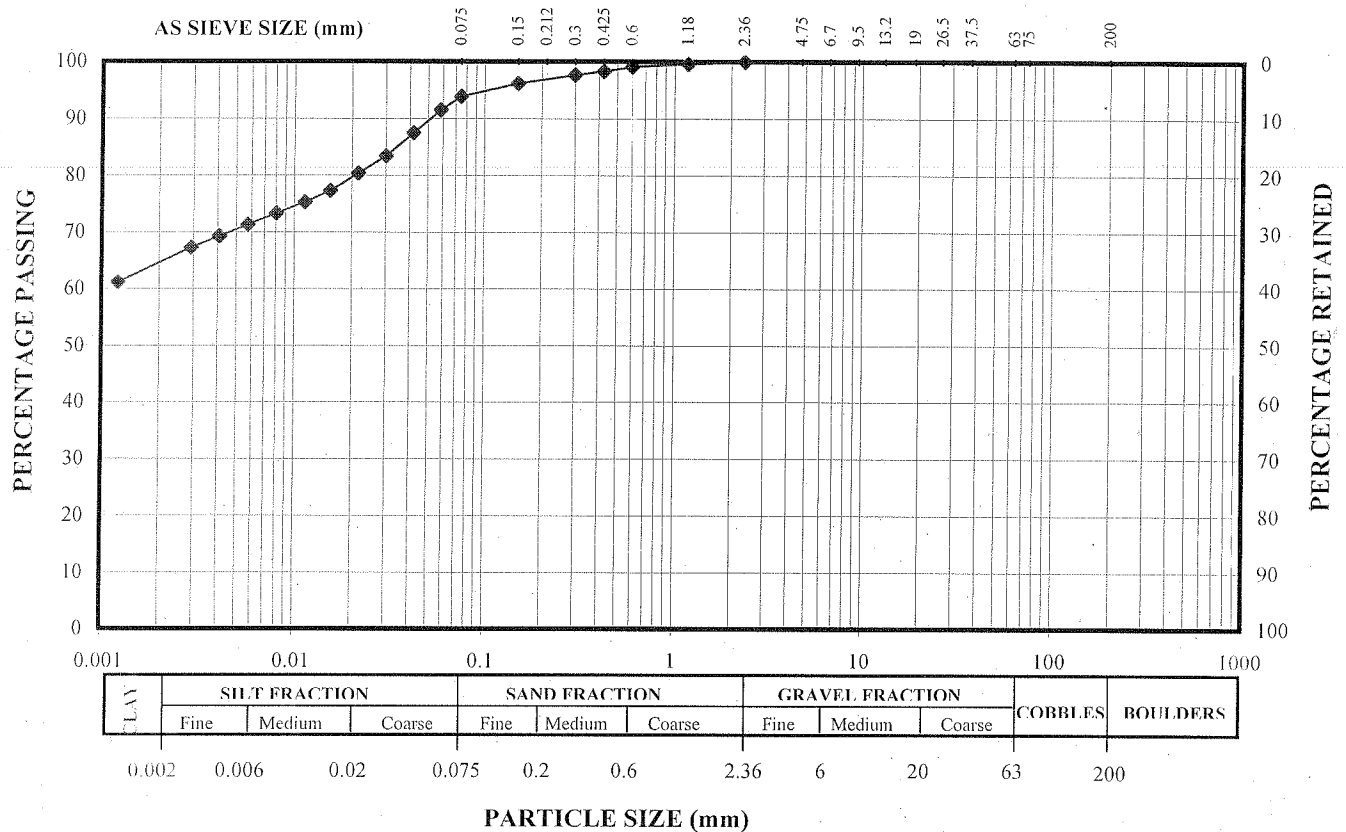
Geotechnical Laboratory Test Results

SOIL CLASSIFICATION REPORT

Trial Hole: TP01
Depth: 0.27 to 0.40
Sample No: 3742/01

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

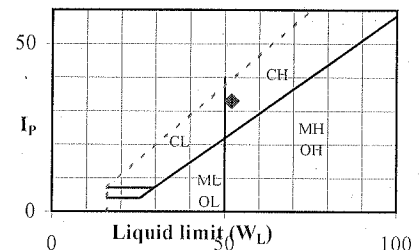
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Red brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 52 Plastic Limit = 19
Plasticity Index = 33 Linear Shrinkage % = 13.0

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 11.03.05
Checked by: *DB*
Date checked: 20.04.05



GHD LONGMAC
57 Herbert St, Artarmon NSW, 2064
Tel: 9462 4700 Fax: 9462 4710



Authorised Signatory:

DB
DBROOME
22/4/05



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JOB No. 2113507

REPORT No. 13462

Ref: PASWUTD/LAD/START/SIEVE

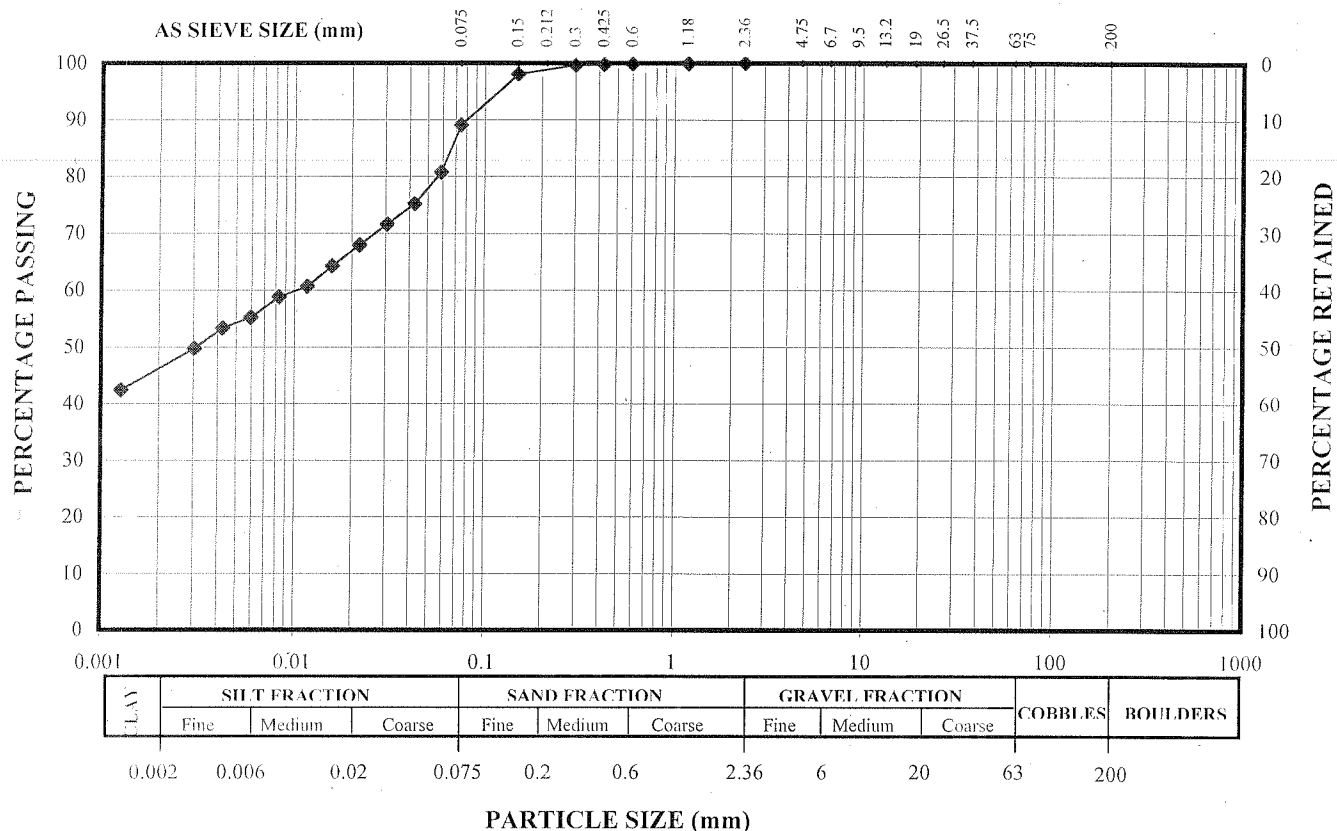
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SOIL CLASSIFICATION REPORT

Trial Hole: TP02
Depth: 5.0 to 5.4.
Sample No: 3742/02

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

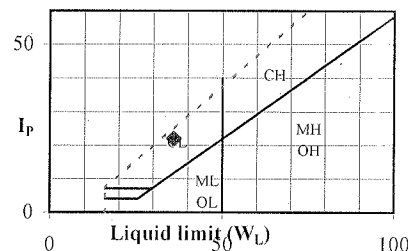
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CL

SOIL NAME: Grey and yellow brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 36 Plastic Limit = 14
Plasticity Index = 22 Linear Shrinkage % = 10.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 11.03.05
Checked by: *gk*
Date checked: 20-04-05



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Authorised Signatory:

Debbie
22/4/05



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JOB No. 2113507

REPORT No. 13463

Ref: PASWUTLELABSTARTSIEVE

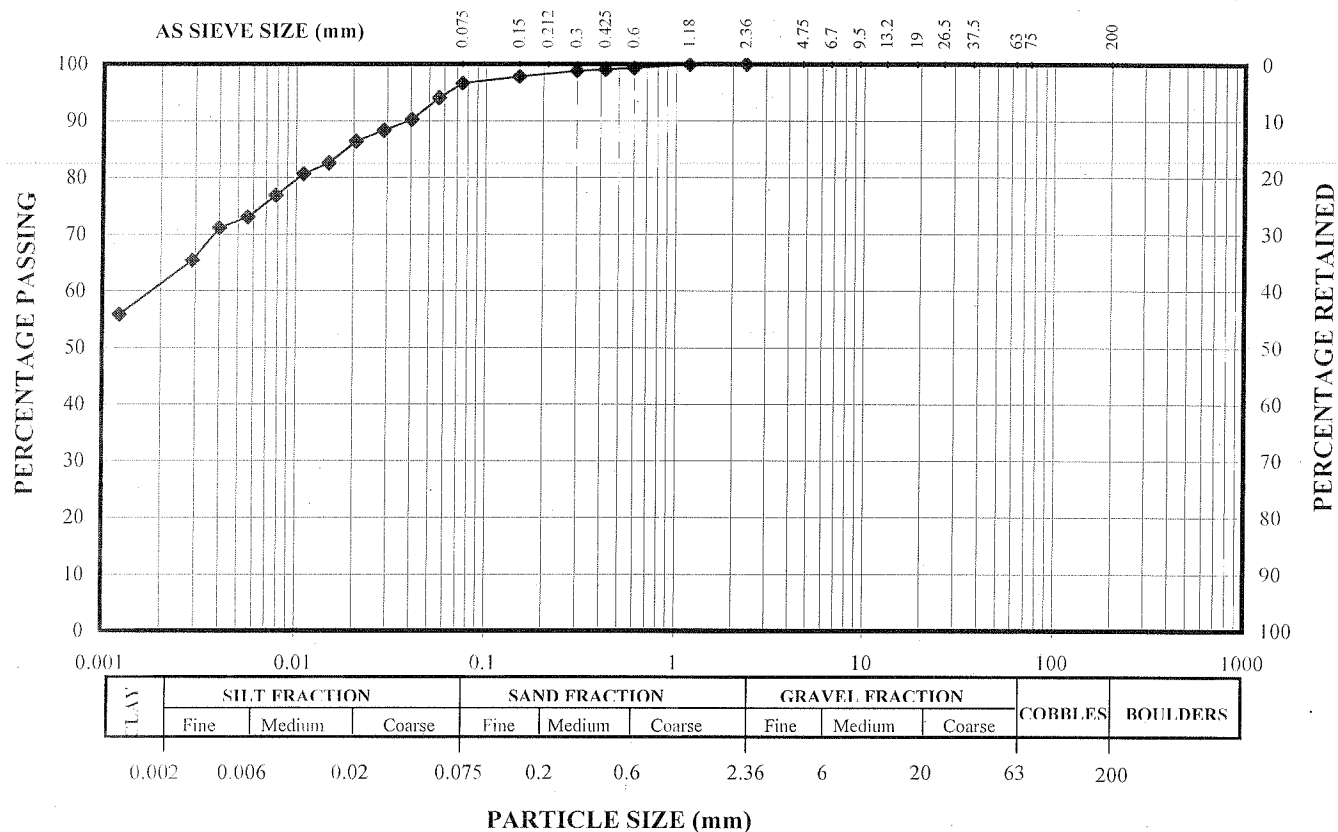
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SOIL CLASSIFICATION REPORT

Trial Hole: TP09
Depth: 2.0 to 2.5
Sample No: 3742/03

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moir Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY

2.65 (assumed)

PRE-TREATMENT HYDROMETER

N/A

TEST CONDITION

Washed sieve with dispersing agent

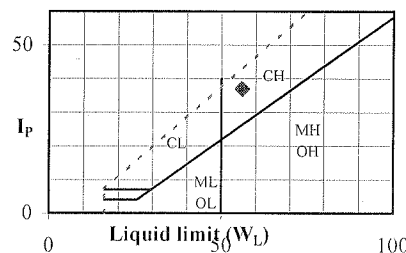
GROUP SYMBOL:

CH

SOIL NAME:

Grey/brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 56 Plastic Limit = 19
Plasticity Index = 37 Linear Shrinkage % = 13.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 11.03.05
Checked by: *gk*
Date checked: 20-04-05



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JOB No. 2113507

REPORT No. 13464

Ref: FASWUTLJLABS-STARTSIEVE

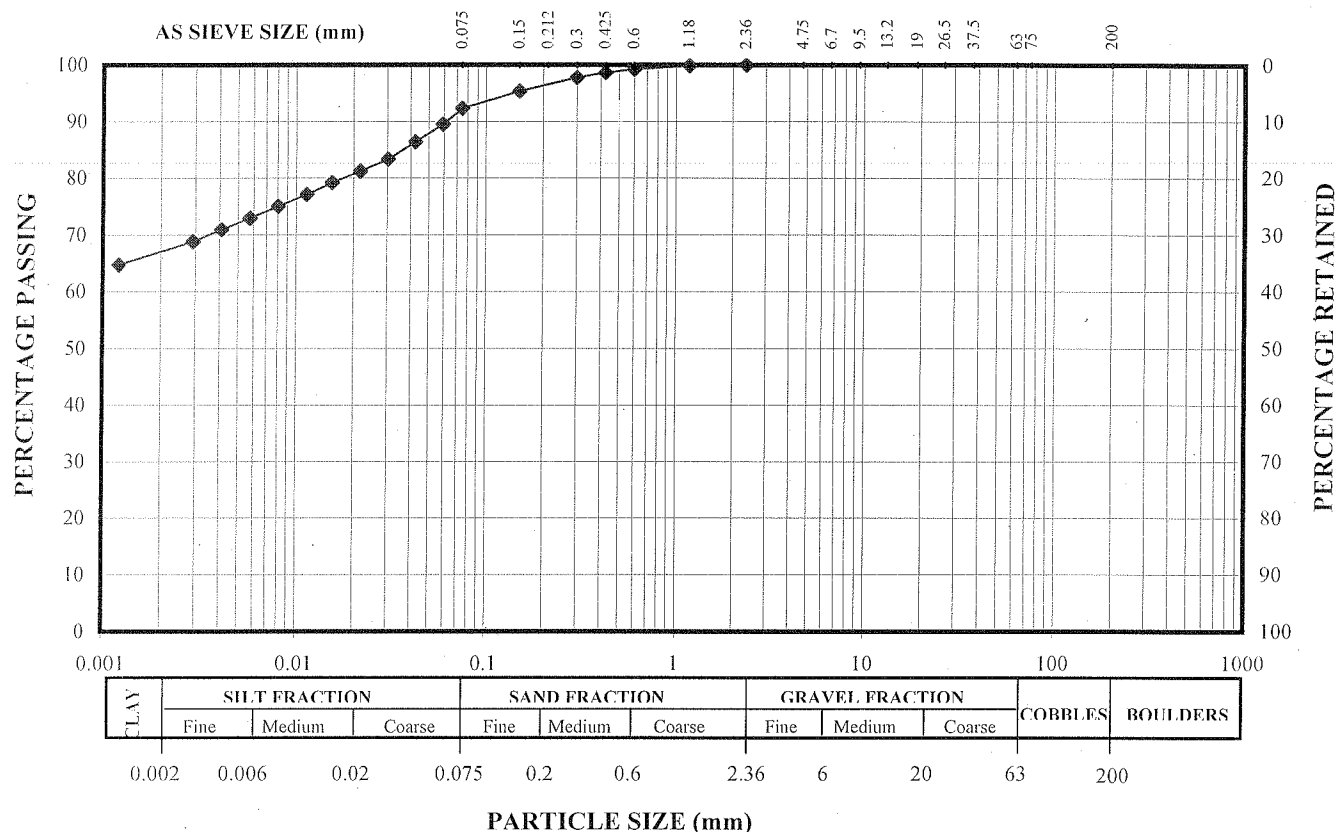
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SOIL CLASSIFICATION REPORT

Trial Hole: TP13
Depth: 0.3 to 0.5
Sample No: 3742/04

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moira Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.3

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (measured)

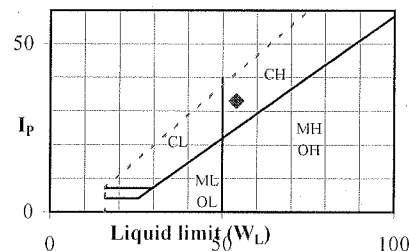
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Red brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 54 Plastic Limit = 21
Plasticity Index = 33 Linear Shrinkage % = 13.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *gcu*
Date checked: 20.04.05



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Authorised Signatory:

OBROONE
22/4/05



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JOB No. 2113507

REPORT No. 13465

Ref: PASWUTHALABSTARTSIEVE

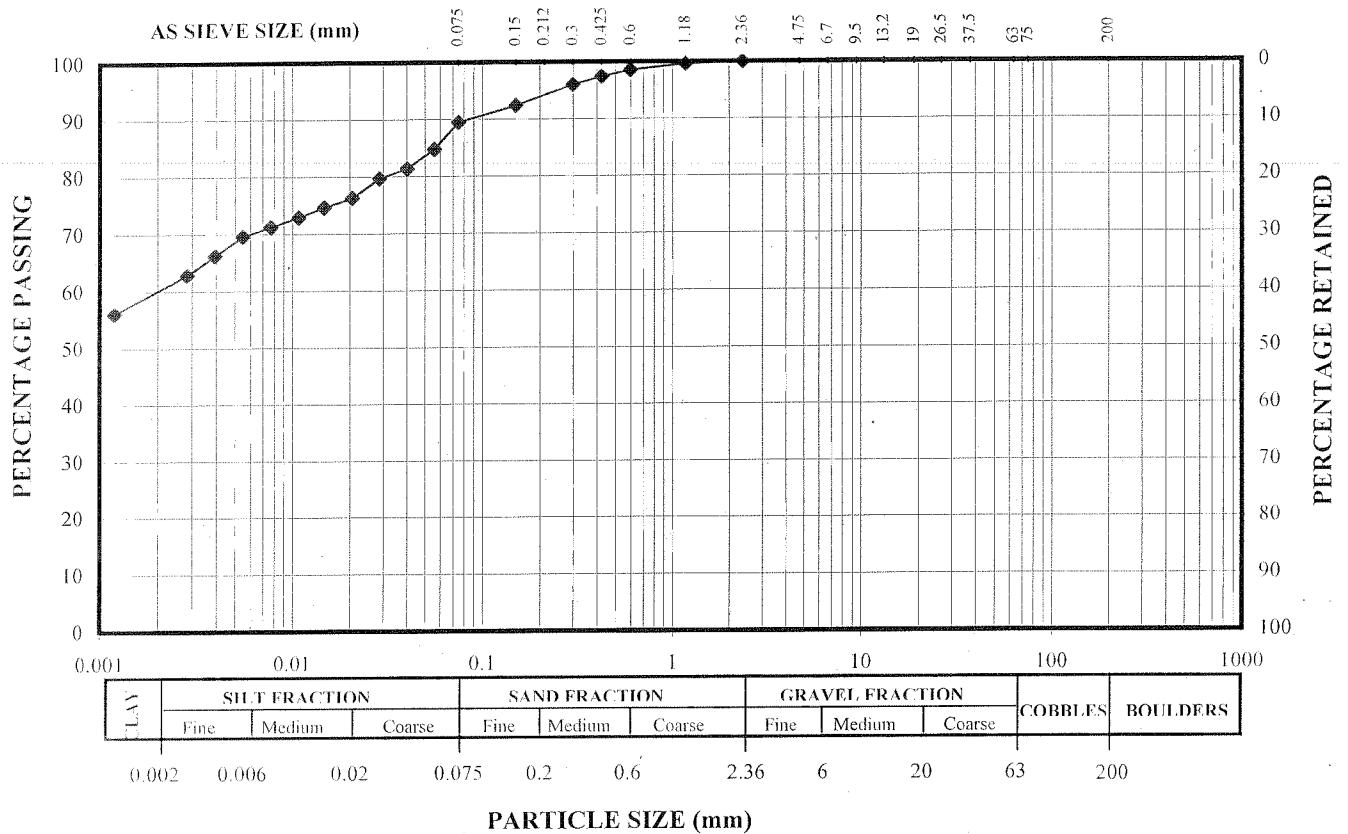
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SOIL CLASSIFICATION REPORT

Trial Hole: TP16
Depth: 2.8 to 3.1
Sample No: 3742/05

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moira Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.3

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

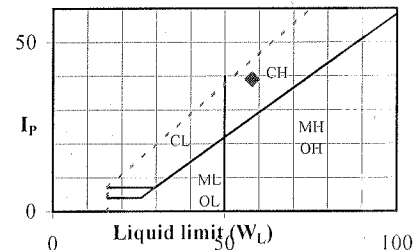
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Orange/brown/grey Light brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 58 Plastic Limit = 19
Plasticity Index = 39 Linear Shrinkage % = 14.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *AB*
Date checked: 22-03-05



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JOB No. 2113507

REPORT No. 13466

Ref: PARWUTHLABS/STARTS/13466

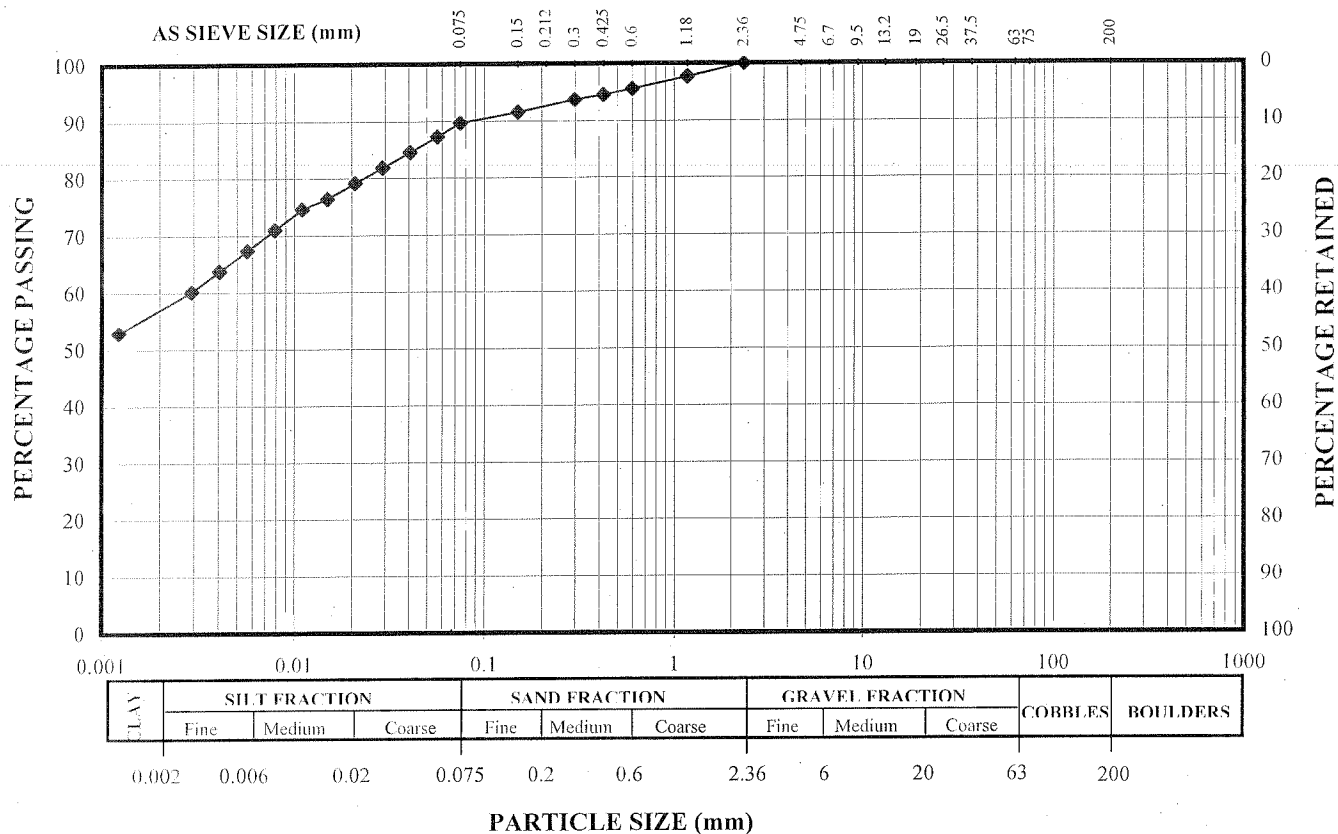
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SOIL CLASSIFICATION REPORT

Trial Hole: TP17
Depth: 1.0 to 1.5
Sample No: 3742/06

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moira Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.3

OTHER TESTS

GRADING

$C_u = D_{60} / D_{10} =$ not determinable

$C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

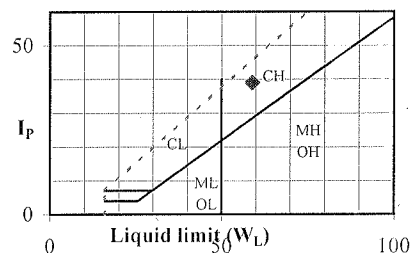
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Grey/brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 59

Plastic Limit = 20

Plasticity Index = 39

Linear Shrinkage % = 15.0

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 11.03.05
Checked by: *GO*
Date checked: 22-03-05



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[Signature]
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JOB No. 2113507

REPORT No. 13467

RGE FSWUTHLABS STARTSIVE

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Soil Index Properties - Report

Report No. : 13503

Client: Agricultural Equity Investment Pty Ltd

Job Number: 2113507

Project: Proposed 80,000 Head Feed Lot

Location: " Moira Station ", Mathoura

TEST METHODS :	Moisture Content	-	☒	AS1289.2.1.1	☐	RTA T120
	Liquid Limit (Four Point)	-	☒	AS1289.3.1.1	☐	RTA T102
	Liquid Limit (One Point)	-	☐	AS1289.3.1.2	☐	RTA T108
	Plastic Limit	-	☒	AS1289.3.2.1	☐	RTA T109
	Plasticity Index	-	☒	AS1289.3.3.1	☐	RTA T103
	Linear Shrinkage	-	☒	AS1289.3.4.1	☐	RTA T113

Sample History : Sampled by GHD-LONGMAC (Geotechnical)

Laboratory Sample No.	Client Sample ID	Test Hole	Depth (m)	Description	NBD/ NDD (t/m ³)	FMC (%)	LL (%)	PL (%)	PI (%)	LS (%)
3742/01	n/a	TP01	0.27 to 0.40	Red brown CLAY	nt	24.7	52	19	33	13.0
3742/02	n/a	TP02	5.00 to 5.40	Grey & yellow brown CLAY	nt	16.1	36	14	22	10.5
3742/03	n/a	TP09	2.00 to 2.50	Grey/brown CLAY	nt	21.8	56	19	37	13.5
3742/04	n/a	TP13	0.30 to 0.50	Red brown CLAY	nt	26.6	54	21	33	13.5
3742/05	n/a	TP16	2.80 to 3.10	Orange/brown/grey Light brown CLAY	nt	19.4	58	19	39	14.5
3742/06	n/a	TP17	1.20 to 1.50	Grey brown CLAY	nt	25.2	59	20	39	15.0
3742/07	n/a	TP19	1.00 to 1.20	Grey brown CLAY	nt	19.8	60	21	39	18.5
3742/08	n/a	TP21	0.50 to 0.60	Red brown CLAY	nt	22.9	48	20	28	12.0

Abbreviations :

LL Liquid Limit
 PL Plastic Limit
 PI Plasticity Index
 LS Linear Shrinkage
 FMC Field Moisture Content
 n/a not applicable
 nt not tested
 n/av not available

NDD Natural Dry Density
 NBD Natural Bulk Density

Sample History

☐ Natural ☐ Air Dried ☒ Oven Dried

Preparation Method

☐ Wet ☒ Dry

Type of Test

☒ Four Point ☐ One Point

Type of Test

☒ 125mm ☐ 150mm ☐ 250mm

Note :

Tested by:	GV
Date tested:	29/03/05
Checked by:	
Authorised Signatory:	
Date:	22/4/05



GHD - LONGMAC

57 Herbert St, Artarmon 2064

Tel: (02) 9462 4700 Fax: (02) 9462 4710

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Soil Index Properties - Report

Report No. : 13504

Client: Agricultural Equity Investment Pty Ltd

Job Number: 2113507

Project: Proposed 80,000 Head Feed Lot

Location: " Moira Station ", Mathoura

TEST METHODS :	Moisture Content	-	☒ AS1289.2.1.1	☐ RTA T120
	Liquid Limit (Four Point)	-	☒ AS1289.3.1.1	☐ RTA T102
	Liquid Limit (One Point)	-	☐ AS1289.3.1.2	☐ RTA T108
	Plastic Limit	-	☒ AS1289.3.2.1	☐ RTA T109
	Plasticity Index	-	☒ AS1289.3.3.1	☐ RTA T103
	Linear Shrinkage	-	☒ AS1289.3.4.1	☐ RTA T113

Sample History : Sampled by GHD-LONGMAC (Geotechnical)

Laboratory Sample No.	Client Sample ID	Test Hole	Depth (m)	Description	NBD/ NDD (t/m ³)	FMC (%)	LL (%)	PL (%)	PI (%)	LS (%)
3742/09	n/a	TP21	1.50 to 2.00	Red/brown & grey/brown sandyCLAY	nt	16.9	48	21	27	14.5
3742/10	n/a	TP26	3.50 to 4.00	Light grey orange SAND with clay	nt	11.7	nt	nt	nt	nt
3742/11	n/a	TP28	0.30 to 0.50	Red/brown CLAY	nt	27.5	61	21	40	18.0
3742/12	n/a	TP28	2.50 to 3.00	Grey/brown & yellow brown CLAY	nt	26.0	66	22	44	18.5

Abbreviations :

LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
LS Linear Shrinkage
FMC Field Moisture Content
n/a not applicable
nt not tested
n/av not available

NDD Natural Dry Density
NBD Natural Bulk Density

Sample History

☐ Natural ☐ Air Dried ☒ Oven Dried

Preparation Method

☐ Wet ☒ Dry

Type of Test

☒ Four Point ☐ One Point

Type of Test

☐ 125mm ☐ 150mm ☐ 250mm

Note :

Tested by:	GV
Date tested:	29/03/05
Checked by:	<i>[Signature]</i>
Authorised Signatory:	<i>[Signature]</i> OBROONE
Date:	22/4/05



GHD - LONGMAC

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Report No. : 13505a

Client : Agricultural Equity Investment Pty Ltd

Project : Proposed 80,000 Head Feed Lot

Location : "Moira Station", Mathoura

TEST METHOD : AS1289.3.8.1

Job No.	2113507
---------	---------

Sample No.:	n/a
-------------	-----

Test Hole No.:	n/a
----------------	-----

Depth (m) :	n/a
-------------	-----

Client Sample ID :	n/a
--------------------	-----

Sample History : Sampled by GHD LongMac Geotechnical

Date Sampled : 18/02/05

Type of Water : Distiled

Water Temperature °C : 21

TEST RESULTS

[illegible]

Notes : Report re-issued 11/05/05 - correction to depth for sample 3742/06

Tested by:	GV
------------	----

Date tested:	10/03/05
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Checked by:	
-------------	---

Authorised
Signatory :

Date:



GHD - LONGMAC

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Tel: (02) 9462 4700 Fax: (02) 9462 4710

GEOTECHNICAL TESTING SERVICES

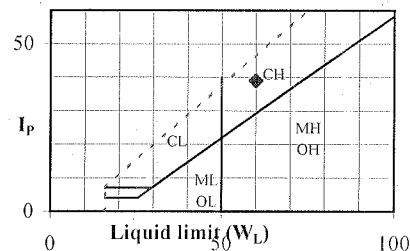


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Trial Hole:	TP19
Depth:	1.0 to 1.2
Sample No:	3742/07

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



125 mm

R&D PASSWORTLABSTARTSIEVE

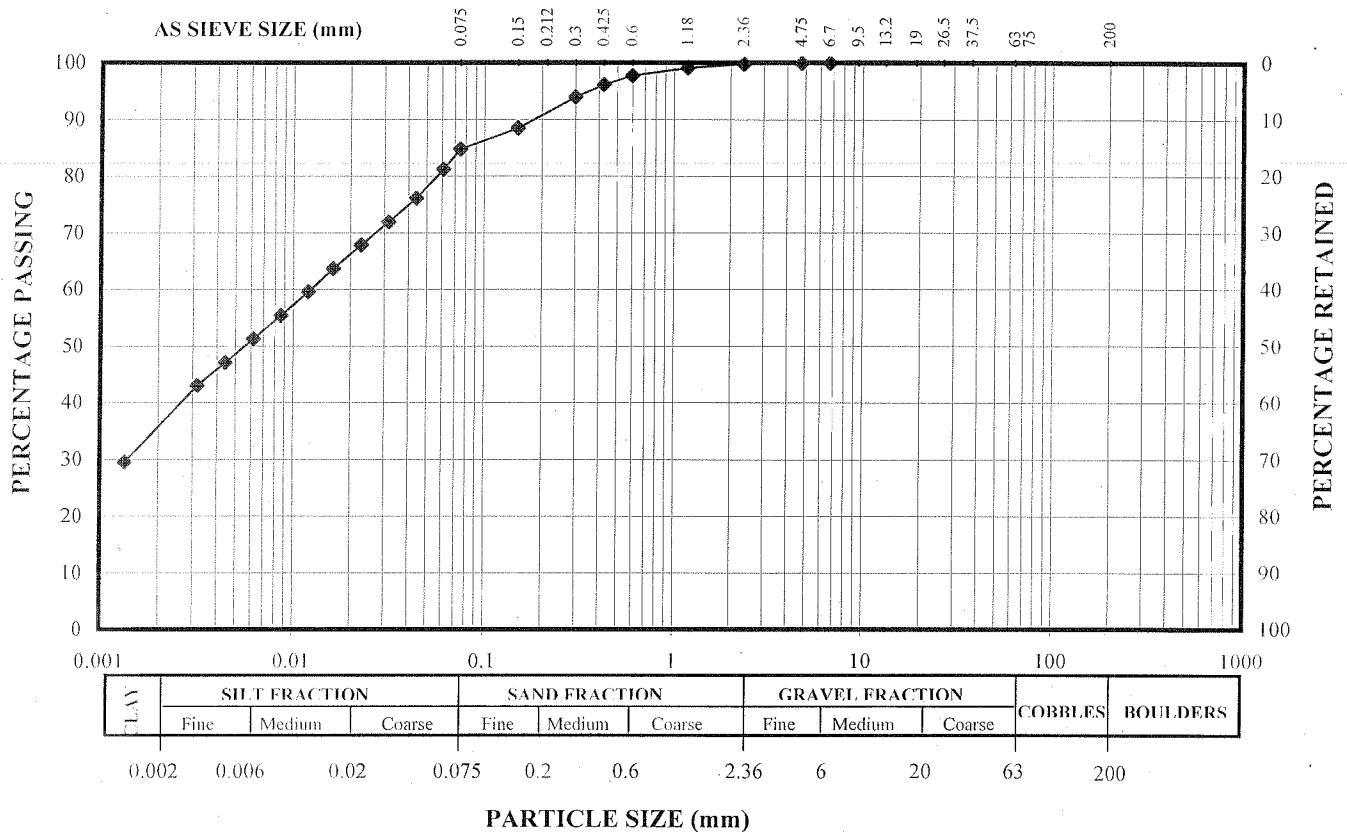
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SOIL CLASSIFICATION REPORT

Trial Hole: TP21
Depth: 0.5 to 0.6
Sample No: 3742/08

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

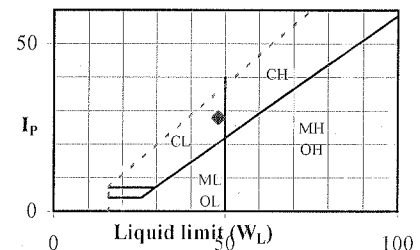
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CL

SOIL NAME: Red brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 48 Plastic Limit = 20
Plasticity Index = 28 Linear Shrinkage % = 12.0

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *CU*
Date checked: 20-09-05



GHD LONGMAC

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Tel: 9462 4700 Fax: 9462 4710

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Authorised Signatory:

DBROOKE
22/4/05



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JOB No. 2113507

REPORT No. 13508

R&E FINWUTILLABS STARTSIEVE

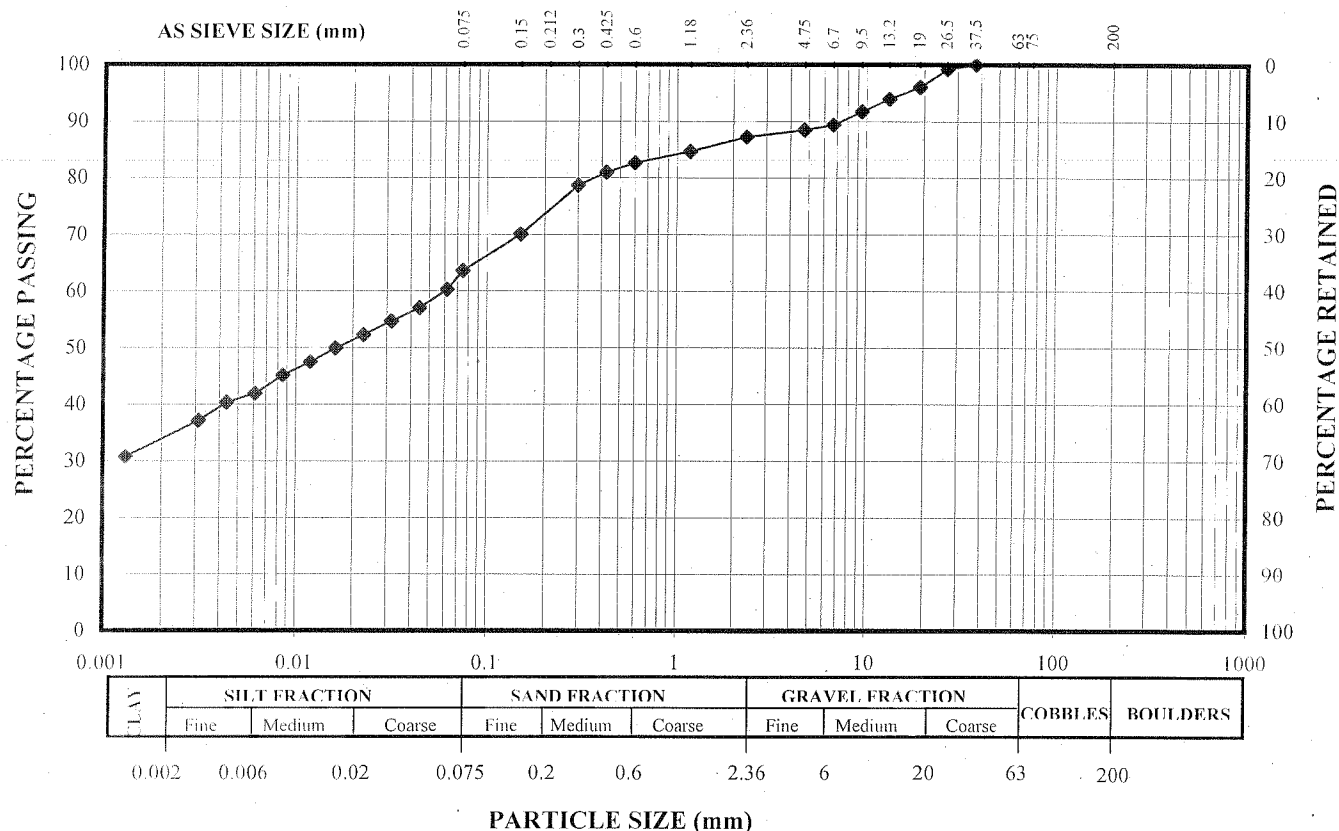
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SOIL CLASSIFICATION REPORT

Trial Hole: TP21
Depth: 1.5 to 2.0
Sample No: 3742/09

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

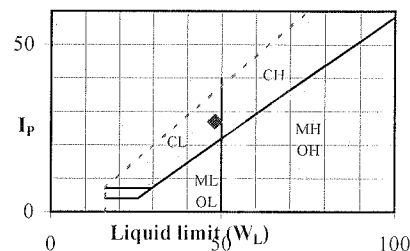
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CL

SOIL NAME: Red/brown & grey brown sandy CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 48 Plastic Limit = 21
Plasticity Index = 27 Linear Shrinkage % = 14.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *EL*
Date checked: 20.04.05



GHD LONGMAC

57 Herbert St, Artarmon NSW, 2064

Tel: 9462 4700 Fax: 9462 4710

GEOTECHNICAL TESTING SERVICES



Authorised Signatory:

[Signature]
OBLOOKE
22/4/05



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JOB No. 2113507

REPORT No. 13509

Ref: FSWUTH/LAB/START/SIEVE

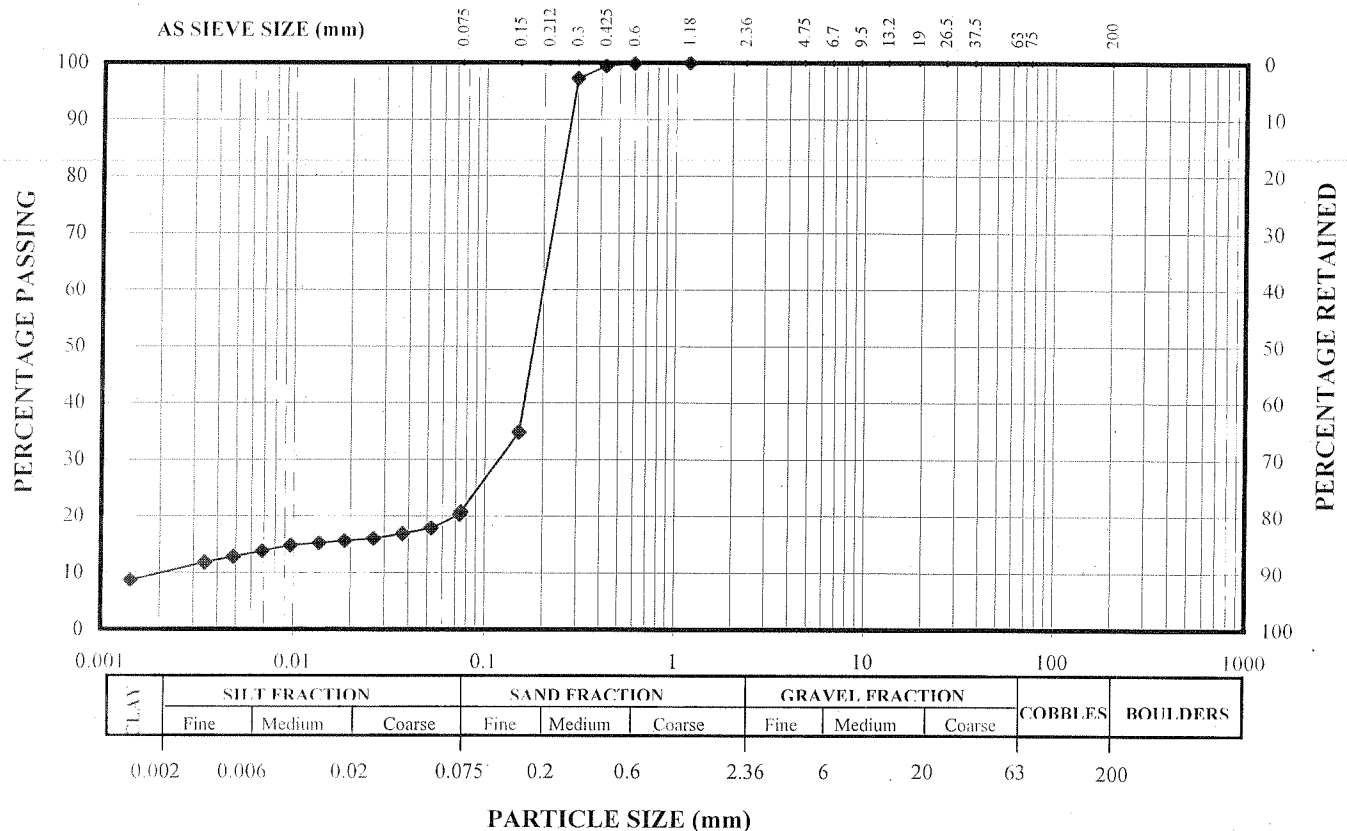
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SOIL CLASSIFICATION REPORT

Trial Hole: TP26
Depth: 3.5 to 4.0
Sample No: 3742/10

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical.



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.3

OTHER TESTS

GRADING

$$C_u = D_{60} / D_{10} = 92.2$$

$$C_c = D_{30}^2 / (D_{10} \times D_{60}) = 32.2$$

PARTICLE DENSITY 2.65 (assumed)

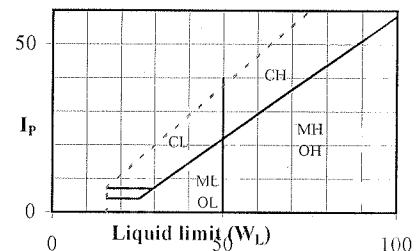
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL:

SOIL NAME: Light grey & orange SAND with clay

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = N/A

Plastic Limit = N/A

Plasticity Index = N/A

Linear Shrinkage % = Not determined

Atterberg Limits (History/preparation)

Liquid Limit (type of test)

Linear Shrinkage (mould size)

Tested by: MG
Date tested: 14.03.05
Checked by: *SL*
Date checked: 20.04.05



GHD LONGMAC

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Tel: 9462 4700 Fax: 9462 4710

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Authorised Signatory:

B
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JOB No. 2113507

REPORT No. 13510

Ref: FSWUTILABNSSTARTSUE

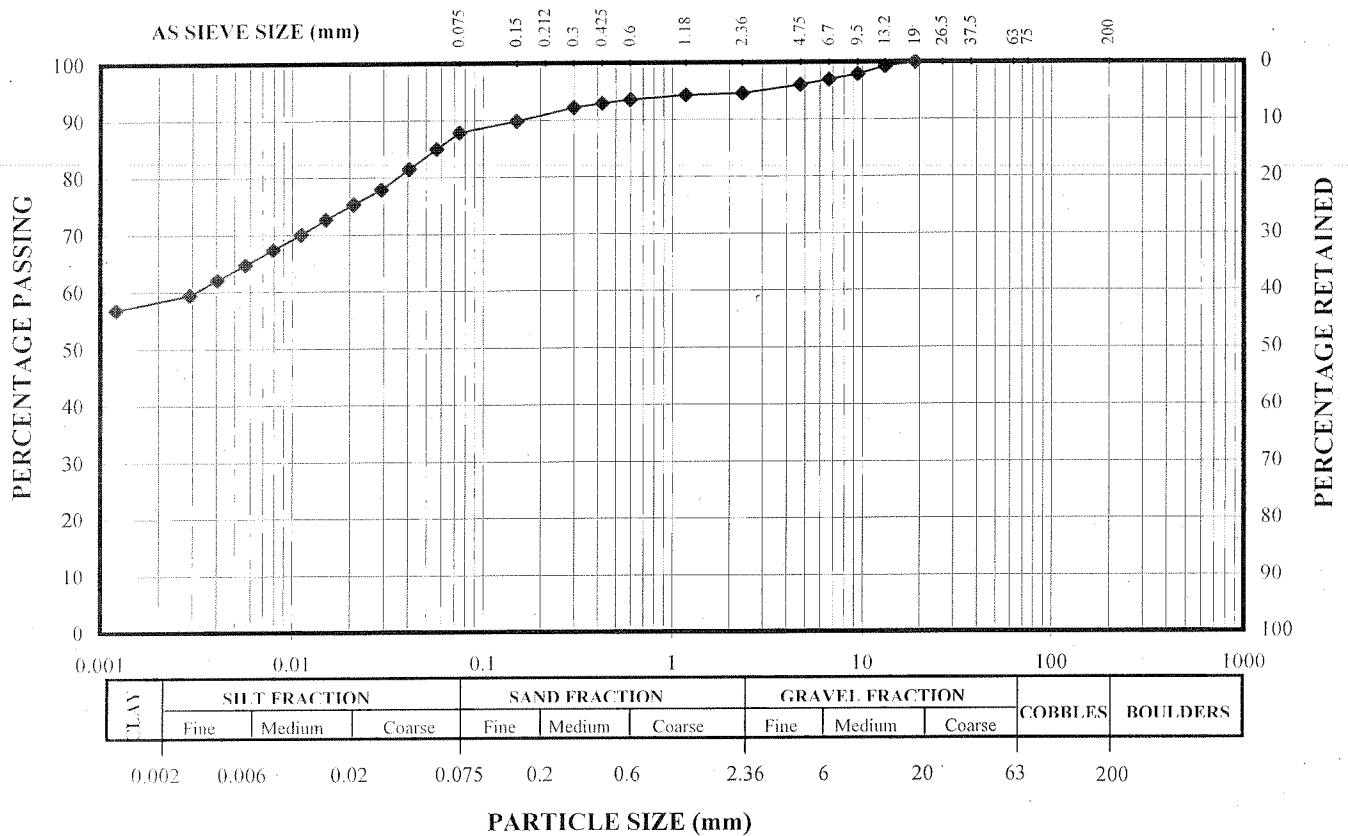
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SOIL CLASSIFICATION REPORT

Trial Hole: TP28
Depth: 0.3 to 0.5
Sample No: 3742/11

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moira Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

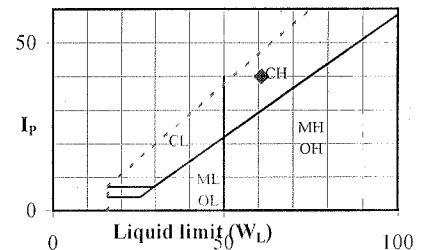
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Red/brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 61 Plastic Limit = 21
Plasticity Index = 40 Linear Shrinkage % = 18.0

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

250 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *gao*
Date checked: 22-03-05



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57 Herbert St, Artarmon NSW, 2064

Tel: 9462 4700 Fax: 9462 4710

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Authorised Signatory:

DeRose
22/4/05



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JOB No. 2113507

REPORT No. 13511

R&P: FSW/UTD/LAB/ST/ART/SP/VE

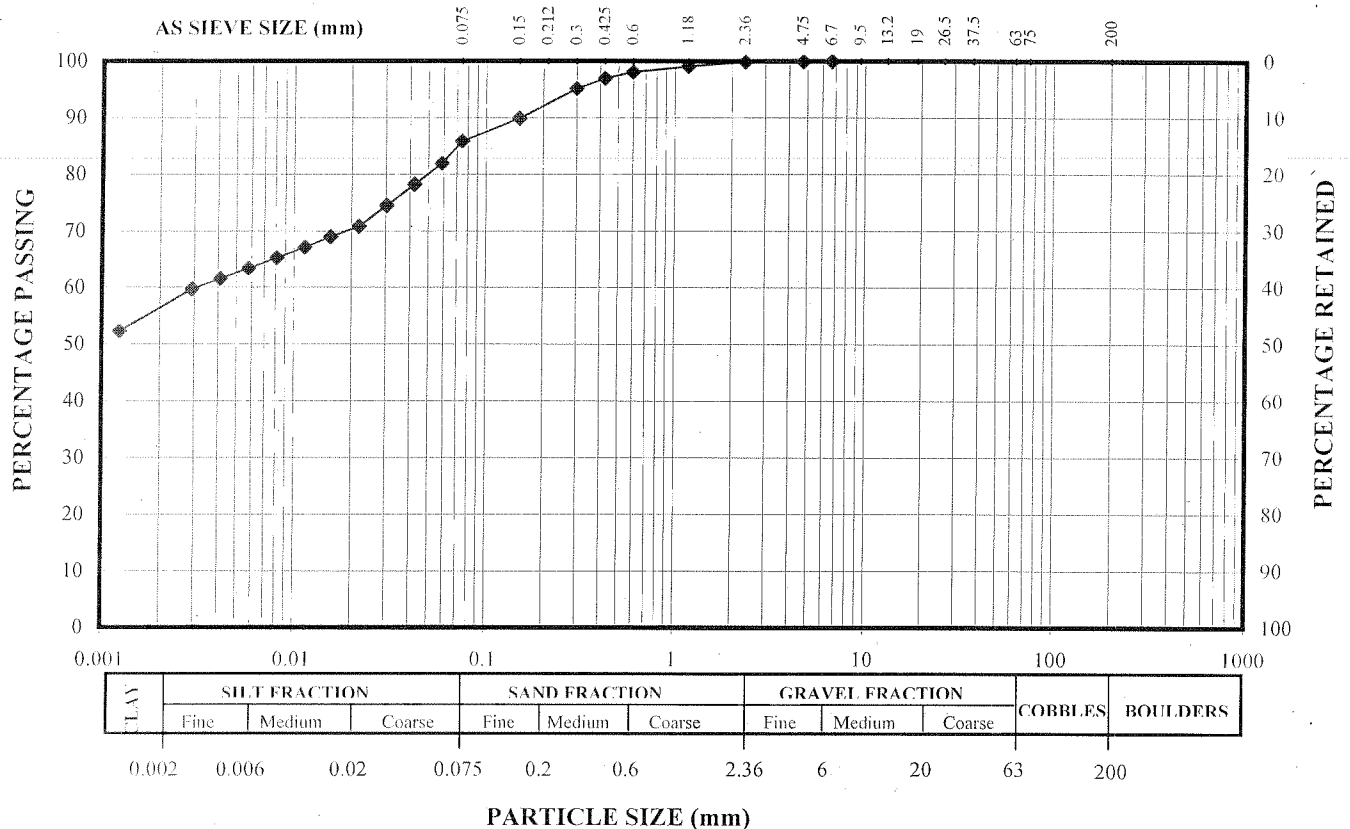
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SOIL CLASSIFICATION REPORT

Trial Hole: TP 28
Depth: 2.5 to 3.0
Sample No: 3742/12

Client: Agricultural Equity Investment Pty Ltd
Project: Proposed 80,000 Head Feed Lot
Location: "Moirra Station" Mathoura

Client Sample No.: n/a
Sample History: Sampled by GHD LongMac Geotechnical



TEST METHODS

Classification AS1726 A2

Particle size AS1289.3.6.2

OTHER TESTS

AS1289.3.1.1
AS1289.3.2.1 AS1289.3.3.1 AS1289.3.4.1

GRADING

$C_u = D_{60} / D_{10} =$ not determinable
 $C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ not determinable

PARTICLE DENSITY 2.65 (assumed)

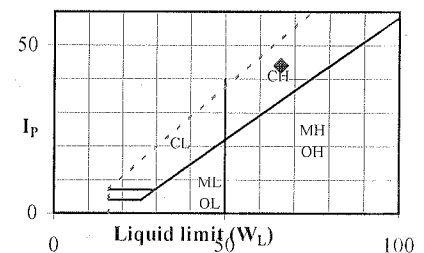
PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve with dispersing agent

GROUP SYMBOL: CH

SOIL NAME: Grey brown & yellow brown CLAY

REMARKS:



INDEX PROPERTIES (%)

Liquid Limit = 66 Plastic Limit = 22
Plasticity Index = 44 Linear Shrinkage % = 18.5

Atterberg Limits (History/preparation)

Dry/oven dry

Liquid Limit (type of test)

Four point

Linear Shrinkage (mould size)

125 mm

Tested by: MG
Date tested: 14.03.05
Checked by: *gl*
Date checked: 20-04-05



GHD LONGMAC

57 Herbert St, Artarmon NSW, 2064

Tel: 9462 4700 Fax: 9462 4710

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Authorised Signatory:

DBLOOMIE
22/4/05



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JOB No. 2113507

REPORT No. 13512

Ref: FSWUTHLABSSTARTSIEVE

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Compaction (Tabulated) - Report

Report No. : 13513

Client: Agricultural Equity Investment Pty Ltd

Job No.: 2113507

Project: Proposed 80,000 Head Feed Lot

Location: " Moira Station ", Mathoura

TEST METHOD : Compaction : AS1289.5.1.1

Moisture Content : AS1289.2.1.1

Sample Number :	3742/02	3742/03	3742/06	3742/07	3742/09	3742/12
Test Hole Number :	TP02	TP09	TP17	TP19	TP21	TP28
Test Hole Depth : (m)	5.00 to 5.40	2.00 to 2.50	1.00 to 1.50	1.00 to 1.20	1.50 to 2.00	2.50 to 3.00
Chainage : (m)	n/a	n/a	n/a	n/a	n/a	n/a
R.L. : (m)	n/a	n/a	n/a	n/a	n/a	n/a
Location :	n/a	n/a	n/a	n/a	n/a	n/a
Date Sampled :	n/a	n/a	n/a	n/a	n/a	n/a
Time Sampled :	n/a	n/a	n/a	n/a	n/a	n/a
Client Sample ID :	n/a	n/a	n/a	n/a	n/a	n/a
Compaction Type :	Standard	Standard	Standard	Standard	Standard	Standard
+19.0 mm Oversize : (%)	0	0	0	0	3.9	0
+37.5 mm Oversize : (%)	0	0	0	0	0	0
Natural Moisture Content : (%)	16.1	21.8	25.2	19.8	16.9	26.0
Optimum Moisture Content : (%)	16.9	22.1	23.9	21.5	19.7	24.8
Maximum Dry Density : (t/m ³)	1.79	1.66	1.61	1.67	1.65	1.59
Soil Description :	Grey & yellow brown CLAY	Grey/brown CLAY	Grey/brown CLAY	Grey/brown CLAY	Red/brown & yellow brown sandy CLAY	Grey/brown & yellow brown CLAY

OVERALL COMMENTS :

Tested by:	GV
Date tested:	22/03/05
Checked by:	
Approved Signatory:	 DBROOKE
Date:	22/4/05



GHD - LONGMAC

57 Herbert St, Artarmon NSW 2064

Tel: (02) 9462 4700 Fax: (02) 9462 4710

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PERMEABILITY BY FALLING HEAD

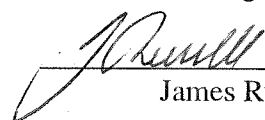
TEST PROCEDURE: AS1289 5.1.1, KH 2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client: GHD Longmac Pty Ltd	Certificate No. 503619-FHP
Project: 2113507 – Moira Station	Date: 2/4/05
Sample No.	503619
Client's ID;	3742/02
Test Pit No.	02
Depth (m):	5.0-5.4
Max. Dry Density (t/m ³):	*1.79
Optimum Moisture Content (%):	*17.0
Placement Moisture Content (%):	17.5
Placement Wet Density (t/m ³):	2.05
Density Ratio at Placement:	97.5
PERMEABILITY: $k_{20} = 6 \times 10^{-11} \text{ m/s}$	
Remarks: * The sample and compaction data were supplied by the client. The specimen was remoulded to a target of 98% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.	



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Authorised Signatory


James Russell



PERMEABILITY BY FALLING HEAD

TEST PROCEDURE: AS1289 5.1.1, KH 2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client: GHD Longmac Pty Ltd
Project: 2113507 – Moira Station

Certificate No. 503620-FHP
Date: 2/4/05

Sample No.	503620
Client's ID;	3742/03
Test Pit No.	09
Depth (m):	2.0-2.5
Max. Dry Density (t/m ³):	*1.66
Optimum Moisture Content (%):	*22.0
Placement Moisture Content (%):	22.1
Placement Wet Density (t/m ³):	1.99
Density Ratio at Placement:	98.0

PERMEABILITY:

$$k_{20} = 8 \times 10^{-11} \text{ m/s}$$

Remarks: * The sample and compaction data were supplied by the client. The specimen was remoulded to a target of 98% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.



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Authorised Signatory

James Russell



PERMEABILITY BY FALLING HEAD

TEST PROCEDURE: AS1289 5.1.1, KH 2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client: GHD Longmac Pty Ltd	Certificate No. 503621-FHP
Project: 2113507 – Moira Station	Date: 2/4/05
Sample No.	503621
Client's ID;	3742/06
Test Pit No.	17
Depth (m):	1.0-1.5
Max. Dry Density (t/m ³):	*1.61
Optimum Moisture Content (%):	*24.0
Placement Moisture Content (%):	24.2
Placement Wet Density (t/m ³):	1.96
Density Ratio at Placement:	98.0
PERMEABILITY: $k_{20} = 1 \times 10^{-10} \text{ m/s}$	
Remarks: * The sample and compaction data were supplied by the client. The specimen was remoulded to a target of 98% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.	



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Authorised Signatory

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PERMEABILITY BY FALLING HEAD

TEST PROCEDURE: AS1289 5.1.1, KH 2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client: GHD Longmac Pty Ltd

Certificate No. 503622-FHP

Project:

Date: 2/4/05

Sample No.	503622
Client's ID;	3742/09
Test Pit No.	21
Depth (m):	1.5-2.0
Max. Dry Density (t/m ³):	*1.65
Optimum Moisture Content (%):	*20.0
Placement Moisture Content (%):	20.2
Placement Wet Density (t/m ³):	1.94
Density Ratio at Placement:	98.0

PERMEABILITY:

$$k_{20} = 9 \times 10^{-11} \text{ m/s}$$

Remarks: * The sample and compaction data were supplied by the client. The specimen was remoulded to a target of 98% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.



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Authorised Signatory


James Russell



Appendix C

Agricultural Laboratory Test Results

WATER TEST

Page 1 of 6

Office:
PO BOX 591
SEVEN HILLS NSW 2147

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8294
Fax: (02) 9838 8919
A.C.N. 098 982 140
A.B.N. 76 098 982 140

ANALYTICAL REPORT for:

GHD LONGMAC PTY LTD

LOCKED BAG 2727
ST LEONARDS NSW 1590

ATTN: R.CHANDLER

JOB NO: WQ0202
CLIENT ORDER: 21/13507
DATE RECEIVED: 01/03/05
DATE COMPLETED: 21/03/05
TYPE OF SAMPLES: SOILS
NO OF SAMPLES: 10

NATA Accredited Laboratory

Number: 1884



NATA ENDORSED TEST REPORT
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.....
Issued on 23/03/05
Sue Wyman
(Laboratory Supervisor)

WATER TEST

Page 2 of 6

ANALYTICAL REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

SAMPLES	Ex.Na MEQ%	Ex.K MEQ%	Ex.Ca MEQ%	Ex.Mg MEQ%	Ex.Al MEQ%	CEC MEQ%
1 TP06/0.0	0.17	0.72	5.3	3.05	<0.1	9.8
2 TP06/0.1	0.06	0.32	4.10	4.65	<0.1	9.1
3 TP07/0.0	1.40	0.18	5.1	7.0	<0.1	14.3
4 TP07/0.2	4.10	0.26	6.2	9.7	<0.1	20.3
5 TP07/1.1	1.60	0.38	29.1	6.0	<0.1	37.5
6 TP23/0.0	0.72	0.30	3.50	3.25	<0.1	8.5
7 TP23/0.3	3.75	0.05	6.8	9.8	<0.1	20.7
8 TP31/0.0	0.32	0.62	4.75	1.65	<0.1	7.8
9 TP31/0.2	2.51	0.79	10.1	5.3	<0.1	18.9
10 TP31/0.8	4.00	0.12	7.1	5.4	<0.1	16.8
DUPLICATES:						
2 TP06/0.1	0.05	0.29	4.20	4.55	<0.1	9.1
MDL	0.01	0.01	0.01	0.01	0.1	0.1
Method Code	WA20	WA20	WA20	WA20	WA20	S7
Preparation	P5	P5	P5	P5	P5	P5

WATER TEST

Page 3 of 6

ANALYTICAL REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

SAMPLES	ESP %	pH 1:5	COND. uS/cm	*TKN mg/kg	*PO4-P mg/kg	*P.SORF mg/kg
1 TP06/0.0	1.7	6.0	220	1500	39	420
2 TP06/0.1	0.7	8.6	1020	630	1.5	480
3 TP07/0.0	9.8	6.5	210	1600	8.5	450
4 TP07/0.2	20.2	8.3	830	700	1.0	430
5 TP07/1.1	4.3	7.4	4130	390	2.5	420
6 TP23/0.0	8.5	5.6	210	1700	9.0	440
7 TP23/0.3	18.1	8.0	470	1000	1.0	480
8 TP31/0.0	4.1	5.9	250	1600	15	360
9 TP31/0.2	13.3	8.4	190	750	<0.5	500
10 TP31/0.8	23.8	8.9	390	480	1.5	340
DUPLICATES:						
2 TP06/0.1	0.5	8.6	1010	600	1.0	470
MDL	0.1	0.1	5	20	0.5	1
Method Code	ESP	S1	S3	WA14	WA51	S9
Preparation	P5	P5	P5	P5	P5	P5

WATER TEST

Page 4 of 6

ANALYTICAL REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

SAMPLES	O.M. %
1 TP06/0.0	2.5
2 TP06/0.1	0.61
3 TP07/0.0	2.8
4 TP07/0.2	0.62
5 TP07/1.1	0.15
6 TP23/0.0	2.9
7 TP23/0.3	1.5
8 TP31/0.0	3.3
9 TP31/0.2	0.86
10 TP31/0.8	0.20
DUPLICATES:	
2 TP06/0.1	0.59

MDL	0.01
Method Code	C4
Preparation	P5

RESULTS ON DRY BASIS

WATER TEST

Page 5 of 6

LABORATORY DUPLICATE REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

Sample Number	Analyte	Units	MDL	Sample Result	Duplicate Result	%RPI
TP06/0.1	Ex.Na	MEQ%	0.01	0.06	0.05	17
TP06/0.1	Ex.K	MEQ%	0.01	0.32	0.29	10
TP06/0.1	Ex.Ca	MEQ%	0.01	4.10	4.20	2
TP06/0.1	Ex.Mg	MEQ%	0.01	4.65	4.55	2
TP06/0.1	Ex.Al	MEQ%	0.1	<0.1	<0.1	0
TP06/0.1	CEC	MEQ%	0.1	9.1	9.1	0
TP06/0.1	ESP	%	0.1	0.7	0.5	33
TP06/0.1	pH		0.1	8.6	8.6	0
TP06/0.1	COND.	uS/cm	5	1020	1010	1
TP06/0.1	*TKN	mg/kg	20	630	600	5
TP06/0.1	*Available P	mg/kg	0.5	1.5	1.0	38
TP06/0.1	*P.Sorption	mg/kg	1	480	470	2
TP06/0.1	Organic Matter	%	0.01	0.61	0.59	3

Acceptance criteria:

RPD <50% for low level (<20xMDL)
RPD <30% for medium level (20-100xMDL)
RPD <15% for high level (>100xMDL)
No limit applies at <2xMDL

MDL = Method Detection Limit

All results are within the acceptance criteria

ANALYTICAL REPORT

JOB NO: WQ0202

CLIENT ORDER: 21/13507

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory.

P5	Sample dried, split and crushed to -150um
WA20	Exchangeable Metal - Silver Thiourea extract Determined by APHA 3500D/3111B
S7	Cation Exchange Capacity - Silver Thiourea Method
ESP	Exchangeable Sodium Percent Determined by Calculation
S1	pH - 1:5 water extract Determined by APHA 4500B
S3	Conductivity - 1:5 soil/water extract Determined by APHA 2510B
*WA14	Total Kjeldahl Nitrogen Determined by APHA 4500B
*WA51	Available Phosphate - Bray Extract Determined by APHA 4500F
*S9	Phosphorus Sorption - Dept of Agriculture Standard Method Determined by APHA 4500F
C4	Organic Matter - AS1289 D4.1.1

*The laboratory's NATA registration does not cover performance of this service

A preliminary report was faxed on 21/03/05

HLA



Environmental Assessment by:

HLA-Envirosciences Pty Ltd

ABN: 34 060 207 702

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