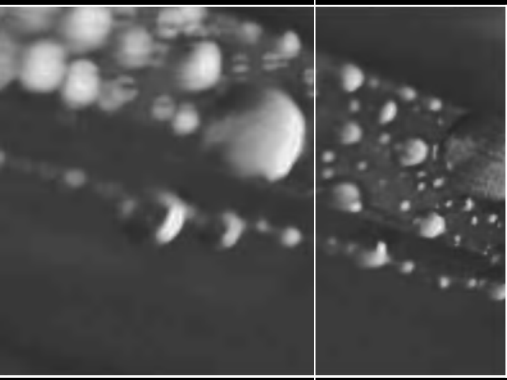
ENVIRONMENTAL ASSESSMENT

STAGE 2 CONCEPT AREA
SPRINGFARM PROJECT AREA
MENANGLE PARK PROJECT AREA

camden gas project



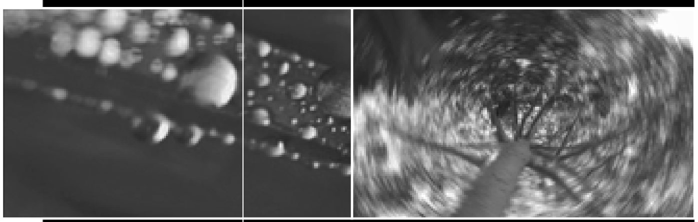
STAGE 2 CONCEPT AREA

Expansion of Stage 2 of the Camden Gas Project
Stage 2 Concept Area
Spring Farm Project Area
Menangle Park Project Area
Environmental Assessment
Volume 2

September 2007

Prepared for:
AGL Gas Production (Camden) Pty Ltd
72 Christie Street, St Leonards

AGL HLA Merged with ENSR in 2007



APPENDIX A

RECORD OF MINISTER'S OPINION

NSW GOVERNMENT
Department of Planning

Record of Minister's opinion for the purposes of Clause 6(1) of the State Environmental Planning Policy (Major Projects) 2005

I, the Director-General of the Department of Planning, as delegate of the Minister for Planning under delegation executed on 31 October 2005, have formed the opinion that the development described in the Schedule below is development of a kind that is described in Schedule 1 of the State Environmental Planning Policy (Major Projects) 2005, namely Clause 6 Petroleum - development for the purpose of drilling and operation of petroleum wells (including associated pipelines) where the principal resource sought is coal seam methane and that is in the local government areas of Camden, Campbelltown and Wollondilly - and is thus declared to be a project to which Part 3A of the *Environmental Planning and Assessment Act 1979* applies for the purpose of section 75B of that Act.

Declaration of this project excludes the aspects of the development described in Schedule 2 below.

Schedule 1

The proposed expansion of Stage 2 of the Camden Gas Project, which includes:

- drilling and construction of new coal seam methane well fields in areas identified as Spring Farm, Menangle Park, Mount Gilead and Kay Park Stage II;
- drilling of new wells from the pads of existing wells in existing well fields, to access additional gas resources;
- drilling of infill wells (with associated infrastructure including gas gathering and water pipelines and access roads) in existing well fields, where the gas reserve is not able to be accessed from existing well head locations;
- subsequent production and transportation of gas from the new well sites to the Rosalind Park Gas Treatment Plant; and
- post-development operational activities including upgrading of existing gas gathering lines, the installation of in-field compression, and refraccing of existing and new wells.

Schedule 2

- Drilling of core or stratigraphic holes;
- geophysical exploration (including seismic exploration); and
- related activities.

SHaddad

Sam Haddad
Director-General

Delegate of the Minister for Planning

Date: 14. 11. 2006.

NSW GOVERNMENT
Department of Planning

Record of Minister's opinion for the purposes of Clause 6(1) of the State Environmental Planning Policy (Major Projects) 2005

I, the Director-General of the Department of Planning, as delegate of the Minister for Planning under delegation executed on 31 October 2005, have formed the opinion that the development described in Schedule 1 below is development of a kind that is described in Schedule 1 of the State Environmental Planning Policy (Major Projects) 2005, namely Clause 6 Petroleum - development for the purpose of drilling and operation of petroleum wells (including associated pipelines) where the principal resource sought is coal seam methane and that is in the local government areas of Camden, Campbelltown and Wollondilly - and is thus declared to be a project to which Part 3A of the *Environmental Planning and Assessment Act 1979* applies for the purpose of section 75B of that Act.

Declaration of this project excludes the aspects of the development described in Schedule 2 below.

Schedule 1

The proposed expansion of Stage 2 of the Camden Gas Project by developing additional wells in areas identified as Spring Farm and Menangle Park, including:

- construction and operation of up 4 surface well locations at Spring Farm and up to 12 surface well locations at Menangle Park (to contain a variety of horizontal, directional and surface-in-seam wells);
- construction and use of access roads, a gas gathering system and water transport lines;
- connection of the wells to the Rosalind Park Gas Plant; and
- production of methane gas.

Schedule 2

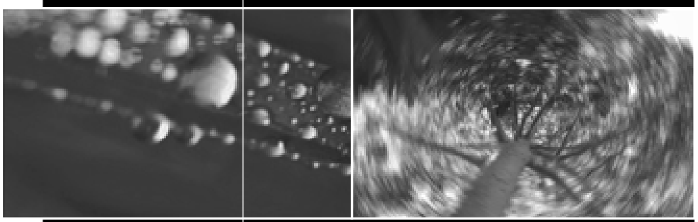
- Drilling of core or stratigraphic holes;
- geophysical exploration (including seismic exploration); and
- related activities.

SHaddad

Sam Haddad
Director-General

Delegate of the Minister for Planning

Date: 14 . 11 . 2006 .



APPENDIX B

ENVIRONMENTAL ASSESSMENT REQUIREMENTS

NSW GOVERNMENT
Department of Planning

Contact: Michael Young
Phone: (02) 9228 6437
Fax: (02) 9228 6466
Email: michael.young@planning.nsw.gov.au

Our ref: S02/02299

Mr David Kelly
Land & Approvals Manager
AGL Gas Production (Camden) Pty Ltd
72 Christie Street
ST LEONARDS NSW 2065

Dear Mr Kelly

Director-General's Requirements -
Proposed Expansion of the Camden Gas Project – Spring Farm and Menangle Park Project

The Department has received your Major Project application for the proposed expansion of the Camden Gas Project – Spring Farm and Menangle Park Project in the Camden and Campbelltown local government areas (Application No. 06_0291).

I have attached a copy of the Director-General's requirements for the Environmental Assessment for the project. These requirements have been prepared in consultation with relevant public authorities, and are based on the information that you have provided to date. I have also attached a copy of comments provided by public authorities for your information.

Please note that under section 75F(3) of the *Environmental Planning and Assessment Act 1979*, the Director-General may alter these requirements at any time.

I would appreciate it if you would contact the Department at least 2 weeks before you propose to submit the Environmental Assessment for the project to determine the:
- fees applicable to the application;
- consultation and public exhibition arrangements that will apply; and
- required number of copies and format (hard-copy or CD-ROM) of the Environmental Assessment for the project.

As you may know, the Department will review the Environmental Assessment in consultation with the relevant authorities to determine if it adequately addresses the Director-General's requirements. If the Director-General considers the Environmental Assessment to be inadequate, you will be required to revise it prior to public exhibition.

The Director-General's requirements will be placed on the Department's website along with other relevant information which becomes available during the assessment of the project. As a result, the Department would appreciate it if all documents that are subsequently submitted to the Department are in a suitable format for the web, and if you would arrange for an electronic version of the Environmental Assessment for the project to be hosted on a suitable website with a link to the Department's website.

Finally, if your proposal contains any actions that could have a significant impact on Matters of National Environmental Significance, it will require an additional approval under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act). This approval would be in addition to any approvals required under NSW legislation. If you have any questions about the application of the EPBC Act to your proposal, you should contact the

Commonwealth Department of Environment and Heritage in Canberra (02 6274 1111 or http://www.deh.gov.au).

If you have any enquiries about these requirements, please contact Michael Young of the Department's Mining and Extractive Industries team, on (02) 9228 6437.

Yours sincerely

Chris Wilson
Executive Director
Major Project Assessment

As delegate of the Director-General

Director-General's Requirements

Section 75F of the *Environmental Planning and Assessment Act 1979*

Application Number	06_0291
Project	The Spring Farm and Menangle Park Project, which includes: • construction and operation of up to 4 surface well locations at Spring Farm and up to 12 surface well locations at Menangle Park (to contain a variety of horizontal, directional and surface-in-seam wells); • construction and use of access roads, a gas gathering system and water transport lines; • connection of the wells to the Rosalind Park Gas Plant; and • production of methane gas.
Site	Spring Farm – east of Camden and south of the Camden by-pass. Menangle Park – south of Spring Farm and bounded by the Hume Highway, Menangle Road and Nepean River.
Proponent	AGL Gas Production (Camden) Pty Ltd
Date of Issue	March 2007
Date of Expiration	March 2009
General Requirements	The Environmental Assessment (EA) must include • an executive summary; • a detailed description of the project including the: − need for the project; − alternatives considered; and − various components and stages of the project; • consideration of any relevant statutory provisions; • an overview of all the environmental impacts of the project, identifying the key issues for further assessment, and taking into consideration the issues raised during consultation; • a detailed assessment of the key issues specified below and any other significant issues identified in the general overview of environmental impacts of the project (see above), which includes: − a description of the existing environment; − an assessment of the potential impacts of the project, including any cumulative impacts; − a description of the measures that would be implemented to avoid, minimise, mitigate, offset, manage, and/or monitor the impacts of the project; • a draft Statement of Commitments, outlining environmental management, mitigation and monitoring measures; • a conclusion justifying the project, taking into consideration the environmental impacts of the project, the suitability of the site, and the benefits of the project; • a signed statement from the author of the Environmental Assessment certifying that the information contained in the report is neither false nor misleading.
Key Issues	• **Surface and Ground Water** – including an assessment of the potential impacts on streams, the local groundwater regime and water quality (including salinity), and a detailed description of the proposed water management system; • **Noise** - including an assessment of construction, operational and off-site transport noise; • **Vibration**; • **Air Quality** – including dust and odour impacts; • **Flooding**; • **Hazards** – including a risk assessment of the construction and operation

	of the proposal; • **Flora and Fauna** – including impacts on threatened species, populations or endangered ecological communities or their habitats; and details of vegetation offsets to ensure that there is no net loss to the flora and fauna values of the area in the medium to long term; • **Rehabilitation and Final Land Form** – including a detailed description of how the site would be progressively rehabilitated and integrated into the surrounding landscape; and a detailed description of the measures that would be put in place to ensure that sufficient resources are available to implement the proposed rehabilitation measures, and for the ongoing management of the site following the cessation of gas production; • **Waste**; • **Visual**; and • **Heritage** – including Aboriginal and non-Aboriginal heritage.
References	The Environmental Assessment must take into account relevant State government technical and policy guidelines. While not exhaustive, guidelines which may be relevant to the project are included in the attached list.
Consultation	During the preparation of the Environmental Assessment, you must consult with the relevant local, State or Commonwealth government authorities, service providers, community groups or affected landowners. The consultation process and the issues raised must be described in the Environmental Assessment. In particular you must consult with: • Department of Education and Training; • Department of Environment and Conservation; • Department of Natural Resources; • Department of Primary Industries; • Landcom; • Mine Subsidence Board; • NSW Heritage Office; • NSW Rural Fire Service; • Roads and Traffic Authority; • Sydney Catchment Authority; • Camden Council; • Campbelltown City Council; and • Australian Rail Track Corporation. The consultation process and the issues raised must be described in the Environmental Assessment.
Deemed refusal period	60 days

State Government Technical and Policy Guidelines - For Reference

Aspect	Policy /Methodology
Soil and Water	
	• *Managing Urban Stormwater: Soils and Construction Volume 1 4th Edition* (Landcom); • *Guidelines for Fresh and Marine Water Quality* and *Guidelines for Water Quality Monitoring and Reporting* (ANZECC); • *Rehabilitation Manual for Australian Streams* (Land and Water Resources Research and Development Corporation); • the various *State Groundwater Policy* documents (DNR); • *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW* (DEC); • *Environmental Guidelines: Use of Effluent by Irrigation* (DEC); • *Bunding and Spill Management* (DEC); • *NSW Salinity Strategy* (DNR); • *Policy and Guidelines for Fish Friendly Waterway Crossings* (DPI); • *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterways Crossings* (DPI);
Flooding	
	• *Floodplain Development Manual 2005* (DNR);
Flora and Fauna	
	• *draft Guidelines for Threatened Species Assessment* (DEC); • *draft Threatened Biodiversity Survey and Assessment: Guidelines for Development and Activities* (DEC);
Noise	
	• *NSW Industrial Noise Policy* (DEC); • *Environmental Criteria for Road Traffic Noise* (DEC); • *Construction Site Noise - Environmental Noise Control Manual* (DEC);
Air Quality	
	• *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC); • *Approved Methods for the Sampling and Analysis of Ait Pollutants in NSW* (DEC); • draft policy *Assessment and Management of Odour from Stationary Sources in NSW 2000* (DEC);
Heritage	
	• draft *Guidelines for Aboriginal Cultural Heritage Assessment and Community Consultation* (DEC); • *Assessing Heritage Significance* (NSW Heritage Office); • *NSW Heritage Manual* (NSW Heritage Office);
Hazards	
	• *Locational Guidelines – Development in the Vicinity of Operating Coal Seam Methane Wells* (Department of Planning); • *Hazardous Industry Planning Advisory Paper No. 1, "Industry Emergency Planning Guidelines"* (DOP); • *Hazardous Industry Planning Advisory Paper No. 9, "Safety Management"* (DOP);
Vibration	
	• *Technical Basis for Guidelines to Minimise Annoyance due to Blasting and Ground Vibration* (ANZECC); • *Assessing Vibration: a Technical Guideline* (DEC);
Traffic	
	• *Guide to Traffic Generating Development* and *Road Design Guide (RTA);* • relevant Austroad standards;
Waste	
	• *Environmental Guidelines: Assessment and Classification and Management of Liquid and Non-Liquid Wastes* (DEC);

NSW GOVERNMENT
Department of Planning

Contact: Michael Young
Phone: (02) 9228 6437
Fax: (02) 9228 6466
Email: michael.young@planning.nsw.gov.au

Our ref: S02/02299

Mr David Kelly
Land & Approvals Manager
AGL Gas Production (Camden) Pty Ltd
72 Christie Street
ST LEONARDS NSW 2065

Dear Mr Kelly

Director-General's Requirements -
Concept Plan for the Proposed Expansion of Stage 2 of the Camden Gas Project

The Department has received your Concept Plan application for the proposed expansion of Stage 2 of the Camden Gas Project in the Camden, Campbelltown and Wollondilly local government areas (Application No. 06_0292).

I have attached a copy of the Director-General's requirements for the Environmental Assessment for the proposal. These requirements have been prepared in consultation with relevant public authorities, and are based on the information that you have provided to date. I have also attached a copy of comments provided by public authorities for your information.

Please note that under section 75F(3) of the *Environmental Planning and Assessment Act 1979*, the Director-General may alter these requirements at any time.

I would appreciate it if you would contact the Department at least 2 weeks before you propose to submit the Environmental Assessment for the Concept Plan to determine the:

- fees applicable to the application;
- consultation and public exhibition arrangements that will apply; and
- required number of copies and format (hard-copy or CD-ROM) of the Environmental Assessment for the Concept Plan.

As you may know, the Department will review the Environmental Assessment in consultation with the relevant authorities to determine if it adequately addresses the Director-General's requirements. If the Director-General considers the Environmental Assessment to be inadequate, you will be required to revise it prior to public exhibition.

The Director-General's requirements will be placed on the Department's website along with other relevant information which becomes available during the assessment of the Concept Plan. As a result, the Department would appreciate it if all documents that are subsequently submitted to the Department are in a suitable format for the web, and if you would arrange for an electronic version of the Environmental Assessment for the Concept Plan to be hosted on a suitable website with a link to the Department's website.

Finally, if your proposal contains any actions that could have a significant impact on Matters of National Environmental Significance, it will require an additional approval under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act). This approval would be in addition to any approvals required under NSW legislation. If you have any questions about the application of the EPBC Act to your proposal, you should contact the

Commonwealth Department of Environment and Heritage in Canberra (02 6274 1111 or http://www.deh.gov.au).

If you have any enquiries about these requirements, please contact Michael Young of the Department's Mining and Extractive Industries team, on (02) 9228 6437.

Yours sincerely

Chris Wilson
Executive Director
Major Project Assessment

As delegate of the Director-General

Director-General's Requirements

Section 75F of the *Environmental Planning and Assessment Act 1979*

Application Number	06_0292

Project	Concept Plan for the proposed expansion of Stage 2 of the Camden Gas Project, which includes:
	• drilling of:
	  o new well fields in areas identified as Spring Farm, Menangle Park, Mount Gilead and Kay Park Stage 2;
	  o new wells from the pads of existing wells in existing well fields, to access additional gas resources; and
	  o infill wells (with associated infrastructure including gas gathering and water pipelines and access roads) in existing well fields, where the gas reserve is not able to be accessed from existing well head locations;
	• constructing and using access roads, gas gathering systems and water transport lines;
	• the subsequent production and transportation of gas from the new well sites to the Rosalind Park Gas Treatment Plant; and
	• post-development operational activities including upgrading of existing gas gathering lines, the installation of in-field compression, and refraccing of existing and new wells.

Site	Stage 2 of the Camden Gas Project within the Camden, Campbelltown and Wollondilly local government areas.
Proponent	AGL Gas Production (Camden) Pty Ltd
Date of Issue	March 2007
Date of Expiration	March 2009

General Requirements	The Environmental Assessment (EA) must include:
	• an executive summary;
	• a detailed description of the Concept Plan including the:
	  - need for the proposal;
	  - alternatives considered; and
	  - various components and stages of the proposal;
	• consideration of any relevant statutory provisions;
	• an overview of all the environmental impacts of the proposal, identifying the key issues for further assessment, and taking into consideration the issues raised during consultation;
	• an assessment of the key issues specified below and any other significant issues identified in the general overview of environmental impacts of the proposal (see above), which includes:
	  - a description of the existing environment;
	  - an assessment of the potential impacts of the proposal, including any cumulative impacts;
	  - a description of the measures that would be implemented to avoid, minimise, mitigate, offset, manage, and/or monitor the impacts of the proposal;
	• a draft Statement of Commitments, outlining environmental management, mitigation and monitoring measures;
	• a conclusion justifying the proposal, taking into consideration the environmental impacts of the proposal, the suitability of the site, and the benefits of the proposal;
	• a signed statement from the author of the Environmental Assessment certifying that the information contained in the report is neither false nor misleading.

Key Issues	• **Surface and Ground Water** – including an assessment of the potential impacts on streams, the local groundwater regime and water quality (including salinity), and a description of the proposed water management system; • **Noise and Vibration** - including a broad assessment of construction and operational noise and vibration and off-site transport noise; • **Air Quality** – including dust and odour impacts; • **Flooding**; • **Hazards** – including a risk assessment of the construction and operation of the proposal; • **Soils and Land Use**; • **Flora and Fauna** – including impacts on threatened species, populations or endangered ecological communities or their habitats; and details of vegetation offsets to ensure that there is no net loss to the flora and fauna values of the area in the medium to long term; • **Rehabilitation and Final Land Form** – including a description of how the site(s) would be progressively rehabilitated and integrated into the surrounding landscape; and a description of the measures that would be put in place to ensure that sufficient resources are available to implement the proposed rehabilitation measures, and for the ongoing management of the site(s) following the cessation of gas production; • **Waste**; • **Visual**; and • **Heritage** – including Aboriginal and non-Aboriginal heritage.
References	The Environmental Assessment must take into account relevant State government technical and policy guidelines. While not exhaustive, guidelines which may be relevant to the proposal are included in the attached list.
Consultation	During the preparation of the Environmental Assessment, you must consult with the relevant local, State or Commonwealth government authorities, service providers, community groups or affected landowners. The consultation process and the issues raised must be described in the Environmental Assessment. In particular you must consult with: • Department of Education and Training; • Department of Environment and Conservation; • Department of Natural Resources; • Department of Primary Industries; • Landcom; • Mine Subsidence Board; • NSW Heritage Office; • NSW Rural Fire Service; • Roads and Traffic Authority; • Sydney Catchment Authority; • Camden Council; • Campbelltown City Council; • Wollondilly Shire Council; and • Australian Rail Track Corporation. The consultation process and the issues raised must be described in the Environmental Assessment.
Deemed refusal period	60 days

State Government Technical and Policy Guidelines - For Reference

Aspect	Policy /Methodology
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	• *Managing Urban Stormwater: Soils and Construction Volume 1 4th Edition* (Landcom); • *Guidelines for Fresh and Marine Water Quality* and *Guidelines for Water Quality Monitoring and Reporting* (ANZECC); • *Rehabilitation Manual for Australian Streams* (Land and Water Resources Research and Development Corporation); • the various *State Groundwater Policy* documents (DNR); • *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW* (DEC); • *Environmental Guidelines: Use of Effluent by Irrigation* (DEC); • *Bunding and Spill Management* (DEC); • *NSW Salinity Strategy* (DNR); • *Policy and Guidelines for Fish Friendly Waterway Crossings* (DPI); • *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterways Crossings* (DPI);
Flooding	
	• *Floodplain Development Manual 2005* (DNR);
Flora and Fauna	
	• *draft Guidelines for Threatened Species Assessment* (DEC); • *draft Threatened Biodiversity Survey and Assessment: Guidelines for Development and Activities* (DEC);
Noise	
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Air Quality	
	• *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC); • *Approved Methods for the Sampling and Analysis of Ait Pollutants in NSW* (DEC); • draft policy *Assessment and Management of Odour from Stationary Sources in NSW 2000* (DEC);
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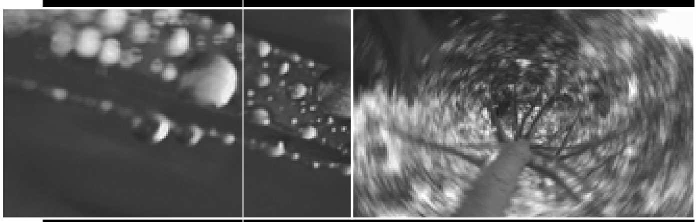
	• *Locational Guidelines – Development in the Vicinity of Operating Coal Seam Methane Wells* (Department of Planning); • *Hazardous Industry Planning Advisory Paper No. 1, "Industry Emergency Planning Guidelines"* (DOP); • *Hazardous Industry Planning Advisory Paper No. 9, "Safety Management"* (DOP);
Vibration	
	• *Technical Basis for Guidelines to Minimise Annoyance due to Blasting and Ground Vibration* (ANZECC); • *Assessing Vibration: a Technical Guideline* (DEC);
Traffic	
	• *Guide to Traffic Generating Development* and *Road Design Guide (RTA);* • relevant Austroad standards;
Waste	
	• *Environmental Guidelines: Assessment and Classification and Management of Liquid and Non-Liquid Wastes* (DEC);



APPENDIX C

AGENCY RESPONSES TO CONSULTATION

ASSET MANAGEMENT DIRECTORATE

NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

Early Childhood and Primary Education
Secondary Education
Technical and Further Education
Vocational Education and Training
Higher Education
Adult and Community Education

Mr Michael England
HLA – Envirosciences Pty Ltd
PO BOX 726
PYMBLE NSW 2073

DOC 07/14782

Attention: Michael England

CAMDEN GAS PROJECT STAGE 2

I refer to your correspondence of 28 March 2007 regarding the exhibition of the Camden Gas Project- Stage 2 Expansion. It is noted that this expansion will be in two areas, Spring Farm where the DET identified a primary school site and Menangle Park where there is an existing site.

The site in Station Street Menangle is listed for disposal and is south of the area identified for new well location and indicative gathering lines. Figure 6 is attached with the indicative location of the DET site.

The 4 hectare primary school site identified on the Spring Farm LEP appears to be approximately 300 metres to the north west of the new gathering lines and proposed well at the southern end of Spring Farm. Proposed well number two is away to the north of the school site. I have attached Figure 5 to indicate where the school site is in relation to the proposed two new gathering lines and wells. It is difficult to pinpoint the actual location of the school sites in relation to proposed wells as there are no existing roads marked on the maps.

It is not anticipated that there will be an operating school in either, Menangle Park or Spring Farm during the scheduled drilling phase between 2007 and mid year 2008 or in the further construction phase.

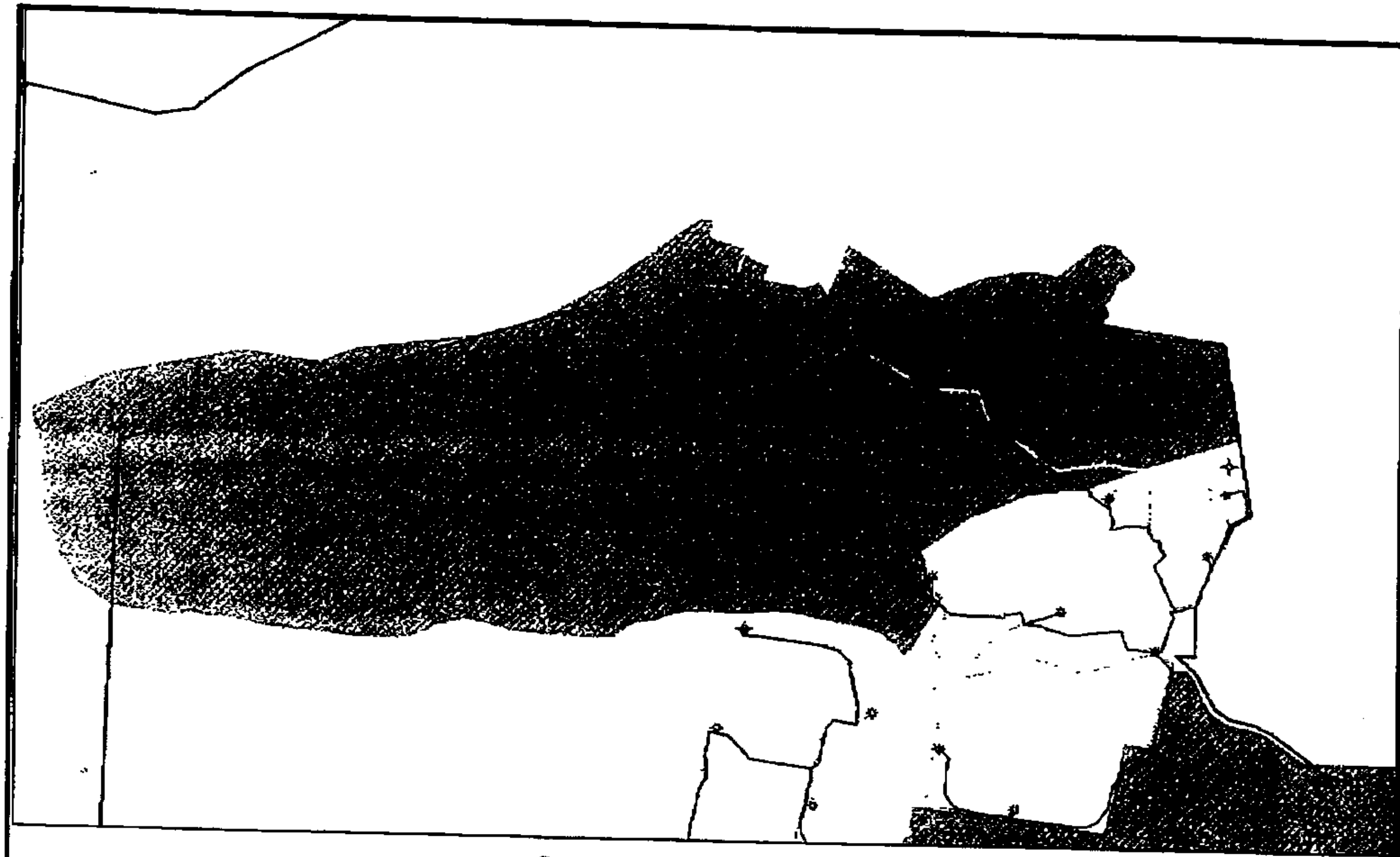
The future operation, amenity and education provision in Spring Farm and Menangle Park should not be compromised by the proposed Camden Gas Project Stage 2 Expansion.

The Department of Education and Training welcomes the opportunity to work with AGL (Camden Gas Production) to ensure that there are no negative impacts in relation to the health, safety and welfare of school students living in the vicinity of a gas well.

Further correspondence on the AGL Camden Gas Project – Stage 2 can continue to be addressed to me. For further enquiries, the contact officer is Sandra Patterson, Demographic Planner 9561-8544 or sandra.patterson@det.nsw.edu.au.

Yours sincerely

for Lesley Greenwood
A/Manager Service Planning



Spring Farm Project Area
Proposed Wells, Gathering Lines & Access (Indicative)

0 0.15 0.3 0.6 0.9 1.2 Kilometers

Legend
- Stage 2 Concept Application Area
- PPL Boundaries
- SUSPENDED
- PRODUCING
- Plugged and Abandoned
- Indicative Well Locations
- Property Boundaries
- Existing Gathering Lines
- Indicative Gathering Lines
- Indicative Access Roads
- Existing Access Roads
- Future Development Areas Drilling Areas selection 2

PROJECT FILE NAME
DATE 28 October 2006
DRAWN
APPROVED

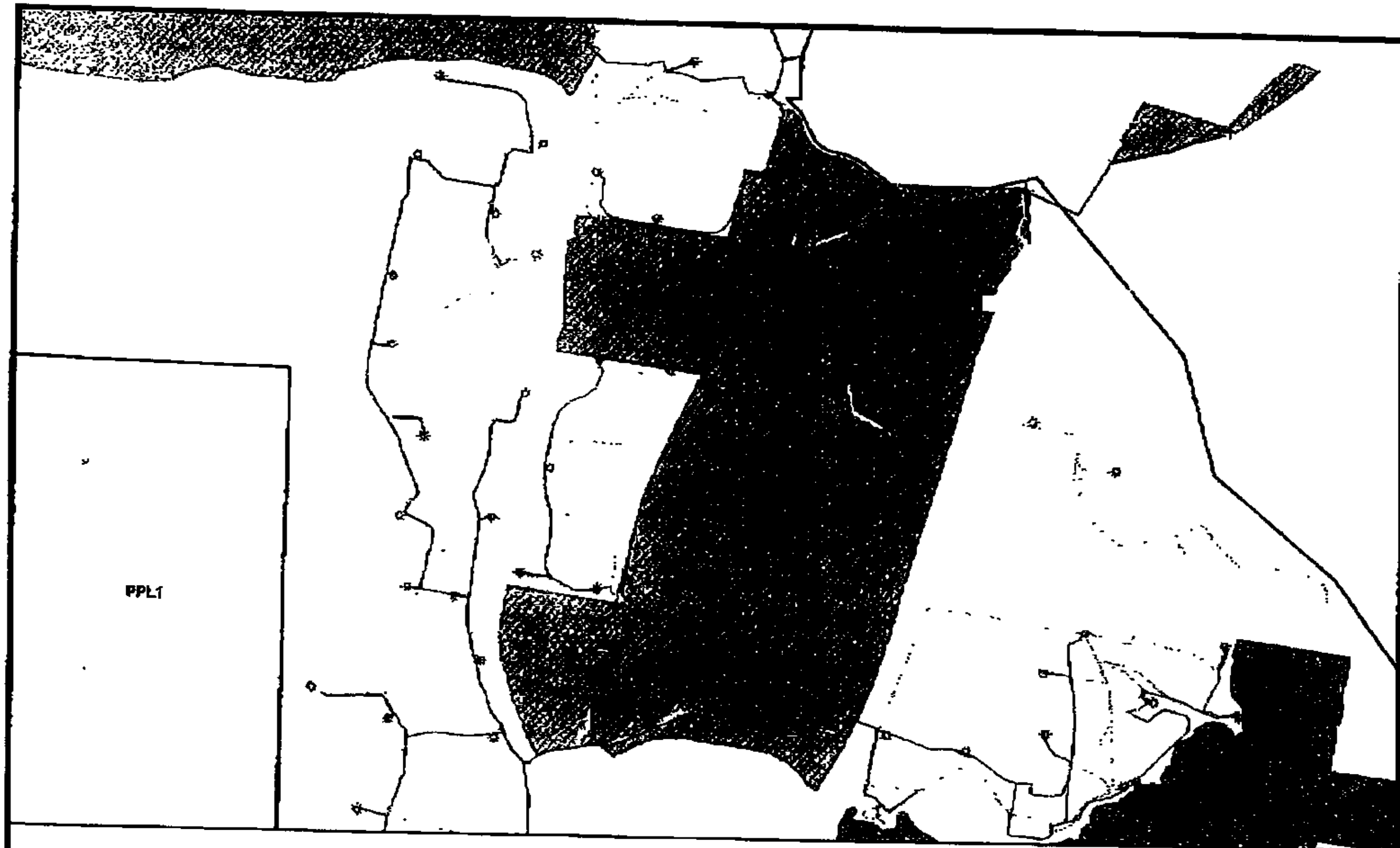
Spring Farm Proposed Works
AGL Gas Production (Camden) Pty Ltd
Environmental Assessment Scoping Report
Expansion of Stage 2 of the Camden Gas Project

HLA

Scale as Shown

FIGURE 5

LST 300 + metres from
well site across Springs Road.



Menangle Park Project Area
Proposed Wells, Gathering Lines & Access (Indicative)

0 0.2 0.4 0.8 1.2 1.6 Kilometers

Legend
- PPL Boundaries
- Property Boundaries
- Existing Access Roads
- Indicative Access Road
- Existing Gathering Lines
- Indicative Gathering Lines
- PRODUCING
- Indicative Well Locations
- Project Application Areas

PROJECT/FILE NAME
DATE 20 October 2006
DRAWN
APPROVED

Menangle Park Proposed Works
AGL Gas Production (Camden) Pty Ltd
Environmental Assessment Scoping Report
Expansion of Stage 2 of the Camden Gas Project

HLA

Scale as Shown

FIGURE **6**

* site listed for disposal.

WOLLONDILLY
SHIRE COUNCIL

Our Reference: 1960-4 GR

04 APR 2007

→ Erin

Michael England
National Practice Leader Environmental Planning
HLA-Envirosciences Pty Ltd
PO Box 726
PYMBLE NSW 2073

3 April 2007

Dear Sir,

CAMDEN GAS PROJECT – STAGE 2 ENVIRONMENTAL ASSEEMENT

Reference is made to your letter dated 28 March 2007 and accompanying copies of the Environmental Assessment Scoping Report for the above application.

It is advised that after review of the subject documents Council requires the following to be assessed as a part of the Environmental Assessment Process:

- In the construction stage:
  - Management of risk and hazard
  - The impacts on the locality with respect to noise, vibration, dust and amenity
  - The impacts on air quality
  - The management of water including stormwater and water used in construction
  - The management of wastes produced
  - The impacts on flora and fauna
  - The suitability of the sites in terms of geotechnical and soil considerations
  - The impacts on items and areas of indigenous and non-indigenous cultural significance
  - The management of access and traffic
  - The impacts of any new access ways to be constructed
- In the operating stage
  - Management of risk and hazard
  - The impacts on the locality with respect to noise, vibration and amenity
  - The impacts on air quality
  - The management of water including stormwater and water used in operation
  - The management of wastes produced

.../2

  - The impacts on flora and fauna
  - The management of access and traffic
  - The impact of the development on adjoining land uses
  - The visual impact of the wells and any ancillary development

- In the post-operating stage
  - The restoration of the sites

It is further advised that Council has concerns regarding the figures provided with the Scoping Report which did not allow for a positive identification of the subject lands. To this end, Council requires that the final Environmental Assessment provide sufficient information to enable a positive identification of all subject sites.

Council thanks you for the opportunity to comment on these proposals. Should you require any further information in respect to this matter please contact the undersigned on 46771172.

Yours faithfully

D Smith

David Smith
Manager Development Services
LAND USE PLANNING & ENVIRONMENT

per CK

Our reference : WO786/15:DOC07/12633:KH
Contact : Kate Hopkins, (02) 4224 4100

HLA-Envirosciences Pty Ltd
(Attention: Erin Saunders)
PO Box 726
PYMBLE NSW 2073

13 APR 2007

Dear Madam

REQUEST FOR ADDITIONAL ENVIRONMENTAL ASSESSMENT REQUIREMENTS
PROJECT APPROVAL AND CONCEPT APPROVAL CAMDEN GAS – STAGE 2

We are writing in regards to the above matters. The Department of Environment and Conservation (DEC) has previously provided Environmental Assessment Requirements (EAR) for the preparation of Environmental Assessments (EA) for the proposals in a letter to the Department of Planning (DoP) dated 11 January 2007.

On 28 March 2007, the DEC received updated information from HLA-Envirosciences on behalf of the proponent. We have reviewed the information provided and determined that additional EAR are required to be addressed in the preparation of the EA. The DEC considers that in addition to the previously provided EAR, an assessment should be undertaken to assess whether there are any potential environmental impacts associated with subsidence due to gas extraction and any potential groundwater contamination due to fraccing.

For your information the DEC has recently been involved in an investigation where surface water pollution was possibly a result of gas extraction activities in the Menangle area. While investigations are continuing the matter has raised the issue on whether gas extraction activities do impact upon groundwaters and thereby cause groundwater and surface water pollution.

In addition, the DEC has identified overseas examples, such as in the Netherlands, where subsidence has occurred as a result of gas extraction activities. In these examples subsidence has caused impacts on the environment by altering local streams by changing slopes and altering flow velocities and surface patterns.

Subsidence may also impact groundwater resources by fracturing aquifers and interacting with surface water by providing alternative pathways for groundwater accession or discharges. In particular water dependant ecosystems can potentially be seriously impacted as a result of subsidence and groundwater contamination.

The EA should include an assessment of the potential for subsidence and groundwater contamination as a result of the proposal including the identification of any mitigation measures to address any such impacts.

If you have any further questions in relation to the above matter, please contact Kate Hopkins on 4224 4100.

Yours sincerely

10/4/07

PETER BLOEM
A/Manager Illawarra
Environment Protection and Regulation

cc: Department of Planning
(Attention: Michael Young)
GPO Box 39
SYDNEY NSW 2001

(N:\KH\part 3a\WO786-15 Camden Gas AGL\Doc 07-12633 Additional EARs project and concept approvals)

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Level 2, 311 High Street
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Tel 1300 722 468 Fax 02 4732 3666
Email info@sca.nsw.gov.au
Website www.sca.nsw.gov.au

Ref: D2007/02290
Your Ref: S6044801

Ms Erin Saunders
HLA-Enviroscieces Pty Ltd
PO Box 726
Pymble NSW 2073

16 APR 2007

Dear Ms Saunders

Proposed Expansion of Stage 2 of the Camden Gas Project (MP 06_0292) Assessment under Part 3A of the EP&Act.

Thank you for consulting with the Sydney Catchment Authority (SCA) with regard to the Environmental Assessment Scoping Report (19 October 2006) for the above project. The SCA replied to the Department of Planning in February 2007 in relation to a request to provide input for the preparation of Director-General's requirements.

The SCA has an interest in this proposal in so far as the proposed works may be in the vicinity of the Upper Canal. The Upper Canal is a critical part of the Sydney drinking water supply system. It is used by the SCA to transfer raw drinking water from the Upper Nepean dams to the Prospect Water Treatment Plant. The Upper Canal is generally located within a strip of land approximately 50 to 100 metres wide classified as *Controlled Area* as defined in the *Sydney Water Catchment Management Act 1998.* The Sydney Water Catchment Management (General Regulation) 2000 contains provisions which restrict persons entering these lands and which restrict pollution of waters. The Upper Canal also has significant heritage value and is listed on the State Heritage Register

The SCA is unable to further comment on this application as the level of information and assessment in the document does not permit the extent of potential interaction to be defined.

If you wish to discuss any matter raised in this letter please contact Zev Fink on 4725 2587 or zev.fink@sca.nsw.gov.au.

Yours sincerely

12/4/07

PAUL GRIMSON
Manager Statutory Planning

NSW GOVERNMENT
Department of Planning

Contact Sam Moody
Telephone: 02 9873 8525
sam.moody@heritage.nsw.gov.au
File: S90/06361/3
Our Ref: HRL45023
Your Ref:
S6044801_FinalEASR_19October 06_v2

17 APR 2007

Ms Erin Saunders
Senior Planner
HLA Envirosciences Pty Limited
PO Box 726
PYMBLE NSW 2073

Dear Ms Saunders,

Re: Environmental Assessment Scoping Report - Camden Gas Project Stage 2 Expansion

Thank you for referring the Environmental Assessment Scoping Report (EASR) for the abovementioned project to the Heritage Office for comment. The Heritage Office has reviewed the forwarded information and the full EASR as viewed on the NSW Department of Planning's website and would like to re-iterate earlier comments forwarded regarding this project. Previous correspondence is attached for your review and consideration.

Additional to earlier comments, we would like to draw your attention to the recent listing of the Elizabeth Macarthur Agricultural Institute on the State Heritage Register as Camden Park and Belgenny Farm (item number 01697). This item is within the boundaries of the Stage 2 area and the heritage significance of the area should be considered in all future assessments and applications regarding proposed Stage 2 developments.

If you have any questions regarding the matters raised in this letter or enclosure please contact Sam Moody at the Heritage Office on the above contact details.

Yours sincerely,

11/04/07

Vincent Sicari
Manager
Conservation Team

Enclosure: Letter dated 11 January 2007
Letter dated 11 January 2007

Heritage Office ***Working with the community to know, value and care for our heritage***

Heritage Council of New South Wales

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heritageoffice@heritage.nsw.gov.au
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Contact: Fiona Leslie
Telephone: 02-9873 8525
Fiona.Leslie@heritage.nsw.gov.au
File: S90/06361/3
Our Ref: HRL43841
Your Ref: S02/02299

Mr Howard Reed
A/Manager
Mining & Extractive Industries
Major Development Assessment
GPO Box 39
SYDNEY NSW 2001

COPY

Dear Mr Reed

CONCEPT PLAN APPLICATION – EXPANSION OF STAGE 2 OF THE CAMDEN GAS PROJECT – MP 06_0292

Proposal:

- Drilling of new well fields in areas identified as Spring Farm, Menangle Park, Mount Gilead and Kay Park Stage 2;
- Drilling of new wells from the pads of existing wells in existing well fields (to access additional gas resources);
- Drilling of infill wells in existing well fields (where the gas resource is not able to be accessed from existing well head locations);
- Construction and use of gas gathering lines, water transport lines and access roads;
- Production and transportation of gas from the new well sites to the Stage 2 gas treatment plant; and
- Post-development operational activities including upgrading of existing gas gathering lines, the installation of in-field compression and refracing of existing and new wells.

Major Project Application No: MP 06_0292

Information received with the Application: Environmental Assessment Scoping (EAS) Report – Expansion of Stage 2 of the Camden Gas Project prepared by HLA – Envirosciences Pty Ltd, dated 19 October 2006.

I refer to your letter dated 18 December 2006, which was received by this Office on 28 December 2006 and refers to the above-mentioned proposal to expand Stage 2 of the Camden Gas Project. The proposal has been classified as a Major Project under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

It is noted that Stage 2 of the Project was approved by the Department of Planning in 2004 and initially comprised forty-three [43] wells, the Rosalind Park Gas Plant and gas gathering system in the Menangle and Menangle Park areas. Since this approval was issued, six [6] subsequent development consents to extend the Stage 1 and 2 works have been granted by the Minister of Planning; namely for:

- An additional 15 wells at Mt Taurus and at Harness Racing at Menangle Park;
- An additional 6 wells at Glenlee and Elizabeth Macarthur Agricultural Institute (EMAI) Stage 1;
- An additional 7 wells at Sugarloaf;
- An additional 10 wells on the El Bethel property;
- An additional 6 wells within the Stage 1 and Stage 2 areas; and
- A further 14 wells in the EMAI property and 10 wells in the adjacent Razorback area.

The Heritage Office provided feedback on Stage 1 works and various subsequent development consents, including additional wells located on the EMAI property and adjacent Razorback area in December 2005.

It is noted that the proponent has submitted an Environmental Assessment Scoping (EAS) report to accompany the Concept Plan Application. The report was prepared by HLA-Envirosciences Pty Ltd and provides a description of the proposal and a preliminary environmental assessment.

Section 8.2 of the report briefly discusses Non-Indigenous heritage issues by describing the results of an internet search of the State Heritage Inventory (SHI) and the Register of the National Estate (RNE). The report states that "*several items were identified, particularly of local heritage significance. The majority of these items are listed in the relevant LEP as having heritage significance, and include old homesteads and cottages. The area identified as Camden Park also accounts for a large portion of the listed items identified in the search*" (p55). Whilst the results of the search are not listed a brief review of the State Heritage Register and relevant Local Environmental Plans confirms that a number of sites are listed in the Concept Plan Area, including the large Camden Park Estate and Belgenny Farm site (SHR No 01697).

It is apparent from the EAS report that the Concept Plan does not identify the exact position of the new wells and supporting infrastructure because of the size of the area and the time required to assess environmental constraints and land access issues. This level of detail will be provided in Environmental Assessments that support subsequent Project applications (EAS Report 2006: p9). As is evident from the following statements, the design and position of the wells will be flexible making conservation and management of heritage items an achievable outcome.

"*In planning the location of future wells and infrastructure as part of the Concept Plan, AGL Camden would avoid matters of heritage significance. This issue would be incorporated into the locational guidelines developed in respect of the Concept Plan works*". (p56)

"*Mitigation measures will be incorporated into the EA to address potential impacts on sub-surface non-Indigenous archaeology.*" (p57) and

"*In the event future wells or gas infrastructure within the Stage 2 Concept Plan area are to be located within the curtilage of an identified heritage item, an appropriate heritage impact assessment would be undertaken as part of future Project applications*". (p57)

Many of the new wells may be drilled in disturbed areas adjacent to existing wells and/or in existing well fields.

The Heritage Office supports this approach and provides the following key issues to be addressed by the Director-Generals Requirements for the environmental assessment for the Concept Plan:

- Future wells and infrastructure that form part of the Concept Plan should be located on disturbed ground adjacent to existing wells, where possible, outside the curtilage of items listed on the State Heritage Register and should avoid disturbing items listed on Local Environmental Plans.

- Prior to finalising the location of future wells and infrastructure, areas where excavation is proposed should be surveyed by a qualified heritage practitioner with historic sites experience to identify and record previously undocumented heritage items. The survey should include an assessment of the potential for sub-surface relics.

- In the event that future wells and infrastructure are unable to be located outside the curtilage of identified heritage items a Statement of Heritage Impact that complies with NSW Heritage Council guidelines should be prepared by a qualified heritage practitioner with historic sites experience.

- Environmental Assessments for subsequent Major Project Application should include a detailed heritage impact assessment and Statements of Heritage Impact(s) that comply with NSW Heritage Council guidelines. These documents are to be prepared by a qualified heritage practitioner with historic sites experience.

It is noted that a Major Project Application for additional wells in Spring Farm and Menangle Park has also been referred to the Heritage Office for comment (S02/02299). More detailed recommendations for the Environmental Assessment required to support this application have been provided in separate correspondence (Our Reference: HRL43842).

If you have any questions regarding the above matter please contact Fiona Leslie at the Heritage Office on (02) 9873 8525.

Yours sincerely

Siobhan Lavelle 11-01-2007
A/Manager
Conservation Team
Heritage Office
Department of Planning

Heritage Council of New South Wales

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Contact: Fiona Leslie
Telephone: 02-9873 8525
Fiona.Leslie@heritage.nsw.gov.au
File: S90/06361/3
Our Ref: HRL43842
Your Ref: S02/02299

Mr Howard Reed
A/Manager
Mining & Extractive Industries
Major Development Assessment
GPO Box 39
SYDNEY NSW 2001

COPY

Dear Mr Reed

MAJOR PROJECT APPLICATION – EXPANSION OF STAGE 2 OF THE CAMDEN GAS PROJECT IN SPRING FARM AND MENANGLE PARK – MP 06_0291

Proposal:

- Construction and operation of up to four [4] surface well locations at Spring Farm and up to 12 surface well locations at Menangle Park (to contain a variety of vertical, directional and surface to inseam (SIS) wells);
- Construction and use of access roads, a gas gathering system and water transport lines;
- Connection of the wells to the Stage 2 gas treatment plant; and
- Production of methane gas.

Major Project Application No: MP 06_0291
Information received with the Application: Environmental Assessment Scoping (EAS) Report – Expansion of Stage 2 of the Camden Gas Project prepared by HLA – Envirosciences Pty Ltd, dated 19 October 2006.

I refer to your letter dated 18 December 2006, which was received by this Office on 28 December 2006 and refers to the above-mentioned proposal to expand Stage 2 of the Camden Gas Project in Spring Farm and Menangle Park.

The proposal has been classified as a Major Project under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and follows a Concept Plan Application for broader expansion of the Stage 2 Project Area. Key issues that should be addressed in the Director-General's Requirements for the Concept Plan have been provided by the Heritage Office in separate correspondence (Our Reference HRL 43841).

It is noted that the proponent has submitted an Environmental Assessment Scoping (EAS) Report to accompany the Major Project Application. The Report was prepared by HLA-Envirosciences Pty Ltd and provides a description of the proposal and a preliminary environmental assessment.

Section 8.2 of this report briefly discusses Non-Indigenous heritage issues by describing the results of an internet search of the State Heritage Inventory (SHI) and the Register of the National Estate (RNE). A list of heritage items currently registered on state, local and commonwealth registers in the Spring Farm and Menangle Park Project Areas is provided in Section 8.2.3. A brief review of the State Heritage Register confirms that the Glenlee outbuildings, garden and gatelodge site (SHR No. 00009) is located within the proposed Menangle Park Project Area. Other heritage items listed on the State Heritage Register in Menangle include Camden Park (SHR No. 00341), Menangle Railway Station Group (SHR No. 01191) and Menangle Rail Bridge over Nepean River (SHR No. 01047).

It is apparent from the EAS report that the exact position of the new wells and supporting infrastructure has not been identified at this stage because of the size of the area and the time required to assess environmental constraints and land access issues. This level of detail should be provided in the supporting environmental assessment. It is also evident from the report that the design and position of the wells and gas infrastructure will be flexible making conservation and management of heritage items an achievable outcome. This is supported by statements made in Section 8.2.4 of the report. Many of the new wells may be drilled in disturbed areas adjacent to existing wells and/or in existing well fields.

The Heritage Office supports this approach and provides the following key issues to be addressed by the Director-Generals Requirements for the environmental assessment for the Major Project Application:

- The heritage significance of identified heritage items and any impacts the project may have upon this significance should be assessed. This assessment should include natural areas and places of Aboriginal, historic or archaeological significance. It should also include a consideration of wider heritage impacts in areas surrounding the project.

- It is noted that an archaeological survey and assessment of Glenlee House, Menangle Road, Campbelltown, NSW was prepared by Edward Higginbotham in 1985. It is recommended that this document be reviewed as part of the Environmental Assessment.

- The Heritage Council maintains the State Heritage Inventory which lists some items protected under the Heritage Act, 1977 and other statutory instruments. This register can be accessed through the Heritage Office home page on the internet (http:/www.heritage.nsw.gov.au).

- In addition, you should consult lists maintained by the National Trust, any heritage listed under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* and relevant local councils in order to identify any identified items of heritage significance in the area affected by the proposal. Please be aware, however, that these lists are constantly evolving and that items with potential heritage significance may not yet be listed.

- Non-Aboriginal heritage items within the area affected by the proposal should be identified by field survey. This should include any buildings, works, relics (including relics underwater), gardens, landscapes, views, trees or places of non-Aboriginal heritage significance. A statement of significance and an assessment of the impact of the proposal on the heritage significance of these items should be undertaken. Any policies/measures to conserve their heritage significance should be identified. This assessment should be undertaken in accordance with the guidelines in the NSW Heritage Manual. It is also recommended that the impact assessments for identified built heritage items should take the form of a Statement of Heritage Impact as described in published Heritage Council guidelines.

- The field survey and assessment should be undertaken by a qualified heritage practitioner with historic sites experience.

- The proposal should have regard to any impacts on places, items or relics of significance to Aboriginal people. Where it is likely that the project will impact on Aboriginal heritage, adequate community consultation should take place regarding the assessment of significance, likely impacts and management/mitigation measures. For guidelines regarding the assessment of Aboriginal sites, please contact the National Parks and Wildlife Division of the Department of Environment and Conservation on (02) 9585 6444.

It is understood that the proposed project will be an "approved project" for the purposes of Part 3A of the EP&A Act and section 75U of the Act therefore suspends the requirement for an excavation permit under section 139 of the *Heritage Act 1977*. The Heritage Office nevertheless recommends that the environmental assessment documents should include an Archaeological Assessment, Methodology and Research Design for any historical archaeological sites which may be affected by excavation for the new wells and associated gas infrastructure.

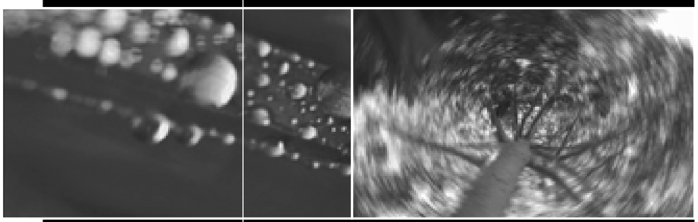
It would be appreciated if a copy of the proponent's environmental assessment is provided to the Heritage Office during the public notification of the project in accordance with section 75H of the EP&A Act. The Heritage Office would be pleased to comment further at that stage.

The Heritage Office would also be available to attend planning focus meetings in relation to this major project.

For further contact in relation to this matter please phone Fiona Leslie on 9873 8525.

Yours sincerely

Siobhan Lavelle 11-01-2007
A/Manager
Conservation Team
Heritage Office
Department of Planning



APPENDIX D

QUANTITATIVE RISK ASSESSMENT, COAL SEAM METHANE PRODUCTION WELLS FOR UP TO SIX WELLHEAD CONFIGURATION

QUANTITATIVE RISK ASSESSMENT, COAL SEAM METHANE PRODUCTION WELLS FOR UP TO SIX WELLHEAD CONFIGURATION FOR AGL GAS PRODUCTION (CAMDEN) PTY LIMITED

Prepared for:	**AGL Gas Production (Camden) Pty Limited**
Document Number:	**02/Report01**
Revision C	**Final**

Prepared by: Karin Nilsson

19 September 2007

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Quantitative Risk Assessment
Up to Six Coal Seam Methane Production Wells
AGL Gas Production (Camden) Pty Limited

Acknowledgment

The author would like to thank Siobhan Barry, Mike Roy and Tofazzel Haque for their assistance in the hazard identification process and in preparing this report.

Disclaimer

This report was prepared by Planager Pty Ltd (Planager) as an account of work for AGL Gas Production (Camden) Pty Limited. The material in it reflects Planager's best judgement in the light of the information available to it at the time of preparation. However, as Planager cannot control the conditions under which this report may be used, Planager and its related corporations will not be responsible for damages of any nature resulting from use of or reliance upon this report. Planager's responsibility for advice given is subject to the terms of engagement with AGL Gas Production (Camden) Pty Limited.

Rev	Date	Description	Prepared By
A	20/03/2007	Draft for Comment	Karin Nilsson
B	30/03/2007	Final Report	Karin Nilsson
C	19/09/2007	Final Report following Department of Planning4/9/07	Karin Nilsson

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EXECUTIVE SUMMARY

E1 Introduction

AGL Gas Production (Camden) Pty Limited operates the Camden Gas Project, which is located 50km southwest of Sydney in the Southern Coalfield of the Sydney Basin. AGL is proposing to drill, test and operate coal seam methane (CSM) gas wells at Spring Farm and Menangle Park. The project also includes the construction of gas gathering lines, water drainage lines and access roads.

An Environmental Assessment (EA) is being prepared on behalf of AGL to assess the potential environmental impacts of the proposed development and to support an application for approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Planager Pty Ltd have been commissioned to undertake a Quantitative Risk Assessment (QRA) to assess the risk associated with up to six CSM wells at one surface location.

The assessment has been carried as per the Hazardous Industry Planning Advisory Paper (HIPAP) 6 - *Guidelines for Hazard Analysis* and in accordance with HIPAP 4 - *Risk Criteria for Land Use Planning*.

The present assessment uses the input information and methodologies described in the *Location Guidelines - Development in Vicinity of Operating Coal Seam Methane Wells*, May 2004 by the Department of Infrastructure, Planning and Natural Resources (now The Department of Planning).

The ultimate aim of the assessment is to assist land use planners in determining appropriate buffer zones around a compound containing up to six gas wells.

The report assesses the risks from the operating gas well from its initial production and onwards, including:

- Normal operation; and
- Maintenance and Workover (post fracturing and clean up).

The risk associated with domino effects from one gas well initiating an incident at another gas well in the same compound was investigated.

The risks associated with the drilling or casing of wells, or bringing them into production (including fracture stimulation and initial Workover), are not included in the present scope of study (i.e. as per normal risk assessment methodology).

Two stages of operation of the CSM well surface location were investigated:

- Early/ intermediate operation (corresponding to high pressure);
- Established operation (corresponding to lower pressures).

E2 Results

CSM is a flammable gas held under pressure. The main risk associated with CSM wells is related to the acute risk of human injury or fatality resulting from the flammable hazards associated with the material.

The acute risk is best represented as *risk transects*, showing the risk as a function of the distance away from the perimeter fence of the well compound. This risk transect would be approximately equal in all directions, and the distance to a particular risk level is the radius of a circle with the CSM well compound at the centre.

The risk at a particular location can be compared with relevant risk criteria used in land use planning in NSW and set by the Department of Planning. Separation distances for various types of land use can be derived by setting the separation distance equal to the radius of the relevant risk contour.

The table below summarises the extent of the separation distances, measured from the edge of the compound, to a number of different land uses during early / intermediate operation of the CSM gas well compound and after a couple of years of operation (during established operation of the compound).

Minimum Distance to Satisfy Risk Criteria[1]				
Gas Well Operation (6 well compound)	**Active open space (10 pmpy)**	**Business (5 pmpy)**	**Residential development (1 pmpy)**	**Sensitive development (0.5 pmpy)**
Early / intermediate operation	20 metres	20 metres	20 metres	20 metres
Established operation	10 metres	10 metres	15 metres	20 metres

The environmental pollution caused by a release of the gas processed and handled in the gas wells under study is considered negligible. Further, combustion products of the gas are water, carbon dioxide and carbon

[1] The minimum distances are measured from the boundary of the compound. The minimum distances have conservatively been rounded up to the nearest 5, i.e. a calculated distance of 11, 12, 13, 14 or 15 metres would all be listed as of minimum distance to safety criteria of 15 metres.

monoxide, and there is minimal environmental damage potential from the burning of gas in air. The risk of damage to the natural environment associated with the proposed facilities after initial start-up is therefore negligible.

The gas processed and handled is a simple asphyxiant and has no toxic properties. Operational hazards associated with any confined space entry by personnel during operation or maintenance of a well are minimal due to the mostly open layout of the facility and the lighter-than-air nature of the CSM. Such hazards are best handled through the use of permit to work or other safety management system which form part of management practices at AGL, and are outside the scope of the present risk assessment.

GLOSSARY

BOP	Blow out Preventer
CSM	Coal Seam Methane
CO_2	Carbon dioxide
KPa	Kilopascals
LFL	Lower Flammable Limit
MJ	Mega Joules
MSDS	Material Safety Data Sheet
NDT	Non Destructive Testing
ppm	parts per million
pmpy	Per million per year
PPE	Personal Protective Equipment
PRV	Pressure Relief Valve
psi (g)	Pounds per square inch (gage)
QRA	Quantitative Risk Assessment

Nomenclature for Appendix 2

Lable	Explanation
A	Area of hole, m^2
C_p	Average heat capacity, kJ/kg.K
f	Fraction of heat radiated
H_c	Heat of combustion, kJ/kg
H_v	Heat of vaporisation, kJ/kg
I	Radiant heat intensity kW/m^2
M	Molecular weight
m	Mass, kg
m_v	Mass of vapour (in cloud), kg
m_{TNT}	Equivalent mass of TNT, kg
m	Mass flow rate of leak, kg/s
P	Pressure, Pa
P_1	Upstream absolute pressure, Pa
Q	Heat release rate, kW
R	Universal gas constant, 8.314 kJ.K/kmol
r	Distance from fire/explosion, m
T	Temperature, K
T_1	Storage temperature, K
T_b	Boiling point, K
t	Duration of leak/time, seconds
z	Gas compressibility factor
α	Explosion efficiency factor
γ	Ratio of specific heats (~1.4)
Δ	Differential sign
λ	Scaled distance
ρ	Density, kg/m^3
τ	Atmospheric transmissivity

REPORT

1 INTRODUCTION

1.1 BACKGROUND

AGL is the operator of the Camden Gas Project Joint Venture (CGPJV) between Sydney Gas (Camden) Operations Pty Ltd (Sydney Gas) and AGL. The Camden Gas Project is a major CSM project involving extraction of gas located within the Southern Coalfield of the Sydney Basin. It forms part of Petroleum Exploration Licence 2 (PEL 2), which covers land extending from Newcastle to Wollongong. The Project currently consists of around 80 wells in Petroleum Production Leases (PPLs) 1, 2, 4 and 5, gas gathering lines, access roads and the Rosalind Park Gas Plant.

In conjunction with the development of Stage 2, a Quantitative Risk Assessment (QRA) was prepared for the CSM wells by (Planager 2002, Ref 1) to determine the risk associated with a set of eight different well configurations, each with one well head within one compound.

Subsequent to this risk assessment, the Department of Planning (then the Department of Infrastructure, Planning and Natural Resources) prepared *Locational Guidelines - Development in Vicinity of Operating Coal Seam Methane Wells* (May 2004, Ref 2) to provide advice to consent authorities across NSW in assessing proposals for development in the vicinity of existing and future operating CSM wells.

Both the QRA and the Locational Guidelines assess the risk associated with single CSM wells located at a distance of several hundred metres away from another CSM well. As such, the interaction from one well to another can be disregarded.

With directional and surface to inseam (SIS) drilling techniques, the bottom hole of a well can be located away from it's surface location. As a result, multiple wells (up to six) can be drilled from a single surface location, to access gas reserves that are restricted or inaccessible by surface developments.

AGL has identified a need to assess the risk associated with a configuration of CSM producing wells where up to six wells are located within a single compound.

1.2 SCOPE AND AIM OF STUDY

Planager Pty Ltd has been commissioned by AGL to prepare a QRA to assess the risk associated with a six CSM well configuration contained within a single compound.

The assessment has been carried as per the Hazardous Industry Planning Advisory Paper (HIPAP) 6 - *Guidelines for Hazard Analysis* (Ref 3) and in accordance with HIPAP 4 - *Risk Criteria for Land Use Planning* (Ref 4).

1.2.1 Facility and Operations Included in the Study

The report assesses the risks from the six operating CSM wells located within a single compound, from their initial production and onwards, including:

- Normal operation; and
- Maintenance and Workover (post fracturing and clean up).

As per the 2002 QRA (Ref 1) and the Department's Locational Guidelines (Ref 2), the risks associated with the drilling or casing of wells, or bringing them into production (including fracturing and initial Workover operations) are not included in the present scope of study.

Likewise, risk associated with drilling is not included in the scope of study. This is as per normal risk assessment methodology for new plant where the assessment focuses on the operating plant without quantitatively assessing the risk of construction and commissioning.

The risks associated with transport of the gas to the gas plant; gas treatment; and compression and transport to the gas network form part of separate risk assessments (McCracken Consulting 2000, Ref 5 and Planager 2002, Ref 6) and are not re-assessed here.

Risks associated with manual handling operations or with the movement of heavy machinery, equipment or heavy vehicles do not form part of the scope of this study.

1.2.2 Types of Risks Reviewed

Consistent with the requirements of the guidelines for QRA in use by the Department (Ref 3) the following types of risks from a flammable event involving release and subsequent ignition of CSM considered in this QRA are:

- Risk of human injury or fatality; and
- Risk of propagation to neighbouring industrial installations / facilities.

The environmental pollution caused by a release of the gas processed and handled in the gas wells under study is considered negligible. Further, combustion products of the gas are water, carbon dioxide and carbon monoxide, and there is minimal environmental damage potential from the burning of gas in air. The risk of damage to the natural environment associated with the proposed facilities after initial start-up is therefore negligible and will not be discussed further in this assessment.

The gas processed and handled is a simple asphyxiant with no toxic properties and as such would not pose any threat of toxicity to the public. The hazards to operating or maintenance personnel associated with any confined space entry are minimal due to the mostly open layout of the facility and the lighter-than-air nature of the CSM. Such hazards are best handled through the use of permit to work or other safety management system which form part of management practices at AGL, and are outside the scope of the present risk assessment because there is no toxic risk to the public.

Hence, the risk associated with proposed facilities is restricted to the acute risk of human injury or fatality resulting from the fire and explosion hazards associated with the flammable material.

1.3 LEGISLATIVE CONTEXT FOR THIS QRA

1.3.1 Applying SEPP 33 – Hazardous and Offensive Development Application Guidelines

The document, *Applying SEPP 33 – Hazardous and Offensive Development Application Guidelines* was prepared by the Department of Infrastructure, Planning and Natural Resources (now the Department of Planning) in 1994 to provide assistance primarily to councils (but also to industry, consultants and other government agencies) in implementing State Environmental Planning Policy 33 (SEPP 33). The Guidelines recommend a 'risk screening' method for determining whether a proposal is hazardous and provide guidance on assessing potentially offensive development proposals. The screening process considers the class and volume of materials to be stored on the site and the distance of the storage area to the nearest site boundary.

The guidelines state that the first step to determining whether SEPP 33 applies to a proposal is to consider whether the proposed use falls within the definition of *industry* adopted by the planning instrument which applies. The proposed expansion of Stage 2 of the Camden Gas Project does not fall within the definition of 'industry' under the relevant environmental planning instruments, therefore the provisions of SEPP 33 do not strictly apply.

However, in order to comprehensively address the issue of hazard and risk in relation to the proposal, a detailed quantitative risk assessment has been prepared in respect of the proposed development. It should be noted that this does not imply that the development falls under the definition of *potentially hazardous industry* under SEPP 33. Rather, it demonstrates AGL's desire to ensure that any risks in relation to the proposal are addressed as part of the environmental assessment process.

1.3.2 Director General's Requirements under Part 3A

An Environmental Assessment is being prepared on behalf of AGL to support an application for approval to drill, test and operate coal seam methane (CSM) gas wells at Spring Farm and Menangle Park under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Director General's Requirements (DGRs) for the Environmental Assessment has not required this QRA, however, a risk assessment of the construction and operation of the proposal is listed as one of the issues to be considered in the impact assessment. The results of the risk assessment will be provided in the Environmental Assessment.

1.3.3 Locational Guidelines for CSM Wells and Their Use in Land Use Planning

The Locational Guidelines for CSM Wells were prepared by the Department in 2002 (Ref 2). The guidelines describe the use of separation distances to ensure an appropriate buffer between a development and an existing or future operating CSM well and its associated equipment. Separation distances result in circular areas around the existing and future operating CSM wells, within which controls should apply to development.

The guidelines determine the separation distances between single gas well installations and Residential Use and between singe gas well installation and Sensitive Use (for further explanation, refer to Table 2 below).

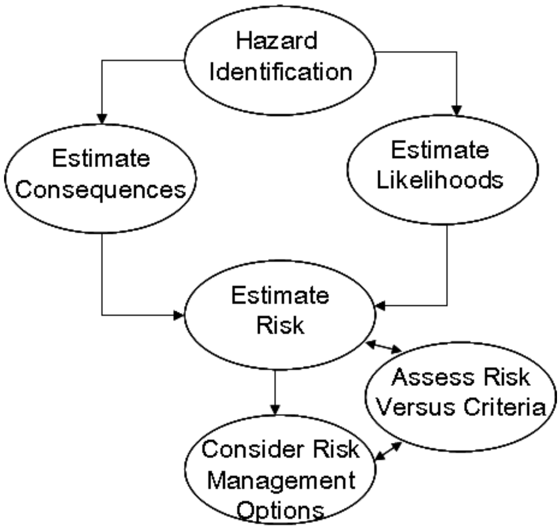
The configuration of the gas well, its operating pressure and the associated technical and operational controls were clearly defined in the guidelines. Separation distances were developed for three types of gas wells and for two different operating pressures[2].

1.4 METHODOLOGY

The methodology for the QRA is well established in Australia. The assessment follows the risk assessment guidelines set out in HIPAP 6 and compares the calculated risk results with criteria established in NSW as per HIPAP 4 (Refs 3 and 4). An outline of the process is conceptually depicted in Figure 1 below.

[2] The operating pressure reduces with time. *Established wells* are typically more than 2 years and *Early/Intermediate Operation Wells* are typically up to 2 years.

Figure 1 – Risk Analysis Process



As per standard risk assessment methodologies, the hazard identification stage involved a systematic consideration of the possible initiation, development and consequences, as well as any mitigating factors. Consequence calculations were carried out on each of the significant incidents determined. Calculations were performed using well established and recognised correlations between outflow rates, consequences of CSM if ignited and the effect on people if exposed to a flammable event. Frequency estimations involved consideration of historical accident and equipment failure rate data from a number of recognised sources. Risk assessment was then performed by combining the consequences with the likelihood for each incident investigated.

As indicated in Section 1.2.2 above, the types of incidents which are of concern for CSM installations are those involving a flammable event. In order for these events to occur, there are two requirements, namely loss of containment of CSM and ignition.

The cause of a CSM release may be equipment failure and maloperation. Initiating release scenarios include:

- Leaks during routine operation from fixed piping, valves, or separator vessel due to equipment failure or mechanical damage; and
- Leaks during equipment maintenance or workover operations.

Further, as more than one CSM well is located within the same compound in the configuration considered, an incident at one well may result in damage to another well, thus initiating a loss of containment and subsequent flammable event from the second well, and so forth. This is commonly referred to as *domino incident* or *domino effect.* Therefore, for the present QRA, another type of initiating release scenario needs investigating, namely:

- Leaks due to a domino effect from one CSM well to another.

The following credible outcomes could be expected, depending on the circumstances of the release:

- Jet fires: these result from the ignition of a (semi-)continuous release of CSM producing a long, stable, high temperature flame; and
- Flash fires: these occur when a cloud of CSM vapour is ignited, resulting in a flame travelling through the cloud.

With regard to the Locational Guidelines, vapour explosions were not considered a credible outcome from a loss of containment from a CSM well. This approach is maintained also in this report. Well head design is not finalised as yet. However, well design must minimise the risk of confinement and subsequent ignition of a release of natural gas, also in the case of an enclosed well (refer to photograph 2 of Fig 4.7 of the Environmental Assessment, Ref 7).

The effect on people who may be exposed to a flammable event depends on the duration of exposure and their distance away from the fire. Flash fires are, by their nature, extremely powerful over a very short time duration. Jet fires are less powerful but their effect may last over a much longer time period.

The convention used in calculating effect on people from jet fires and flash fires are detailed in Table 1 below.

Table 1 – Effects and Impact of Jet and Flash Fires

Event and Impact	Criterion
Jet fire - fatality	The probability of fatality from exposure to a jet fire is based on probit calculation Y = -14.9 + 2.56 x ln(Q x $t^{1.33}$) with Q being the heat radiation at the target (kW/m_2) and t the duration of exposure to the jet fire (in minutes).
Flash fire - fatality	The probability of fatality from exposure to a flash fire is based on 100% of people within a vapour cloud concentration greater than 0.5 times the lower flammable limit LFL.

Only jet fires are credible initiators of domino effects as flash fires are of too short duration to cause serious effect on steel structures of the design proposed for the CSM well.

The consequence distances of some incident scenarios extend beyond the CSM well compound. However, after the likelihood of occurrence has been taken into account, they may not contribute significantly to the cumulative individual risk of fatality at that location.

Three factors are considered when determining the likelihood of the consequences resulting from the identified failure cases:

- The basic failure rate of each type of failure (for example the likelihood of a flange failure or of a particular hole size per meter of piping);
- The overall failure rate applicable to the case, taking into account the number of flanges, piping lengths and equipment configurations; and
- The probability of ignition of the released flammable gas, i.e. that a jet fire or a flash fire will occur.

The failure rate data and the ignition probabilities used in this study were those used in the Locational Guidelines. The failure rate data corresponds to the HSE *Offshore Hydrocarbon Release Statistics 2001, Offshore Technology Report* (Ref 8). The ignition probabilities are as per the note from the Department of Planning to Planager 10 March 2007 (Ref 9).

The calculated risk results were compared with the relevant risk criteria from HIPAP 4 (Ref 3) as summarised in below.

Table 2 – Selected Individual Fatality Risk Criteria

Land Use	Suggested Criteria (pmpy)
Sensitive development (hospitals, schools, child-care facilities, old age housing)	0.5
Residential (and hotels, motels, tourist resorts)	1
Business (commercial developments including retail centres, offices and entertainment areas)	5
Active open space (including sporting complexes)	10

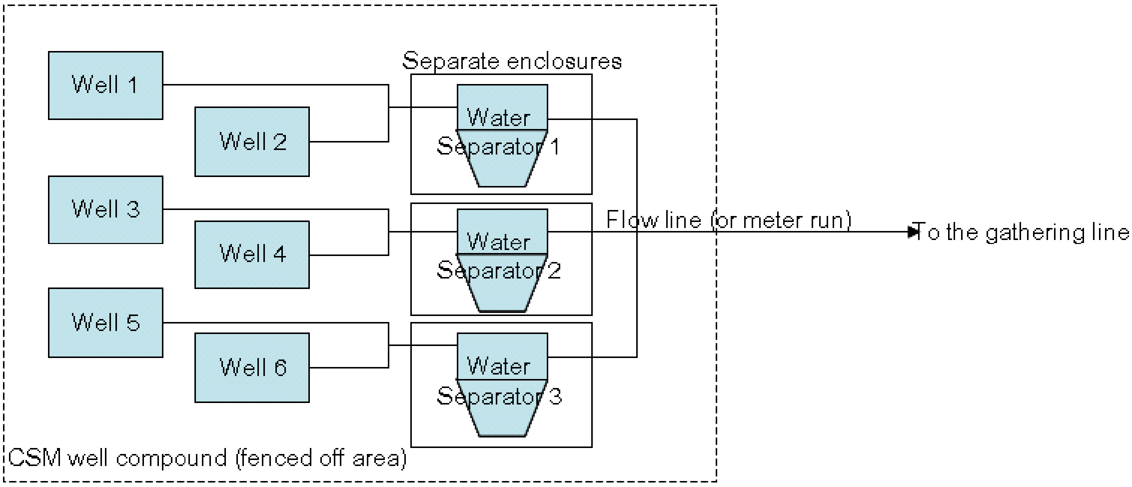
Appendix 1 details the configuration of the gas well design and the identified incident scenarios. Appendix 2 details the methodologies used and the results of the consequence assessment. Appendix 3 details the frequency and probability analysis used as input data for the risk assessment. Appendix 4 details the incidents identified, their consequences and their likelihood. The overall risk results are detailed in Section 4 below.

2 FACILITIES AND OPERATIONS

2.1 DESCRIPTION OF EQUIPMENT ARRANGEMENT

The design evaluated in the present study consists of six CSM wells located within one compound. Two wells would share one water separator so there would be three separators in each compound. The compound would be fenced in for security reasons with the dimensions of the fenced in area corresponding to or exceeding the area defined by Hazardous Area Zoning requirements. Each separator would be located within a separate enclosure. A schematic of the configuration of the compound is presented in Figure 2 below.

Figure 2 – CSM Well Configuration With Six Wells



The surface equipment for each gas well includes:

- Wellhead collar which connects the well head casing and tubing to the well head manifold, complete with shut down valve, pressure control and a number of instrumented protective features (detailed in Table 5 and Table 6 below).
- Separator (with pressure relief) used to separate water from incoming gas. The separator is connected to a water tank to collect the separated water.
- Flow line inlet piping (or *meter run*) - connects the water separator with the gathering line, complete with pressure control, non return valve and instrumented protective features (detailed in Table 5 and Table 6 below).
- Fenced off area and enclosure - Acts as a safety and operational barrier.

A detailed piping and instrument diagram of the CSM well is presented in Appendix 1. Information relating to the piping associated with the well is shown in Table 3 below.

Table 3 – Pipelines and Equipment

Piping	Nominal Length	Internal diameter	Features	Number of flanges
Gas line from well head within casing	0.9 m	5 ½" (140 mm)	-	0
Casing at well head	0.1 m	5 ½" (140 mm)	-	0
Gas line from well head to shutdown valve	1 m	1.94" (50 mm)	Pressure transmitter communicating to the Shutdown valve during operation and BOP during Workover	5
Line from the shut down valve to the water separator	1.5 m	1.94" (50 mm)	Manual choke (pressure control)	5
Line from the separator to the flow line	5 m	1.94" (50 mm)	Gas meter, Level switches (high and Low) Pressure switch (high and low) and flow switch (high and low).	11

2.2 DESCRIPTION OF OPERATIONS

2.2.1 Operation and Maintenance

CSM well production yield depends on the thickness of the coal seam(s) intersected, their permeability (or the ability for the gas to flow), the depth of the coal seam and the purity of the gas. Once CSM well production is established, the gas is allowed to flow from the well through the well head piping into underground gathering lines (low pressure pipe) to the gas plant.

At this point any excess water is removed, the quality of the gas is regulated and the gas is compressed. CSM in the Camden area, containing over 95% methane, is considered very pure and generally requires less processing than conventional natural gas.

General inspection and maintenance activities form part of the ongoing operation of the well, and are designed to maintain the integrity of the equipment and systems. These include:

- Visual inspections of each well (at least three-weekly);
- Regular leak testing (soap testing, 6-monthly or more often depending on the location of the well in relation to urban development);
- Regular inspection of the separator, fittings and pressure piping and regular testing of pressure safety valves, as per regulatory requirement AS3788-2001, Pressure Equipment Inservice Inspection.

In addition, field operating personnel will visit the well regularly, to monitor equipment operation, record gas flow rates and pressures.

2.2.2 Workover Operation

Throughout the operation of the well, a work-over rig may at times be required to perform a variety of downhole functions such as washing of the production casing to the total depth of the casing to circulate sand or debris from the well. These *post frac workover operations* are achieved by running small bore tubing from the workover rig into the production casing. A high pressure pump is then used to circulate water down the tubing to remove debris or sand from the well.

Although the frequency of the workover operations is very low they are potentially hazardous and require close attention. For the purposes of this risk assessment, the frequency of workover operations is set as one per year (in line with the Department's Locational Guidelines).

2.2.3 Well Isolation

The wells are occasionally isolated, for example during shut down of the gas plant. When isolated, the shut down valve on the well head piping is closed, allowing the pressure in the well to rise. In line with the Departments guidelines, the wells are assumed to be isolated (shut-in) for 10 days each year.

2.3 OPERATING CONDITIONS

In general, the maximum pressure associated with CSM wells reduce over the first two years of a well's operating life. As per the Department's Guidelines, two sets of operating pressures have been assessed as part of this QRA (as shown in Table 4 below) corresponding to two stages of CSM well operation.

Table 4 – Well and Operating Stage

Well and Operating Stage	Absolute Pressure (kPa)
Early/ intermediate operation	
• Free flowing well, up to variable choke (early operation)	830 kPa
• Shut-in well (early operation)	3790 kPa
Established operation (typically after 2 years)	
• Free flowing well, up to variable choke	<=414 kPa
• Shut-in well (established well – typically after 2 years	1038 kPa

2.4 TECHNICAL CONTROLS

From previous operating experience, CSM well pressure may fluctuate and therefore control of overpressure is required through the use of a number of independent mechanisms, as described in Table 5 below.

Table 5 – CSM Well Overpressure Control Mechanisms

Type of control	Equipment	Overpressure control
Pressure monitoring and control	Complete facility from well head to meter run	Pressure transmitters transmit pressure information (and alarm conditions) from the wells to the SCADA control room at the gas plant (which is monitored 24hr/7 days). Ability to shut down the well from remote location. Variable choke acts as pressure control valve to limit the maximum flow from the well.

Type of control	Equipment	Overpressure control
Pressure rating of equipment	Well head casing and tubing	Schedule 80. Pressure rated to 27MPa and 53MPa respectively, or more than 30 times higher than operating pressure for a new well or more than 7 times the shut-in pressure of a new well.
	Well head and well head manifold	Schedule 80. Pressure rated to 13MPa, or more than 15 times higher than operating pressure for a new well or 3 times the shut-in pressure of a new well.
	Water separator and piping connecting to the meter run (*flow line inlet piping*).	Schedule 80. Pressure rated to 850kPa, or about 2 times the operating pressure.
Instrumented protective features	Casing, tubing, well head and well head manifold; and Water separator and piping connecting to the meter run.	Pressure switch high would initiate emergency shut down (ESD), including shut in the well head upstream of the automatic shut down valve and alarming in the control room.
Pressure relief	From well head to meter run (or, if shut-down valve closed, from shutdown valve to meter run)	Pressure relief on the water separator in the form of a Pressure Safety Valve (PSV), set to open at 500 kPa and designed to relieve the total overpressure of the system. The vent line is vertical and at least 2m above the top of the enclosure or 3m above ground level or any platform on which a person can stand, whichever is the higher. The PSV will reseat after relieving excess pressure. A Blow-Out Preventer (BOP) is fitted to each well head, protecting the well during workover operations.

Technical risk management features that would protect in case of CSM leak or fire are shown in Table 6 below.

Table 6 – Leak and Fire Protection

Type of control	Equipment	Overpressure control
Instrumented protective features	Well head facility	Flow switch low (if the leak is upstream of the sensor) and flow switch high (if it is downstream) would initiate emergency shut down (ESD), including shutting in the well head upstream of the automatic shut down valve and alarming in the control room.
Fire detection	Well head facility	Fusible loop in the form of black poly-piping, looped around high risk areas and linked to the shut down valve. In case of a fire, the poly-pipe would burn through and initiate ESD.

3 RESULTS

Individual risk is a measure of the likelihood of a given outcome at a particular location. In this case, the *individual risk of fatality* has been calculated.

The risk associated with the six well head compound is best represented as *risk transects*, showing the risk as a function of the distance away from the perimeter fence of the well compound. This risk transect would be approximately equal in all directions, and the distance to a particular risk level is the radius of a circle with the CSM well compound at the centre.

The risk transects for the compound containing six gas wells are shown in the following figures:

- Figure 3 shows the individual fatality transects for risk associated with the early to intermediate stages of operation of the six gas wells situated within one compound.
- Figure 4 shows the individual fatality transects for risk associated with the established operation of the six wells gas wells within one compound.

Figure 3 - Individual Fatality Risk Transect for Early/Intermediate Operation of Six-Well-Compound

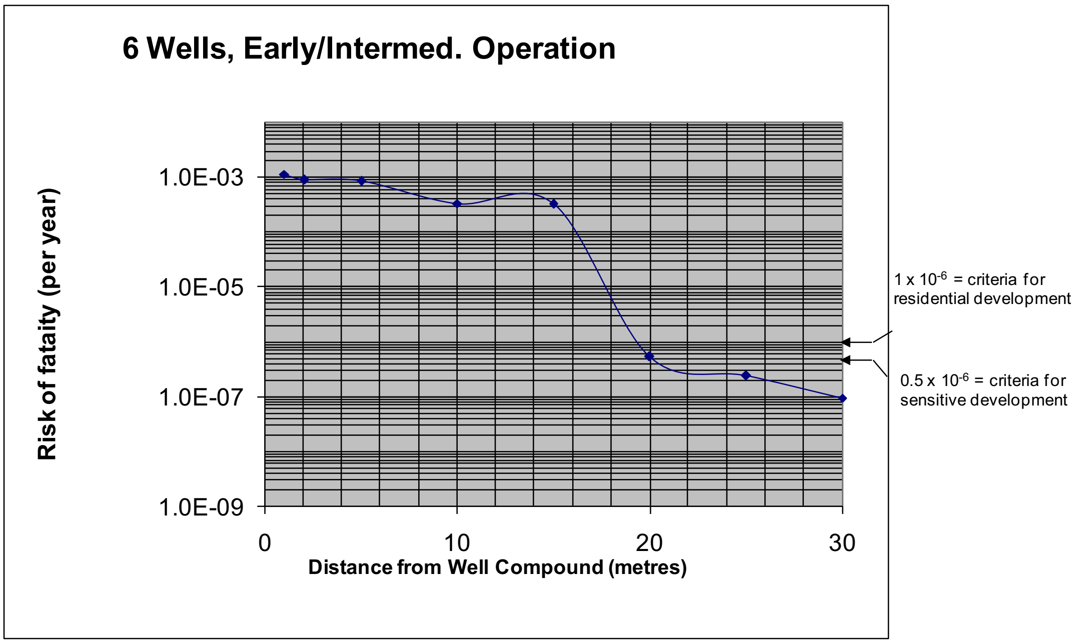
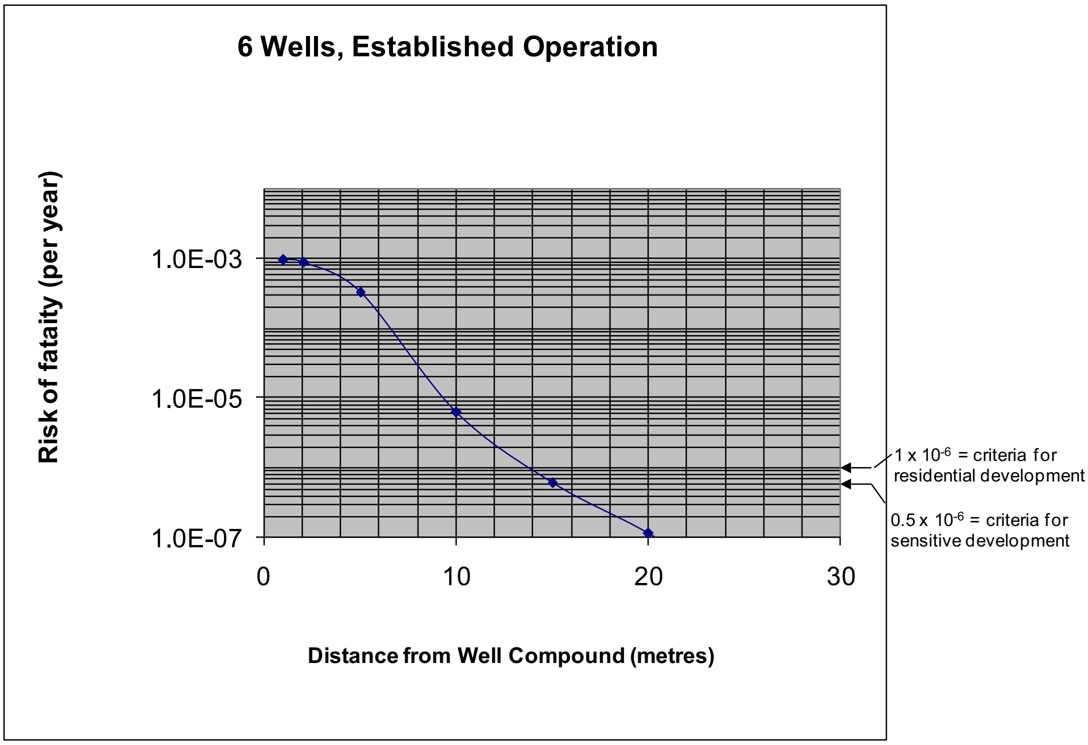


Figure 4 – Individual Fatality Risk Transect for Established Operation of Six-Well-Compound



4 CONCLUSION

The individual risk of fatality can be compared with relevant risk criteria from HIPAP 4 (Ref 3) as summarised in Table 2 above.

Separation distances for various types of land use can be derived by setting the separation distance equal to the radius of the relevant fatality risk contour, taking into account sensitivity issues, as shown in below.

Table 7 – Minimum Distance to Satisfy Landuse Criteria[3]

Gas Well Operation (6 well compound)	Minimum Distance (metres)			
	Active open space (10 pmpy)	Business (5 pmpy)	Residential development (1 pmpy)	Sensitive development (0.5 pmpy)
Early / intermediate operation	20 metres	20 metres	20 metres	20 metres
Established operation	10 metres	10 metres	15 metres	20 metres

3 The minimum distances are measured from the boundary of the compound. The minimum distances have conservatively been rounded up to the nearest 5, i.e. a calculated distance of 11, 12, 13, 14 or 15 metres would all be listed as of minimum distance to safety criteria of 15 metres.

5 RISK PERSPECTIVE

In order to put the risk criteria into perspective, published information on the level of risk to which each of us may be exposed from day to day due to a variety of activities has been shown in Table 8 below. Some of these are voluntary, for which we may accept a higher level of risk due to a perceived benefit, while some are involuntary. Generally, we tend to expect a lower level of imposed or involuntary risk especially if we do not perceive a direct benefit. The criteria have been chosen so as not to impose a risk which is significant when compared to the background risk we are already exposed to.

Table 8 – Risk to Individuals

Activity / Type of Risk	Published levels of risk (pmpy[4])
VOLUNTARY RISKS (AVERAGED OVER ACTIVE PARTICIPANTS)	
Smoking	5,000
Drinking alcohol	380
Swimming	50
Playing rugby	30
Travelling by car	145
Travelling by train	30
Travelling by aeroplane	10
INVOLUNTARY RISKS (AVERAGED OVER WHOLE POPULATION)	
Cancer	1,800
Accidents at home	110
Struck by motor vehicle	35
Fires	10
Electrocution (non industrial)	3
Falling objects	3
Storms and floods	0.2
Lightning strikes	0.1

[4] pmpy = per million per year

The level of risk associated with the proposed well configuration which is considered “tolerable” for residential housing is three times lower than the risk of being killed by a falling object or being electrocuted in an non industrial environment, and is about ten times lower than the risk of being killed in an aeroplane accident in Australia (or 145 times lower than being killed while travelling in a car).

Note also that in the QRA methodology used in NSW a person is assumed to be at their residence 100% of the time (day and night, day in and day out) throughout the year. As this is rarely the case the risk imposed on the person from a potentially hazardous installation is in fact lower than that calculated in the QRA.

6 RECOMMENDATIONS

To further reduce the risk associated with the proposed gas wells, the following recommendations have been identified:

Recommendation 1: Ensure that the Hazardous Area zone (as defined in the Australian Standard for electrical zoning in potentially flammable areas) of the well compound does not extend beyond perimeter fence. Fenced-off area to at least exceed the hazardous zone.

Recommendation 2: Determine any need to expand on the stated separation distances due to other types of risks not part of the scope of the present risk assessment (e.g. due to risk associated with manual handling / maintenance activities).

Recommendation 3: Install bollards or other physical protection in high risk areas to protect the installation against damage from vehicles or other moving machinery.

Recommendation 4: Assess the practicality of extending the fusible link past the shut down valve, to incorporate the entire gas well installation in this protective system up to and including the meter run.

Recommendation 5: Investigate the possibility of shutting down all wells within one compound in case of initiation of the shut down valve from an identified emergency scenario (for example in case of a closure of the shut down valve due to a failure of the fusible link).

Recommendation 6: Minimise the pipe-length between the well head and the first shut down valve.

Recommendation 7: Minimise the number of connections used on the wells.

Recommendation 8: Investigate the use of flanges instead of screwed connections.

Recommendation 9: Final well design must minimise the risk of confinement and subsequent ignition of a release of natural gas, also in the case of an enclosed well.

Appendix 1

Concept Well Configuration

Quantitative Risk Assessment, Coal Seam Methane Production Wells for Up to Six Wellhead Configuration, AGL Gas Production (Camden) Pty Limited

A1.1 QRA Scenarios

QRA SCENARIOS EARLY OPERATION

EQUIPMENT	LENGTH	#JOINTS	LEAK FREQ.	HORIZ. JET	FLASH FREQ.	GAS PRES.	DIAM ORIF.	OUTFLOW	CLOUD (KG)
	meters		1/yr	1/yr	1/yr	kPa	m	kg/s	
Casing at well head	0.1	0	2.04E-06	1.53E-08	1.63E-09	6.90E+05	0.115	1.24E+01	2.23E+03
Casing at well head	0.1	0	1.48E-06	1.11E-08	1.18E-09	6.90E+05	0.025	5.85E-01	1.05E+02
Casing at well head	0.1	0	2.59E-06	1.94E-08	2.07E-09	6.90E+05	0.013	1.58E-01	2.85E+01
Casing at well head	0.1	0	1.41E-05	1.05E-07	1.12E-08	6.90E+05	0.003	8.42E-03	1.52E+00
Casing at well head	0.1	0	0.00E+00	0.00E+00	0.00E+00	6.90E+05	0.006	5.85E-01	1.05E+02
Gas line from well head within casing	0.9	0	1.83E-05	1.37E-07	1.47E-08	6.90E+05	0.058	1.24E+01	2.23E+03
Gas line from well head within casing	0.9	0	1.33E-05	9.99E-08	1.07E-08	6.90E+05	0.025	5.85E-01	1.05E+02
Gas line from well head within casing	0.9	0	2.33E-05	1.75E-07	1.86E-08	6.90E+05	0.013	4.24E-01	7.63E+01
Gas line from well head within casing	0.9	0	1.27E-04	9.49E-07	1.01E-07	6.90E+05	0.003	8.42E-03	1.52E+00
Gas line from well head within casing	0.9	0	0.00E+00	0.00E+00	0.00E+00	6.90E+05	0.006	5.85E-01	1.05E+02
Gas line from well head to shutdown valve	1	5	2.04E-05	1.53E-07	1.63E-08	6.90E+05	0.058	1.24E+01	2.23E+03
Gas line from well head to shutdown valve	1	5	1.48E-05	1.11E-07	1.18E-08	6.90E+05	0.025	5.85E-01	1.05E+02
Gas line from well head to shutdown valve	1	5	2.59E-05	1.94E-07	2.07E-08	6.90E+05	0.013	3.97E-01	7.14E+01
Gas line from well head to shutdown valve	1	5	1.41E-04	1.05E-06	1.12E-07	6.90E+05	0.003	8.42E-03	1.52E+00
Gas line from well head to shutdown valve	1	5	6.37E-04	4.78E-06	5.10E-07	6.90E+05	0.006	5.85E-01	1.05E+02
Line from the shut down valve to the water separator	1.5	5	7.63E-08	2.84E-11	1.22E-09	5.00E+05	0.058	2.28E+00	4.11E+02
Line from the shut down valve to the water separator	1.5	5	5.56E-08	2.08E-11	8.89E-10	5.00E+05	0.025	4.24E-01	7.63E+01
Line from the shut down valve to the water separator	1.5	5	3.89E-05	1.46E-08	3.11E-08	5.00E+05	0.013	0.00E+00	0.00E+00
Line from the shut down valve to the water separator	1.5	5	2.11E-04	7.91E-08	3.37E-06	5.00E+05	0.003	6.10E-03	1.10E+00
Line from the shut down valve to the water separator	1.5	5	6.37E-04	2.39E-07	1.02E-05	5.00E+05	0.006	4.24E-01	7.63E+01
Line from the separator to the flow ine	5	11	2.54E-07	1.91E-09	4.07E-09	5.00E+05	0.058	2.28E+00	4.11E+02
Line from the separator to the flow ine	5	11	1.85E-07	1.39E-09	2.96E-09	5.00E+05	0.025	4.24E-01	7.63E+01
Line from the separator to the flow ine	5	5	1.30E-04	2.56E-09	1.04E-07	5.00E+05	0.013	0.00E+00	0.00E+00
Line from the separator to the flow ine	5	11	7.03E-04	5.27E-06	1.12E-05	5.00E+05	0.003	6.10E-03	1.10E+00
Line from the separator to the flow ine	5	11	1.40E-03	1.05E-05	2.24E-05	5.00E+05	0.006	4.24E-01	7.63E+01
Relief valve	0	11	4.16E-08	3.12E-10	6.66E-10	5.00E+05	0.058	2.28E+00	4.11E+02
Relief valve	0	11	4.16E-08	3.12E-10	6.66E-10	5.00E+05	0.025	4.24E-01	7.63E+01
Relief valve	0	11	1.52E-04	1.14E-06	2.43E-06	5.00E+05	0.003	6.10E-03	1.10E+00
Separator	0	0	3.75E-10	2.81E-12	6.00E-12	5.00E+05	0.050	2.28E+00	4.11E+02
Separator	0	0	3.75E-10	2.81E-12	6.00E-12	5.00E+05	0.023	4.24E-01	7.63E+01
Separator	0	0	6.00E-06	4.50E-08	9.60E-08	5.00E+05	0.011	1.15E-01	2.06E+01
Separator	0	0	2.40E-05	1.80E-07	3.84E-07	5.00E+05	0.003	7.07E-06	1.27E-03
Workover initiated incident	0	0	4.98E-07	3.74E-09	7.97E-09	6.90E+05	0.115	4.31E-02	7.76E+00
Shut in well head piping (incident during)	0.9	0	5.02E-07	1.56E-12	8.03E-09	1.73E+06	0.058	1.24E+01	2.23E+03
Shut in well head piping (incident during)	0.9	0	3.65E-07	1.14E-12	5.84E-09	1.73E+06	0.025	5.85E-01	1.05E+02
Shut in well head piping (incident during)	0.9	0	2.33E-05	3.43E-10	1.86E-08	1.73E+06	0.013	0.00E+00	0.00E+00
Shut in well head piping (incident during)	0.9	0	3.47E-06	1.08E-11	5.55E-08	1.73E+06	0.003	8.42E-03	1.52E+00
Shut in well head piping (incident during)	0.9	0	0.00E+00	0.00E+00	0.00E+00	1.73E+06	0.006	5.85E-01	1.05E+02
Shut in well head casing (incident during)	0.1	0	5.58E-08	1.74E-13	8.92E-10	1.73E+06	0.115	1.24E+01	2.23E+03
Shut in well head casing (incident during)	0.1	0	4.05E-08	1.26E-13	6.49E-10	1.73E+06	0.025	5.85E-01	1.05E+02
Shut in well head casing (incident during)	0.1	0	2.59E-06	5.13E-11	2.07E-09	1.73E+06	0.013	0.00E+00	0.00E+00
Shut in well head casing (incident during)	0.1	0	3.85E-07	1.20E-12	6.16E-09	1.73E+06	0.003	8.42E-03	1.52E+00
Shut in well head casing (incident during)	0.1	0	0.00E+00	0.00E+00	0.00E+00	1.73E+06	0.006	5.85E-01	1.05E+02

PLANAGER
Risk Management Consulting

QRA SCENARIOS ESTABLISHED OPERATION

EQUIPMENT	LENGTH	#JOINTS	LEAK FREQ.	HORIZ. JET	FLASH FREQ.	GAS PRES.	DIAM ORIF.	CROSS AREA	OUTFLOW
	meters		1/yr	1/yr	1/yr	kPa	m	m2	kg/s
Casing at well head	0.1	0	2.04E-06	1.53E-08	1.63E-09	2.75E+05	0.115	0.0104	7.4260
Casing at well head	0.1	0	1.48E-06	1.11E-08	1.18E-09	2.75E+05	0.025	0.0005	0.3509
Casing at well head	0.1	0	2.59E-06	1.94E-08	2.07E-09	2.75E+05	0.013	0.0001	0.0949
Casing at well head	0.1	0	1.41E-05	1.05E-07	1.12E-08	2.75E+05	0.003	0.0000	0.0051
Casing at well head	0.1	0	0.00E+00	0.00E+00	0.00E+00	2.75E+05	0.006	0.0000	0.3509
Gas line from well head within casing	0.9	0	1.83E-05	1.37E-07	1.47E-08	2.75E+05	0.058	0.0026	7.4260
Gas line from well head within casing	0.9	0	1.33E-05	9.99E-08	1.07E-08	2.75E+05	0.025	0.0005	0.3509
Gas line from well head within casing	0.9	0	2.33E-05	1.75E-07	1.86E-08	2.75E+05	0.013	0.0001	0.1272
Gas line from well head within casing	0.9	0	1.27E-04	9.49E-07	1.01E-07	2.75E+05	0.003	0.0000	0.0051
Gas line from well head within casing	0.9	0	0.00E+00	0.00E+00	0.00E+00	2.75E+05	0.006	0.0000	0.3509
Gas line from well head to shutdown valve	1	5	2.04E-05	1.53E-07	1.63E-08	2.75E+05	0.058	0.0026	7.4260
Gas line from well head to shutdown valve	1	5	1.48E-05	1.11E-07	1.18E-08	2.75E+05	0.025	0.0005	0.3509
Gas line from well head to shutdown valve	1	5	2.59E-05	1.94E-07	2.07E-08	2.75E+05	0.013	0.0001	0.2379
Gas line from well head to shutdown valve	1	5	1.41E-04	1.05E-06	1.12E-07	2.75E+05	0.003	0.0000	0.0051
Gas line from well head to shutdown valve	1	5	6.37E-04	4.78E-06	5.10E-07	2.75E+05	0.006	0.0000	0.3509
Line from the shut down valve to the water separator	1.5	5	7.63E-08	2.86E-11	1.22E-09	1.50E+05	0.058	0.0026	0.6844
Line from the shut down valve to the water separator	1.5	5	5.55E-08	2.08E-11	8.88E-10	1.50E+05	0.025	0.0005	0.1272
Line from the shut down valve to the water separator	1.5	5	3.89E-05	1.46E-08	3.11E-08	1.50E+05	0.013	0.0001	0.0000
Line from the shut down valve to the water separator	1.5	5	2.11E-04	7.91E-08	3.37E-06	1.50E+05	0.003	0.0000	0.0018
Line from the shut down valve to the water separator	1.5	5	6.37E-04	2.39E-07	1.02E-05	1.50E+05	0.006	0.0000	0.1272
Line from the separator to the flow ine	5	11	2.54E-07	1.91E-09	4.07E-09	1.50E+05	0.058	0.0026	0.6844
Line from the separator to the flow ine	5	11	1.85E-07	1.39E-09	2.96E-09	1.50E+05	0.025	0.0005	0.1272
Line from the separator to the flow ine	5	5	1.30E-04	2.56E-09	1.04E-07	1.50E+05	0.013	0.0001	0.0000
Line from the separator to the flow ine	5	11	7.03E-04	5.27E-06	1.12E-05	1.50E+05	0.003	0.0000	0.0018
Line from the separator to the flow ine	5	11	1.40E-03	1.05E-05	2.24E-05	1.50E+05	0.006	0.0000	0.1272
Relief valve	0	11	4.16E-08	3.12E-10	6.66E-10	1.50E+05	0.058	0.0026	0.6844
Relief valve	0	11	4.16E-08	3.12E-10	6.66E-10	1.50E+05	0.025	0.0005	0.1272
Relief valve	0	11	1.52E-04	1.14E-06	2.43E-06	1.50E+05	0.003	0.0000	0.0018
Separator	0	0	3.75E-10	2.81E-12	6.00E-12	1.50E+05	0.05	0.0020	0.6844
Separator	0	0	3.75E-10	2.81E-12	6.00E-12	1.50E+05	0.023	0.0004	0.1272
Separator	0	0	6.00E-06	4.50E-08	9.60E-08	1.50E+05	0.011	0.0001	0.0344
Separator	0	0	2.40E-05	1.80E-07	3.84E-07	1.50E+05	0.0025	0.0000	0.0000
Workover initiated incident	0	0	4.98E-07	3.74E-09	7.97E-09	2.75E+05	0.115	0.0104	0.0431
Shut in well head piping (incident during)	0.9	0	5.02E-07	1.56E-12	8.03E-09	1.04E+06	0.058	0.0026	7.4260
Shut in well head piping (incident during)	0.9	0	3.65E-07	1.14E-12	5.84E-09	1.04E+06	0.025	0.0005	0.3509
Shut in well head piping (incident during)	0.9	0	2.33E-05	3.43E-10	1.86E-08	1.04E+06	0.013	0.0001	0.0000
Shut in well head piping (incident during)	0.9	0	3.47E-06	1.08E-11	5.55E-08	1.04E+06	0.003	0.0000	0.0051
Shut in well head piping (incident during)	0.9	0	0.00E+00	0.00E+00	0.00E+00	1.04E+06	0.006	0.0000	0.3509
Shut in well head casing (incident during)	0.1	0	5.58E-08	1.74E-13	8.92E-10	1.04E+06	0.115	0.0104	7.4260
Shut in well head casing (incident during)	0.1	0	4.05E-08	1.26E-13	6.49E-10	1.04E+06	0.025	0.0005	0.3509
Shut in well head casing (incident during)	0.1	0	2.59E-06	5.13E-11	2.07E-09	1.04E+06	0.013	0.0001	0.0000
Shut in well head casing (incident during)	0.1	0	3.85E-07	1.20E-12	6.16E-09	1.04E+06	0.003	0.0000	0.0051
Shut in well head casing (incident during)	0.1	0	0.00E+00	0.00E+00	0.00E+00	1.04E+06	0.006	0.0000	0.3509

WELL HEAD CASING

5 1/2" 15.5#/FT K55 STC 8 RD R3 SNLS CASING
TO API 5 CT(BUL-5C2, BUL-5C3)
COLLAPSE PRESSURE 33,163 kPag
INTERNAL YIELD PRESSURE 27,854 kPag
MIN PARTING LOAD 95,710 Kg

WELL HEAD TUBING

2 3/8" 4.7#/FT J55 EUE 8 RD R2 SNLS TUBING
TO API 5 CT
COLLAPSE PRESSURE 55,819 kPag
INTERNAL YIELD PRESSURE 53,081 kPag

WELL HEAD

DESIGN PRESSURE : 13,240 kPag
DESIGN TEMPERATURE : -10°C TO 50°C
BALL VALVES : DESIGN – BS5351
RATING – ASME B16.34 CL800
FIRE – BS6755 (2)
API-607

WELL HEAD MANIFOLD

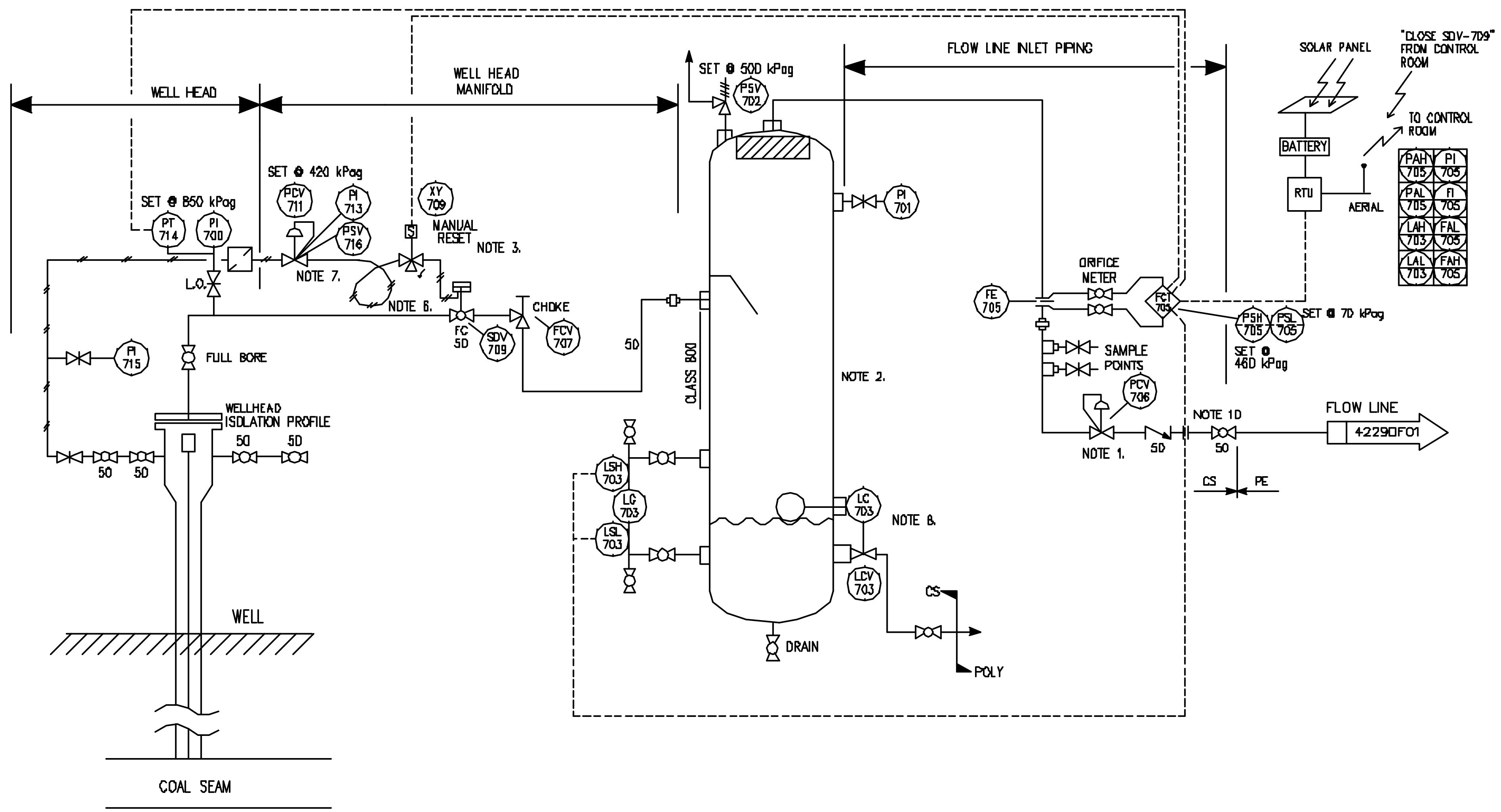
DESIGN PRESSURE : 13240 kPag
DESIGN TEMPERATURE : -10°C TO 50°C
BALL VALVES : DESIGN – BS5351
RATING – ASME B16.34 CL800
FIRE – BS6755 (2)
API-607

WELL HEAD SEPARATOR

DESIGN PRESSURE : 850 kPag
DESIGN TEMPERATURE : 50°C
DIAMETER : 400mm
TAN/TAN : 1520mm
AS1210 CLASS 3

FLOW LINE INLET PIPING

DESIGN PRESSURE : 850 kPag
DESIGN TEMPERATURE : 50°C
BALL VALVES : DESIGN – BS5351
RATING – ASME B16.34 CL150
FIRE – BS6755 (2)
API-607



NOTES:

1. MAXIMUM SET POINT 450 kPag
2. SEPARATOR MAYBE VERTICAL OR HORIZONTAL (DRAIN VALVE ONLY ON VERTICAL)
3. MANUAL RESET LOCATED ON LOCAL CONTROL PANEL AT THE WELLHEAD.
4. ALL PIPING TO BE SCHEDULE 80.
5. DELETED.
6. 1500mm LONG BLACK POLY FUSIBLE LINE FOR FIRE DETECTION.
7. INST. GAS REGULATOR PCV-711 INCLUDES PRESSURE GAUGE & RELIEF VALVE.
8. LIQUID LEVEL TO BE ESTABLISHED BEFORE COMISSIONING.
9. ALL PRESSURE INSTRUMENT TAPPING POINTS TO HAVE 3mm MAX. BORE.
10. THESE FLANGES (ANSI B16.5 CLASS150) TO BE EITHER SCREW-ON OR SOCKET WELD TYPE. IF SCREW-ON FLANGES ARE USED THEY MUST BE SEAL WELED.

CLIENT: SYDNEY GAS
ORDER No.
CLIENT DRG No.
CLIENT REVISION

DRG. No.	TITLE
REFERENCE DRG'S	

No.	DATE	REVISION DETAILS	BY	CHKD	APPD.
0	03/05/04	ISSUED FOR HAZOP 20/02/04	JP		
REVISION					

PROJECT 1

DWG TITLE: CAMDEN GAS PROJECT
WELL HEAD FACILITIES (NEW)
CATEGORY 2 FREE FLOWING
PIPING & INSTRUMENTATION DIAGRAM

SCALE: –
DRG. No. 42280F50
REV. 0

Appendix 2

Consequence Assessment

Quantitative Risk Assessment, Coal Seam Methane Production Wells for Up to Six Wellhead Configuration, AGL Gas Production (Camden) Pty Limited

Appendix 1 – Consequence Assessment

The leak rates from the postulated hole sizes were calculated using consequence modelling techniques. The consequence effects of each of the scenarios (flash fire, jet fire etc) were then analysed.

A2.1 Evaluation Techniques

A2.1.1 Leak Rates

For gas or vapour flows, the appropriate equation to calculate leak rates from a hole in process equipment or piping is:

$$\dot{m} = 0.8AP_1\sqrt{\frac{M\gamma}{zRT_1}\left(\sqrt{\frac{2}{\gamma+1}}\right)^{\frac{\gamma+1}{\gamma-1}}}$$

Note that this applies to the condition known as critical or choked flow, which applies when the internal pressure is more than double atmospheric pressure (approximately).

A2.1.2 Duration of Release

The duration of a leak will depend on the hardware systems available to isolate the source of the leak, the nature of the leak itself and the training, procedures and management of the facility.

The gas wells are designed with an automatic trip of the shut down valve, thus closing in the well and, provided the leak is downstream of the shut down valve, cutting off the gas leak. This trip is designed to act both on loss of pressure (which would indicate a major leak) and on a substantial change of flow rate (either loss of flow rate if the leak is upstream of the sensor, or an increase in the flow rate is the leak is downstream).

Provided the shut down valve is closed, the release of gas from a leak downstream of this valve would be minimal. Only in the case of a failure to close this valve would the release of gas continue over a substantial period of time. In this QRA, in cases where the automatic shut down has failed (with the appropriate probability of failure), the release of gas is assumed to be continuous.

A jet fire generated as an immediate ignition from such a release will continue over a long period of time. The mass of flammable vapour contained in a cloud, which could flash, is set as the total amount which would leak out in 3 minutes. This is a common assumption in risk assessments and is based on the assumption that a flammable cloud travelling in the direction of the wind will either encounter a source of ignition within this time[5] or would disperse to concentrations below the Lower Flammable Limit (LFL). In the case of a release of the buoyant CSM gas this is a particularly conservative assumption as the gas cloud would disperse before this time to below LFL.

A2.1.3 Radiation Effects – The Point Source Method

Radiation effects are evaluated using the point source method, which assumes that a fire is a point source of heat, located at the centre of the flame, and radiating a proportion of the heat of combustion. The radiation intensity at any distance is then determined according to the inverse square law, making allowance for the attenuating effect of atmospheric water vapour over significant distances (e.g. 100m or more).

$$I = \frac{Qf\tau}{4\pi r^2}$$

The rate of heat release, Q, is given by:

$$Q = \dot{m}H_c$$

A2.2 Impact Assessment

The above techniques allow the level of radiation resulting from fires to be determined at any distance from the source. The effect or impact of heat radiation on people is shown in Table 9.

Table 9 - Effects of Heat Radiation

Radiant Heat Level (kW/m^2)	Physical Effect (exact effect depends on exposure duration)
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds' exposure
12.6	Significant chance of fatality for extended exposure High chance of injury

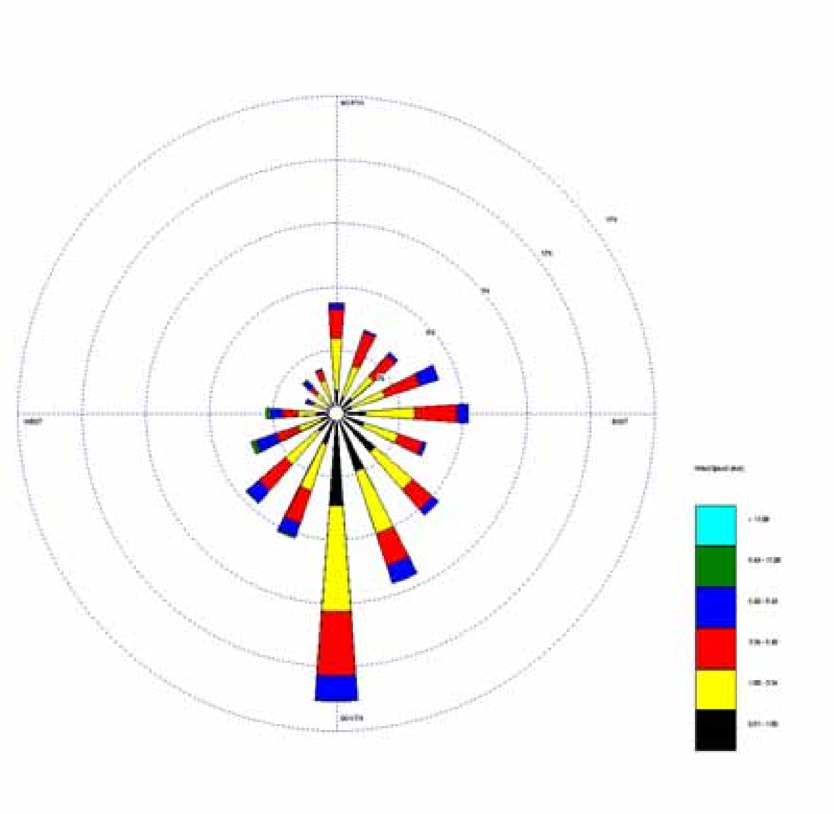
[5] In a relatively moderate wind force of say 4 m/s, the cloud would after 3 minutes have covered a distance of 240 metres.

Radiant Heat Level (kW/m^2)	Physical Effect (exact effect depends on exposure duration)
23	Likely fatality for extended exposure and chance of fatality for instantaneous (short) exposure
35	Significant chance of fatality for people exposed instantaneously

The probit equation Probit $Y = -14.9 + 2.56 \times \ln(Q \times t^{1.33})$, with Q being the heat radiation at the target (in kW/m^2) and t the duration of exposure (set as 60 seconds). In the case of flash fires, 100% fatality was assumed for anyone engulfed within the flaming cloud, and 0% probability outside it.

A2.3 Meteorological Data The meteorology of the well head site plays a role in determining the impacts of a release of gas. The prevailing winds are from the south over much of the year as shown in the annual wind rose in Figure A2.1 (Department of Meteorology for the Camden area).

Figure A2.1 – Annual Wind Speed and Direction



Calms are observed on 29% of the hours indicating very stable conditions in the region.

A2.4 Calculation Results

A2.4.1 Jet Fire Calculations, Early Operation

JET FIRE - POINT SOURCE METHOD

Assume :

Heat of combustion Hc=	50000 kJ/kg	*Probit Y = -A + B x ln(Q x t^n)*		**Length of jet**	
Radiation efficiency =	0.15	A	-14.9	*F. P. Lees*	$L = 6M^{0.5}$
Transmissivity =	1	B	2.56		(M = mass fl
Duration of exposure =	60 s	n	1.333		
Duration for total mass of vapour in cloud	180 s				

1 Mass burn rate = outflow rate

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame metres	Jet Fire: Distance to Heat Radiation (m) 4.7kW/m²	12.5kW/m²	23.5kW/m²	Probit value Y = -14.9 + 2. 4.7kW/m²	12.5kW/m²
3.00E-03	Up to pressure control valve	8.42E-03	6.32E+01	0.55	1.0	0.6	0.5	0.9	4.2
6.00E-03	Up to pressure control valve	3.37E-02	2.53E+02	1.10	2.1	1.3	0.9	0.9	4.2
1.30E-02	Up to pressure control valve	1.58E-01	1.19E+03	2.39	4.5	2.7	2.0	0.9	4.2
2.50E-02	Up to pressure control valve	5.85E-01	4.39E+03	4.59	8.6	5.3	3.9	0.9	4.2
5.80E-02	Up to pressure control valve	3.15E+00	2.36E+04	10.65	20.0	12.3	9.0	0.9	4.2
1.15E-01	Up to pressure control valve	1.24E+01	9.28E+04	21.11	39.7	24.3	17.9	0.9	4.2
3.00E-03	From the pressure control valve	6.10E-03	4.58E+01	0.47	0.9	0.5	0.4	0.9	4.2
6.00E-03	From the pressure control valve	2.44E-02	1.83E+02	0.94	1.8	1.1	0.8	0.9	4.2
1.30E-02	From the pressure control valve	1.15E-01	8.60E+02	2.03	3.8	2.3	1.7	0.9	4.2
2.50E-02	From the pressure control valve	4.24E-01	3.18E+03	3.91	7.3	4.5	3.3	0.9	4.2
5.80E-02	From the pressure control valve	2.28E+00	1.71E+04	9.06	17.0	10.4	7.7	0.9	4.2
3.00E-03	Shut-in well (after two years)	2.11E-02	1.58E+02	0.87	1.6	1.0	0.7	0.9	4.2
2.50E-02	Shut-in well (after two years)	1.47E+00	1.10E+04	7.27	13.6	8.4	6.2	0.9	4.2
5.80E-02	Shut-in well (after two years)	7.89E+00	5.92E+04	16.86	31.7	19.4	14.3	0.9	4.2

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame metres	Heat radiation (kW/m2) at Distance from Centre of F 1	2	5	10	15
3.00E-03	Up to pressure control valve	8.42E-03	6.32E+01	0.55	5	1	0	0	0
6.00E-03	Up to pressure control valve	3.37E-02	2.53E+02	1.10	20	5	1	0	0
1.30E-02	Up to pressure control valve	1.58E-01	1.19E+03	2.39	94	24	4	1	0
2.50E-02	Up to pressure control valve	5.85E-01	4.39E+03	4.59	349	87	14	3	2
5.80E-02	Up to pressure control valve	3.15E+00	2.36E+04	10.65	1880	470	75	19	8
1.15E-01	Up to pressure control valve	1.24E+01	9.28E+04	21.11	7390	1848	296	74	33
3.00E-03	From the pressure control valve	6.10E-03	4.58E+01	0.47	4	1	0	0	0
6.00E-03	From the pressure control valve	2.44E-02	1.83E+02	0.94	15	4	1	0	0
1.30E-02	From the pressure control valve	1.15E-01	8.60E+02	2.03	68	17	3	1	0
2.50E-02	From the pressure control valve	4.24E-01	3.18E+03	3.91	253	63	10	3	1
5.80E-02	From the pressure control valve	2.28E+00	1.71E+04	9.06	1362	341	54	14	6
3.00E-03	Shut-in well (after two years)	2.11E-02	1.58E+02	0.87	13	3	1	0	0
2.50E-02	Shut-in well (after two years)	1.47E+00	1.10E+04	7.27	876	219	35	9	4
5.80E-02	Shut-in well (after two years)	7.89E+00	5.92E+04	16.86	4713	1178	189	47	21

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame metres	Distance to this heat radiation from the source (in m				
					1	2	5	10	15
3.00E-03	Up to pressure control valve	8.42E-03	6.32E+01	0.55	1	2	5	10	15
6.00E-03	Up to pressure control valve	3.37E-02	2.53E+02	1.10	2	3	6	11	16
1.30E-02	Up to pressure control valve	1.58E-01	1.19E+03	2.39	2	3	6	11	16
2.50E-02	Up to pressure control valve	5.85E-01	4.39E+03	4.59	3	4	7	12	17
5.80E-02	Up to pressure control valve	3.15E+00	2.36E+04	10.65	6	7	10	15	20
1.15E-01	Up to pressure control valve	1.24E+01	9.28E+04	21.11	12	13	16	21	26
3.00E-03	From the pressure control valve	6.10E-03	4.58E+01	0.47	1	2	5	10	15
6.00E-03	From the pressure control valve	2.44E-02	1.83E+02	0.94	1	2	5	10	15
1.30E-02	From the pressure control valve	1.15E-01	8.60E+02	2.03	2	3	6	11	16
2.50E-02	From the pressure control valve	4.24E-01	3.18E+03	3.91	3	4	7	12	17
5.80E-02	From the pressure control valve	2.28E+00	1.71E+04	9.06	6	7	10	15	20
3.00E-03	Shut-in well (after two years)	2.11E-02	1.58E+02	0.87	1	2	5	10	15
2.50E-02	Shut-in well (after two years)	1.47E+00	1.10E+04	7.27	5	6	9	14	19
5.80E-02	Shut-in well (after two years)	7.89E+00	5.92E+04	16.86	9	10	13	18	23

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame metres	Probit				
					1	2	5	10	15
3.00E-03	Up to pressure control valve	8.42E-03	6.32E+01	0.55	1	-4	-10	-15	-17
6.00E-03	Up to pressure control valve	3.37E-02	2.53E+02	1.10	6	1	-5	-10	-13
1.30E-02	Up to pressure control valve	1.58E-01	1.19E+03	2.39	11	6	0	-5	-7
2.50E-02	Up to pressure control valve	5.85E-01	4.39E+03	4.59	16	11	5	0	-3
5.80E-02	Up to pressure control valve	3.15E+00	2.36E+04	10.65	21	17	10	6	3
1.15E-01	Up to pressure control valve	1.24E+01	9.28E+04	21.11	26	21	15	10	7
3.00E-03	From the pressure control valve	6.10E-03	4.58E+01	0.47	0	-5	-11	-16	-18
6.00E-03	From the pressure control valve	2.44E-02	1.83E+02	0.94	5	0	-6	-11	-14
1.30E-02	From the pressure control valve	1.15E-01	8.60E+02	2.03	10	5	-1	-6	-8
2.50E-02	From the pressure control valve	4.24E-01	3.18E+03	3.91	14	10	3	-1	-4
5.80E-02	From the pressure control valve	2.28E+00	1.71E+04	9.06	20	15	9	4	2
3.00E-03	Shut-in well (after two years)	2.11E-02	1.58E+02	0.87	4	-1	-7	-11	-14
2.50E-02	Shut-in well (after two years)	1.47E+00	1.10E+04	7.27	19	14	8	3	0
5.80E-02	Shut-in well (after two years)	7.89E+00	5.92E+04	16.86	24	20	13	9	6

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame	Probability of fatality				
3.00E-03	Up to pressure control valve	8.42E-03	6.32E+01	0.55	0.00	0.00	0.00	0.00	0.00
6.00E-03	Up to pressure control valve	3.37E-02	2.53E+02	1.10	0.85	0.00	0.00	0.00	0.00
1.30E-02	Up to pressure control valve	1.58E-01	1.19E+03	2.39	1.00	0.85	0.00	0.00	0.00
2.50E-02	Up to pressure control valve	5.85E-01	4.39E+03	4.59	1.00	1.00	0.50	0.00	0.00
5.80E-02	Up to pressure control valve	3.15E+00	2.36E+04	10.65	1.00	1.00	1.00	0.85	0.25
1.15E-01	Up to pressure control valve	1.24E+01	9.28E+04	21.11	1.00	1.00	1.00	1.00	0.60
3.00E-03	From the pressure control valve	6.10E-03	4.58E+01	0.47	0.00	0.00	0.00	0.00	0.00
6.00E-03	From the pressure control valve	2.44E-02	1.83E+02	0.94	0.50	0.00	0.00	0.00	0.00
1.30E-02	From the pressure control valve	1.15E-01	8.60E+02	2.03	1.00	0.50	0.00	0.00	0.00
2.50E-02	From the pressure control valve	4.24E-01	3.18E+03	3.91	1.00	1.00	0.25	0.00	0.00
5.80E-02	From the pressure control valve	2.28E+00	1.71E+04	9.06	1.00	1.00	1.00	0.30	0.10
3.00E-03	Shut-in well (after two years)	2.11E-02	1.58E+02	0.87	0.30	0.00	0.00	0.00	0.00
1.30E-02	Shut-in well (after two years)	1.15E-01	8.60E+02	2.03	1.00	1.00	1.00	0.30	0.10
2.50E-02	Shut-in well (after two years)	1.47E+00	1.10E+04	7.27	1.00	1.00	1.00	0.14	0.00
5.80E-02	Shut-in well (after two years)	7.89E+00	5.92E+04	16.86	1.00	1.00	1.00	1.00	0.85

A2.4.2 Jet Fire Calculations, Established Operation

JET FIRE - POINT SOURCE METHOD

Assume :

Heat of combustion Hc=	50000 kJ/kg	*Probit Y = -A + B x ln(Q x t^n)*		Length of jet		
Radiation efficiency =	0.15	A	-14.9	*F. P. Lees*	$L = 6M^{0.5}$	
Transmissivity =	1	B	2.56		(M = mass fl	
Duration of exposure =	60 s	n	1.333			
Duration for total mass of vapour in cloud	180 s					
1 Mass burn rate = outflow rate						

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame metres	Jet Fire: Distance to Heat Radiation (m) 4.7kW/m²	12.5kW/m²	23.5kW/m²	Probit value Y = -14.9 + 2. 4.7kW/m²	12.5kW/m²
3.00E-03	Up to pressure control valve	5.05E-03	3.79E+01	0.43	0.8	0.5	0.4	0.9	4.2
6.00E-03	Up to pressure control valve	2.02E-02	1.52E+02	0.85	1.6	1.0	0.7	0.9	4.2
1.30E-02	Up to pressure control valve	9.49E-02	7.12E+02	1.85	3.5	2.1	1.6	0.9	4.2
2.50E-02	Up to pressure control valve	3.51E-01	2.63E+03	3.55	6.7	4.1	3.0	0.9	4.2
5.80E-02	Up to pressure control valve	1.89E+00	1.42E+04	8.25	15.5	9.5	7.0	0.9	4.2
1.15E-01	Up to pressure control valve	7.43E+00	5.57E+04	16.35	30.7	18.8	13.9	0.9	4.2
3.00E-03	From the pressure control valve	1.83E-03	1.37E+01	0.26	0.5	0.3	0.2	0.9	4.2
6.00E-03	From the pressure control valve	7.32E-03	5.49E+01	0.51	1.0	0.6	0.4	0.9	4.2
1.30E-02	From the pressure control valve	3.44E-02	2.58E+02	1.11	2.1	1.3	0.9	0.9	4.2
2.50E-02	From the pressure control valve	1.27E-01	9.54E+02	2.14	4.0	2.5	1.8	0.9	4.2
5.80E-02	From the pressure control valve	6.84E-01	5.13E+03	4.96	9.3	5.7	4.2	0.9	4.2
3.00E-03	Shut-in well (after two years)	1.27E-02	9.50E+01	0.68	1.3	0.8	0.6	0.9	4.2
2.50E-02	Shut-in well (after two years)	8.80E-01	6.60E+03	5.63	10.6	6.5	4.8	0.9	4.2
5.80E-02	Shut-in well (after two years)	4.74E+00	3.55E+04	13.06	24.5	15.0	11.1	0.9	4.2

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame metres	Heat radiation (kW/m2) at Distance from Centre of F 1	2	5	10	15
3.00E-03	Up to pressure control valve	5.05E-03	3.79E+01	0.43	3	1	0	0	0
6.00E-03	Up to pressure control valve	2.02E-02	1.52E+02	0.85	12	3	0	0	0
1.30E-02	Up to pressure control valve	9.49E-02	7.12E+02	1.85	57	14	2	1	0
2.50E-02	Up to pressure control valve	3.51E-01	2.63E+03	3.55	210	52	8	2	1
5.80E-02	Up to pressure control valve	1.89E+00	1.42E+04	8.25	1128	282	45	11	5
1.15E-01	Up to pressure control valve	7.43E+00	5.57E+04	16.35	4434	1109	177	44	20
3.00E-03	From the pressure control valve	1.83E-03	1.37E+01	0.26	1	0	0	0	0
6.00E-03	From the pressure control valve	7.32E-03	5.49E+01	0.51	4	1	0	0	0
1.30E-02	From the pressure control valve	3.44E-02	2.58E+02	1.11	21	5	1	0	0
2.50E-02	From the pressure control valve	1.27E-01	9.54E+02	2.14	76	19	3	1	0
5.80E-02	From the pressure control valve	6.84E-01	5.13E+03	4.96	409	102	16	4	2
3.00E-03	Shut-in well (after two years)	1.27E-02	9.50E+01	0.68	8	2	0	0	0
2.50E-02	Shut-in well (after two years)	8.80E-01	6.60E+03	5.63	525	131	21	5	2
5.80E-02	Shut-in well (after two years)	4.74E+00	3.55E+04	13.06	2828	707	113	28	13

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame metres	Distance to this heat radiation from the source (in n 1	2	5	10	15
3.00E-03	Up to pressure control valve	5.05E-03	3.79E+01	0.43	1	2	5	10	15
6.00E-03	Up to pressure control valve	2.02E-02	1.52E+02	0.85	1	2	5	10	15
1.30E-02	Up to pressure control valve	9.49E-02	7.12E+02	1.85	2	3	6	11	16
2.50E-02	Up to pressure control valve	3.51E-01	2.63E+03	3.55	3	4	7	12	17
5.80E-02	Up to pressure control valve	1.89E+00	1.42E+04	8.25	5	6	9	14	19
1.15E-01	Up to pressure control valve	7.43E+00	5.57E+04	16.35	9	10	13	18	23
3.00E-03	From the pressure control valve	1.83E-03	1.37E+01	0.26	1	2	5	10	15
6.00E-03	From the pressure control valve	7.32E-03	5.49E+01	0.51	1	2	5	10	15
1.30E-02	From the pressure control valve	3.44E-02	2.58E+02	1.11	2	3	6	11	16
2.50E-02	From the pressure control valve	1.27E-01	9.54E+02	2.14	2	3	6	11	16
5.80E-02	From the pressure control valve	6.84E-01	5.13E+03	4.96	3	4	7	12	17
3.00E-03	Shut-in well (after two years)	1.27E-02	9.50E+01	0.68	1	2	5	10	15
2.50E-02	Shut-in well (after two years)	8.80E-01	6.60E+03	5.63	4	5	8	13	18
5.80E-02	Shut-in well (after two years)	4.74E+00	3.55E+04	13.06	8	9	12	17	22

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame metres	Probit 1	2	5	10	15
3.00E-03	Up to pressure control valve	5.05E-03	3.79E+01	0.43	-1	-5	-12	-16	-19
6.00E-03	Up to pressure control valve	2.02E-02	1.52E+02	0.85	4	-1	-7	-12	-14
1.30E-02	Up to pressure control valve	9.49E-02	7.12E+02	1.85	9	5	-2	-6	-9
2.50E-02	Up to pressure control valve	3.51E-01	2.63E+03	3.55	14	9	3	-2	-5
5.80E-02	Up to pressure control valve	1.89E+00	1.42E+04	8.25	20	15	9	4	1
1.15E-01	Up to pressure control valve	7.43E+00	5.57E+04	16.35	24	19	13	8	6
3.00E-03	From the pressure control valve	1.83E-03	1.37E+01	0.26	-4	-9	-15	-20	-23
6.00E-03	From the pressure control valve	7.32E-03	5.49E+01	0.51	1	-4	-10	-15	-18
1.30E-02	From the pressure control valve	3.44E-02	2.58E+02	1.11	6	1	-5	-10	-13
2.50E-02	From the pressure control valve	1.27E-01	9.54E+02	2.14	10	6	-1	-5	-8
5.80E-02	From the pressure control valve	6.84E-01	5.13E+03	4.96	16	11	5	0	-2
3.00E-03	Shut-in well (after two years)	1.27E-02	9.50E+01	0.68	2	-2	-8	-13	-16
2.50E-02	Shut-in well (after two years)	8.80E-01	6.60E+03	5.63	17	12	6	1	-2
5.80E-02	Shut-in well (after two years)	4.74E+00	3.55E+04	13.06	23	18	12	7	4

Leak size(mm)	Location	Burn rate (kg/s)	Heat rad (kW)	Length of jet flame	Probability of fatality				
3.00E-03	Up to pressure control valve	5.05E-03	3.79E+01	0.43	0.00	0.00	0.00	0.00	0.00
6.00E-03	Up to pressure control valve	2.02E-02	1.52E+02	0.85	0.10	0.00	0.00	0.00	0.00
1.30E-02	Up to pressure control valve	9.49E-02	7.12E+02	1.85	1.00	0.50	0.00	0.00	0.00
2.50E-02	Up to pressure control valve	3.51E-01	2.63E+03	3.55	1.00	1.00	0.02	0.00	0.00
5.80E-02	Up to pressure control valve	1.89E+00	1.42E+04	8.25	1.00	1.00	1.00	0.14	0.00
1.15E-01	Up to pressure control valve	7.43E+00	5.57E+04	16.35	1.00	1.00	1.00	1.00	0.60
3.00E-03	From the pressure control valve	1.83E-03	1.37E+01	0.26	0.00	0.00	0.00	0.00	0.00
6.00E-03	From the pressure control valve	7.32E-03	5.49E+01	0.51	0.00	0.00	0.00	0.00	0.00
1.30E-02	From the pressure control valve	3.44E-02	2.58E+02	1.11	0.85	0.00	0.00	0.00	0.00
2.50E-02	From the pressure control valve	1.27E-01	9.54E+02	2.14	1.00	0.85	0.00	0.00	0.00
5.80E-02	From the pressure control valve	6.84E-01	5.13E+03	4.96	1.00	1.00	0.50	0.00	0.00
3.00E-03	Shut-in well (after two years)	1.27E-02	9.50E+01	0.68	0.00	0.00	0.00	0.00	0.00
1.30E-02	Shut-in well (after two years)	3.44E-02	2.58E+02	1.11	1.00	0.00	0.00	0.00	0.00
2.50E-02	Shut-in well (after two years)	8.80E-01	6.60E+03	5.63	1.00	1.00	0.85	0.00	0.00
5.80E-02	Shut-in well (after two years)	4.74E+00	3.55E+04	13.06	1.00	1.00	1.00	1.00	0.25

A2.4.3 Flash Fire Calculations, Early Operation

Equivalent mass TNT = [Explosion efficiency compared with TNT] x [Mass of vapour in cloud] x [Heat of combustion of vapour] / 4,600 =
Scaled distance = Radius [metres] / (M TNT)0.333

Explosion efficiency = 4%
Hc = 50000 kJ/kg
Mass in cloud after (s) = 1.80E+02

Leak size(mm) (m)	Location	Burn rate (kg/s)	Mass in cloud (k (kg)	M(TNT) (kg)	Scaled distance 2 m	5 m	10 m	15 m	20 m
3.00E-03	Up to pressure control valve	8.42E-03	1.52E+00	6.59E-01	2.3	5.7	11.5	17.2	23.0
6.00E-03	Up to pressure control valve	3.37E-02	6.06E+00	2.64E+00	1.4	3.6	7.2	10.9	14.5
1.30E-02	Up to pressure control valve	1.58E-01	2.85E+01	1.24E+01	0.9	2.2	4.3	6.5	8.7
2.50E-02	Up to pressure control valve	5.85E-01	1.05E+02	4.58E+01	0.6	1.4	2.8	4.2	5.6
5.80E-02	Up to pressure control valve	3.15E+00	5.67E+02	2.46E+02	0.3	0.8	1.6	2.4	3.2
1.15E-01	Up to pressure control valve	1.24E+01	2.23E+03	9.69E+02	0.2	0.5	1.0	1.5	2.0
3.00E-03	From the pressure control valve	6.10E-03	1.10E+00	4.78E-01	2.6	6.4	12.8	19.2	25.6
6.00E-03	From the pressure control valve	2.44E-02	4.39E+00	1.91E+00	1.6	4.0	8.1	12.1	16.1
1.30E-02	From the pressure control valve	1.15E-01	2.06E+01	8.97E+00	1.0	2.4	4.8	7.2	9.6
2.50E-02	From the pressure control valve	4.24E-01	7.63E+01	3.32E+01	0.6	1.6	3.1	4.7	6.2
5.80E-02	From the pressure control valve	2.28E+00	4.11E+02	1.79E+02	0.4	0.9	1.8	2.7	3.6
3.00E-03	Shut-in well (after two years)	2.11E-02	3.80E+00	1.65E+00	1.7	4.2	8.5	12.7	16.9
1.30E-02	Shut-in well (after two years)	3.97E-01	7.14E+01	3.10E+01	0.6	1.6	3.2	4.8	6.4
2.50E-02	Shut-in well (after two years)	1.47E+00	2.64E+02	1.15E+02	0.4	1.0	2.1	3.1	4.1
5.80E-02	Shut-in well (after two years)	7.89E+00	1.42E+03	6.18E+02	0.2	0.6	1.2	1.8	2.4

Leak size(mm) (m)	Location	Burn rate (kg/s)	Mass in cloud (k (kg)	M(TNT) (kg)	Overpresure (kPa) 2 m	5 m	10 m	15 m	20 m
3.00E-03	Up to pressure control valve	8.42E-03	1.52E+00	6.59E-01	100	30	10	8.5	7
6.00E-03	Up to pressure control valve	3.37E-02	6.06E+00	2.64E+00	100	70	20	16.0	12
1.30E-02	Up to pressure control valve	1.58E-01	2.85E+01	1.24E+01	100	100	45	40.0	35
2.50E-02	Up to pressure control valve	5.85E-01	1.05E+02	4.58E+01	100	100	95	66.5	38
5.80E-02	Up to pressure control valve	3.15E+00	5.67E+02	2.46E+02	100	100	100	100.0	90
1.15E-01	Up to pressure control valve	1.24E+01	2.23E+03	9.69E+02	100	100	100	100.0	100
3.00E-03	From the pressure control valv	6.10E-03	1.10E+00	4.78E-01	90	25	8.0	4.0	3.0
6.00E-03	From the pressure control valv	2.44E-02	4.39E+00	1.91E+00	100	50	15	10.0	6
1.30E-02	From the pressure control valv	1.15E-01	2.06E+01	8.97E+00	100	95	40	18.0	12
2.50E-02	From the pressure control valv	4.24E-01	7.63E+01	3.32E+01	100	100	90	40.0	30
5.80E-02	From the pressure control valv	2.28E+00	4.11E+02	1.79E+02	100	100	100	90.0	65
3.00E-03	Shut-in well (after two years)	2.11E-02	3.80E+00	1.65E+00	100	50	15	10.0	6
1.30E-02	Shut-in well (after two years)	3.97E-01	7.14E+01	3.10E+01	100	100	90	40.0	30
2.50E-02	Shut-in well (after two years)	1.47E+00	2.64E+02	1.15E+02	100	100	100	90.0	65
5.80E-02	Shut-in well (after two years)	7.89E+00	1.42E+03	6.18E+02	100	100	100	100.0	95

Leak size(mm)	Location	Burn rate (kg/s)	Mass in cloud (k	M(TNT)				Probability of fatality	
(m)			(kg)	(kg)	2 m	5 m	10 m	15 m	20 m
3.00E-03	Up to pressure control valve	8.42E-03	1.52E+00	6.59E-01	1.00	0.23	0.04	0.03	0.01
6.00E-03	Up to pressure control valve	3.37E-02	6.06E+00	2.64E+00	1.00	1.00	0.90	0.05	0.04
1.30E-02	Up to pressure control valve	1.58E-01	2.85E+01	1.24E+01	1.00	1.00	1.00	0.14	0.05
2.50E-02	Up to pressure control valve	5.85E-01	1.05E+02	4.58E+01	1.00	1.00	1.00	0.68	0.35
5.80E-02	Up to pressure control valve	3.15E+00	5.67E+02	2.46E+02	1.00	1.00	1.00	1.00	1.00
1.15E-01	Up to pressure control valve	1.24E+01	2.23E+03	9.69E+02	1.00	1.00	1.00	1.00	1.00
3.00E-03	From the pressure control valv	6.10E-03	1.10E+00	4.78E-01	1.00	0.09	0.03	0.02	0.01
6.00E-03	From the pressure control valv	2.44E-02	4.39E+00	1.91E+00	1.00	0.40	0.04	0.04	0.04
1.30E-02	From the pressure control valv	1.15E-01	2.06E+01	8.97E+00	1.00	1.00	0.20	0.14	0.07
2.50E-02	From the pressure control valv	4.24E-01	7.63E+01	3.32E+01	1.00	1.00	0.80	0.65	0.50
5.80E-02	From the pressure control valv	2.28E+00	4.11E+02	1.79E+02	1.00	1.00	1.00	0.80	0.60
3.00E-03	Shut-in well (after two years)	2.11E-02	3.80E+00	1.65E+00	1.00	0.40	0.08	0.04	0.02
1.30E-02	Shut-in well (after two years)	3.97E-01	7.14E+01	3.10E+01	1.00	0.40	1.00	0.65	0.14
2.50E-02	Shut-in well (after two years)	1.47E+00	2.64E+02	1.15E+02	1.00	1.00	1.00	1.00	0.40
5.80E-02	Shut-in well (after two years)	7.89E+00	1.42E+03	6.18E+02	1.00	1.00	1.00	1.00	1.00

FLASH FIRE

Distance to fatality for flash fires= dist. To 70kPa = scaled distance of 4

Leak size(mm)	Location	Burn rate (kg/s)	Mass in cloud (k	Flash fire				Probability of Fatality	
(m)			(kg)	danger zone (m)	1 m	2 m	5 m	10 m	15 m
3.00E-03	Up to pressure control valve	8.42E-03	1.52E+00	4	1.00	1.00	0.00	0.00	0.00
6.00E-03	Up to pressure control valve	3.37E-02	6.06E+00	6	1.00	1.00	1.00	0.00	0.00
1.30E-02	Up to pressure control valve	1.58E-01	2.85E+01	10	1.00	1.00	1.00	1.00	0.00
2.50E-02	Up to pressure control valve	5.85E-01	1.05E+02	15	1.00	1.00	1.00	1.00	1.00
5.80E-02	Up to pressure control valve	3.15E+00	5.67E+02	25	1.00	1.00	1.00	1.00	1.00
1.15E-01	Up to pressure control valve	1.24E+01	2.23E+03	25	1.00	1.00	1.00	1.00	1.00
3.00E-03	From the pressure control valve	6.10E-03	1.10E+00	3	1.00	1.00	0.00	0.00	0.00
6.00E-03	From the pressure control valve	2.44E-02	4.39E+00	5	1.00	1.00	1.00	0.00	0.00
1.30E-02	From the pressure control valve	1.15E-01	2.06E+01	10	1.00	1.00	1.00	1.00	0.00
2.50E-02	From the pressure control valve	4.24E-01	7.63E+01	15	1.00	1.00	1.00	1.00	1.00
5.80E-02	From the pressure control valve	2.28E+00	4.11E+02	24	1.00	1.00	1.00	1.00	1.00
3.00E-03	Shut-in well (after two years)	2.11E-02	3.80E+00	5	1.00	1.00	1.00	0.00	0.00
1.30E-02	Shut-in well (after two years)	3.97E-01	7.14E+01	15	1.00	1.00	1.00	1.00	1.00
2.50E-02	Shut-in well (after two years)	1.47E+00	2.64E+02	20	1.00	1.00	1.00	1.00	1.00
5.80E-02	Shut-in well (after two years)	7.89E+00	1.42E+03	40	1.00	1.00	1.00	1.00	1.00

A2.4.4 Flash Fire Calculations, Established Operation

Equivalent mass TNT = [Explosion efficiency compared with TNT] x [Mass of vapour in cloud] x [Heat of combustion of vapour] / 4,600 =
Scaled distance = Radius [metres] / (MTNT)0.333

Explosion efficiency = 4%
Hc = 50000 kJ/kg
Mass in cloud after (s) = 1.80E+02

Leak size(mm) (m)	Location	Burn rate (kg/s)	Mass in cloud (kg)	M(TNT) (kg)	Scaled distance 2 m	5 m	10 m	15 m	20 m
3.00E-03	Up to pressure control valve	5.05E-03	9.10E-01	3.95E-01	2.7	6.8	13.6	20.4	27.2
6.00E-03	Up to pressure control valve	2.02E-02	3.64E+00	1.58E+00	1.7	4.3	8.6	12.9	17.2
1.30E-02	Up to pressure control valve	9.49E-02	1.71E+01	7.43E+00	1.0	2.6	5.1	7.7	10.3
2.50E-02	Up to pressure control valve	3.51E-01	6.32E+01	2.75E+01	0.7	1.7	3.3	5.0	6.6
5.80E-02	Up to pressure control valve	1.89E+00	3.40E+02	1.48E+02	0.4	0.9	1.9	2.8	3.8
1.15E-01	Up to pressure control valve	7.43E+00	1.34E+03	5.81E+02	0.2	0.6	1.2	1.8	2.4
3.00E-03	From the pressure control valve	1.83E-03	3.30E-01	1.43E-01	3.8	9.5	19.1	28.6	38.2
6.00E-03	From the pressure control valve	7.32E-03	1.32E+00	5.73E-01	2.4	6.0	12.0	18.1	24.1
1.30E-02	From the pressure control valve	3.44E-02	6.19E+00	2.69E+00	1.4	3.6	7.2	10.8	14.4
2.50E-02	From the pressure control valve	1.27E-01	2.29E+01	9.95E+00	0.9	2.3	4.7	7.0	9.3
5.80E-02	From the pressure control valve	6.84E-01	1.23E+02	5.36E+01	0.5	1.3	2.7	4.0	5.3
3.00E-03	Shut-in well (after two years)	1.27E-02	2.28E+00	9.92E-01	2.0	5.0	10.0	15.0	20.1
1.30E-02	Shut-in well (after two years)	2.38E-01	4.28E+01	1.86E+01	0.8	1.9	3.8	5.7	7.6
2.50E-02	Shut-in well (after two years)	8.80E-01	1.58E+02	6.89E+01	0.5	1.2	2.4	3.7	4.9
5.80E-02	Shut-in well (after two years)	4.74E+00	8.52E+02	3.71E+02	0.3	0.7	1.4	2.1	2.8

Leak size(mm) (m)	Location	Burn rate (kg/s)	Mass in cloud (kg)	M(TNT) (kg)	Overpressure (kPa) 2 m	5 m	10 m	15 m	20 m
3.00E-03	Up to pressure control valve	5.05E-03	9.10E-01	3.95E-01	90	25	8.0	4.0	3.0
6.00E-03	Up to pressure control valve	2.02E-02	3.64E+00	1.58E+00	100	50	15	10.0	6
1.30E-02	Up to pressure control valve	9.49E-02	1.71E+01	7.43E+00	100	95	40	18.0	12
2.50E-02	Up to pressure control valve	3.51E-01	6.32E+01	2.75E+01	100	100	90	40.0	30
5.80E-02	Up to pressure control valve	1.89E+00	3.40E+02	1.48E+02	100	100	100	90.0	65
1.15E-01	Up to pressure control valve	7.43E+00	1.34E+03	5.81E+02	100	100	100	100.0	100
3.00E-03	From the pressure control valv	1.83E-03	3.30E-01	1.43E-01	70	15	4.5	3.8	3
6.00E-03	From the pressure control valv	7.32E-03	1.32E+00	5.73E-01	100	30	10	8.5	7
1.30E-02	From the pressure control valv	3.44E-02	6.19E+00	2.69E+00	100	70	20	16.0	12
2.50E-02	From the pressure control valv	1.27E-01	2.29E+01	9.95E+00	100	100	45	40.0	35
5.80E-02	From the pressure control valv	6.84E-01	1.23E+02	5.36E+01	100	100	95	66.5	38
3.00E-03	Shut-in well (after two years)	1.27E-02	2.28E+00	9.92E-01	100	40	15	8.0	5
1.30E-02	Shut-in well (after two years)	2.38E-01	4.28E+01	1.86E+01	100	100	70	40.0	18
2.50E-02	Shut-in well (after two years)	8.80E-01	1.58E+02	6.89E+01	100	100	100	70.0	40
5.80E-02	Shut-in well (after two years)	4.74E+00	8.52E+02	3.71E+02	100	100	100	100.0	90

Leak size(mm)	Location	Burn rate (kg/s)	Mass in cloud (k	M(TNT)				Probability of fatality	
(m)			(kg)	(kg)	2 m	5 m	10 m	15 m	20 m
3.00E-03	Up to pressure control valve	5.05E-03	9.10E-01	3.95E-01	1.00	0.23	0.04	0.03	0.01
6.00E-03	Up to pressure control valve	2.02E-02	3.64E+00	1.58E+00	1.00	1.00	0.90	0.05	0.04
1.30E-02	Up to pressure control valve	9.49E-02	1.71E+01	7.43E+00	1.00	1.00	1.00	0.14	0.05
2.50E-02	Up to pressure control valve	3.51E-01	6.32E+01	2.75E+01	1.00	1.00	1.00	0.68	0.35
5.80E-02	Up to pressure control valve	1.89E+00	3.40E+02	1.48E+02	1.00	1.00	1.00	1.00	1.00
1.15E-01	Up to pressure control valve	7.43E+00	1.34E+03	5.81E+02	1.00	1.00	1.00	1.00	1.00
3.00E-03	From the pressure control valv	1.83E-03	3.30E-01	1.43E-01	1.00	0.09	0.03	0.02	0.01
6.00E-03	From the pressure control valv	7.32E-03	1.32E+00	5.73E-01	1.00	0.40	0.04	0.04	0.04
1.30E-02	From the pressure control valv	3.44E-02	6.19E+00	2.69E+00	1.00	1.00	0.20	0.14	0.07
2.50E-02	From the pressure control valv	1.27E-01	2.29E+01	9.95E+00	1.00	1.00	0.80	0.65	0.50
5.80E-02	From the pressure control valv	6.84E-01	1.23E+02	5.36E+01	1.00	1.00	1.00	0.80	0.60
3.00E-03	Shut-in well (after two years)	1.27E-02	2.28E+00	9.92E-01	1.00	0.40	0.08	0.04	0.02
1.30E-02	Shut-in well (after two years)	2.38E-01	4.28E+01	1.86E+01	1.00	0.40	1.00	0.65	0.14
2.50E-02	Shut-in well (after two years)	8.80E-01	1.58E+02	6.89E+01	1.00	1.00	1.00	1.00	0.40
5.80E-02	Shut-in well (after two years)	4.74E+00	8.52E+02	3.71E+02	1.00	1.00	1.00	1.00	1.00

FLASH FIRE

Distance to fatality for flash fires= dist. To 70kPa = scaled distance of 4

Leak size(mm)	Location	Burn rate (kg/s)	Mass in cloud (k	Flash fire				Probability of Fatality	
(m)			(kg)	danger zone (m)	1 m	2 m	5 m	10 m	15 m
3.00E-03	Up to pressure control valve	5.05E-03	9.10E-01	2	1.00	1.00	0.00	0.00	0.00
6.00E-03	Up to pressure control valve	2.02E-02	3.64E+00	4	1.00	1.00	0.00	0.00	0.00
1.30E-02	Up to pressure control valve	9.49E-02	1.71E+01	7.5	1.00	1.00	1.00	0.00	0.00
2.50E-02	Up to pressure control valve	3.51E-01	6.32E+01	12.5	1.00	1.00	1.00	1.00	0.00
5.80E-02	Up to pressure control valve	1.89E+00	3.40E+02	17.5	1.00	1.00	1.00	1.00	1.00
1.15E-01	Up to pressure control valve	7.43E+00	1.34E+03	17.5	1.00	1.00	1.00	1.00	1.00
3.00E-03	From the pressure control valve	1.83E-03	3.30E-01	3	1.00	1.00	0.00	0.00	0.00
6.00E-03	From the pressure control valve	7.32E-03	1.32E+00	4	1.00	1.00	0.00	0.00	0.00
1.30E-02	From the pressure control valve	3.44E-02	6.19E+00	5	1.00	1.00	1.00	0.00	0.00
2.50E-02	From the pressure control valve	1.27E-01	2.29E+01	7.5	1.00	1.00	1.00	0.00	0.00
5.80E-02	From the pressure control valve	6.84E-01	1.23E+02	15	1.00	1.00	1.00	1.00	1.00
3.00E-03	Shut-in well (after two years)	1.27E-02	2.28E+00	3	1.00	1.00	0.00	0.00	0.00
1.30E-02	Shut-in well (after two years)	2.38E-01	4.28E+01	3	1.00	1.00	0.00	0.00	0.00
2.50E-02	Shut-in well (after two years)	8.80E-01	1.58E+02	15	1.00	1.00	1.00	1.00	1.00
5.80E-02	Shut-in well (after two years)	4.74E+00	8.52E+02	22	1.00	1.00	1.00	1.00	1.00

Appendix 3

Frequency Assessment

Quantitative Risk Assessment, Coal Seam Methane Production Wells for Up to Six Wellhead Configuration, AGL Gas Production (Camden) Pty Limited

Appendix 2 - Frequency Assessment.

A3.1 Equipment failure frequency

The frequency of each postulated equipment failure was determined using the data in the table below. These failure rate are derived from the UK Health and Safety Executive *Offshore Hydrocarbon Release Statistics 2001, Offshore Technology Report, January 2002* as used in the Department of Planning's[6] Locational Guidelines *Development in the Vicinity of Operating Coal Seam Methane Wells*, May 2004. These failure rates are summarised in the table below.

Table A3.1 - Equipment Failures and Associated Frequencies

Type of Failure	Failure Rate (pmpy)
PIPING AND FLANGES/JOINTS	
3 mm hole	141 pmpy / m
13 mm hole	26 pmpy / m
25 mm hole	15 pmpy / m
Guillotine fracture (full bore) for pipe ≥58mm	20 pmpy / m
Guillotine fracture (full bore) for pipe ≥100mm	20 pmpy / m
Flange failure all leak sizes (for pipe < 3") as 6mm leak size	43 pmpy / joint
(Screw-connection taken as 3xfailure rate for flange, as 6 mm leak size)	129 pmpy / joint
CHOKE AND SHUTDOWN VALVES	
3 mm hole	152 pmpy / valve
25 mm hole	17 pmpy / valve
58 mm hole (rupture)	17 pmpy / valve
RELIEF VALVE	
3 mm hole	133 pmpy / valve
25 mm hole	52 pmpy / valve
58 mm hole (rupture)	0 pmpy / valve
VESSELS (VERTICAL PRESSURE VESSEL)	
6 mm hole	24 pmpy

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Table A3.1 - Equipment Failures and Associated Frequencies

Type of Failure	Failure Rate (pmpy)
13 mm hole	6 pmpy
25 mm hole	3 pmpy
50 mm hole	3 pmpy
Catastrophic rupture	1 pmpy

A3.2 Failure of automatic protection

The shut down valve will be positioned to automatically isolate the well head in case of four major operations upset conditions, namely:

- High pressure on the well (PSH);
- Low pressure on the well (PLH);
- High flow of gas through the meter run (FSH);
- Low flow of gas through the meter run (FSL).

A high pressure event would trip the shut down valve, effectively isolating the well head which is designed such that it can withstand very high pressures (more than 30 times higher than operating pressure for a new well).

The low pressure trip, the high flow trip and the low flow trip are all three protective devices in case of a major leak scenario. The primary device is the low pressure trip which would initiate the closure of the shut down valve. If it was to fail, the low flow trip would sense a loss of flow if the leak is upstream of the flow sensor. If the leak is downstream of the sensor then the high flow sensor would initiate the closure of the valve. In this manner, there are always two independent trips that would close the shut down valve provided the leak is downstream of this valve.

Further, a fusible loop, consisting of a pipe small diameter polythene pipe, is wrapped around the well piping from the shut down valve to the separator. In case of a fire, the pipe would quickly burn through causing a loss of the power source keeping the shut down valve open, resulting in its closure (the shut down valve is "fail safe").

The following estimates of probabilities have been used as a guide for the purposes of determining the reliability of the automatic protection (Ref 10).

Table A3.2 – Safety Integrity Levels

Safety Integrity Level (SIL)	Low Demand Mode of Operation (probability of failure to perform as intended on demand)
4	>=10^{-5} to < 10^{-4}
3	>=10^{-4} to < 10^{-3}
2	>=10^{-3} to < 10^{-2}
1	>=10^{-2} to < 10^{-1}

The protective systems will be designed to SIL 1 requirements. Table A3.3 shows the probability of failure used for the automatic protective systems of the wells.

Table A3.3 - Probability of Failure of Automatic Protection

Safety Integrity Level (SIL)	Low Demand Mode of Operation (probability of failure to perform as intended on demand)
High pressure on the well (PSH)	0.05
Low pressure on the well (PLH)	0.05
High flow of gas through the meter run (FSH)	0.05
Low flow of gas through the meter run (FSL)	0.05
Fusible loop	0.05

A3.3 Frequency of leak per well

The frequency of leak for each well is shown in Table A3.4 below. For a compound of six wells, these frequencies are multiplied by six.

Table A3.4 – Leak Frequency per Well

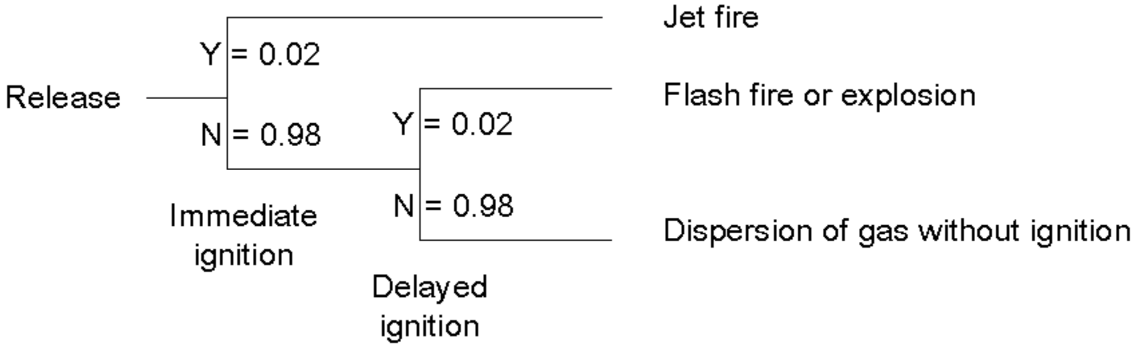
Piping / Equipment	Length / flanges	Hole size	Automatic protection			Leak frequency per well (pmpy)
			Pressure Switch Low	Flow Switch High	Flow Switch Low	
Gas line from well head within casing	0.9 m / 0 flanges	- Rupture (0.115 mm) - 25mm - 13mm - 3mm	- NO - NO - NO - NO	- NO - NO - NO - NO	- NO - NO - NO - NO	- 18 - 13 - 23 - 127

Piping / Equipment	Length / flanges	Hole size	Automatic protection			Leak frequency per well (pmpy)
			Pressure Switch Low	Flow Switch High	Flow Switch Low	
Casing at well head	0.1 m / 0 flanges	- Rupture (0.058mm) - 25mm - 13mm - 3mm	- NO - NO - NO - NO	- NO - NO - NO - NO	- NO - NO - NO - NO	- 2 - 1.5 - 3 - 14
Gas line from well head to shutdown valve	1 m / 5 flanges	- Rupture (0.058mm) - 25mm - 13mm - 3mm - 6mm (flange)	- NO - NO - NO - NO - NO	- NO - NO - NO - NO - NO	- NO - NO - NO - NO - NO	- 20 - 15 - 26 - 141 - 637
Line from the shut down valve to the water separator	1.5 m / 5 flanges	- Rupture (0.058mm) - 25mm - 13mm - 3mm - 6mm (flange)	- YES - YES - NO - NO - NO	- NO - NO - NO - NO - NO	- YES - YES - NO - NO - NO	- 0.08 - 0.06 - 39 - 211 - 637
Line from the separator to the flow line	5 m / 11 flanges	- Rupture (0.058mm) - 25mm - 13mm - 3mm - 6mm (from flange)	- YES - YES - NO - NO - NO	- YES - YES - NO - NO - NO	- NO - NO - NO - NO - NO	- 0.3 - 0.2 - 130 - 703 - 1400
Relief valve	N/A	- Rupture (0.058mm) - 25mm - 3mm	- YES - YES - NO	- NO - NO - NO	- YES - YES - NO	- 0.04 - 0.04 - 153
Separator	N/A	- Rupture (vessel rupture) - 50mm - 23mm - 11mm - 3mm	- YES - YES - YES - NO - NO	- NO - NO - NO - NO - NO	- YES - YES - YES - NO - NO	- 0.01 - 0.04 - 0.04 - 6 - 24

A3.4 Probability of Ignition

The probability of ignition if leak and the probability of a jet fire or a flash fire are as per the work by the Department for the *Locational Guidelines Development in the Vicinity of Operating Coal Seam Methane Wells* (Ref 9), as shown in Figure 5 below. These probabilities were developed by the Department to determine the likelihood of a flammable event following a release of gas from gas well installations located within a number of different types of development (open space, business, residential and sensitive development), and for the types of ignition sources which may be encountered within these developments.

Figure 5 – Ignition Probabilities



The frequency of a jet fire and of a flash fire is shown in Table A3.4 below. For a compound of six wells, these frequencies are multiplied by six.

Table A3.4 – Frequency of Jet and Flash Fire (per Well)

Piping	Fusible loop	Frequency (pmpy)		
		Leak	Jet Fire (sustained)	Flash Fire
Gas line from well head within casing				
- Rupture (0.058mm)	- NO	- 18	- 0.4	- 0.02
- 25mm	- NO	- 13	- 0.3	- 0.01
- 13mm	- NO	- 23	- 0.5	- 0.02
- 3mm	- NO	- 127	- 2	- 0.1
Casing at well head				
- Rupture (0.115mm)	- NO	- 2	- 0.04	- 0.01
- 25mm	- NO	- 1.5	- 0.03	- 0.01
- 13mm	- NO	- 3	- 0.05	- 0.02
- 3mm	- NO	- 14	- 0.03	- 0.01
Gas line from well head to shutdown valve				
- Rupture (0.058mm)	- NO	- 20	- 0.04	- 0.02
- 25mm	- NO	- 15	- 0.03	- 0.02
- 13mm	- NO	- 26	- 0.5	- 0.02
- 3mm	- NO	- 141	- 3	- 0.1
- 6mm (flange)	- NO	- 637	- 13	- 0.5
Line from the shut down valve to the water separator				
- Rupture (0.058mm)	- YES	- 0.08	- 0.008	- 0.01
- 25mm	- YES	- 0.06	- 0.005	- 0.0006
- 13mm	- YES	- 39	- 0.04	- 0.03
- 3mm	- YES	- 211	- 0.2	- 3
- 6mm (flange)	- YES	- 637	- 0.6	- 10

Piping	Fusible loop	Frequency (pmpy)		
		Leak	Jet Fire (sustained)	Flash Fire
Line from the separator to the flow line				
- Rupture (0.058mm) - 25mm - 13mm - 3mm - 6mm (flange)	- NO - NO - NO - NO - NO	- 0.3 - 0.2 - 130 - 703 - 1400	- 0.006 - 0.005 - 0.003 - 14 - 28	- 0.04 - 0.004 - 0.003 - 11 - 22
Relief valve				
- Rupture (0.058mm) - 25mm - 13mm - 3mm - 6mm (flange)	- NO - NO - NO	- Rupture - 25mm - 3mm	- 0.008 - 0.008 - 3	- 0.007 - 0.007 - 2
Separator				
- Rupture (0.058mm) - 25mm - 13mm - 3mm - 6mm (flange)	- NO - NO - NO - NO - NO	- Rupture - 50mm - 23mm - 11mm - 3mm	- 0.0002 - 0.0007 - 0.0007 - 0.1 - 0.5	- 0.0002 - 0.0006 - 0.0006 - 0.1 - 0.4

Note that 40% of jet fires are assumed to have the potential to have an effect outside the compound in any particular direction (provided they are long enough).

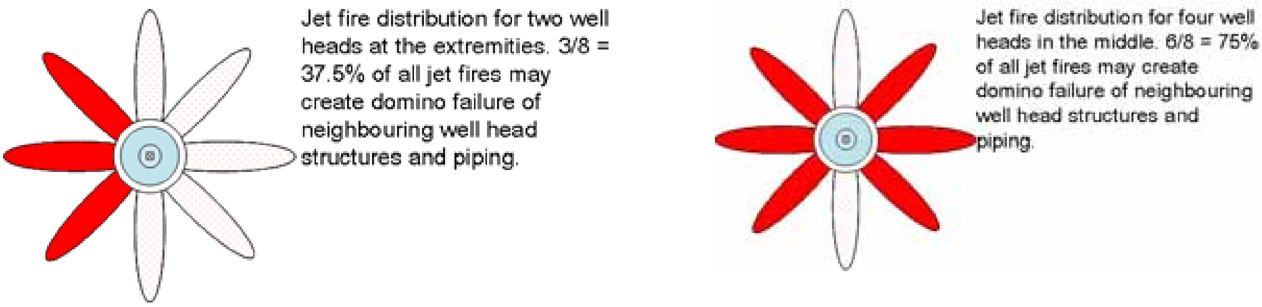
A3.5 Domino Effects

Domino incidents may be created if a jet fire at one well impinges on the piping structure of a neighbouring well for sufficient long time and with sufficient radiant heat to cause thermal stress and failure of the steel. Due to the short duration of the flash fire, domino incidents from a flash fire are not credible events. Jet fires may however generate domino incidents.

To determine the probability with which a jet fire may initiate a domino effect, the following reasoning was made.

Jet fires are directional and only the proportion of jet fires that are directed towards another well may initiate a domino incident. Figure A3.1 below shows the jet fire distribution around a gas well.

Figure A3.1 – Jet Fire Distribution



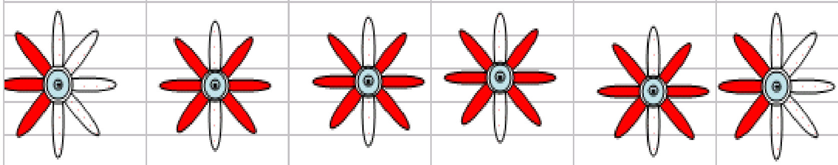
If the total number of directions for the jet fire at the gas well is 8, then 3/8 (about 38%) of all potential jet fires may initiate a domino event for the two wells on the extreme, and 6/8 (about 75%) of all jet fires may initiate a domino event for the other four wells in the centre of the compound. Therefore, the factor described by the equation:

$$2 \times 0.38 \times F_{(\text{single well jet fire})} + 4 \times 0.75 \times (F_{(\text{single well jet fire})}, \text{ or}$$

$$(2 \times 0.38 + 4 \times 0.75) \times F_{(\text{single well jet fire})} = 3.75 \times F_{(\text{single well jet fire})}$$

describes the factor with which the single well jet fire frequency needs to be multiplied to account for the domino effect potential. As the jet fire provides an immediate source of ignition it can safely be assumed that all incidents created this way would result in another jet fire. Figure A3.2 below describes this logic.

Figure A3.2 – Calculation of Domino Effect Factor

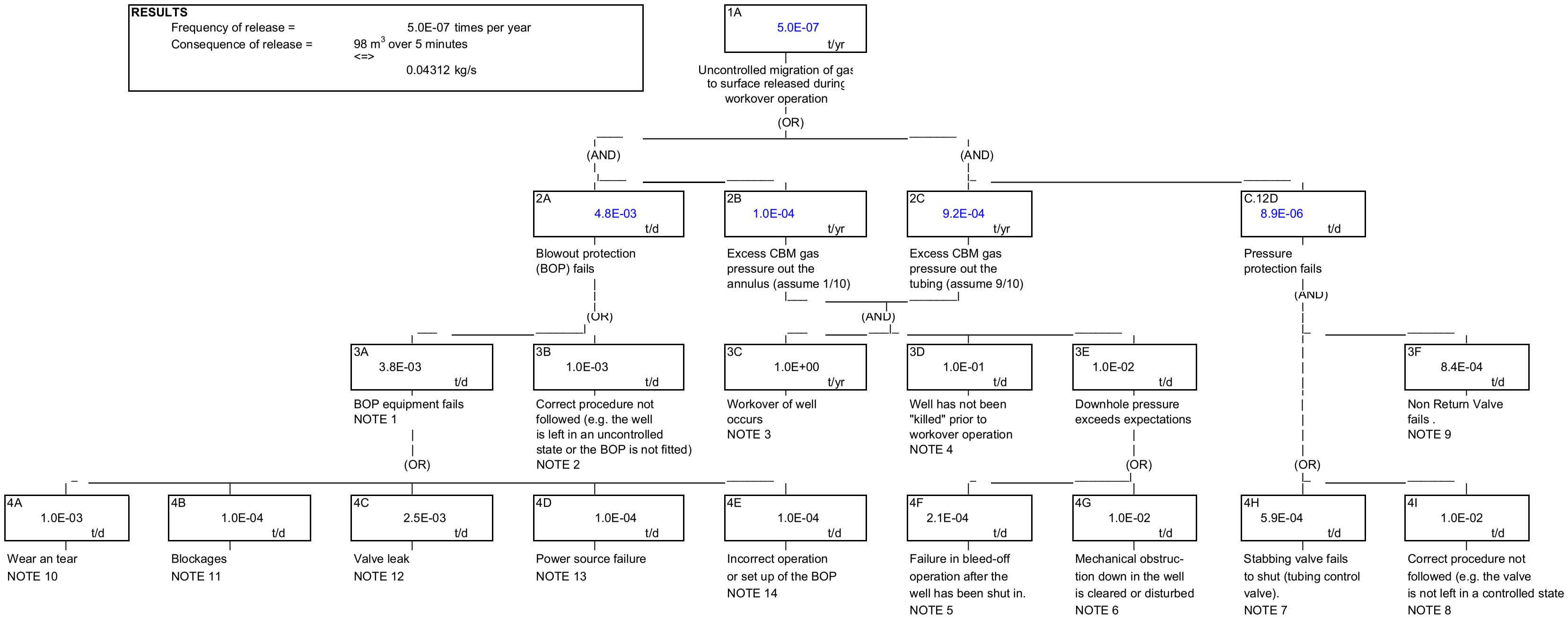


WELLHEAD 1	WELLHEAD 2	WELLHEAD 3	WELLHEAD 4	WELLHEAD 5	WELLHEAD 6				
0.375 x $F_{(single)}$	0.75 x $F_{(single)}$	0.75 x $F_{(single)}$	0.75 x $F_{(single)}$	0.75 x $F_{(single)}$	0.375 x $F_{(single)}$	= $F_{(single)}$x (0.375x2 + 0.75 x 4) =			
						$F_{(6\ well\ heads\ domino)}$ =	3.75	x	$F_{(single)}$

A3.6 Workover operations

The fault tree below details the frequency of a loss of containment event due to failure of a workover operations.

FAULT TREE FOR RELEASE OF CBM DURING WORK OVER OPERATION



NOTE 1	The BOP is the Blow Out Preventer which is fitted to the well for the duration of the workover operation, as part of the NSW Petoleum (Onshore) Act for the control of well maintenance and drilling. The BOP consists of a complex arrangement of pressure rated hydraulic rams (cylinders) which, when activated isolate the flow of the fluid or gas between the product tubing and the product casing. One of three independent sources of energy are activated to close the rams.			
NOTE 2	Assume that the failure is initiated 0.01 times per workover operation (as per Ref 2, failure in routine operation when other duties present). Also as per Ref 2, this failure rate is reduced by 10 due to the ease in which the failure can be recognised by a co-worker.	Ref 2	t/d	1.00E-03
NOTE 3	Workover of the well will occur in average once within the first 6 months (say after 3 months) and then every 5 years. The expected life of a well is in the order of 15 years. As per the Department of Infrastructure, Planning and Natural Resources *Locational Guidelines*, one workover operation per year is assumed. This is conservative.	Ref 3	t/yr	1.00E+00
NOTE 4	The well may or may not be killed before a workover operation. The decision to kill a well depends on it's previous history (including such information as pressures, flows, stability etc.) which will be analysed prior to any workover and which will form part of the input of the work instructions which are put together for each workover. Basically, a well which performs in a stable manner will not be killed which one which may pose problems during workover will be killed. A well which has been killed will not produce unexpected slugs of gas which may migrate to the surface, which it is possible that a not killed well can produce such slugs (see NOTE 5). Killing a well is performed by pumping a fluid (water or a mixture of water and a weighting agent, e.g. a salt) into the well to a pressure exceeding the hydrostatic pressure of the well (in effect it provides a sort of "lid" down within the well). It is assumed that 10% of the wells are not killed prior to workover operations.	Ref 3	t/d	1.00E-01
NOTE 5	This is a procedural failure. The well will be shut in and made safe during lunch hours or any time while the well is left unattended. On return the excess well pressure will need to be vented off (or bled off) in a controlled manner. If not controlled then this operation is very noisy and it is very easy to recognise an uncontrolled operation. Assume failure rate of 3 x 10-3 times per demand (Ref 2, "General error of commission". Doing the wrong thing), but reduce this rare by 0.01 (Ref 2, some type of special precautions) due to the excessive noise. Resulting probability of failure is 3 x 10-5 per day,	Ref 2	t/d	2.10E-04
NOTE 6	Assumed to be one in a hundred workovers. The fact that the well hadn't been killed prior to workover operation was taken into account. This means that the history of the well is such that the likelihood of such disturbance is low.	Ref 3	t/d	1.00E-02
NOTE 7	The stabbing valve (or the "tubing control valve) is a ball valve. It's operation is checked prior to each workover operation. It will then be in operation for one week per workover operation. Failure rate of the stabbing valve is taken from Ref 1 as 3.5 times per million hours of operation (to account for the "dirty" operation during workovers, the higher end of the failure rates was chosen [the reference states a failure of between 1 and 3.5 per million hours]). Assuming that each workover operation lasts for 7 days, 24 hours per day, the probability of failure anytime during each operation is calculated as 3.5 / 106 hrs x (7 x 24) = 0.001 per operation.	Ref 1	t/d	5.88E-04
NOTE 8	Assume that the failure is initiated 0.1 times per workover operation (as per Ref 2, Failure in non-routine operation when other duties present). Also as per Ref 2, this failure rate is reduced by 10 due to the ease in which the failure can be recognised by a co-worker.	Ref 2	t/d	1.00E-02
NOTE 9	Failure rate of Non Return Valve (NRV) taken from Ref 1 as 5 times per million hours of operation of the NRV (to account for the "dirty" operation during workovers, the higher end of the failure rates was chosen [the reference states a failure of between 2 and 5 per million hours]). Assuming that each workover operation lasts for 7 days, 24 hours per day, the probability of failure anytime during each operation is calculated as 5 / 10^6 hrs x (7 x 24) = 0.001 per operation.	Ref 1	t/d	8.40E-04
NOTE 10	The BOP is certified every 5 years. Further, it is subject to periodic preventative maintenance. Assume that only unrevealed faults are to danger. Plant experience point towards a 1/1000 operation fault to danger.	Ref 3	t/d	1.00E-03
NOTE 11	Plant experience point toward a 1/10000 operations.	Ref 3	t/d	1.00E-04
NOTE 12	Three independent four way valves must leak. Assume leak frequency of gate valve (highest leak frequency), and take higher end of the frequencies referred to in the literature to account for the relatively "dirty" operation of the workover [the reference states a failure of between 1 and 15 per million hours per valve]). Assuming that each workover operation lasts for 7 days, 24 hours per day, the probability of failure anytime during each operation is calculated as (15 / 106 hrs x (7 x 24))^3 x 10^{-9} per operation. Take into account a probability of common mode failure (e.g. a human failure to correctly fit the valves) and add a 0.0025 t/d probability (this is extrapolated from the common mode failure probability of trip failure, Ref 4).	Ref 1	t/d	2.50E-03
NOTE 13	There are three independent sources of energy which operates the valve. However, they come together in a common tubing arrangement. The simultaneous probability of failure of the three sources of energy is assumed to be negligible compared with the probability of failure of the common tubing arrangement. This tubing can fail from a mechanical impact (e.g. vehicle damage), overpressure or wear and tear. Plant experience points towards a probability of failure of 1/10000 operations.	Ref 3	t/d	1.00E-04
NOTE 14	Incorrect operation or set up of the BOP. Prevention of this type of failure includes training of personnel and preventative maintenance programs. Assume (as per Ref 2) 1/100 faulty set up and 1/100 that the fault is not picked up by co-workers.	Ref 2	t/d	1.00E-04

Ref 1 Reliability and Maintainability in Perspective, Smith D, Higher and Further Education Division, Macmillan Publishers, 1985
Ref 2 Lees F P, Loss Prevention in the Process Industry, Butterworth, 1996
Ref 3 Data provided by Sydney Gas based on well operation experience
Ref 4 MOND Data (Reliability information from ICI's MOND Data Division)

7 REFERENCES

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2 Department of Infrastructure, Planning and Natural Resources, *Location Guidelines - Development in Vicinity of Operating Coal Seam Methane Wells*, May 2004

3 Department of Planning, *Hazardous Industry Planning Advisory Paper Nº 6: Guidelines for Hazard Analysis*; NSW Government, Sydney, 1992.

4 Department of Planning, *Hazardous Industry Planning Advisory Paper Nº 4: Risk Criteria for Land Use Planning*; NSW Government, Sydney, 1992.

5 *Quantitative Risk Assessment of Sydney Gas Company's Johndilo Pilot Plant Coal Bed Methane Project – Initial Assessment Phase*, McCracken Consulting, September 2000

6 Nilsson K, *Quantitative Risk Assessment of the Camden Gas Project Stage 2*, *Sydney Gas Operations Pty Ltd, Camden*, Planager Pty Ltd, November 2002

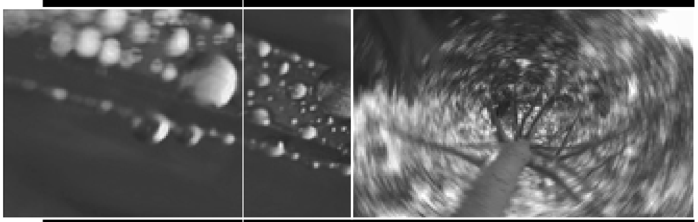
7 E*xpansion of Stage 2 of the Camden Gas Project,* HLA ENSR*,* September 2007

8 Health and Safety Executive, *Offshore Hydrocarbon Release Statistics 2001, Offshore Technology Report*, January 2002

9 *Information regarding ignition source probability and failure frequency*, File note Department of Planning, 10 March 2007

10 Bologna, S, Bobbio A, Tronci E, *Advanced techniques for safety analysis applied to the gas turbine control system of ICARO co generative plant*.

APPENDIX E



SUBSIDENCE REPORT

Camden Gas Project
Proposed Expansion of Stage 2

Report

on

**The Potential for
Coal Seam Methane Gas Extraction
to result in Subsidence at the Surface**

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**Report Number MSEC305
Revision C**

April 2007

Executive Summary

AGL Gas Production (Camden) Pty Limited (AGL) intends to apply for approval under Part 3A of the *Environmental Planning & Assessment Act 1979* (EP&A Act) to expand the Camden Gas Project through the development of additional well fields, including wells and supporting infrastructure.

The Concept Plan for the extension of Stage 2 of the Camden Gas Project extends from the suburbs of Narellan and Currans Hill in the north, to south of Menangle, extending across to Glen Alpine and Ambervale in the east, and Camden in the west. The Stage 2 Concept Application Area is shown in Figure 1, in Appendix C.

In addition, concurrent Project approval will be sought for the development of new well fields in Spring Farm and Menangle Park involving the development of well surface locations, gas gathering lines and access roads.

Four new well surface locations are proposed within the Spring Farm Project Area and twelve new well surface locations are proposed within the Menangle Park Project Area as shown in Figures 2 and 3, in Appendix C.

The proposed well surface locations will comprise a mix of vertical, directional and horizontal Surface to In-Seam (SIS) well heads. The wells will initially target coal seam methane in the Bulli Seam, though additional gas resources are believed to exist in the subsequent lower formations.

An Environmental Assessment Scoping Report (EASR) has already been submitted to the Department of Planning for review. The EASR is the first step in the application process and as part of this process a number of consultations have been held to canvass the views of stakeholders and the general public.

During the early consultations with members of the general public, a number of issues were raised including the potential for subsidence to occur at the surface as a result of coal seam methane extraction below ground.

AGL therefore commissioned Mine Subsidence Engineering Consultants Pty Ltd (MSEC), in February 2007, to study the proposals for coal seam methane extraction in the Camden area and to consider the potential for the coal seam methane extraction to result in subsidence at the surface. This report was prepared on completion of that study.

Chapter 2 of this report has addressed the methods of extraction that are proposed in the Spring Farm and Menangle Park areas. Sixteen new well surface locations are proposed (each comprising up to 6 individual wells), which will involve the drilling of boreholes up to 180 mm diameter from the surface into the coal seam or seams. The subterranean spacing of the bores will generally be more than 350 metres. Some of the vertical bores may be reamed out to 2 metres diameter within the seam. Other bores will use hydraulic fracturing techniques to facilitate the extraction of the gas.

Chapter 3 of this report has addressed the major causes of surface subsidence and has indicated that there are a number of activities and mechanisms that can cause subsidence. These have been provided to illustrate the general conditions that are necessary for subsidence to occur. Surface subsidence will not occur unless:

- Large voids are created in the strata by the mining or extractive activity, leading to subsequent collapse, consolidation and subsidence of the overlying strata.
- Large voids are created in the strata by the mining or extractive activity, leading to subsequent failure of remnant pillars and subsidence of the overlying strata.
- Unconsolidated beds of strata are present, which can subsequently be consolidated by the weight of the overburden, following the removal of interstitial fluids.

The proposed extraction of coal seam methane at Camden will not create large voids in the strata, nor leave remnant pillars. The strata within the coal measures are not unconsolidated and in fact are hard and well consolidated rocks. The conditions for significant subsidence to occur are not therefore present and it is concluded that the potential for subsidence to occur as the gas is extracted is almost negligible.

When coal waste gas is extracted by coal mining companies prior to mining, this is achieved by drilling horizontal gas drainage bores into the coal seam from the adjacent development headings, or roadways underground. The bores are generally 90 mm diameter and are drilled at very close centres. This is a much more invasive method than the method of gas extraction proposed within the Camden Gas Project and results in the creation of a considerably greater number of voids in the coal seam. It does not, however, result in any measurable subsidence at the surface, which provides further support to the above conclusion.

According to Gray, 1986, coal has been shown to shrink on desorption of gas and to expand again on resorption. It is possible therefore that there could be some shrinkage of the coal seam due to the extraction of the methane, but any shrinkage would be a matter of a few millimetres. Any subsidence that might occur at the surface, due to shrinkage of the coal seam, would, therefore, be negligible.

Contents

Chapter 1 Background

1.1 Coal Seam Methane Gas

Coal Seam Methane (CSM) is a natural gas, which was formed as a by-product during the process by which organic matter was turned into coal. The Sydney Basin, covering Sydney, Wollongong and Newcastle, holds vast coal resources and, therefore, very large amounts of CSM. The exploration for CSM resources and the subsequent extraction of the resources are controlled by the Department of Primary Industries, by the issue of exploration licences and production leases under the Petroleum (Onshore) Act, 1991.

1.2 The AGL and Sydney Gas Joint Venture

In November 2005, AGL entered into a joint venture agreement with Sydney Gas Limited (SGL) to participate in the development and production of coal seam methane gas.

The joint venture holds Petroleum Exploration Licences (PELs) 2, 4, 5 and 267 stretching from the Upper Hunter to the Southern Highlands of NSW. The joint venture also holds Petroleum Production Leases (PPLs) 1, 2, 4 and 5 in the Camden and Campbelltown area.

The boundaries of the PELs and PPLs are shown in Figure 1.1, below.

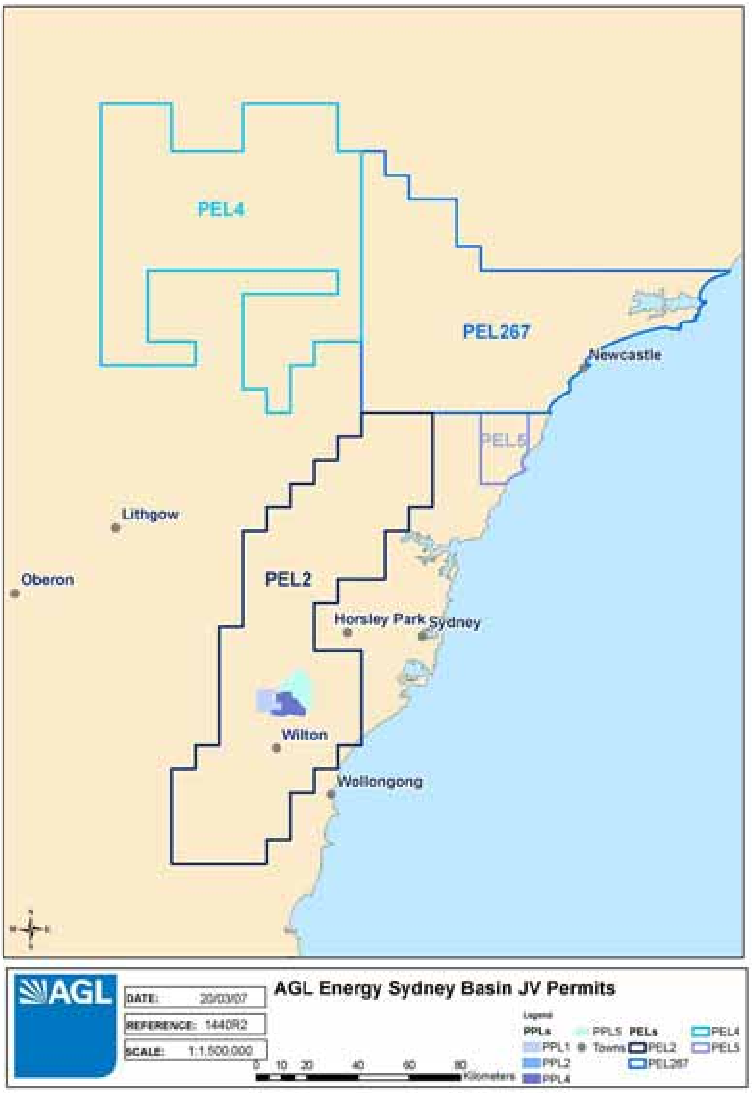

Figure 1.1 Petroleum Exploration Licence Areas in NSW

1.3 The Camden Gas Project

The Camden Gas Project is located 65 km southwest of Sydney, as shown in Figure 1.1, and involves the exploration for gas under Petroleum Exploration Licence 2 (PEL 2) and the production of gas from Petroleum Production Leases (PPLs) 1, 2, 4 and 5.

The project is a joint venture between AGL and Sydney Gas (Camden) Operations Pty Limited (SGL). SGL is responsible for the exploration component of the joint venture, while AGL is responsible for the development and production of the gas assets.

The Project currently consists of approximately 80 wells and the Rosalind Park Gas Plant south of Campbelltown where the gas is treated and compressed before it is sold into the Moomba – Sydney gas pipeline.

1.4 Proposed Expansion of Stage 2 of the Camden Gas Project

AGL has applied for Concept approval under Part 3A of the EP&A Act for the development of additional well fields, including wells and supporting infrastructure, as an expansion of Stage 2 of the Camden Gas Project.

In addition, concurrent Project approval will be sought for the development of new well fields in Spring Farm and Menangle Park involving the development of well surface locations, gas gathering lines and access roads.

An Environmental Assessment Scoping Report (EASR) was submitted to the Department of Planning in October 2006 for review. The EASR is the first step in the application process and as part of this process a number of consultations have been held to canvass the views of stakeholders and the general public.

1.5 Stage 2 Concept Approval

The concept plan, for the extension of Stage 2 of the Camden Gas Project extends from the suburbs of Narellan and Currans Hill in the north, to south of Menangle, extending across to Glen Alpine and Ambervale in the east, and Camden in the west. The Concept Plan area includes the proposed new well fields identified as Spring Farm, Menangle Park, Mount Gilead and Kay Park Stage II (see Figure 1 in Appendix C).

1.6 Spring Farm and Menangle Park Project Approval

Concurrent Project approval is also being sought at this stage for the construction of wells and the installation of gas gathering lines within the Spring Farm and Menangle Park well fields.

The area known as Spring Farm is located within the Camden LGA, approximately 65 km south west of Sydney, to the north of the existing well fields of Glenlee and EMAI Stages I and 2 (see Figure 1 in Appendix C). Up to four new well surface locations are proposed within the Spring Farm Project Area, as shown in Figure 2, in Appendix C.

The Menangle Park area falls within the Campbelltown LGA. The land is situated south of the proposed Spring Farm Project Area and is surrounded by the existing well fields of EMAI Stage 1, Menangle Park Stage 1, Glenlee, Sugarloaf Farm and Rosalind Park as shown in Figure 1, in Appendix C. Up to twelve new surface well locations are proposed within the Menangle Park Project Area, as shown in Figure 3, in Appendix C.

Each well surface location may contain up to six wells depending upon resources and environmental constraints. The proposed well surface locations will comprise a mix of vertical, directional and horizontal surface to inseam (SIS) well heads. The wells will initially target coal seam methane in the Bulli Seam, though additional gas resources are believed to exist in the subsequent lower formations.

1.7 The Geological Setting

Camden lies in the Southern Coalfield, which is located in the southern part of the Permo-Triassic Sydney Basin, within which the main coal bearing sequence is the Illawarra Coal Measures, of Late Permian age. The Illawarra Coal Measures contain a number of workable seams throughout the area, the uppermost of which is the Bulli Seam, which contains valuable coking coal resources and reserves of coal seam methane gas. Below the Bulli Seam are the Balgownie, Wongawilli, American Creek, Tongarra and Woonona Seams, which are also believed to contain reserves of coal seam methane resources. A typical stratigraphic section for the Southern Coalfield is shown in Figure 1.2.

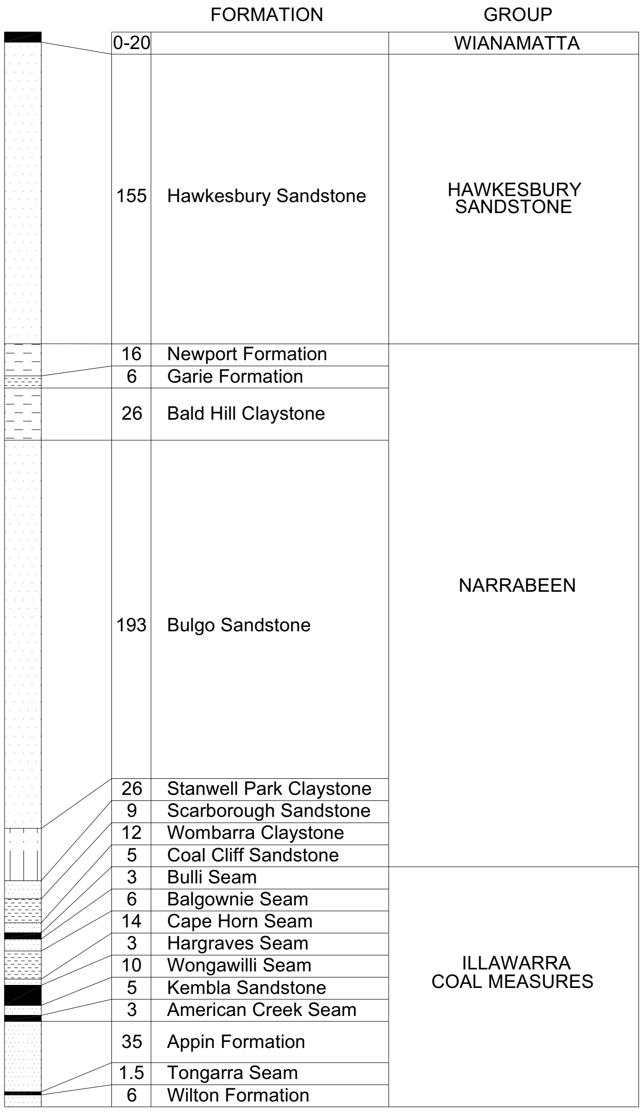

Figure 1.2 Typical Stratigraphic Section – Southern Coalfield

All of the sediments that form the overburden to the Bulli Seam belong to the Hawkesbury Tectonic Stage, which comprises three stratigraphic divisions. The lowest division is the Narrabeen Group, which is subdivided into a series of interbedded sandstone and claystone units. It ranges in age from Lower to Middle Triassic and varies in thickness up to 450 metres.

Overlying the Narrabeen Group is the Hawkesbury Sandstone Group, which is a series of bedded sandstone units which dates from the Middle Triassic and has a thickness of up to 185 metres.

Above the Hawkesbury is the Wianamatta Group, which consists dominantly of shales and siltstones with occasional sandstone interbeds. These sediments vary up to 90 metres thickness over the project area.

The major sandstone units are interbedded with other rocks and, though shales and claystones are quite extensive in places, the sandstone predominates. The major sandstone units are the Scarborough, the Bulgo and the Hawkesbury Sandstones and these units vary in thickness from a few metres to as much as 200 metres. The rocks exposed in the river gorges and creek alignments belong to the Hawkesbury Group.

The other rocks generally exist in discreet but thinner beds of less than 15 metres thickness, or are interbedded as thin bands within the sandstone.

1.8 The Basis of this Study

During the early consultations with members of the general public a number of issues were raised including the potential for subsidence to occur at the surface as a result of coal seam methane extraction below ground.

AGL therefore commissioned Mine Subsidence Engineering Consultants Pty Ltd (MSEC), in February 2007, to study the joint venture proposals for coal seam methane extraction in the Camden area and to consider the potential for the coal seam methane extraction to result in subsidence at the surface. This report was prepared on completion of that study.

As background to the project, MSEC was provided with a copy of a report entitled, "Environmental Assessment Scoping Report - Expansion of Stage 2 of the Camden Gas Project" (EASR), dated 19th October 2006, which was prepared by HLA-Envirosciences Pty Limited for AGL. Some of the background information given in the EASR has been relied on in the preparation of this report.

Further information regarding the Camden Gas Project has been obtained from the AGL website.

Chapter 2 The Extraction of Coal Seam Methane

2.1 Coal Seam Methane

As indicated in Chapter 1, Coal Seam Methane (CSM) is a natural gas, which was formed as a by-product during the process by which organic matter was turned into coal. CSM is also referred to as coal bed methane or coal seam gas.

If the gas is removed directly from underground coal mines as part of the mining process, it is called mine waste gas or coal mine methane. CSM is used in the same way as any other gas to power such things as barbecues, stoves, heaters and water heaters in homes and businesses and is also used as a direct source of power for industry and as a fuel for electricity generation.

Unlike conventional natural gas reservoirs, where gas is trapped in the pores or void spaces of a rock such as sandstone, shale or limestone, methane trapped in coal is adsorbed onto the coal surface (cleats and joints) or micropores and is held in place by reservoir (water) pressure. Hence the coal is both the source and the reservoir for the methane.

Because the micropore surface area is very large, coal can potentially hold significantly more methane per unit volume than most conventional reservoirs, making the Sydney Basin's coal seams an excellent source of fuel and energy. Coal generally has lower permeability, however, than conventional reservoirs and the rates of production are usually lower. In order to achieve optimal production rates, it is generally necessary to stimulate the coal reservoirs by fracture stimulation.

A photograph of a typical rehabilitated wellhead is shown in Plate 1.

Plate 1. Typical Rehabilitated Wellhead

2.2 Drilling Activities

There are a variety of technologies used for the drilling of wells, taking into consideration land access constraints, aboriginal/heritage and other environmental issues and geological technical issues. A summary of the different methods that are available for drilling wells in Stage 2 of the Camden Gas Project is provided, below.

Underbalanced Vertical Drilling

- This is the traditional method used in the Camden programme and currently represents 95% of wells drilled;
- Penetration rates are maximised through shallow abrasive sands of medium hardness by underbalanced percussion drilling;
- Drilling rates of 300 metres per day or more can be achieved;
- Requires a drilling rig equipped with 2 air compressors and booster package for fluid circulation. Drilling action employed uses a percussion air hammer, button bit and drill collars to provide the impacts to break up formations.

Overbalanced Vertical Drilling

- Allows drilling of wells where land access constraints or environmental features limit the use of drill pits.
- Improvements are being made to the rate of penetration to a level which is comparable with underbalanced drilling.
- Equipment includes a drilling rig and equipment required to focus on drill fluid circulation and solid control systems with an operating capacity of 1800 litres per minute. The drilling relies on applied weight on bit and rotation to penetrate and remove formations. Weight is provided by running drill collars behind the bit with rotation provided by the rig's top drive or a downhole motor.

Directional Drilling

- The major advantage of directional drilling is that bottom hole locations can be located up to 400 metres away from the surface location, depending on the vertical depth of the seam. Therefore, wells can be drilled into areas that do not permit a vertical well intersecting a desired target.
- Multiple wells can be drilled from a single location and gas reserves that are stranded by surface developments can be accessed from outside the developed areas.
- Similar surface equipment is required to that used for overbalanced drilling, however directional equipment is added to the downhole equipment to allow control of drilling angle and direction.

Surface to Inseam (SIS) or Horizontal Drilling

- The well is drilled vertically from the surface and gradually builds angle so as to intersect the seam near parallel with the seam dip angle. Once intersected, this portion of the well bore is cased, cemented and a smaller hole is subsequently drilled through the seam for up to some 2000 metres.
- Horizontal wells are used to increase the drainage area of a reservoir and provide a means of stimulating the reservoir through the drilling process.
- If this technique is successful in Camden (3 trial wells have been established), the number of surface locations would potentially be reduced along with the ability to extract inaccessible gas reserves more than 1500 metres away from the well site location.
- This technique is more complex and requires drilling operations to be conducted 24 hours a day, 7 days a week for certain sections of the well.

2.3 Fracture Stimulation

Upon completion of drilling, the well is cased off with steel casing which is pressure cemented in place to ensure zonal isolation behind the pipe. The well is then perforated across the selected coal seam intervals and is subsequently fracture stimulated (known as 'fracing') through the injection of a slurry of sand and water at sufficient pressure to create a conductive pathway into the coal reservoir.

This process mechanically stimulates the gas-bearing zone to facilitate the mobility of the gas and water from the coal seam, allowing the gas and water to flow up the well bore to the surface.

Following fracing, the waters are removed from the coal seam either to future drilling and fracing campaigns or are transported to licensed disposal facilities due to the saline nature of the formation waters mixed with the fracing water.

Dewatering pumps are used in approximately 20% of wells to remove the injected fracture stimulation water and the formation water, which reduces reservoir pressure and allows gas desorption of the coal seam methane wells.

Chapter 3 Surface Subsidence

3.1 The Major Causes of Surface Subsidence

Surface subsidence can be caused by a number of activities and mechanisms, the most common being:

- Underground coal extraction.
- Underground mineral extraction.
- Pumping of oil and gas from underground reservoirs.
- Dewatering of sandy or fissured subsoils.
- Withdrawal of geothermal fluid.
- Erosion or leaching of fine particles in the surface soils and underlying rocks.
- Swelling and Shrinkage of cohesive subsoils due to changes in moisture content.

Surface subsidence occurs due to the removal or displacement of solid or liquid materials below ground and the consequential creation of voids or change in hydrostatic pressure, which result in subsidence of the overlying strata. The amount of subsidence that is likely to develop is dependent upon the nature of the surface soils and underlying strata and the extent of the underground voids that are created by mining and other activities.

Generally, when coal or other minerals are extracted below ground, as the volume of extraction increases the amount of subsidence also increases. The extent of the subsidence is, however, dependent upon the sizes and distribution of the voids that are left and the capacity of the overlying strata to bridge the voids.

3.2 Underground Coal Extraction

In underground mines, coal has generally been extracted using bord and pillar mining methods, employing continuous miners, or longwall mining methods, which require very expensive longwall face equipment. Most modern coal mines today use longwall mining techniques, which allow greater efficiency in the extraction of the coal resources. These methods of coal mining are described below.

Bord and Pillar Mining

Fig. 3.1 shows an idealised layout of a mine using the bord and pillar method of extraction.

In this method, a series of parallel tunnels, referred to as headings, is driven into the coal seam from the mine entrance using mining machines, known as continuous miners. As the coal is removed it is transferred by shuttle cars to belt conveyors, which carry the coal out of the mine.

This leaves the strata in the roof above the seam supported on a regular distribution of coal pillars, though in some mines the sizes and shapes of the pillars were in fact quite irregular.

The extent to which the coal in these districts is removed is dependent upon the amount of mine subsidence that is permitted above the extracted area. Figure 3.1 shows three alternative options in this regard. If no subsidence is permitted, then all of the pillars are left in place. If a small amount of subsidence is permitted, then alternate rows of pillars can be removed. If a greater amount of subsidence is permitted, then, wide panels of coal can be extracted by removing several rows of pillars.

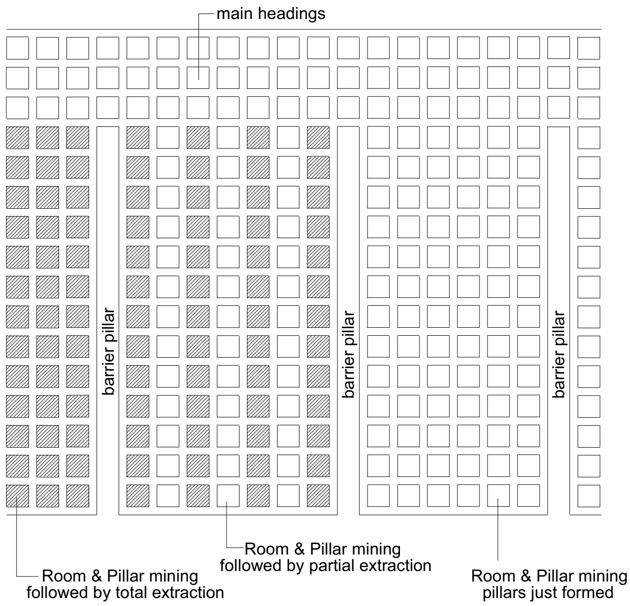

Figure 3.1 Typical Layout of a Bord and Pillar Mine

Longwall Mining

In longwall mining, a panel of coal, typically around 150 to 400 metres wide, 1000 to 4000 metres long and 2 to 5 metres thick, is totally removed by longwall shearing machinery, which travels back and forth across the coalface.

The area immediately in front of the coalface is supported by a series of hydraulic roof supports, which temporarily hold up the strata in the roof above the seam and provide a working space for the shearer and face conveyor. A typical section through coal face is shown in Figure 3.2.

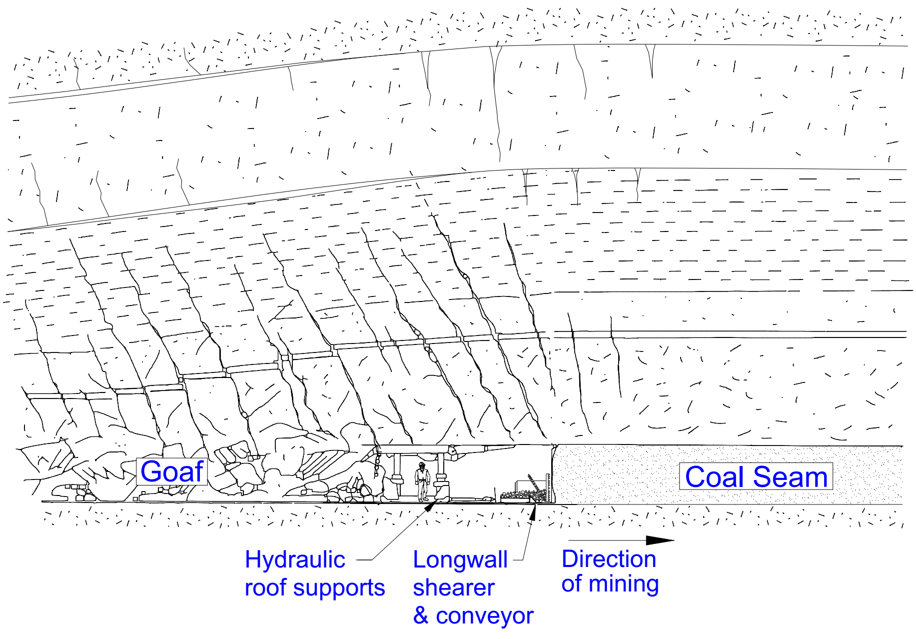

Figure 3.2 Cross Section of a Typical Longwall Face

The shearer cuts a slice of coal from the coalface each time it passes and this falls onto an armoured plate conveyor, which runs along the full length of the coalface. At the end of the coalface, the armoured plate conveyor discharges onto a belt conveyor that carries the coal out of the mine.

When coal is extracted using this method, the roof immediately above the seam is allowed to collapse into the void that is left as the face retreats. This void is referred to as the goaf. Miners working along the coalface, operating the machinery, are shielded from the collapsing strata by the canopy of the hydraulic roof supports.

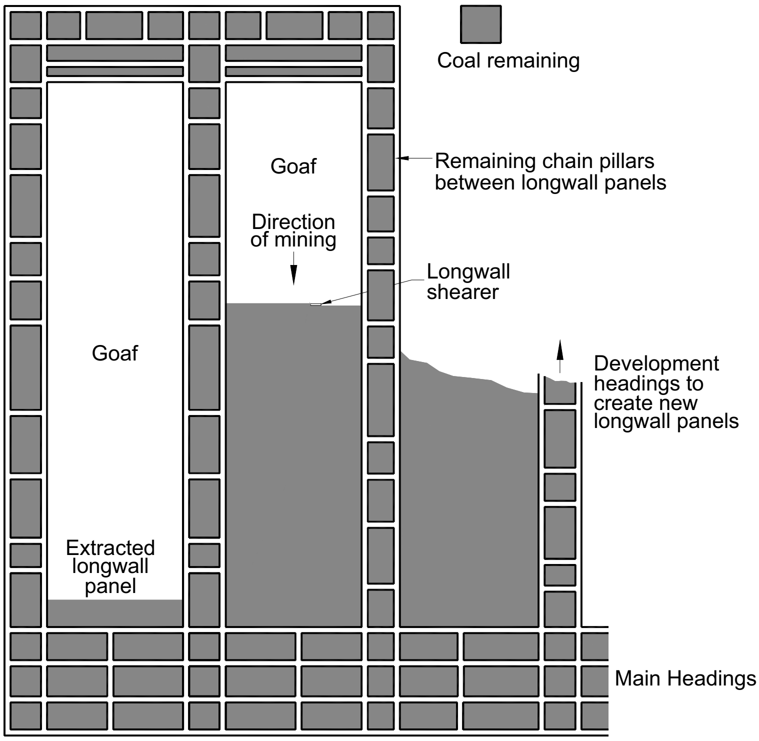

Figure 3.3. Typical Plan View of a Series of Longwall Panels

Figure 3.3 shows a typical layout of a group of longwalls. Before the extraction of a longwall panel commences, continuous mining equipment extracts coal to form roadways, which are known as headings, around the longwall panel. These roadways form the mine ventilation passages and provide access for people, machinery, electrical supply, communication systems, water pump out lines, compressed air lines and gas drainage lines.

The roadways, which provide access from the mine entrance to the longwalls, are referred to as the main headings. Once the main headings have been established additional roadways, known as development headings, are driven on both sides of the longwall panel and are connected together across the end of the longwall.

As the coal is extracted, the overlying strata are allowed to collapse into the void behind the face. Miners working along the coalface, operating the machinery, are shielded from the collapsing strata by the canopy of the hydraulic roof supports. As the roof collapses into the goaf behind the roof supports, the fracturing and settlement of the rocks progresses through the overlying strata and results in sagging and bending of the near surface rocks and subsidence of the ground above, as illustrated in Figure 3.2.

If the width of an extracted panel of coal is small and the rocks above the seam are sufficiently strong, it is possible that the overlying strata will not collapse and hence no appreciable subsidence will occur at the surface. However, to maximise the utilisation of coal resources and for other economic reasons, wide panels of coal are generally extracted and, in most cases, the roof is unable to support itself.

As the immediate roof strata, i.e. the rocks immediately above the seam, collapse into the goaf, the rocks above them lose support and sag to fill the void beneath them. The mechanism progresses towards the surface and the affected width increases so that at the surface, an area somewhat larger than the extracted panel of coal undergoes settlement.

The subsidence of the surface is considerably less than the thickness of coal removed, due to the voids that are left within the collapsed strata. The extent of the settlement at the surface is therefore dependent upon the strength and nature of the rocks overlying the coal seam and is a direct function of their capacity to bridge over the voids.

Subsidence impacts at the surface are determined by the relationships between the subsidence to seam thickness ratio (S/M) and the width to depth of cover ratio (w/h) and vary from coalfield to coalfield. The subsidence in each case is determined by the strengths of the rocks in the overburden to the coal seams. Where the overburden is strong, the rocks are able to span further before subsidence is initiated and the amount of subsidence is reduced. In all cases, where the width of extraction is small, the subsidence is generally negligible.

The methods of coal extraction described above are generally used in New South Wales where the coal seams are relatively flat. Not all coal deposits, however, occur in flat seams and in some countries, such as Spain and Korea the coal seams are so steeply folded and undulating in nature that normal methods of extraction cannot be employed. In those circumstances the methods used are similar to those used in extracting other mineral deposits.

In the Southern Coalfield of New South Wales, the extracted thickness of the coal seams generally varies from 2 metres to 3.5 metres. The depth of cover varies from approximately 400 metres to 650 metres and the longwall widths vary from approximately 250 metres to 320 metres. The maximum subsidence at the surface therefore varies from 600 mm to 1500 mm, depending on the mining geometry.

This subsidence occurs because large quantities of coal are extracted using the longwall mining process, leaving large voids into which the strata above the seam is allowed to collapse, with consequential sagging of the strata that are closer to the surface.

Quite clearly, there is no comparison between the surface subsidence impacts of the longwall mining operation, which extracts the coal seam and the coal seam methane extraction operation, which simply releases the gas from the coal seam.

3.3 Underground Mineral Extraction

The extraction of minerals underground is dependent upon the form and distribution of the mineral body. Some minerals such as rock salt and phosphate are present in sedimentary deposits and occur in relatively flat seams similar to coal seams. The effect of mining these can be compared directly with the effects of coal mining.

Rock salt in the United Kingdom was generally mined using bord and pillar methods, leaving the pillars in place as permanent roof supports and this did not result in any significant subsidence, even though large voids were left in the strata. In some cases, however, solution mining has been used for the extraction of rock salt, with the consequential development of sinkholes.

In other cases ground water movements have affected the long-tern stability of rock salt pillars causing pillar failure and consequential subsidence.

Phosphate mining has also generally been carried out using bord and pillar or longwall techniques, with limited subsidence in some cases. Mining at Boulby Phosphate Mine, near Whitby in North Yorkshire, UK, was carried out using solution mining techniques and large voids were formed by removal of the phosphate, resulting in surface subsidence. This can be equated to longwall mining or the removal of pillars in bord and pillar mining.

Metaliferous mining generally uses different techniques to remove bodies of ore which are of irregular form within igneous rocks. In these circumstances the ore is generally extracted using sublevel caving techniques. In this method, intermediate levels divide a deposit into horizontal slices, which are then blasted down from the bottom up on an angled front.

Two other methods which belong in this category are open-stope caving and block caving, both of which have been used in ore mining. The first of these, adopted in steep dipping deposits, having a certain minimum strength of wall rock, provides for an underground excavation, or open stope, over 15 metres high, from which the mineral is worked laterally by caving at several sub-levels, to be collected at a lower level for hauling to the surface.

In block caving, a massive ore body of considerable height is freed from the host rock surrounding its vertical sides, is undercut across its entire base, and is then brought down in sections from lower levels by shot firing and gravity.

This is similar to the procedure followed, with comparatively thin horizontal slices, in sublevel caving. In the latter method, as caving progresses upwards to the roof the waste rock and the main body of overlying strata follow the collapsing ore down forming subsidence troughs or trenches at the surface, which can be several metres deep.

3.4 Pumping of Oil and Gas from Underground Reservoirs

The pumping of oil and gas from conventional underground deposits, usually sandstone, shale or limestone, can result in subsidence of the ground surface if the nature of the strata is such that support of the overburden is reduced by the process. This depends upon the nature of the oil and gas reservoir and the surrounding and overlying strata. Subsidence of this type is generally greatest at the oil well and spreads laterally for a considerable distance.

By way of example, the maximum subsidence at the Wilmington Oil Field, which is the third largest oil field in the USA, was reported to be almost 9 metres. Similarly the maximum subsidence at the Ekofisk Oil Field in the North Sea was reported in 1985 to be 2.6 metres.

The subsidence depression was indicated to be approximately 6km long and 4km wide, which resembles the size and shape of the underlying reservoir 3km below. This type of subsidence can be reduced by replacing the extracted oil with water.

The extraction of coal seam methane gas is, however, quite different, because unlike conventional natural oil and gas reservoirs, where the oil and gas are trapped in the pores or void spaces of a rock such as sandstone, shale or limestone, methane trapped in coal is adsorbed onto the coal surface and is released without significant change in the volume of the coal seam.

3.5 Dewatering of Sandy or Fissured Subsoils

The pumping of water from competent sandstone beds beneath the surface does not normally result in subsidence movement at the surface.

The pumping of water from unconsolidated sandy and fissured subsoils, however, can result in significant subsidence at the surface due to drawdown of the water table.

For example, Mexico City is founded on water bearing alluvial deposits, which have provided a supply of water to the city for many years. The extraction of water from the underlying aquifer, however, has resulted in considerable subsidence of the surface.

According to the Mexico Valley Water Authority, the net subsidence over the last 100 years has lowered the central, urbanized area of the city by an average of 7.5 meters. The result has been extensive damage to the city's infrastructure, including building foundations and the sewer system.

In this case, the subsidence is caused by the loss of support to the unconsolidated water-bearing strata, which was provided by the hydrostatic pressure of the groundwater.

The extraction of coal bed methane gas is, however, quite different, because it is extracted from the relatively hard and consolidated coal seam and the process does not significantly affect the water table.

3.6 Withdrawal of Geothermal Fluid

It was reported in 1975 that the withdrawal of fluid from the geothermal field at Wairakei on the North Island of New Zealand had resulted in subsidence of 4.5 metres, with accompanying horizontal ground displacements of up to 0.5 metres.

The area affected was apparently approximately 3 square kilometres and was located essentially over the main geothermal reservoir, which had a thickness of 370 metres to 790 metres.

The cause of subsidence was attributed to volume changes in the reservoir undergoing depletion of geothermal fluid storage, coupled with thermal contraction.

The extraction of coal bed methane gas is, however, quite different, because it is extracted from the relatively hard and consolidated coal seam, the volume of which is not significantly reduced as the methane is desorbed.

3.7 Drainage of Organic Soils

Subsidence can occur due to the drainage of organic soils such as peat beds, which have a naturally high void ratio and high water content, when submerged. Subsidence rates are determined by the nature of the peat, the depth to the water table and the temperature. Subsidence tends to occur at a faster rate in warmer regions when compared to similar deposits in cooler climates.

Drainage of some of the fen lands in England has resulted in almost 3.5 metres of subsidence since drainage began in the 17^{th} century. The extent of the subsidence is dictated by the nature of the peat and its ability to consolidate as the water is removed from the voids within it.

3.8 Erosion or Leaching of Fine Particles in the Surface Soils and Underlying Rocks

In many cases the flow of water through the ground results in the leaching and erosion of soil and rock particles and the formation over time of underground water paths, tunnels and caves. This often occurs in limestone rocks creating large and extensive cave systems. In some case the caves expand in size, by scouring to the point where the overlying rocks can no longer span the voids and sinkholes develop through to the surface. There are many examples of this type of subsidence, which results in sinkholes that are many metres in depth. The major reason for the subsidence is the presence of large voids in the strata as the materials from the voids are washed away downstream.

The extraction of coal bed methane gas is, however, quite different, because it does not result in the extraction of solid particles from the coal seam or the formation of significant voids.

3.9 Swelling and Shrinkage of Cohesive Subsoils due to Changes in Moisture Content

It is well known that certain reactive clays swell and shrink in response to moisture changes. These effects are greatest close to the surface, where the clay is less confined by overburden and where the moisture can be more quickly reduced by evaporation.

Reduction in the moisture content of the clay results in subsidence at the surface. As an example, a clay bed 1.5 metres thick at Beaudesert in South Queensland was calculated to swell or shrink by up to 100mm due to seasonal drying and wetting.

This problem is often exacerbated by the presence of tree roots, which absorb the moisture from the clay, causing ground movement. This is one of the primary causes of damage to building foundations in urban environments.

3.10 Conclusion

Conventional reservoirs have oil and/ or gas trapped within sandstones, shales or limestones. Some formations such as friable or unconsolidated sands and high porosity vugular limestones rely on the presence of fluids or gas pressurising the formation to stop compaction of the weak rocks. As coal stores gas differently to conventional reservoirs, sandstones, shales or limestones, it does not rely on the presence of gas to provide support to the strata, thus any removal of gas will not alter the competency of the rock to cause large scale compaction. Coal seam gas is also referred to as unconventional gas as it is not found in a conventional reservoir.

Chapter 4 The Potential for Coal Seam Methane Gas Extraction to result in Subsidence at the Surface

4.1 The Project

Chapter 1 of this report has outlined the proposal to extend Stage 2 of the Camden Gas Project and has identified that the proposal involves the installation of additional gas wells in the Spring Farm and Menangle Park areas for the extraction of coal seam methane. The proposed wells will comprise a mix of vertical, directional and surface to inseam (SIS) or horizontal drilled wells, and the well surface locations that are illustrated in HLA Figures 5 and 6 in Appendix C are only indicative. The wells will initially target coal seam methane in the Bulli Seam, though additional gas resources are believed to exist in the subsequent lower formations.

4.2 The Gas Wells

Chapter 2 of this report has addressed the methods of extraction that are proposed in the Spring Farm and Menangle Park areas as an extension to Stage 2 of the Camden Gas Project. Up to sixteen new well surface locations are proposed (each of which may contain up to 6 individual wells), which will involve the drilling of boreholes up to 180 mm diameter from the surface into the coal seam or seams. The subterranean spacing of the wells will generally be more than 350 metres. Some of the vertical wells may be reamed out to 2 metres diameter within the seam. Other wells may use fracture stimulation techniques to facilitate the extraction of the gas.

The well bores will be cased and sealed, particularly through aquifers closer to the surface to prevent hydraulic linkage between aquifers at different levels in the strata. It should also be noted that coal seams are confined aquifers and that dewatering has little effect on the surrounding aquifers.

4.3 Surface Subsidence

Chapter 3 of this report has addressed the major causes of surface subsidence and has indicated that there are a number of activities and mechanisms that can cause subsidence. These have been provided to illustrate the general conditions that are necessary for subsidence to occur. Surface subsidence will not occur unless:

- Large voids are created in the strata by the mining or extractive activity, leading to subsequent collapse, consolidation and subsidence of the overlying strata.
- Large voids are created in the strata by the mining or extractive activity, leading to subsequent failure of remnant pillars and subsidence of the overlying strata.
- Unconsolidated beds of strata are present, which can subsequently be consolidated by the weight of the overburden, following the removal of interstitial fluids.

4.4 The Potential Surface Impacts of the Coal Seam Methane Extraction at Camden

The proposed extraction of coal seam methane at Camden will not create large voids in the strata, nor leave remnant pillars. The strata within the coal measures are not unconsolidated and in fact are hard and well consolidated rocks. The conditions for significant subsidence to occur are not therefore present and it is concluded that the potential for subsidence to occur as the gas is extracted is almost negligible.

When coal waste gas is extracted by coal mining companies prior to mining, this is achieved by drilling horizontal gas drainage bores into the coal seam from the adjacent development headings, or roadways. These bores are generally 90 mm diameter and are drilled at very close centres, which is a much more invasive method than the method of gas extraction proposed within the Camden Gas Project and results in the creation of a considerably greater number of voids in the coal seam. It does not, however, result in any measurable subsidence at the surface, which provides further support to the above conclusion.

It should be noted that coal mine degasification works are regularly undertaken beneath established urban areas and result in negligible subsidence impact on the existing surface infrastructure.

According to Gray, 1986, coal has been shown to shrink on desorption of gas and to expand again on resorption. Gray noted that Hargraves, 1963, had conducted a series of tests on coal from Metropolitan Colliery, New South Wales, Australia, which showed an average linear strain of 0.00182, per MPa change in equivalent sorption pressure, using CO_2 as the gas. Japanese workers showed a similar but lesser effect using methane on coal from the northern Ishikari coal field in Hokkaido. Their average value was 0.000125 linear strain, per MPa, which is more than an order of magnitude less.

It is possible therefore that there could be some shrinkage of the coal seam due to the extraction of the methane, but at such low strain values any shrinkage would be a matter of a few millimetres. Any subsidence that might occur at the surface due to shrinkage of the coal seam would, therefore, be negligible.

Appendix A Glossary of Terms and Definitions

Glossary of Terms and Definitions

Some of the mining terms used in this report are defined below:

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections.
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel.
Face length	The width of the coalface measured across the longwall panel.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Overlap adjustment factor	A factor that defines the ratio between the maximum incremental subsidence of a panel and the maximum incremental subsidence of that panel if it were the first panel in a series.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e. from rib to rib.
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points.
Sub-critical area	An area of panel smaller than the critical area.
Subsidence	The vertical movement of a point on the surface of the ground as it settles above an extracted panel.
Super-critical area	An area of panel greater than the critical area.
Tilt	The difference in subsidence between two points divided by the horizontal distance between the points.
Uplift	An increase in the level of a point relative to its original position.
Upsidence	A reduction in the expected subsidence at a point, being the difference between the predicted subsidence and the subsidence actually measured.

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Appendix C Drawings

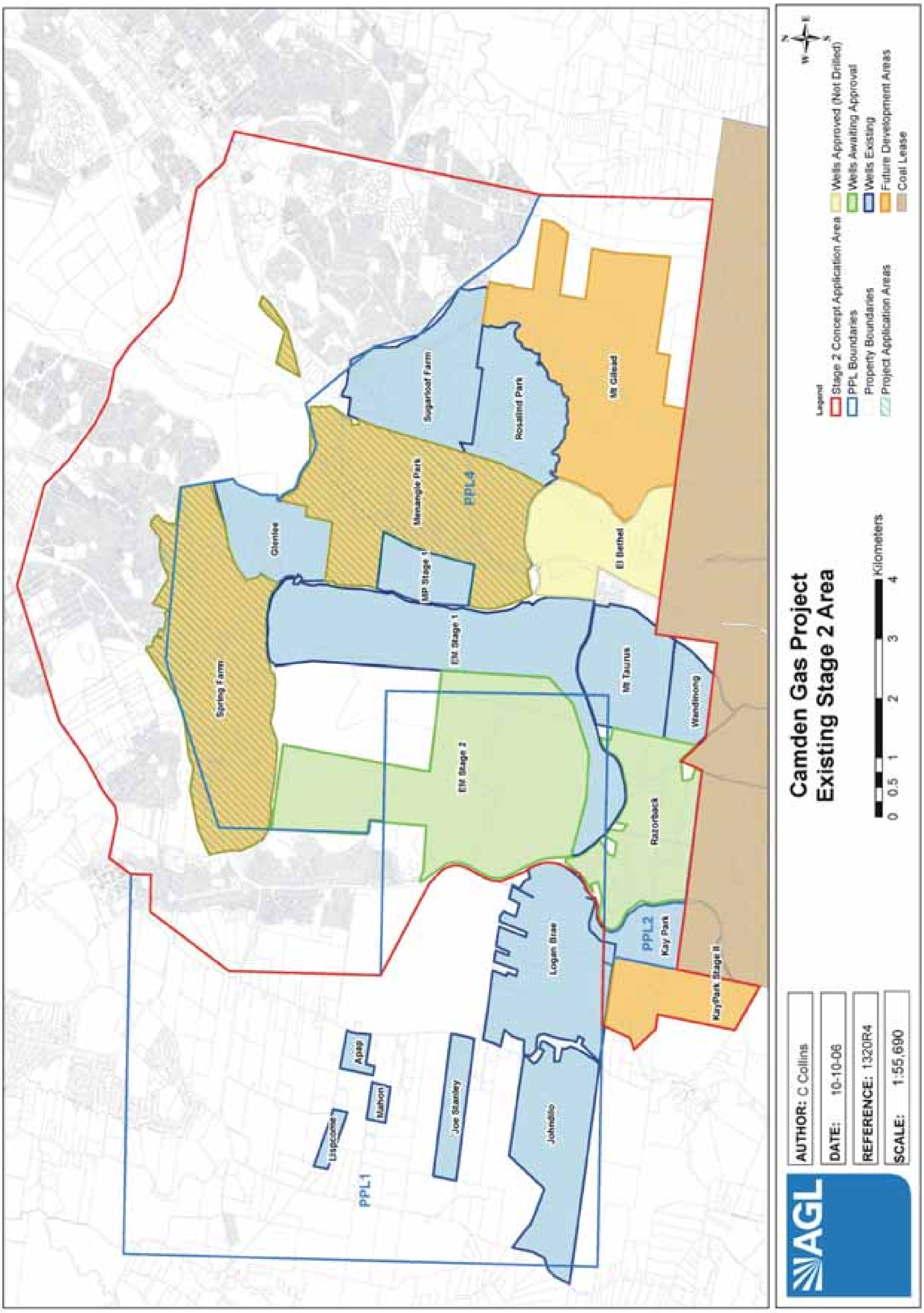


Figure 1. Camden Gas Project Stage 2 Concept Plan

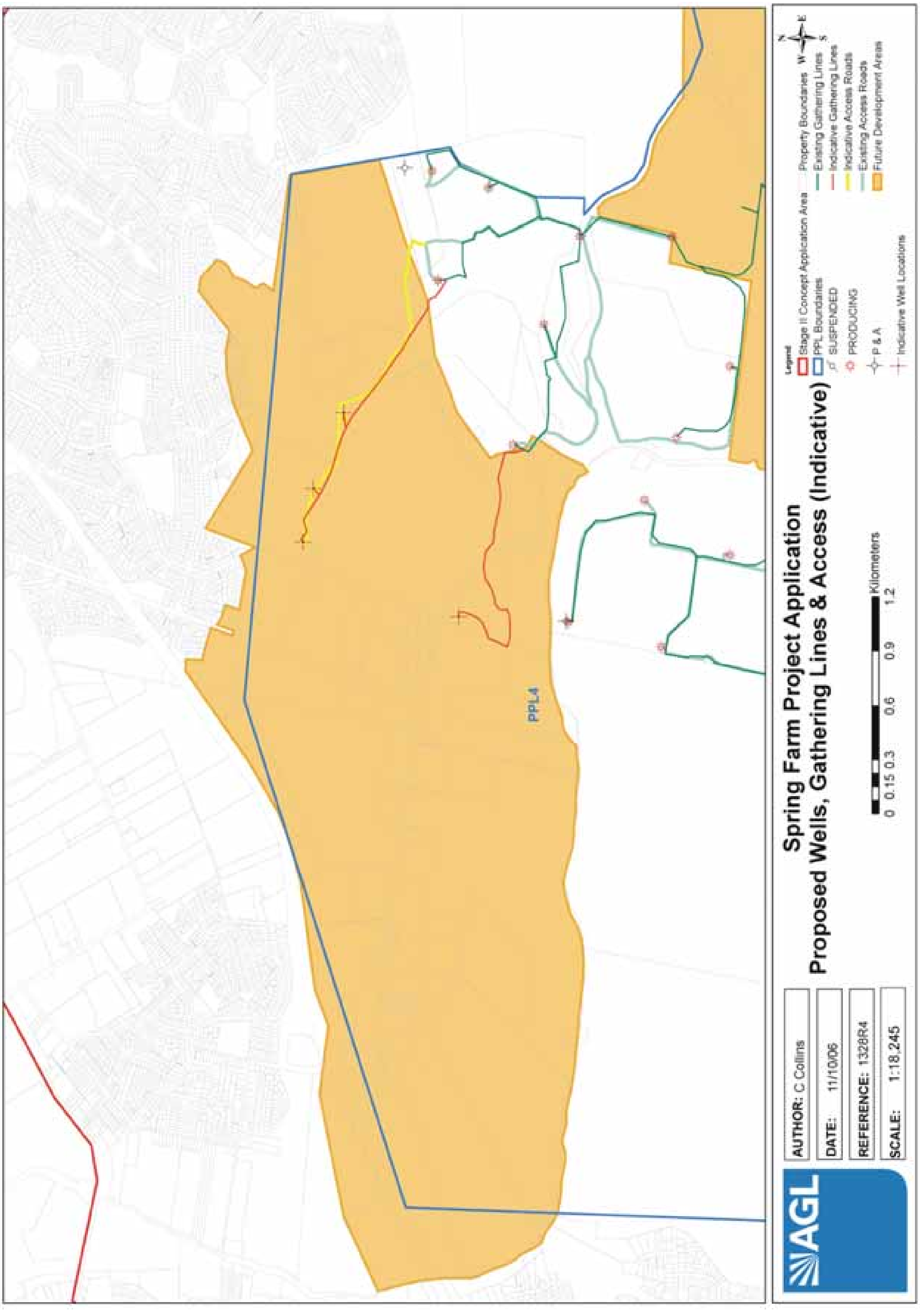


Figure 2. Proposed Gas Wells in the Spring Farm Area

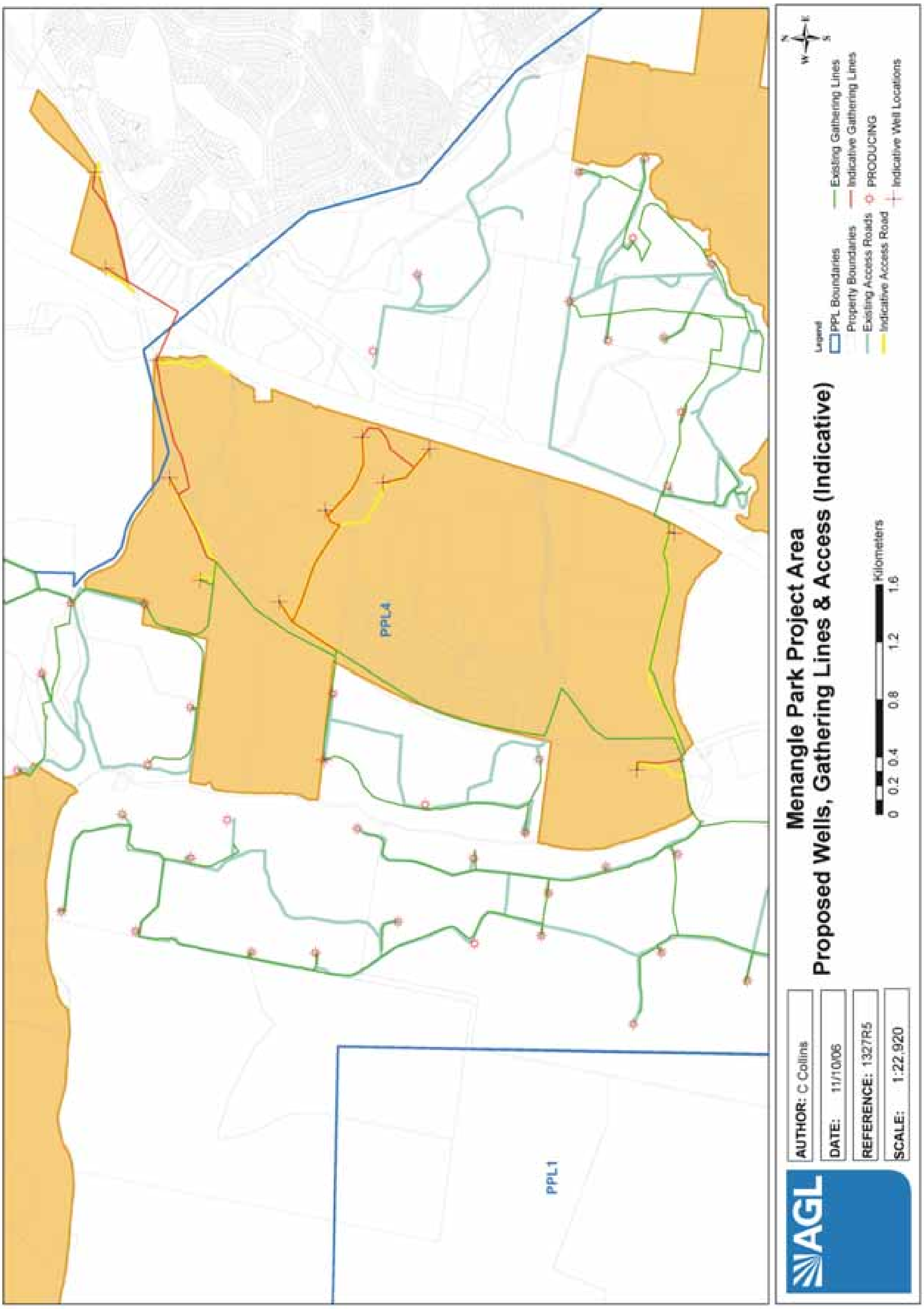
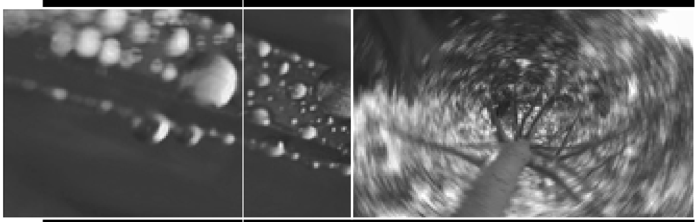


Figure 3. Proposed Gas Wells in the Menangle Park Area



APPENDIX F

CONSTRUCTION AND OPERATIONAL NOISE ASSESSMENT

CAMDEN GAS PROJECT EXPANSION: STAGE 2 CONCEPT PLAN, SPRING FARM & MENANGLE PARK PROJECT APPLICATIONS

CONSTRUCTION & OPERATIONAL NOISE ASSESSMENT

ACOUSTICS AND AIR

REPORT NO. 06151

WILKINSON MURRAY

CAMDEN GAS PROJECT EXPANSION: STAGE 2 CONCEPT PLAN, SPRING FARM & MENANGLE PARK PROJECT APPLICATIONS

CONSTRUCTION & OPERATIONAL NOISE ASSESSMENT

REPORT NO. 06151

JUNE 2007

PREPARED FOR

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ACOUSTICS AND AIR

TABLE OF CONTENTS

1 INTRODUCTION

AGL Gas Production (Camden) Pty Limited operates the Camden Gas Project, which is located 65km southwest of Sydney in the Southern Coalfield of the Sydney Basin. AGL is proposing a Concept Plan covering the remaining works in the Stage 2 area concurrently with a Project application for up to 16 well surface locations at Spring Farm and Menangle Park. The project also includes the construction of gas gathering lines, water transfer lines and access roads.

An Environmental Assessment (EA) is being prepared on behalf of AGL to assess the potential environmental impacts of the proposed development and to support an application for approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This noise assessment has been prepared to specifically address the potential noise impacts of the proposal.

1.1 Approvals Process

AGL's Part 3A Major Project application has two components. Concept approval is being sought for works within Stage 2 of the Camden Gas Project, and concurrent Project approval is being sought for specific works within the Spring Farm and Menangle Park Project Areas.

Project approval is being sought for the development of up to 16 well surface locations and associated infrastructure (gas gathering and water transfer lines and access roads) within the Spring Farm and Menangle Park areas.

The Concept Plan is discussed in Section 10 and some recommendations are made to guide the preparation of future project proposals from a noise perspective. Any activity covered by the Concept Plan will be subject to future application and a more comprehensive environmental assessment.

1.2 Assessment Scope

This report considers the following potential environmental noise impacts:

- Noise from construction of the gas wells (in accordance with the criteria nominated in the NSW Department of Environment & Climate Change (DECC) *Environmental Noise Control Manual (ENCM)*)
- Noise from the construction of the gas gathering systems, water drainage lines and access roads (in accordance with the *ENCM*)
- Operational noise from the proposed well surface locations (in accordance with the DECC's *NSW Industrial Noise Policy (INP)*)
- Traffic noise (in accordance with the DECC's *Environmental Criteria for Road Traffic Noise (ECRTN)*)

Vibration from the construction sites rarely exceeds the criteria for human comfort at distances greater than 100m, even for the most impulsive equipment such as excavator mounted rock breakers and vibratory rollers. Due to the distance of the proposed surface locations to residences, vibration levels from construction sites will not be an issue, therefore a detailed assessment of vibration impacts is not required.

During the operational phase of the wells the main potential source of vibration would be pump assisted wells wherever they are used, however, they would not cause vibration above the criteria for human comfort beyond the boundary of the well surface location. Therefore any potential vibration will be satisfactory at any receiver before or after urban land releases.

In both Project Areas there are new land release areas proposed near the well surface locations of a residential, commercial or industrial nature. The implications of this Project on these future land uses are also discussed.

1.3 Assessment Approach

The approach adopted for the assessment involves describing the types of activities that may occur within the area and identifying the potential impacts. Project approval is being sought for the proposed works within Spring Farm and Menangle Park, for which proposed well surface locations are shown.

Some of the well surface locations are indicative to ensure any site constraints can be managed and to give AGL the flexibility to work with landowners and any future land uses. An envelope approach has been taken to the assessment of all the proposed works so that the final well surface locations can be within a 50m radius of the crosshair in the case of Spring Farm and a 100m radius of the crosshair in the case of Menangle Park. The result is an envelope surrounding the well surface location within which the potential noise impacts of the well would be within identified noise criteria.

The well surface locations could therefore be sited anywhere within this 50-100m envelope area in the knowledge that noise impacts upon surrounding receivers would be acceptable. This envelope may be further expanded with the implementation of mitigation measures as recommended by this report.

A similar envelope approach has been taken to the assessment of the routes for gas gathering lines and access roads, so that the routes can be moved up to 25m either side of the proposed route.

The worst-case scenario assessed for noise impacts is drilling of up to six Surface to Inseam (SIS) wells at a single surface location and the fracture stimulation of wells. An SIS well typically involves continuous 24-hour drilling over a period of approximately 25 days per well. Fracture stimulation or fracing involves the injection of a slurry of sand and water at high pressure into the coal seam to create a conductive pathway for the gas to flow into the well. The fracing process typically takes up to one day for each well.

As the overall construction process may take more than six months for up to six SIS wells to be drilled at the one surface location, the assessment has been conducted on the basis of more than six months and up to 12 months.

The construction process is staged. Various activities are necessary for the establishment of the site, of which well drilling is the loudest. Drilling would only occur for approximately half of the total time at any site.

The noise assessment has therefore been undertaken on the basis of up to six SIS wells at each well surface location. It should be noted that this is unlikely to be the final well configuration at every location. By demonstrating that up to six SIS wells can be drilled so that noise criteria are met at all receivers, the assessment also demonstrates that vertical or directional wells would also not result in any unacceptable noise impacts. The drilling of SIS wells requires mud drilling, which is the loudest drilling that would be employed at any surface location in this study and as air drilling is quieter than mud drilling, noise from air drilling will comply.

This report assesses the impact of the proposed works within the Spring Farm and Menangle Park Project Areas and gives an overview of the potential noise issues that are likely to arise from activities under the Concept Plan.

2 OVERVIEW OF ACOUSTIC ISSUES

2.1 Construction Noise

The most significant noise emissions from this project are from construction noise. The major features of the construction phase of the project likely to generate noise impacts include:

- Drilling of wells;
- Fracture stimulation of the coal seam (fracing) where required; and
- Earthmoving activities associated with site construction, trenching for the gas gathering system and water drainage lines (if required) and access roads.

The works described above are best described as bulk excavation and drilling processes. While earthmoving works will be undertaken mostly using conventional construction plant such as excavators and graders, drilling processes will involve specialised plant such as high-performance compressors and drilling machinery.

As there may be up to six wells located at a surface location in this project, construction at any site could take between six and up to 12 months to complete. This worst case scenario has been taken into account in the approach taken to the assessment, described in Section 1.3 of this report.

As indicated in Section 1.2, given the distance of the construction sites to residences, and that vibration will not affect receivers at such long distances, a detailed assessment of vibration impacts is not required.

2.2 Operational Noise

The noise impact from the operational stage of this project is not as significant as the noise during the construction phase. Operational noise potentially impacting on nearby receivers includes:

- Noise emanating from free-flow wells;
- Noise emanating from pump-operated wells; and
- Noise from periodic work over operations for well maintenance.

Noise emanating from free-flow wells is dependent on the productivity of the well and the design of the surface well head equipment, with highly productive wells typically generating more noise than the less productive wells.

Noise from operating wells is also dependent on factors such as:

- Well head design;
- The direction of the neighbouring residences;
- Meteorological factors such as wind and temperature inversion;
- The number of wells at the surface location;
- Maintenance and workover of wells.

It is worth noting that both the Spring Farm and Menangle Park areas are earmarked for future residential, industrial and commercial subdivisions and the change from a semi-rural character will increase the background noise level at the operational stage of the project. As the background noise level increases, the noise criteria could increase, hence the impact of the same noise from this project would be reduced.

During operation of the well surface locations the main source of vibration would be pumps wherever they are used. Properly maintained wells and pumps would not cause vibration above the criteria for human comfort beyond the boundary of the well surface location, hence vibration will be satisfactory before or after urban land releases.

3 EXISTING AMBIENT NOISE LEVELS

3.1 What is the Noise Environment?

In Sections 4 and 5 of this report, noise criterion will be set for this project. Because the noise criteria are set with relation to existing ambient noise levels, the existing environment will be discussed first.

The existing ambient noise levels are the result of all industrial, traffic and environmental noise at the receiver location. To exclude the influence of temporary noise, such as wind in trees and barking dogs, the noise levels are usually measured over an extended period.

At most residences in the study area the noise is characteristically semi-rural, with some influence from major roads and railway lines. At the north of the Spring Farm study area the housing density increases. Higher ambient noise levels can be expected as housing density increases and this could also be expected as residential, commercial and industrial development approaches the well surface locations during the operational life of the project.

3.2 Measurement Procedures

The noise monitoring equipment used for the long-term unattended measurements consisted of an Environmental Noise Logger set to A-Weighted, Fast response continuously monitoring over 15-minute sampling periods. This equipment is capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift had occurred. Monitoring was conducted in free-field conditions (i.e. away from building facades and other reflecting surfaces).

The noise logger determines the L_{A1}, L_{A10}, L_{A90} and L_{Aeq} levels of the existing noise environment. (A glossary of acoustic terms is provided in Appendix A). The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1%, 10% and 90% of the sample time respectively. The L_{A1} is indicative of maximum noise levels due to individual noise events such as the passby of a heavy vehicle. The L_{A90} level is normally taken as the background noise level. The L_{Aeq} level represents the Equivalent Continuous Sound Level and has the same sound energy over the sampling period as the actual noise environment with its fluctuating sound levels. The L_{A10} noise level is taken to represent the average maximum noise level of the noise source under measurement.

A descriptor known as the Rating Background Level (RBL) is defined in the *INP*. The RBL is used in determining criteria for construction and operational noise from the proposal. This is calculated from the measured logger data by taking tenth percentile L_{A90} values for each day, and forming the median of the resulting levels.

Table 3-1 summarises the important noise level parameters for the monitoring locations. The daytime (7.00am-6.00pm), evening (6.00-10.00pm) and night time (10.00pm-7.00am) Rating Background Level value is shown. These values are used in determining criteria for noise from construction activities and for the operational noise of the well surface locations. (This is discussed further in Section 4 for construction and Section 5 for operation).

3.3 Measurement Locations & Results

Most of the area covered by this study is semi-rural, or bordering the suburban areas of Narellan, Elderslie, Menangle Park and Glen Alpine. To determine existing ambient noise levels, five locations were monitored, as shown in Figure 3-1 and the results are given in Table 3-1. The noise logger charts are attached as Appendix C. The logger locations were chosen to be representative of residences in any area potentially affected by noise from the well surface locations. Locations were chosen that were unaffected by other noise sources from industry or transportation.

Figure 3-1 Noise Logger Locations

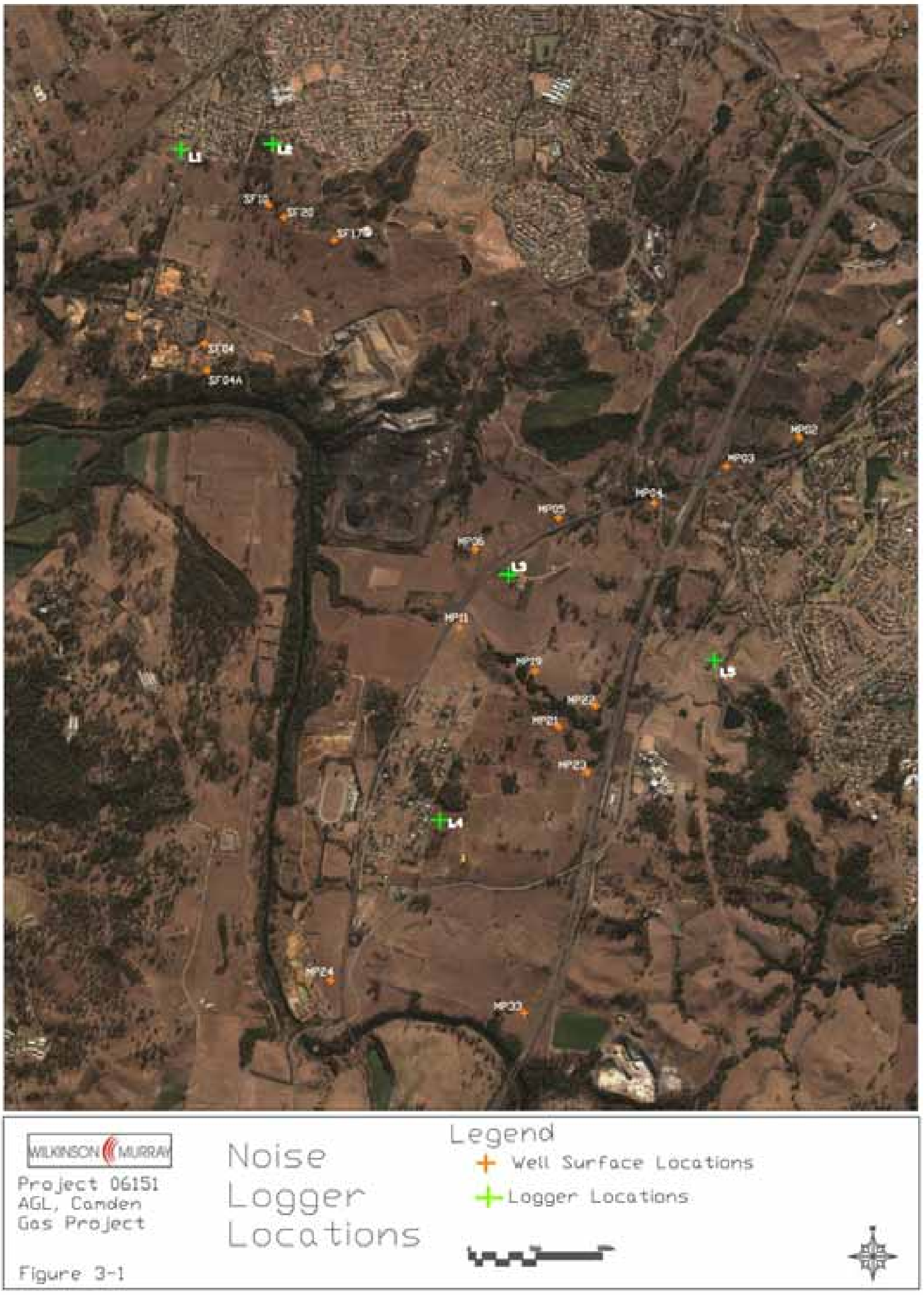


Table 3-1 Summary of Noise Monitoring Results

Location No.	Monitoring Location	Monitoring Period	Measured Noise Level RBL (dBA)		
			Daytime (7am-6pm)	Evening (6pm-10pm)	Night (10pm-7am)
1	St Thomas Church, Elderslie	Approx. between 14/9/06 & 6/10/06	38	37	32
2	Gundungurra Reserve, Spring Farm		38	36	31
3	Glenlee House, Glenlee		35	38	35
4	44 Cummins Rd, Menangle Park		37	37	35
5	Sugar Loaf Residence, Sugarloaf	18/12/06-22/12/06	44	42	36

Some residences in the area are exposed to noise from transportation – notably houses along the railway line or near Menangle Park Road or the Hume Highway. While transportation noise is generally perceived independently to industrial noise, its presence may mitigate industrial noise if they have similar characteristics.

Residential, commercial and industrial development is planned in much of the area covered by this study. Therefore, over the lifetime of the well surface locations the background noise level will increase as urbanisation approaches and intensifies.

It is noted that the measured evening noise levels at Location 3, Glenlee House, are higher than the measured daytime levels. The DECC application notes to the INP state that when evening levels are greater than daytime, the daytime levels should be used to develop intrusiveness noise criteria.

4 CONSTRUCTION NOISE CRITERIA

4.1 NSW Environmental Noise Control Manual Guidelines

The *NSW Environmental Noise Control Manual (ENCM)* (DECC Ref. 94/31) provides guidelines for the assessment of construction noise. Although officially superseded, the document offers guidelines for the assessment of construction noise at residences that are still recognised and considered relevant.

As a worst case scenario, the guidelines used for the assessment of construction noise at residences specified in Chapter 171 of the *ENCM* are as follows:

- For construction periods of 4 weeks or less, the L_{A10} level should not exceed the background (L_{A90}) level by more than 20dBA;
- For periods greater than four weeks and less than 26 weeks, the L_{A10} level should not exceed the background (L_{A90}) level by more than 10dBA.

In addition, if noise is audible at residential premises, the ENCM specifies the following time restrictions for construction activities:

- Monday to Friday 7.00am-6.00pm
- Saturday 8.00am-1.00pm
- No construction work is to take place on Sundays or Public Holidays.

It should be noted that for the drilling stage of this project, working hours need to be 24 hours per day.

4.2 Guidelines for this Project

Multiple well drilling at any single location on this project may take more than 26 weeks, the maximum period considered in the *ENCM*. Also, it will be necessary to drill during night time hours, 24 hours per day seven days per week. Guidelines for neither case is given in the *ENCM*, so the following criterion is often adopted and will be used for well drilling of periods greater than 26 weeks and/ or night time drilling:

- The L_{A10} level should not exceed the background (L_{A90}) level by more than 5dBA.

This criterion is based on the intrusiveness criterion of the *INP* (discussed in Section 5 with respect to operational noise). As well as noise from construction at the well surface locations, there will be daytime construction noise from trenching and laying of the gas gathering lines. The gathering line construction works move rapidly typically between 300m and 400m per day depending on terrain and any receiver would only be exposed to noise from that activity for short periods of less than four weeks. The *ENCM* guideline for construction noise less than four weeks will be used for gas gathering construction activity as follows:

- The L_{A10} level should not exceed the background (L_{A90}) level by more than 20dBA.

As there will be up to six wells at a single surface location, as a conservative measure the activity will be assessed as taking more than 26 weeks but less than 12 months.

Fracing may be necessary at some well surface locations. This would take up to one day per well and would always be carried out during daytime hours.

Work over and well maintenance during the operational phase of the well surface locations would also be best considered as construction noise as it is short term and occurs occasionally during daytime hours. It will be considered as construction noise of less than four weeks duration.

For this project the construction noise criteria are therefore:

- Daytime – gathering line construction – L_{10} less than background + 20dBA
- Daytime – well drilling – L_{10} less than background + 5dBA
- Night time – well drilling – L_{10} less than background + 5dBA
- Daytime – fracing (if required) – L_{10} less than background + 20dBA
- Daytime – workover (when required) - L_{10} less than background + 20dBA

Noise criteria specific to individual well surface locations are shown in the results tables in Section 8. During the construction phase of the project the most significant traffic will typically be mobilising the machinery and equipment to and from the surface location. The only other traffic will generally be light vehicles for personnel. As there is no significant traffic associated with the construction stage of the project, the noise impact of construction traffic has therefore not been considered.

4.3 Sleep Disturbance from Night Time Construction

As construction activities will take place during night time hours, sleep disturbance has been addressed. It is difficult to accurately predict the potential for sleep disturbance due to instantaneous noise events and appropriate noise criteria are currently being considered by the DECC. The most conservative of the recognised criteria is set out in Guidelines from the DECC's *Noise Guide for Local Government (NGLG)* which indicates that to protect against sleep disturbance, the L_{A1} noise level external to the facade of any residence from any construction event should not exceed the background noise level by more than 15dBA. This guideline is independent of the duration of the works.

The L_{A1} is a measure of short duration noises (see Appendix A for a more complete description). Such noise could potentially arise from this project for example from drill rods dropping, or metal hitting against metal.

4.4 Construction Noise to Parks & Reserve

The ENCM provides no guidelines for construction noise to parks and reserves. The *INP* does provide amenity criteria for areas reserved for "passive" or "active" recreation. The areas potentially affected by this project are all "passive recreation" areas. The acceptable and maximum noise levels given in the *INP* are L_{Aeq} 50 and 55 respectively. These levels are to be applied when the areas are in use: daytime in this case. The *INP* applies these criteria "at the most-affected point within 50m of the area boundary."

In assessing noise to any reserve, the nature, size and use of the reserve is taken into account. For example, a picnic area would be more noise sensitive than an area of bushland distant from a carpark. Also, considering the temporary nature of construction noise it is considered that the maximum noise criterion, L_{Aeq} 55dBA is suitable. The aim of the construction noise assessment is therefore to minimise the area within that reserve that exceeds L_{Aeq} 55dBA.

5 OPERATIONAL NOISE CRITERIA

5.1 Operational Noise from Well Surface Locations

Criteria for noise from the long-term operation of the well surface locations are derived from the *INP*. The *INP* seeks to appropriately control the noise emission of industrial noise sources (such as gas wells) through its "intrusiveness" and "amenity" criteria.

The intrusiveness criterion requires that the L_{Aeq} noise emission level of the combined proposed gas wells measured over a period of 15-minutes not exceed the RBL by more than 5dBA.

The amenity criterion sets an absolute limit on the value of the total L_{Aeq} noise level measured over a day, evening or night period. In this case, the subject receiver locations may generally be conservatively classified as being located in a "semi-rural" area. Consequently, the acceptable level of noise from all industrial noise sources for such receivers is 50, 45 and 40dBA for the daytime, evening and night time periods respectively.

The residences considered by this assessment are generally not presently exposed to any industrial noise sources apart from the Glenlee Coal Washery and industrial area and the Jacks Gully Regional Waste Disposal Facility, located between the Spring Farm and Menangle Park Project Areas. While the *INP* does not regard traffic as an industrial source, it is worth noting that the M5 Freeway and the main Southern Rail line pass through the Menangle Park Project Area. Hence, in the absence of other industrial sources, the total noise from the proposed well surface locations may be assessed directly against the amenity criteria (i.e. no allowance for the contribution from other industrial noise sources need be considered). During workover maintenance activities, the most significant traffic will typically be mobilising the machinery and equipment to and from the surface location. The only other traffic will generally be light vehicles for personnel. As there is no significant traffic associated with workover, the noise impact of operational traffic has therefore not been considered.

To assess operational noise at individual well surface locations, the noise criteria is set from the results at the nearest relevant noise monitoring site. These "project specific" noise criteria are summarised in Table 5-1. The project-specific criteria result from the more stringent of either the amenity or intrusiveness criteria.

Table 5-1 Project-Specific Noise Criteria for Operational Noise

Noise Logger Site	Nearby Well Surface Locations	Criterion Type	L_{Aeq} Operational Noise Criterion (dBA)		
			Day (7am-6pm)	Evening (6-10pm)	Night (10pm-7am)
1. St Thomas Church, Elderslie	SF10	Intrusiveness Criterion	43	42	37
		Amenity Criterion	50	45	40
		Project-Specific Criteria	43	42	37
2. Gundungurra Reserve, Spring Farm	SF17, SF20, SF04, SF04A	Intrusiveness Criterion	43	41	36
		Amenity Criterion	50	45	40
		Project-Specific Criteria	43	41	36
3. Glenlee House, Glenlee	MP05, MP06, MP11	Intrusiveness Criterion	40	40	40
		Amenity Criterion	50	45	40
		Project-Specific Criteria	40	40	40
4. Cummins Rd, Menangle Park	MP19, MP21, MP24, MP33	Intrusiveness Criterion	42	42	40
		Amenity Criterion	50	45	40
		Project-Specific Criteria	42	42	40
5. Sugarloaf Residence, Sugarloaf	MP04, MP03, MP02, MP22, MP23	Intrusiveness Criterion	49	47	41
		Amenity Criterion	50	45	40
		Project-Specific Criteria	49	45	40

Note: Project Specific Criteria are determined by taking the more stringent of either the intrusiveness or amenity criteria. In this case, the intrusiveness criterion is more stringent.

No "modifying factor" adjustment need be made to this criterion as the noise emission of both pump / generator operated and free-flow gas wells do not exhibit tonal, impulsive or intermittent characteristics.

There will be up to six wells at any surface location. Noise from individual wells can vary daily according to gas production and wellhead design so the assessment of the total noise impact from a surface location will consider the worst case when all wells are producing at a high rate.

5.2 Sleep Disturbance from Well Operations

The criterion for sleep disturbance from operational noise is the same as that for construction noise: the L_{A1} noise level external to the facade of any residence from any construction event should not exceed the background noise level by more than 15dBA.

Sleep disturbance is typically caused by short-term noise events. Noise from the proposed well surface locations does not have short-term characteristics that would cause sleep disturbance.

This noise assessment was based on the existing ambient noise level. As urbanisation increases in the area the RBL is predicted to increase accordingly. Although the increase cannot be predicted, a noise assessment based on existing noise levels will be conservative for the future situation.

5.3 Workover

Occasionally a workover rig will come onto the site for maintenance works. Due to the infrequency and temporary nature of this work it is considered to be short term construction noise. The criterion for this is then background noise plus 20dBA.

5.4 Operational Noise to Parks & Reserves

The existing areas potentially affected by this project are all "passive recreation" areas. The acceptable and maximum noise levels from the *INP* are L_{Aeq} 50 and 55 respectively. These levels are to be applied when the areas are in use: daytime in this case. The *INP* applies these criteria "at the most-affected point within 50m of the area boundary".

Some of the proposed well surface locations are within the boundaries of existing and future reserves. The aim, as for construction noise, is to minimise the area within the reserve that exceeds the criterion - L_{Aeq} 50dBA in this case.

Future reserves would be assessed similarly. If future reserves are for active recreation, such as sporting fields, the acceptable and maximum noise levels from the *INP* are L_{Aeq} 55 and 60 respectively.

6 PROPOSED WELL SURFACE LOCATIONS

There are 17 proposed well surface locations in this study comprising:

- Up to four well surface locations within the Spring Farm Project Area, which includes two options assessed for a single SF04 location; and
- Up to 12 well surface locations within the Menangle Park Project Area.

The proposed well surface locations are shown in Figure 6-1 for Spring Farm, and Figure 6-2 for Menangle Park.

Some of the well surface locations are indicative at this stage and could vary depending upon noise constraints imposed by the most affected receivers. In general, for the purposes of the assessment, it is assumed that the well head could be located at any point within a radius of 100m from the identified well surface location for Menangle Park and at any point within a 50m radius of the identified well surface location for Spring Farm.

The envelope approach explained in earlier sections allows flexibility for the project to fit in with future land uses and other development constraints. The reason that the envelope changes from a 50m radius at Spring Farm to a 100m radius at Menangle Park reflects the level of detail currently available about future land uses.

As discussed in Section 1.3, an envelope approach has been used for the assessment of potential noise impacts, adopting the worst-case scenario in terms of noise generation for each well surface location. In this respect, the assessment has been undertaken on the basis of up to six SIS well heads being placed at each well surface location.

Figure 6-1 Spring Farm Proposed Well Surface Locations

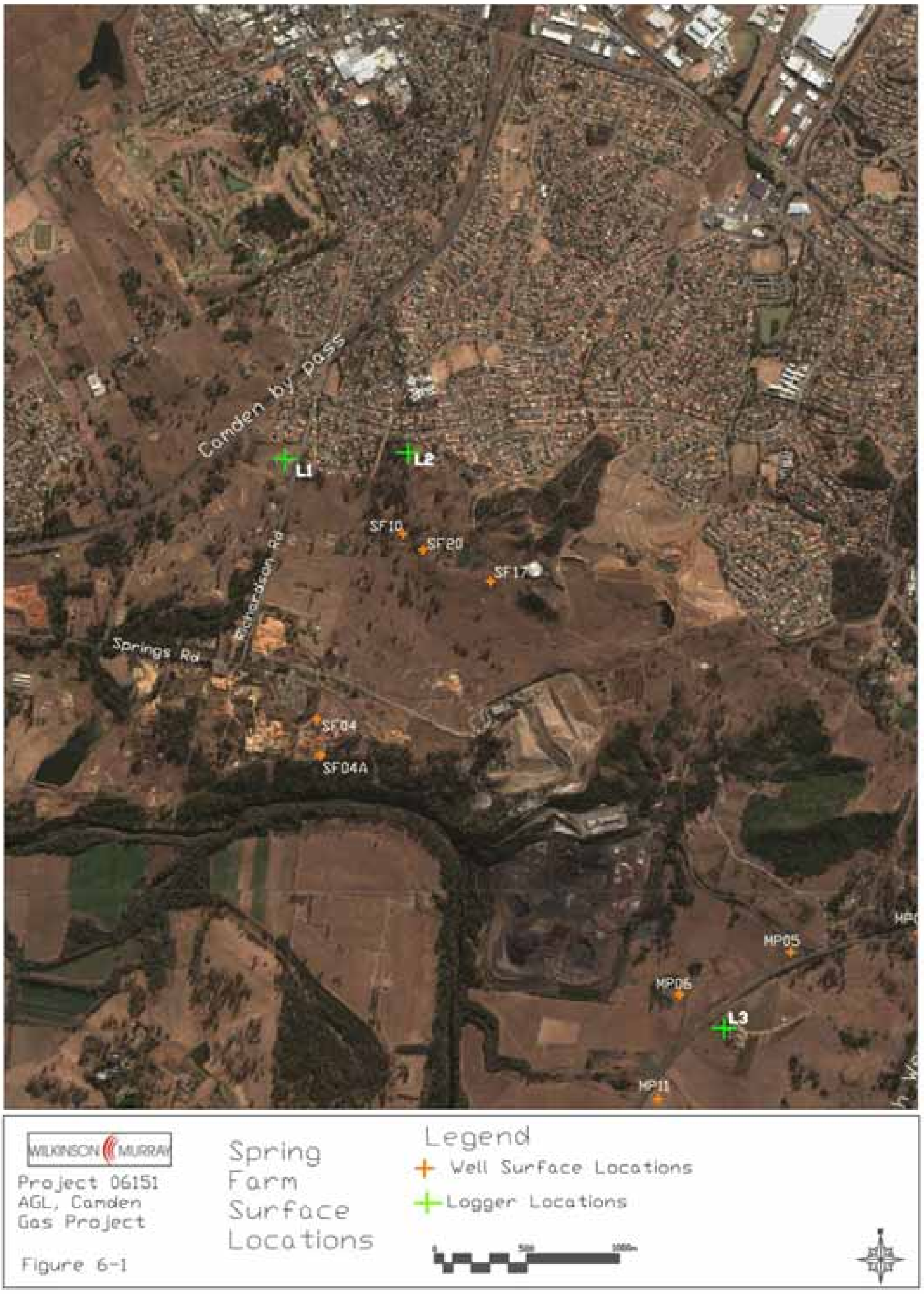


Figure 6-2 Menangle Park Proposed Well Surface Locations

7 ASSESSMENT OF CONSTRUCTION NOISE - METHODOLOGY

7.1 Construction & Assessment Methodology

The construction of the project will be during daytime hours with 24-hour night time drilling works. Construction activities typically include the following major stages:

- Excavation and earth moving associated with construction of access roads to well surface locations (where necessary);
- Excavation and earth moving associated with construction of wells;
- Well drilling, including logging and perforating (if required);
- Well fracing, if required (stimulation of coal seam by pumping sand and water);
- Excavation and earth moving associated with installation of gas gathering system and water transfer lines, including underboring; and
- Well workover (initial clean out and installation of production tubing, also refers to maintenance later in well life).

There are several complicating aspects to the assessment:

- There will be night time drilling at well surface locations;
- The well surface locations have been assessed to allow flexibility – it is assumed that the well surface location could be sited at any point within a radius of 100m from the identified location for Menangle Park and at any point within a 50m radius of the identified well surface location for Spring Farm;
- Construction noise itself is difficult to assess, as there are many varied stages, each with its own noise level and characteristics.

To determine noise levels at residential receivers a computer model covering the whole study area has been created. The ENM computer program has been used to calculate noise contours around each surface location. For each well a contour from a typical construction noise source is presented and implications for the variables above listed are discussed. To minimise cumulative impacts well surface locations closer than 1km to each other will not be drilled simultaneously.

For each well surface location the noise contours are shown for daytime conditions, and for an adverse night time meteorological condition. At night time in this area there is the possibility of temperature inversions, during which noise is propagated greater distances and this has been assessed.

Wilkinson Murray has a database of noise levels of typical plant that would be used for this project. Noise levels are sourced from measurements, manufacturers' data and other published studies. After prediction of noise from well drilling, any necessary noise mitigation can be designed for individual well surface locations. Such mitigation measures could include:

- Using the directionality of the mud pumps – a 3dBA reduction can be achieved by orienting the mud pump inlet louvres away from the most sensitive receiver;
- Placing the mud pumps on the ground – in this way the efficacy of any natural or artificial noise shielding is increased;
- Using temporary or permanent noise barriers – temporary barriers could be shipping containers placed between the drill site and the receiving houses for the duration of the work, and permanent barriers could be a compound fence built around the site;

- Using quieter mud pumps. The mud pumps assumed for this assessment were those measured on other similar sites. It is noted that these pumps do not incorporate significant acoustic treatment, and it is quite possible to reduce the noise of the mud pumps by, for example, putting them in a better enclosure fitted with acoustic louvres.

7.2 Source Noise Levels of Construction Phases

The wells are constructed in phases. The duration of each phase will depend on the circumstances at individual well surface locations. The phases are listed in Table 7-1. They will vary in noise emission due to the different equipment used.

The L_{A10} sound power level of each item of plant is shown. As a conservative measure, the total sound power level detailed for each phase of construction represents the L_{A10} noise level presumed for all listed plant operating simultaneously. Consequently, the predicted noise levels represent the 'worst case' rather than the 'typical' noise emissions expected from the works.

Table 7-1 Construction Phases and "Worst Case" Noise Levels

Activity	Typical Maximum L_{A10} Sound Power Levels (dBA)
Excavation and earth moving associated with installation of gas gathering system and water pipes (including underbore works)	110
Excavation and earth moving associated with construction or upgrade of access roads (where necessary)	115
Excavation and earth moving associated with construction of wells	115
Well drilling – includes noise of drill and pumps/generators	106-112
Well logging	87
Well fracing (if required)	130
Workover – includes noise of rigs, pumps and generators	106

7.3 Prevailing Meteorological Conditions

Meteorological conditions can affect noise propagation. During temperature inversions noise propagates further and can impact on more residences than would occur in the daytime. The prevailing conditions were measured at Camden Airport for the environmental assessment of the Coal Bed Methane Project – Stage II, June 2003, prepared by Environmental Resources Management Australia Pty Ltd. Those results are considered relevant to this study.

The data from Camden Airport show that the occurrence of temperature inversions during winter nights is greater than 30%. At this level of occurrence the *INP* requires assessment of noise during times of temperature inversion. In the absence of inversion data the default for this area would be a temperature inversion of 3°/100m.

The data show that the inversions are not accompanied by assessable winds on more than 30% of occasions. Hence concurrent assessment of inversions and prevailing winds is not required according to the *INP*.

Drainage winds are considered in the construction phase. As the well surface locations are generally below, or level with, existing housing, drainage winds will not occur. The exceptions to this are the Spring Farm Wells SF10, SF17 and SF20 which are above residences R22 and R26. However, these well surface locations and residences are so far apart that any coincidence of wind with temperature inversions will not cause a noise impact at these residences.

7.4 Predicted Noise Levels

Noise level contours for daytime and night time construction were calculated. Noise contours are isolines around a noise source showing the locations around that source where noise has been attenuated to a particular level. The contours and an assessment for each well surface location are shown in Section 8.

For this assessment noise level contours have been calculated for daytime and night time scenarios at each well surface location. The contours were calculated with noise mitigation appropriate to the well surface location, though at some wells no mitigation was necessary. The following meteorological conditions were assumed:

- Daytime – calm, isothermal meteorological conditions.
- Night time – temperature inversion of 3°/100m.

7.5 Options for Construction Noise Mitigations

At some of the well surface locations construction will require noise mitigation to achieve the noise criteria. The level of mitigation required needs to be determined on a site by site basis. For the purposes of this assessment a worst case is assumed at each well surface location, i.e. drilling up to six SIS wells at each surface location over a period of up to 12 months, including 24 hour operation of drills and mud pumps/generators during drilling. The options for noise mitigation include, but are not limited to:

- Use of only one mud pump;
- Placing mud pumps on the ground;
- Orientation of mud pumps away from sensitive receivers;
- Temporary or permanent noise barriers;
- Acoustic treatment of mud pumps;
- Length of construction;
- Hours of construction; and
- Best practice, construction equipment and noise mitigation.

The amount of reduction for each of these options depends on the circumstances at each well, but generally is:

- Use of only one mud pump – 3dBA reduction;
- Placing mud pumps on the ground – 3dBA reduction;
- Orientation of mud pumps away from sensitive receivers – 3dBA reduction in the direction of the mud pump louvres;
- Temporary or permanent noise barriers – 5 to 10dBA reduction. In the noise modelling it was assumed that the barriers were approximately 10m from the drill rigs (except for SF10 and SF20, as noted);
- Acoustic treatment of mud pumps – 10dBA reduction.

In cases where extensive noise mitigation is required, it may be necessary to consider the following:

- Noise monitoring;
- Community consultation and notification;
- Complaints handling; and
- Acoustically treated mud pumps.

7.6 Cumulative Noise from Well Drilling

If there is simultaneous drilling at more than one well surface location this may create cumulative noise impacts at some residences. The sum of noise levels would depend on the residence and the location of the well surface locations. In general, cumulative noise impact will be minimised if the distance of 1km is maintained between well drilling locations. At this distance noise from each location will be reduced to well below the noise criterion.

This distance is conservative and does not take into account any natural shielding provided by topography. There may be combinations of wells that can be drilled at closer distances.

7.7 Construction Noise from Gathering Line Construction

The noisiest component of the construction of the gathering line is the trenching machine. Typical L_{A10} sound power level for the equipment used for excavation of trenches and pipe laying is 110dBA. Gas gathering line construction works, including trenching, pipe laying and backfill, move at a rate of between 300-400m per day depending on the terrain. The noise is transient, it will only occur once during construction, and it is not constant noise.

The criteria for this activity are background + 20dBA. As the background noise level varies across the study area, so will the noise criteria.

As the gathering construction site will cover distances of between 300-400m per day, any one receiver will only experience exceedances of the criterion for part of one day.

Throughout most of the area under study, that is Spring Farm and the western part of Menangle Park, the daytime background noise level is between 35-38dBA. As the trencher approaches houses in these areas the noise would exceed the noise criterion if the construction site is within 120-180m of the houses for a very short time.

While the exact location of this infrastructure may move up to 25m either side of the proposed routes, the preliminary designs show no receivers within a 120-180m distance of the gathering lines in the Spring Farm area: that is the gathering lines for SF04, SF04A, SF10, SF17 and SF20.

In the western part of Menangle Park there will be one residence marginally impacted by the gathering line joining MP11 to the existing line at MP14. This is residence R7 on the construction noise impact Figures. As the line goes within 150m of the residence the noise would be approximately 60dBA, or 3dBA above the noise criterion. The exceedance is expected to be for a few hours during one daytime. A 3dBA exceedance for a short period is considered a minor noise impact.

Noise from the construction of the line between MP03 and MP04 would also exceed the criterion at one house (residence R1). The exceedance would be less than 5dBA for a limited period of time.

In the eastern part of Menangle Park the daytime background noise level is 44dBA. Here the noise criterion will be exceeded if the trenching site approaches closer than 70m to any residence. No houses are this close to the proposed line.

Due to the speed with which the construction site moves, noise mitigation is best done by selection of the quietest machinery and best work practices. Residences where noise impact is expected will be notified in an appropriate time frame.

7.8 Construction Traffic

As there are low traffic volumes associated with the proposal, construction will not cause significant traffic on local roads. Any night time traffic will be light vehicles only for staff to access the site. This will cause negligible impact, both from the site itself and the extra traffic on local roads.

Construction traffic would cause an insignificant change to traffic on local roads, and would not result in any noise impact.

8 ASSESSMENT OF CONSTRUCTION NOISE – RESULTS

In this section, the noise assessments for each well surface location are presented. The closest residences, or those most affected by noise from a particular surface location, are identified. The noise assessment at those receivers is presented in a table, which also includes recommendations for noise mitigation wherever necessary to reduce the construction noise to below the relevant criteria at all residences. Unless expressly stated, the compliance measures recommended to meet the criteria are independent of each other. The compliance measures suggested in the Tables are designed as a guide and this does not limit the use of a variety of mitigation options at a surface location, so long as the measures used achieve the criteria.

Note that suggested mitigation for some of the wells is that the "use of only one mud pump". For any of these wells, using two mud pumps in acoustic enclosures will also achieve the criteria and is a suitable alternative to using only one pump.

Well drilling is the longest duration in the construction phase; hence noise impact will be assessed based on the noise level of drilling. During other phases of construction such as gas gathering lines, there may be short-term noise levels above the noise criteria. These exceedances will usually be less than 3dBA. For short-term construction noise this is considered a minor exceedance.

The noise levels from fracing, where it is required, will exceed the criteria by up to 15dBA, but as it only occurs during daytime for up to one day during the construction of each well, this would only have an impact for a very short period.

For each well surface location the noise emission is presented on two figures (day and night) showing noise contours around the well surface location. The contour lines are drawn with reference to the noise criteria for each surface location and they include the different mitigation requirements for each, so the contour for one well surface location will not represent the same noise level as that for another different well surface location. Each figure is drawn with two contours surrounding the well surface location. The inner contour is where noise decreases to the noise criterion if the well were located at the indicative location – the centre of the assessed area. The contours for each well surface location have different shapes because they are specific to the noise control requirements and noise criteria. The shape is also affected by the different barriers at the well surface location, topography of the land surrounding it, and the directionality of the mud pump noise.

The contours represent the noise criteria for residential receivers. For five well surface locations (MP04, MP05, SF10, SF17 and SF20) these contours enter existing parks and reserves. The potential noise impact on the recreation areas will be discussed. In general the noise impact will be in a confined area near the well surface location, and only during the drilling phase of the construction. This would be intermittent, and for a maximum of approximately six months of the up to 12 months assessed for construction at any site.

As described earlier, the well locations could vary by up to 50m in the Spring Farm Project Area and up to 100m in the Menangle Park Project Area. As the noise contours are calculated based on a source at the central point of this possible area the contours could vary by up to 50m or 100m in any direction. At many well surface locations the residences are within a few hundred metres of the surface location and the difference in level from the centre to the edge of the proposed area could be significant.

To show this a second contour has been drawn that is the worst case in any direction, that is, it assumes the well location is at the limit of the 50m or 100m radius from the indicative crosshair marker. Residences within the shaded area between the contours will not necessarily experience a noise impact. For example if the noise source were moved away from the receiver within the limits of the 50m or 100m, it would fall outside the criterion contour. Receivers beyond the shaded area will not experience a noise impact given the noise management applied.

The envelope approach allows AGL the flexibility to be able to locate the well surface location at a point where noise impact to nearby residences is minimised.

Two figures are presented for each well surface location; daytime and night time. The contours assume the incorporation of any noise control measures as described. Night time noise contours always assume a temperature inversion of 3°/100m as discussed in Section 7.3.

8.1 Noise Impacts for MP02 Well Surface Location

8.1.1 Description of Surrounding Area

The proposed MP02 surface location is in a rural area, along side the main southern rail line and north of the Glen Alpine suburban area. The nearest residences and their approximate distances from the well surface location are:

- R19 – 200m to south, which is the nearest house in the suburban area of Glen Alpine
- R20 – 400m to northeast
- R18 – 290m to southwest

8.1.2 Construction Noise Impact

The RBLs measured at Measurement Location 5 (Sugarloaf Property) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for MP02 are shown in Table 8-1. Noise contours for daytime operation are shown on Figure 8-1. Noise contours for night time operation are shown on Figure 8-2.

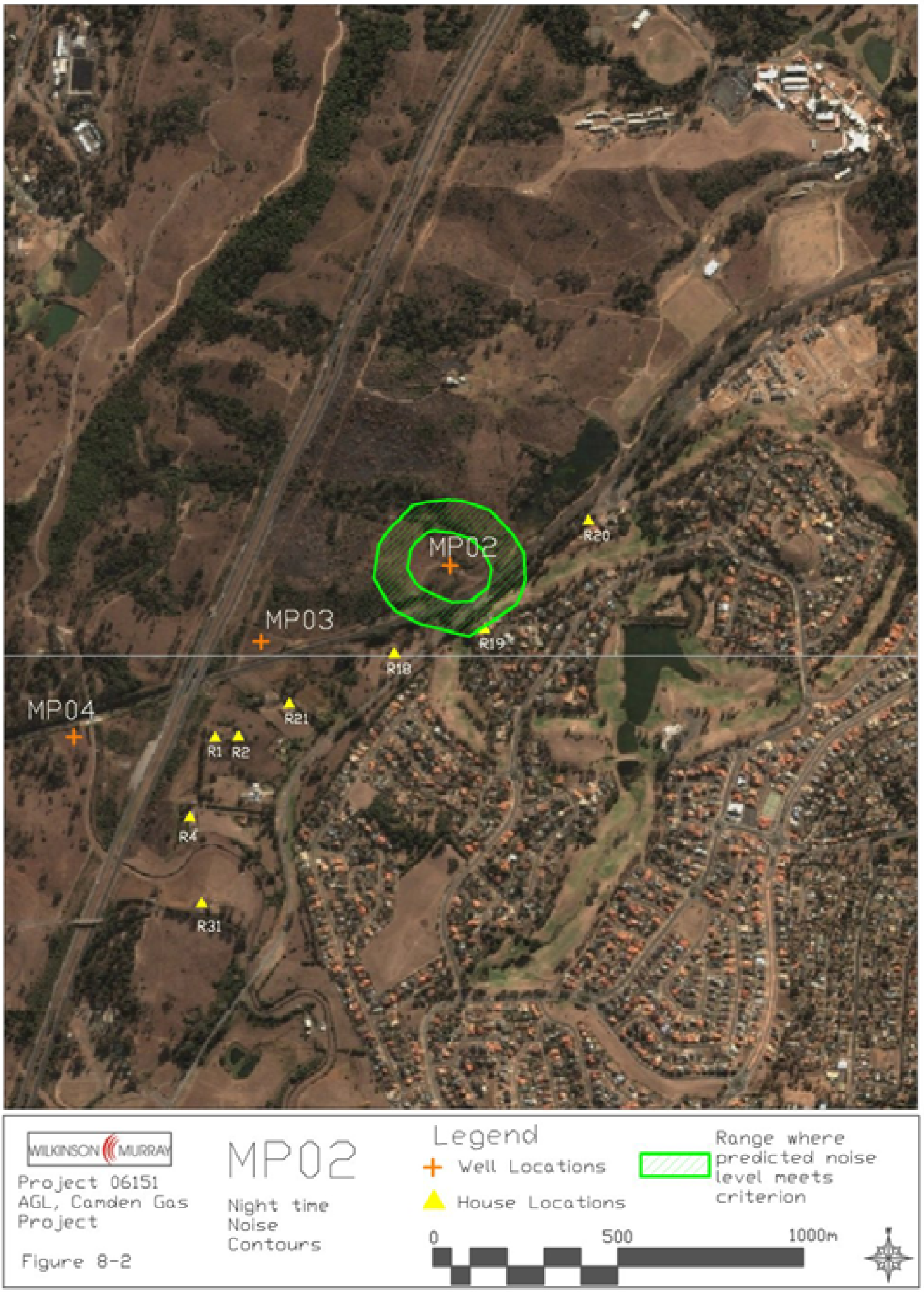
Table 8-1 Construction Noise – MP02 Well Surface Location

MP02		Weekday (7am–6pm) & Saturday (7am–1pm)	Evening (6-10pm)	Night (10pm-7am)	Saturday (1pm–6pm) & Sunday (7am–6pm)
RBL		44	42	36	42
Noise Criteria, L_{A10} dBA		49	47	41	47
Normal operation (2 pumps)	Predicted Noise Level at R19	57	57	57	57
	Compliance	☒☒☒	☒☒☒	☒☒☒	☒☒☒
Compliance Measure 1	Barriers to south	☒	☒	☒☒	☒
Compliance Measure 2	Compliance measure 1 and 1 Mud Pump only, oriented to north.	☒	☒	☒	☒
Compliance Measure 3	Compliance measure 1 and Acoustic enclosure on both mud pumps, site>200m from R19)	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-1 Daytime Noise Contours- MP02

Figure 8-2 Night Time Noise Contours – MP02



8.2 Noise Impacts for MP03 Well Surface Location

8.2.1 Description of Surrounding Area

The proposed well surface location MP03 is sited in a semi-rural area, immediately east of the F5 Freeway, with scattered residences adjacent to the main southern rail line. The nearest residences and their approximate distances from the surface location are (with the designation as shown in the Figures below):

- R21 – 200m to southeast
- R1 and R2 - 250m to south
- R18 – 350m to southeast
- R19 – 610m to southeast (Glen Alpine Estate)
- R31 – 720m to south

8.2.2 Construction Noise Impact

The RBLs measured at Measurement Location 5 (Sugarloaf Property) are considered appropriate for assessment of noise impact at this well surface location. Noise levels, assessments and compliance measures for MP03 are shown in Table 8-2. Noise contours for daytime operation are shown on Figure 8-3. Noise contours for night time operation are shown on Figure 8-4.

Table 8-2 Construction Noise –MP03 Well Surface Location

MP03		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		44	42	36	42
Noise Criteria L_{A10} dBA		49	47	41	47
Normal operation (2 pumps)	Predicted Noise Level at R21	51	51	51	51
	Compliance	☑	☒	☒☒	☑
Compliance Measure 1	Barriers to south & east	☑	☑	☒	☑
Compliance Measure 2	1 Mud Pump only, oriented to west.	☑	☑	☑	☑
Compliance Measure 3	Compliance measure 1 and Acoustic enclosure on mud pumps (both mud pumps operate)	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-3 Daytime Noise Contours – MP03

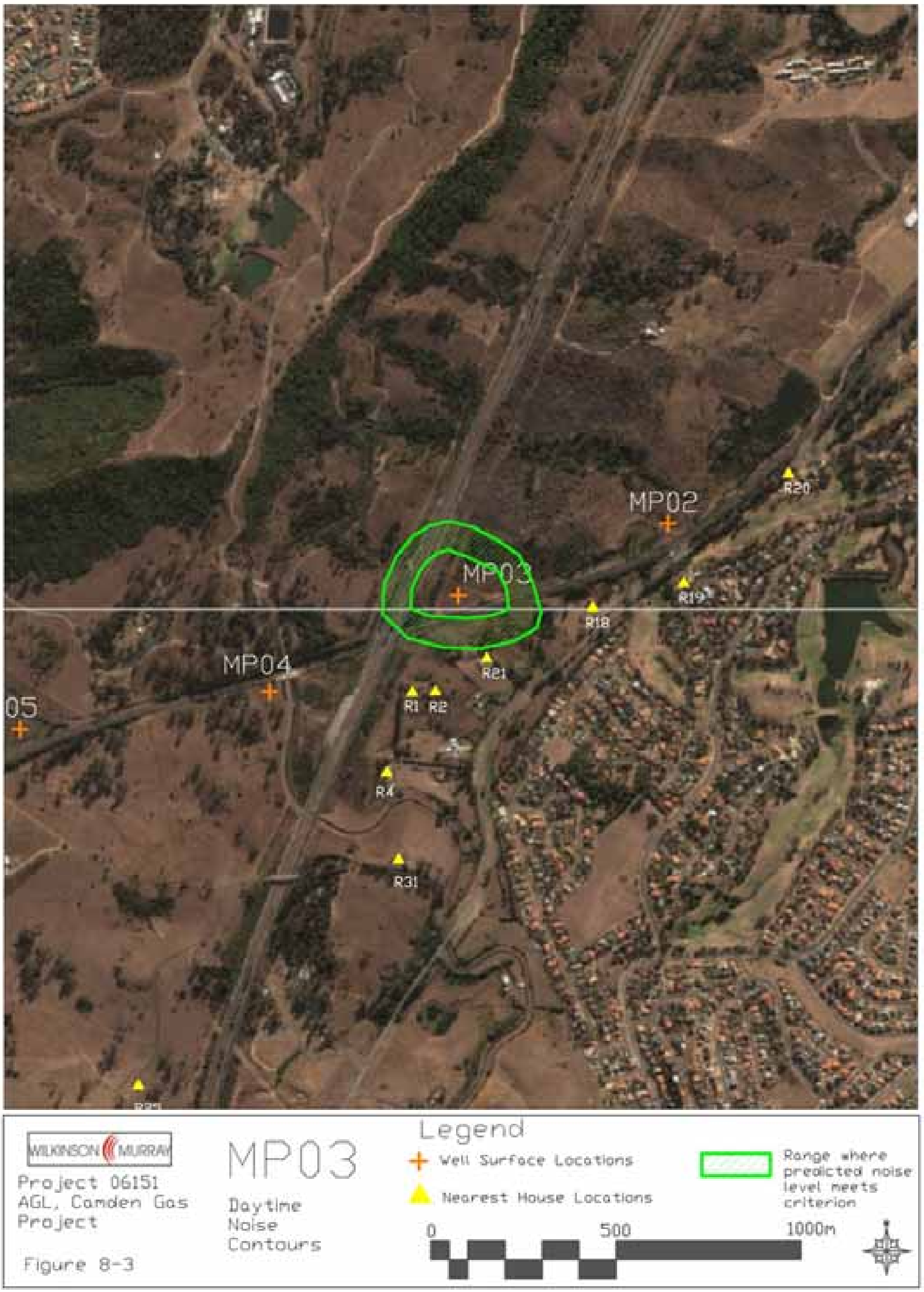


Figure 8-4 Night Time Noise Contours – MP03

8.3 Noise Impacts for Well Surface Location MP04

8.3.1 Description of Surrounding Area

The proposed MP04 well surface location is in a rural area, with scattered residences and the main southern rail line to the north. The nearest residence and its approximate distance from the surface location are:

- R1 – 390m to east
- R2 - 450m to east
- R4 –380m to southeast
- R31 – 570m to southeast

8.3.2 Construction Noise Impact to Residences

The RBLs measured at Measurement Location 5 (Sugarloaf) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for the *normal* operation and *noise-mitigated* operation around MP04 are shown in Table 8-3. Noise contours for daytime operation are shown on Figure 8-5. Noise contours for night time operation are shown on Figure 8-6.

Table 8-3 Construction Noise –MP04 Well Surface Location

MP04		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		44	42	36	42
Noise Criteria L_{A10} dBA		49	47	41	47
Normal operation (2 pumps)	Predicted Noise Level at residence R1	47	47	48	47
	Compliance	☑	☒	☒☒	☑
Compliance Measure 1	Barriers to east	☑	☑	☒	☑
Compliance Measure 2	1 Mud pump only – oriented to northwest.	☑	☑	☑	☑
Site Location Comments	Acoustic enclosures on both pumps would allow operation of two mud pumps at night.				

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

8.3.3 Construction Noise Impact to Parks & Reserves

The well surface location is just south of the southern boundary of the Mount Annan Botanic Gardens (the "area boundary" mentioned in the *INP* criteria). With an acoustic barrier on the north of the surface location the noise will be reduced to L_{A10} 55 dBA approximately 120m north of the site. Depending on the final well surface location this will be approximately at Caley Drive, and there will be some noise impact for a short section of the Boundary Track along the perimeter of the park. At the pavilions at the southern part of the Gardens noise will be below 50dBA during drilling.

Figure 8-5 Daytime Noise Contours – MP04

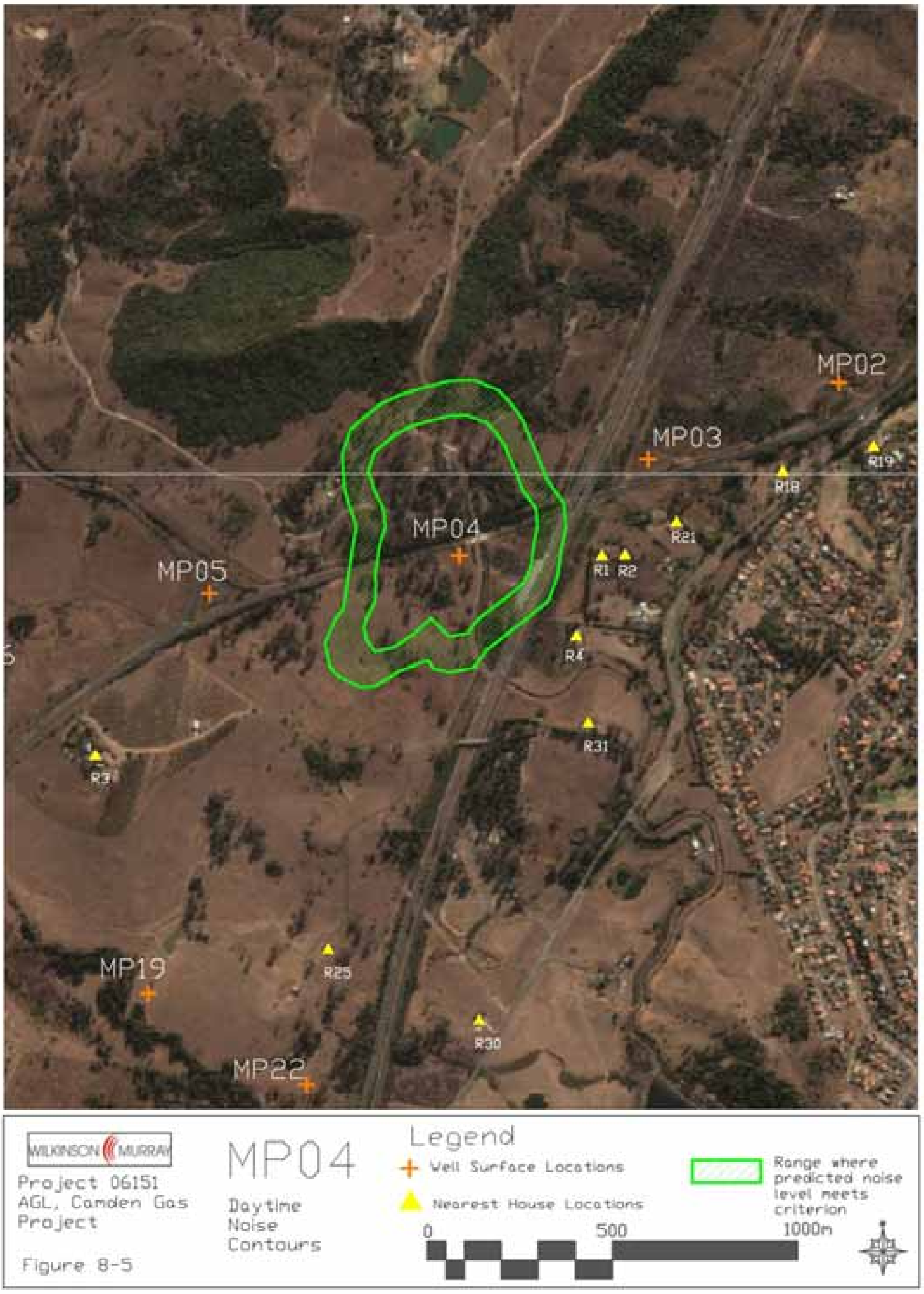


Figure 8-6 Night Time Noise Contours – MP04

8.4 Noise Impacts for MP05 Well Surface Location

8.4.1 Description of Surrounding Area

The proposed MP05 well surface location is in a rural area, it is surrounded by the built up Glenlee rail spur and main southern rail line, with scattered residences to the south and east. The nearest residences and their approximate distances from the surface location are (with the designation as shown in the Figures below):

- R3 – 520m to southwest (Glenlee House)
- R4 – 1000m to east
- R1 and R2 – 1070m to east
- R31 – 1080m to southeast

8.4.2 Construction Noise Impact

The RBLs measured at Measurement Location 3 (Glenlee House) are considered appropriate for assessment of noise impact at this well surface location. Noise levels, assessments and compliance measures for MP05 are shown in Table 8-4. Noise contours for daytime operation are shown in Figure 8-7. Noise contours for night time operation are shown on Figure 8-8. In this case the night time contour is smaller than the daytime contour because it is assumed that only one mud pump will operate. If two mud pumps operated at night temperature inversion conditions would extend the contour beyond R3.

Table 8-4 Construction Noise - MP05 Well Surface Location

MP05		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		35	38	35	35
Noise Criteria L_{A10} dBA		40	40	40	40
Normal operation (2 pumps)	Predicted Noise Level at Residence R3	57	57	58	57
	Compliance	☒☒☒	☒☒☒	☒☒☒	☒☒☒
Compliance Measure 1	Barriers to southwest	☒	☒	☒☒	☒
Compliance Measure 2	1 Mud pump only – oriented to northeast.	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

8.4.3 Construction Noise Impact to Parks & Reserves

The well surface location is just south of the southern boundary of the Mount Annan Botanic Gardens (the "area boundary" mentioned in the *INP* criteria). With an acoustic barrier on the north of the surface location the noise will be reduced to L_{A10} 55dBA approximately 120m north of the site - depending on the final well surface location. There will be some noise impact for a short section of the Boundary Track along the perimeter of the park. At the pavilions at the southern part of the Gardens noise will be below 45dBA during drilling.

Figure 8-7 Daytime Noise Contours – MP05

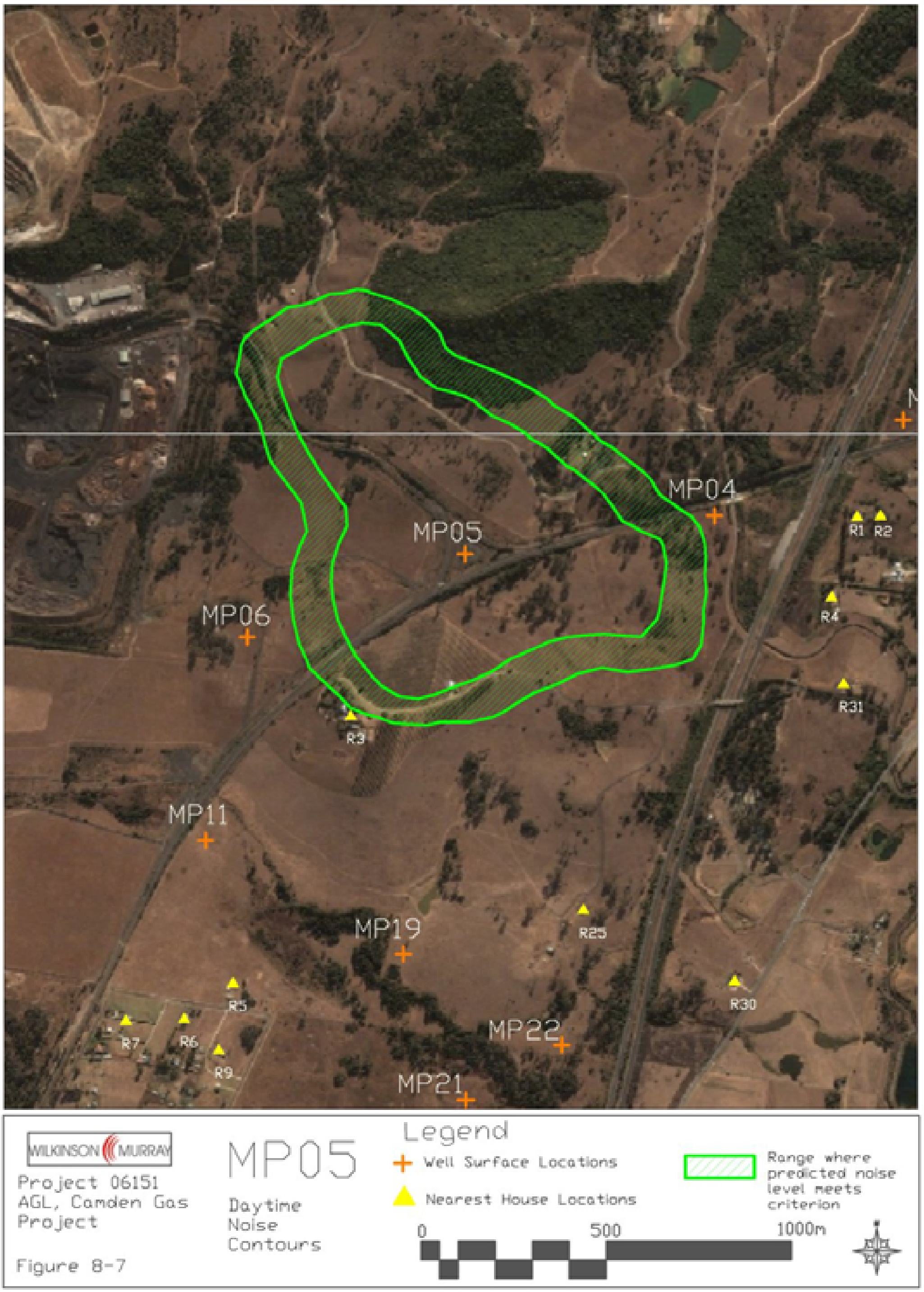
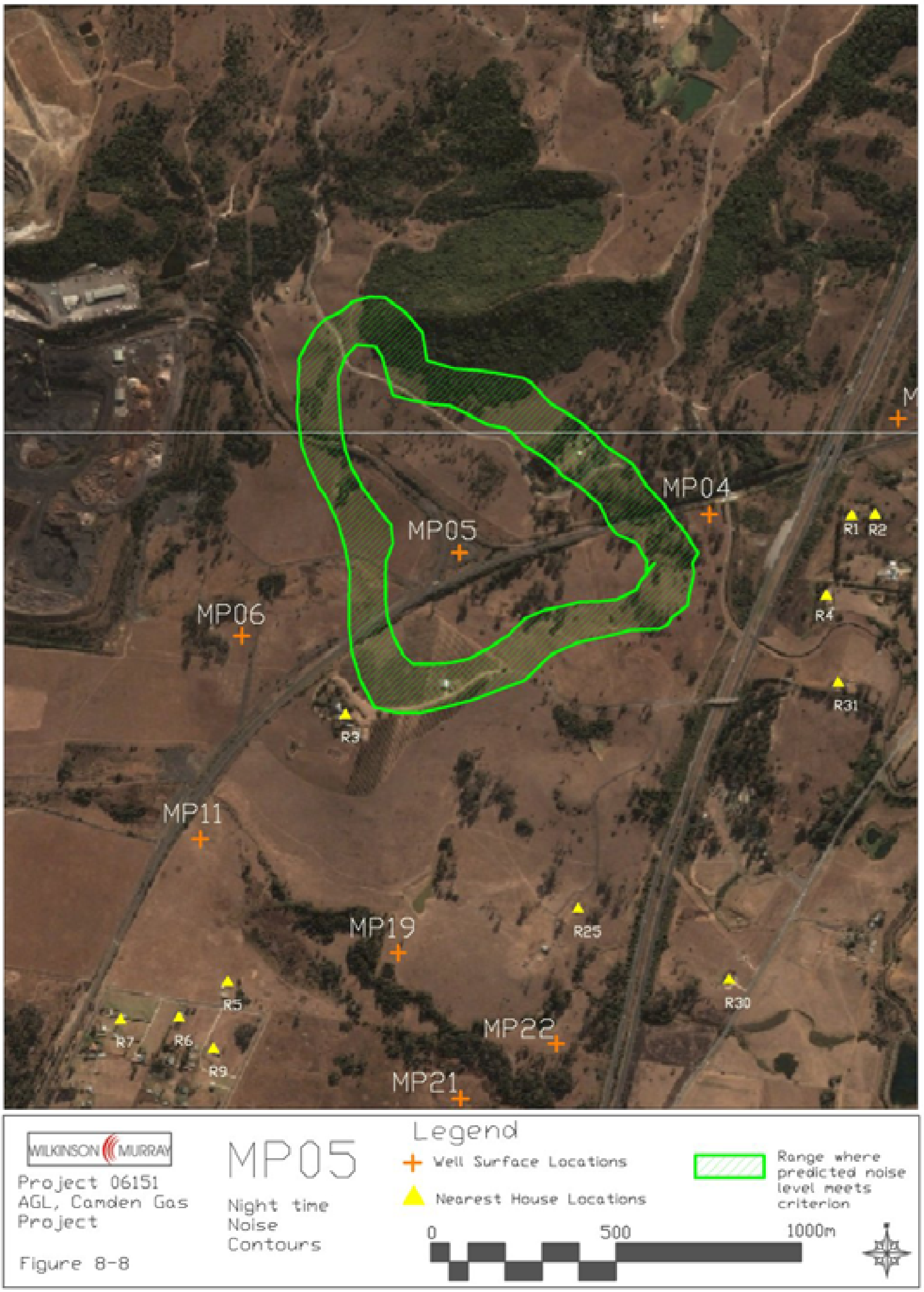


Figure 8-8 Night Time Noise Contours – MP05



8.5 Noise Impacts for MP06 Well Surface Location

8.5.1 Description of Surrounding Area

The proposed MP06 well surface location is in a rural area, with scattered residences. The nearest residence and its approximate distance from the site is (with the designation as shown in the Figures below) R3 – 350m to southeast (Glenlee House). The rail line is built up to more than 5 metres between the surface location and Glenlee House, and the shielding provided by the rail line has been taken into account.

8.5.2 Construction Noise Impact

The RBLs measured at Measurement Location 3 (Glenlee House) are considered appropriate for assessment of noise impact at this well surface location. Noise levels, assessments and compliance measures MP06 are shown in Table 8-5. Noise contours for daytime operation are shown in Figure 8-9. Noise contours for night time operation are shown in Figure 8-10.

Table 8-5 Construction Noise – MP06 Well Surface Location

MP06		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		35	38	35	35
Noise Criteria L_{A10} dBA		40	40	40	40
Normal operation (2 pumps)	Predicted Noise Level to Residence R3	61	61	62	61
	Compliance	☒☒☒	☒☒☒	☒☒☒	☒☒☒
Compliance Measure 1	Barriers to south & east	☒☒	☒☒	☒☒	☒☒
Compliance Measure 3	Compliance Measure 1 and Acoustic enclosure on mud pumps	☑	☑	☑	☑
Site Location Comments	Should not approach R3 closer than point shown on map				

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-9 Daytime Noise Contours – MP06

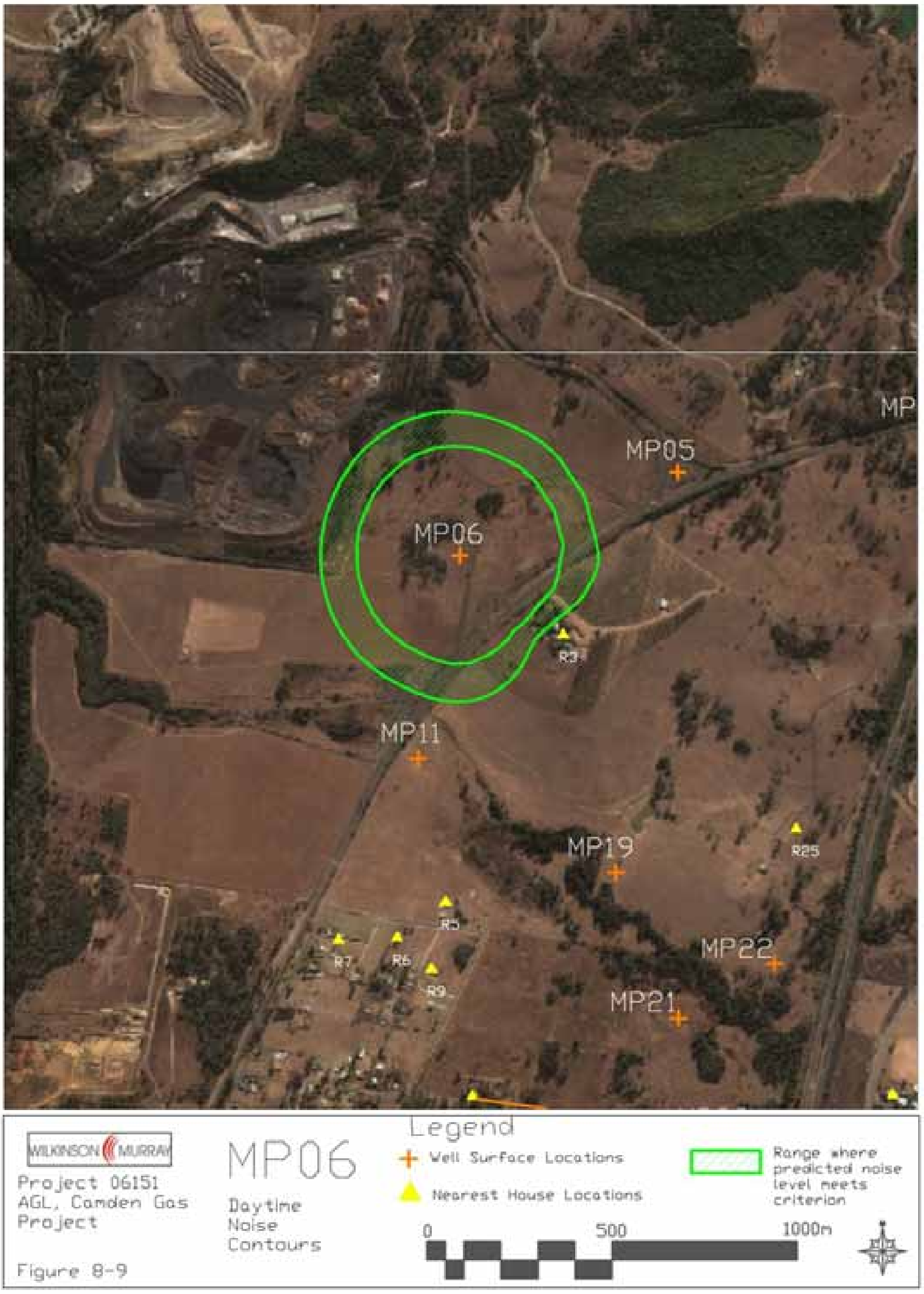
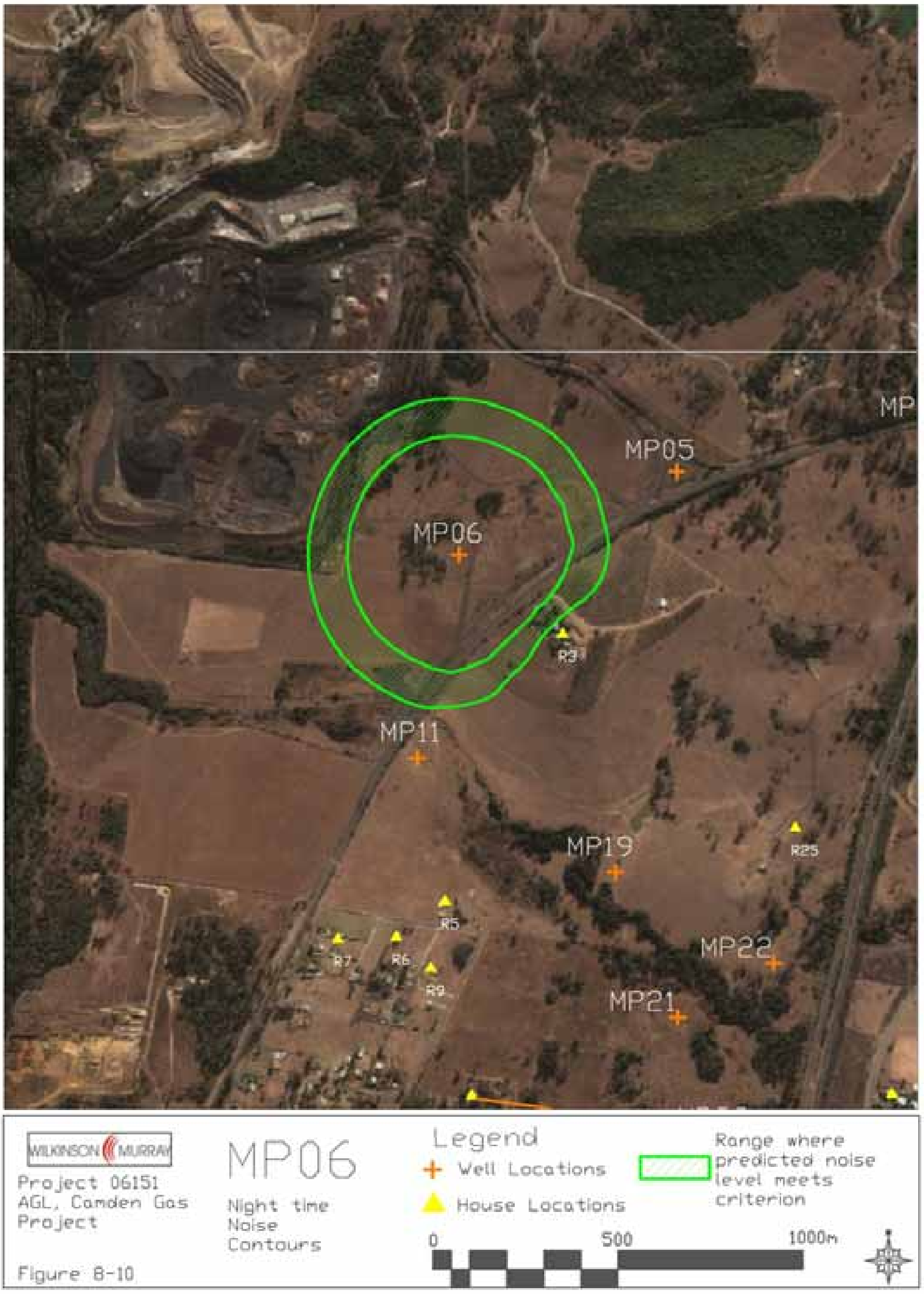


Figure 8-10 Night Time Noise Contours – MP06



8.6 Noise Impacts for MP11 Well Surface Location

8.6.1 Description of Surrounding Area

The proposed MP11 well surface location is in a rural area, with scattered residences. The nearest residences and their approximate distances from the surface location are (with the designation as shown in the Figures below):

- R3 – 530m to northeast
- R5 – 380m to southeast
- R6 – 470m to south
- R7 – 520m to south

The rail line is more than 5m high to the west of the surface location but it does not protect any residences from noise.

8.6.2 Construction Noise Impact

The RBLs measured at Measurement Location 4 (Cummins Road) are considered appropriate for assessment of noise impact at this surface location. Although Logger Location 2, Glenlee House, is at a similar distance, it is well shielded from this surface location. Noise levels, assessments and compliance measures for MP11 are shown in Table 8-6. Noise contours for daytime operation are shown in Figure 8-11. Noise contours for night time operation are shown in Figure 8-12.

Table 8-6 Construction Noise – MP11 Well Surface Location

MP11		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		37	37	35	37
Noise Criteria L_{A10} dBA		42	42	40	42
Normal operation (2 pumps)	Predicted Noise Level to Residence R5	54	54	55	54
	Compliance	☒☒☒	☒☒☒	☒☒☒	☒☒☒
Compliance Measure 1	Barriers to southeast, orient pumps to northwest	☑	☑	☒	☑
Compliance Measure 2	1 Mud pump only – oriented to northwest	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-11 Daytime Noise Contours – MP11

Figure 8-12 Night Time Noise Contours – MP11

8.7 Noise Impacts for MP19 Well Surface Location

8.7.1 Description of Surrounding Area

The proposed MP19 well surface location is in a rural area, with scattered residences. The nearest residences and their approximate distances from the surface location are (with the designation as shown in the Figures below):

- R3 – 650m to north
- R5 – 450m to southwest
- R9 – 560m to southwest
- R25 - 500m east
- R30 – 900m to east

8.7.2 Construction Noise Impact

This well is located between the Measurement Locations 3, 4 and 5. That is, it potentially affects residences with different background noise levels, and therefore different noise criteria. While residences near Location 4 (Cummins Road) are closer to this surface location than R3, those residences are well shielded by a ridge from this surface location and Glenlee House (R3) is the most affected residence. The second most affected residence is R25, whose RBLs are most appropriately taken from measurement Location 5.

Two different noise contours are therefore drawn with respect to two different sets of criteria. These two contours do not join, so there are breaks in the contours on the figures. The contours near R3 are taken from the criteria for Measurement Location 3 (which is in fact R3). The contours near R25 are drawn with respect to the criteria for Measurement Location 5.

Noise levels, assessments and compliance measures for MP19 are shown in Table 8-7. The calculated noise level at R3 is reported. The compliance measures listed will ensure compliance at R3 and R25.

Noise contours for daytime operation are shown in Figure 8-13. Noise contours for night time operation are shown in Figure 8-14.

Table 8-7 Construction Noise – MP19 Well Surface Location

MP19		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL	To R3	35	38	35	35
Noise Criteria L_{A10} dBA		40	40	40	40
RBL	To R25	44	42	36	42
Noise Criteria L_{A10} dBA		49	47	41	47
Normal operation (2 pumps)	Predicted Noise Level to R3	50	50	51	50
	Compliance	☒☒	☒☒	☒☒	☒☒
Compliance Measure 1	Barriers to northwest and northeast, orient southeast (to protect R3)	☑	☑	☒	☑
Compliance Measure 2	1 Mud pump only – oriented to northwest.	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-13 Daytime Noise Contours – MP19

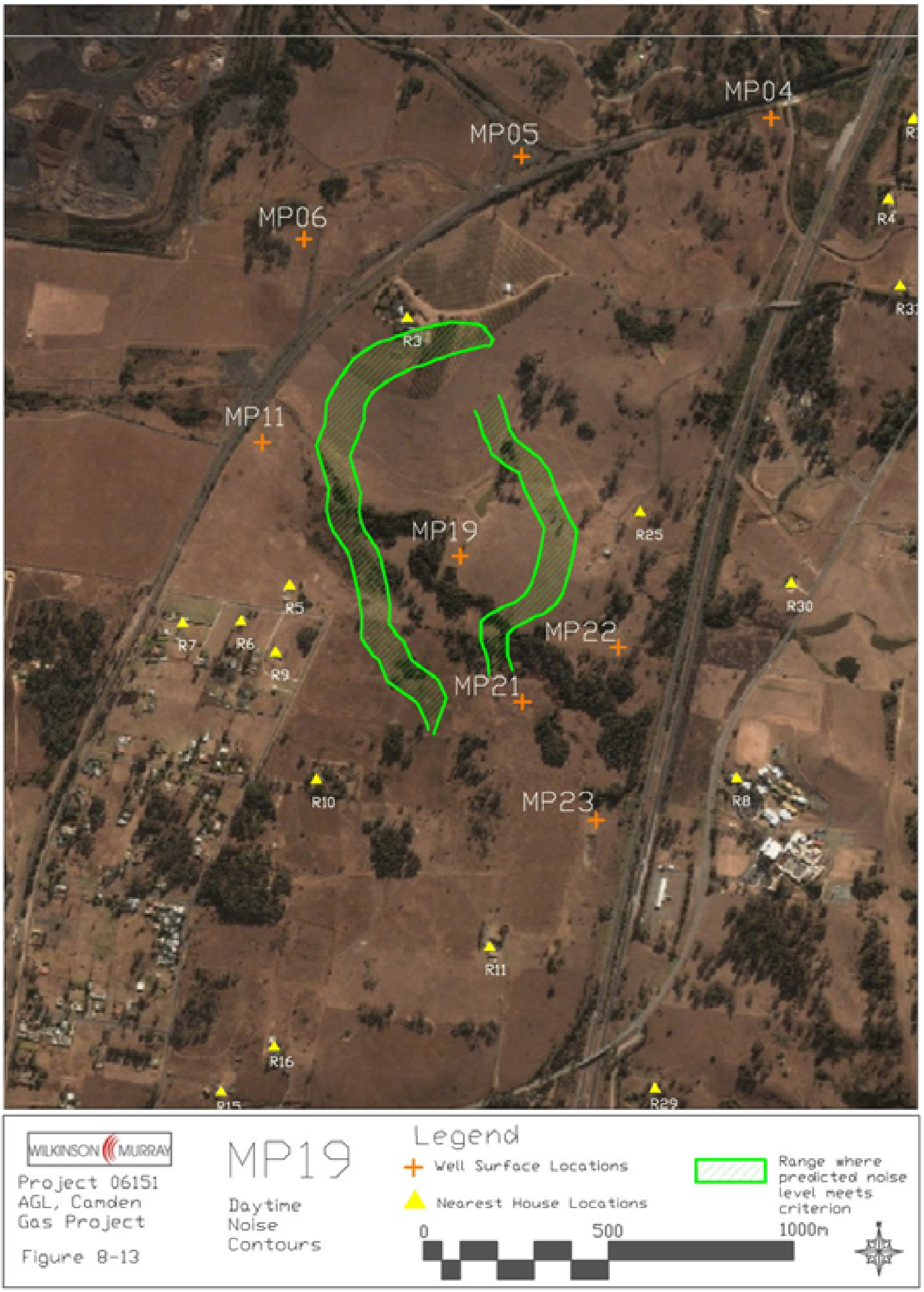
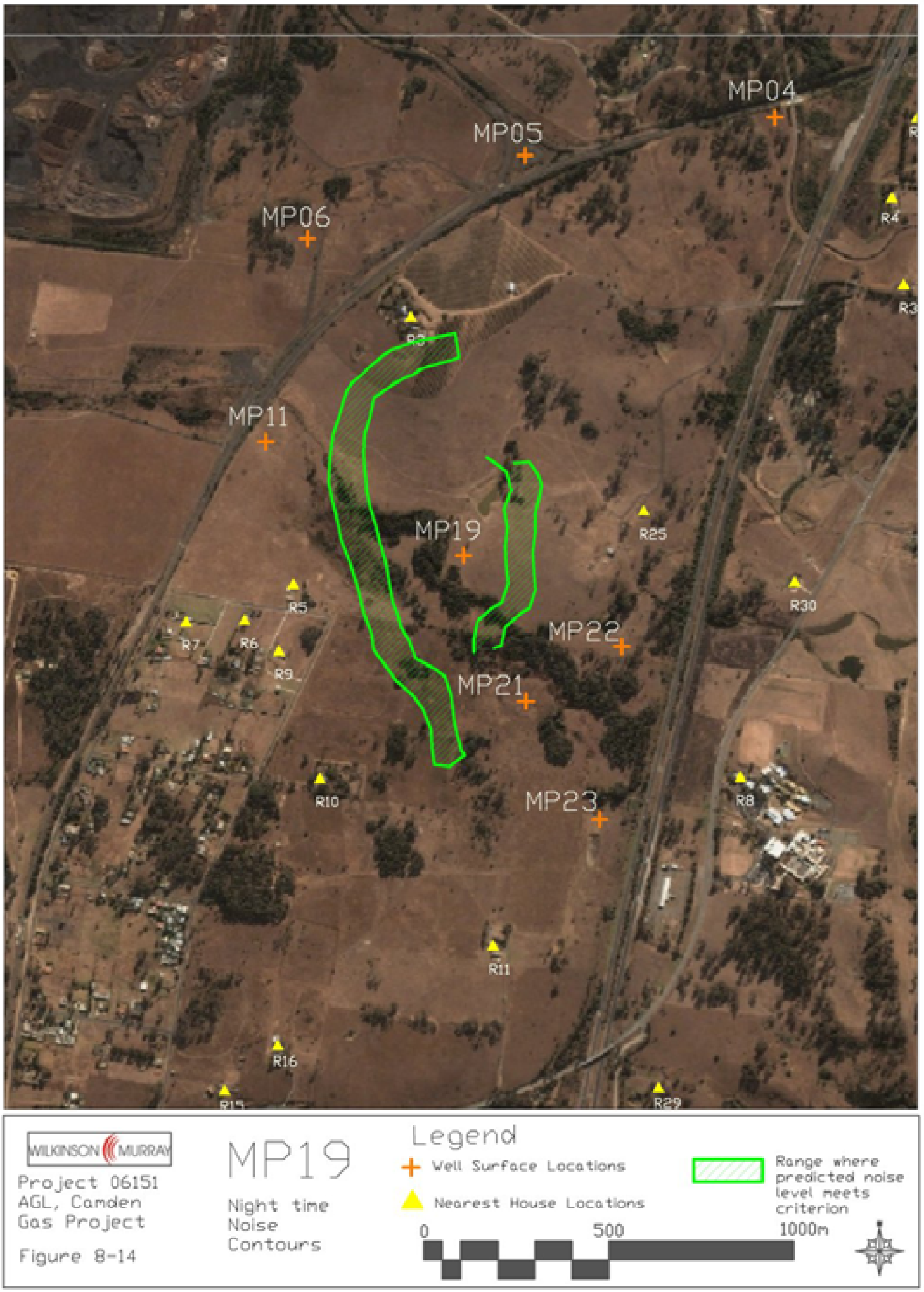


Figure 8-14 Night Time Noise Contours – MP19



8.8 Noise Impacts for MP21 Well Surface Location

8.8.1 Description of Surrounding Area

The proposed MP21 well surface location is in a rural area, with scattered residences. The nearest residences and their approximate distances from the well surface location are (with the designation as shown in the Figures below):

- R25 – 590m to northeast
- R8 – 600m to southeast (Principal's residence – Broughton College)
- R9 – 660 to west
- R10 – 580m to southwest
- R5 – 690m to northwest
- R30 – 770m to northeast

8.8.2 Construction Noise Impact

The RBLs measured at Measurement Location 5 (Sugarloaf Property) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for MP21 are shown in Table 8-8.

Noise contours for daytime operation are shown in Figure 8-15. Noise contours for night time operation are shown in Figure 8-16.

Table 8-8 Construction Noise - MP21 Well Surface Location

MP21		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		44	42	36	42
Noise Criteria L_{A10} dBA		49	47	41	47
Normal operation (2 pumps)	Predicted Noise Level to R25	51	51	52	51
	Compliance	☒	☒	☒☒☒	☒
Compliance Measure 1	Barriers northeast, orient south west (to protect R25)	☑	☑	☒☒	☑
Compliance Measure 2	1 Mud pump only – oriented to northwest.	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-15 Daytime Noise Contours – MP21

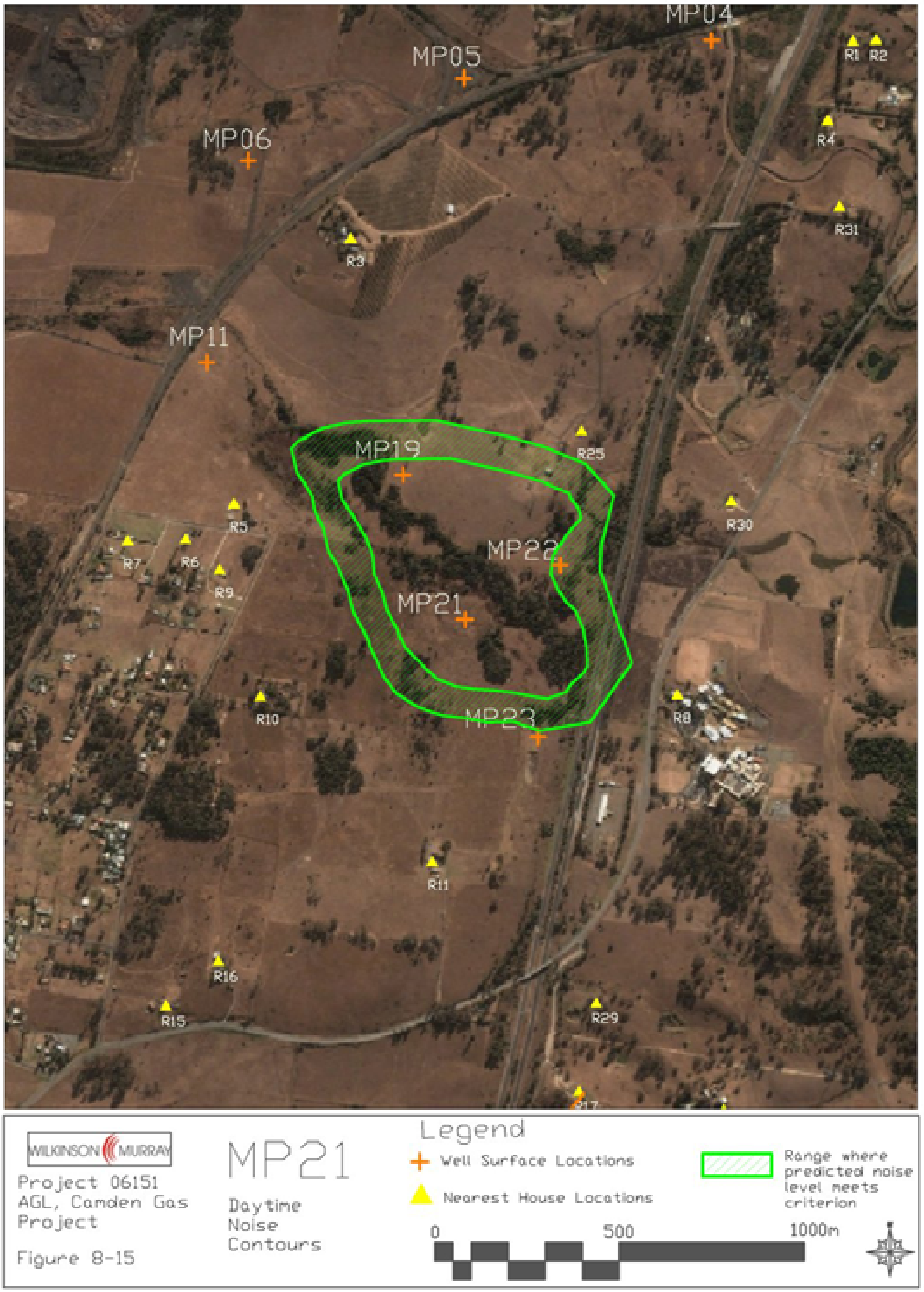


Figure 8-16 Night Time Noise Contours – MP21

8.9 Noise Impacts for MP22 Well Surface Location

8.9.1 Description of Surrounding Area

The proposed MP22 well surface location is in a rural area, along the western side of the M5 freeway with scattered residences. The nearest residences and their approximate distances from the well surface location are (with the designation as shown in the Figures below):

- R25 – 360m to north
- R8 – 470m to southeast
- R30 – 480m to northeast
- R9 – 920m to west
- R10 – 860m to southwest

8.9.2 Construction Noise Impact

The RBLs measured at Measurement Location 5 (Sugarloaf Property) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for MP22 are shown in Table 8-9. Noise contours for daytime operation are shown on Figure 8-17. Noise contours for night time operation are shown on Figure 8-18.

Table 8-9 Construction Noise – MP22 Well Surface Location

MP22		Weekday (7am–6pm) & Saturday (7am–1pm)	Evening (6-10pm)	Night (10pm-7am)	Saturday (1pm–6pm) & Sunday (7am–6pm)
RBL		44	42	36	42
Noise Criteria L_{A10} dBA		49	47	41	47
Normal operation (2 pumps)	Predicted Noise Level	53	53	55	53
	Compliance	☒☒	☒☒	☒☒☒	☒☒
Compliance Measure 1	Barriers to north	☑	☑	☒☒	☑
Compliance Measure 2	1 Mud pump only – oriented to northwest.	☑	☑	☒	☑
Compliance Measure 3	Compliance measure 1 and Acoustic enclosure on both mud pumps.	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-17 Daytime Noise Contours – MP22

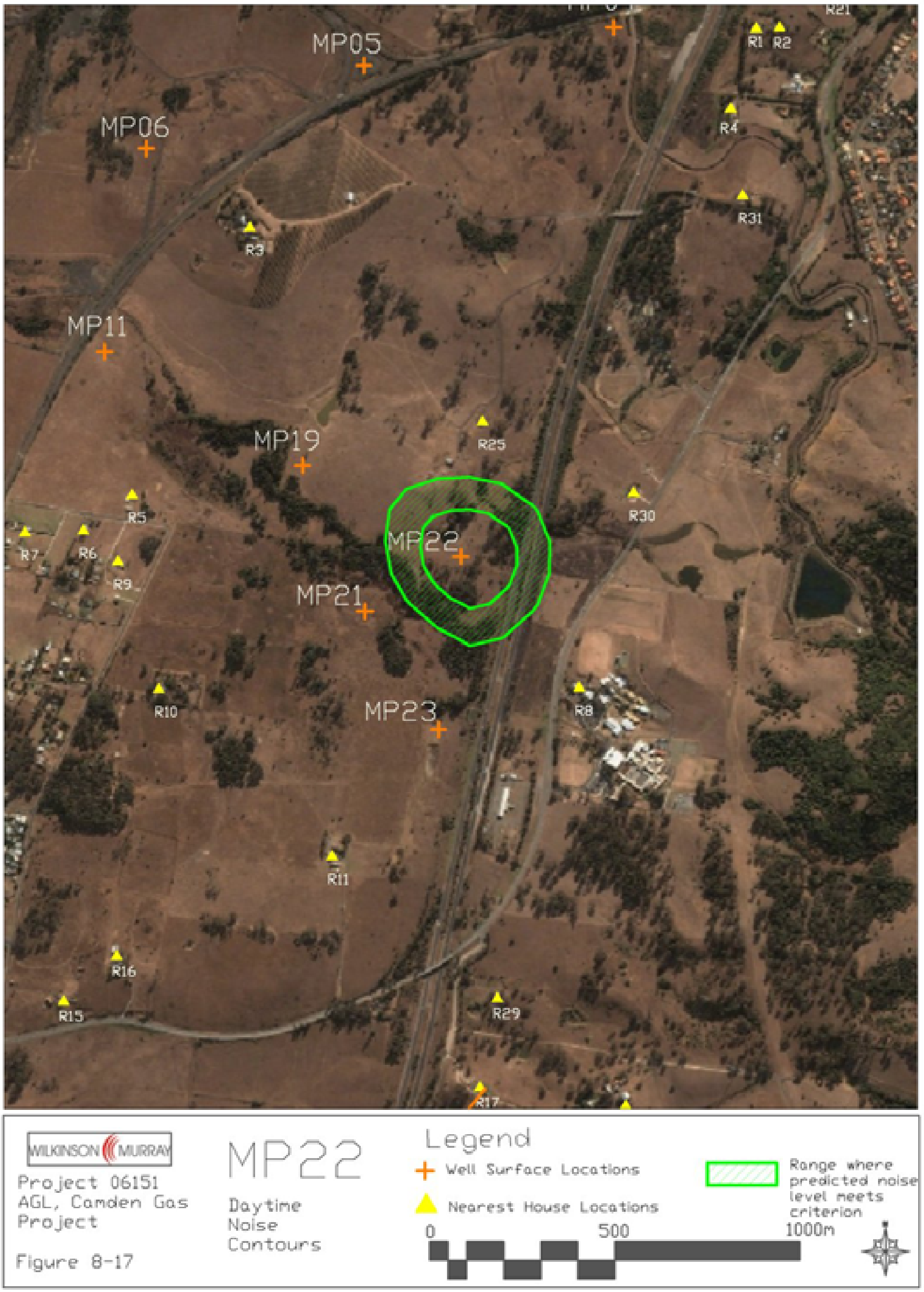


Figure 8-18 Night Time Noise Contours – MP22

8.10 Noise Impacts for MP23 Well Surface Location

8.10.1 Description of Surrounding Area

The proposed MP23 well surface location is in a rural area, along the western side of the M5 freeway with scattered residences. The nearest residences and their approximate distances from the surface location are (with the designation as shown in the Figures below):

- R8 – 380m to East (Principal's residence – Broughton College)
- R9, R6, R5 – >950m to northwest
- R10 – 750m to west
- R11 – 440m to southwest
- R25 - 830m to north
- R30 – 820m to northeast
- R29 – 720m to southeast
- R17 – 1120m to southeast

8.10.2 Construction Noise Impact

The RBLs measured at Measurement Location 5 (Sugarloaf Property) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for MP23 are shown in Table 8-10. Noise contours for daytime operation are shown on Figure 8-20. Noise contours for night time operation are shown on Figure 8-20.

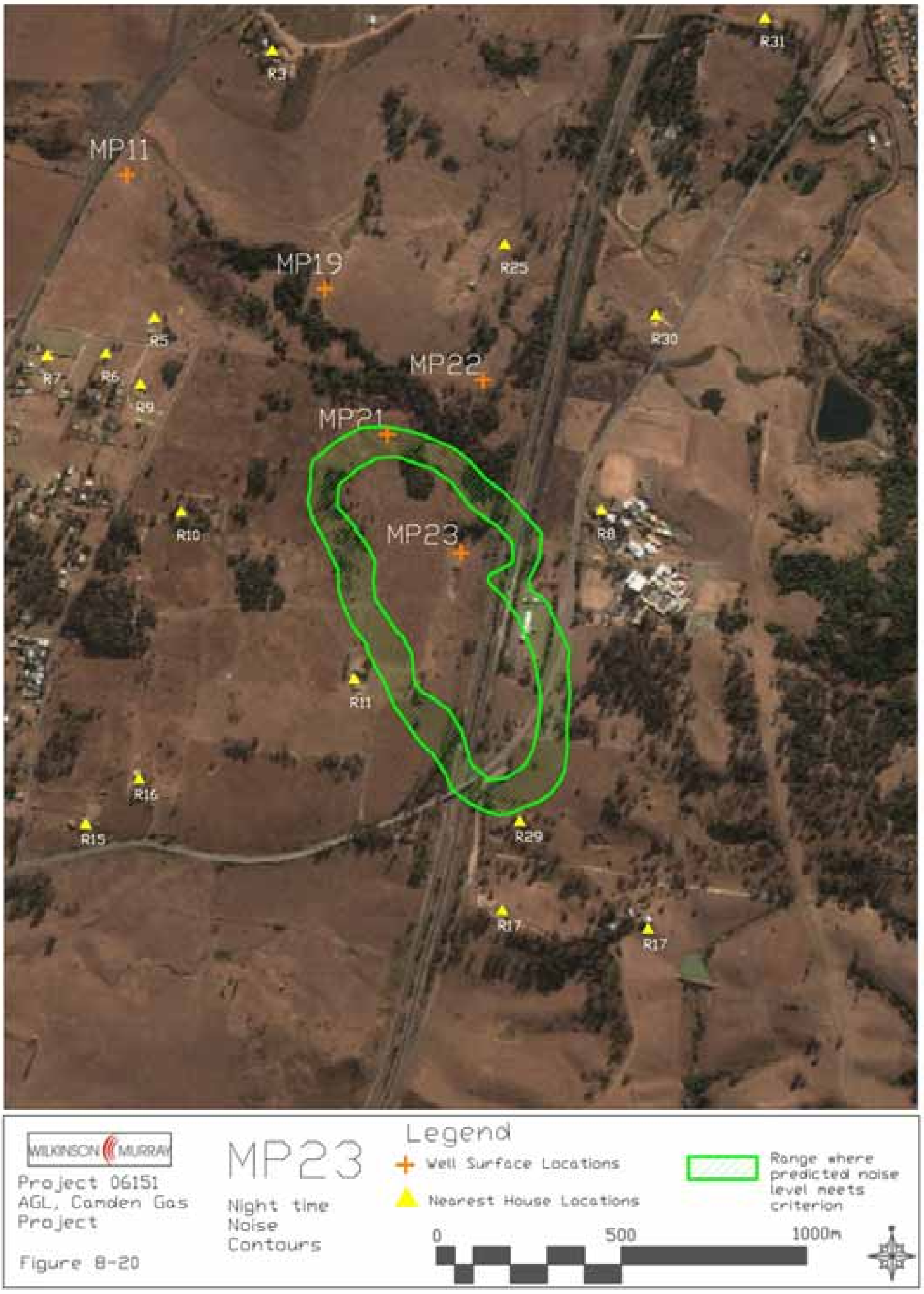
Table 8-10 Construction Noise – MP23 Well Surface Location

MP23		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		44	42	36	42
Noise Criteria L_{A10} dBA		49	47	41	47
Normal operation (2 pumps)	Predicted Noise Level at R8	35	35	37	35
	Compliance	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-19 Daytime Noise Contours – MP23

Figure 8-20 Night Time Noise Contours – MP23



8.11 Noise Impacts for MP24 Well Surface Location

8.11.1 Description of Surrounding Area

The proposed MP24 well surface location is in a rural area south of Menangle Park, between the main southern rail line and a quarry. The nearest residences are to the north and their approximate distances from the surface location are (with the designation as shown in the Figures below):

- R12 – 320m to northeast
- R13 – 370m to northeast
- R14 – 570m to southwest

R12 and R13 are acoustically shielded from MP24 by the railway viaduct (approximately 7m high at this point), making R14 the most potentially affected residence.

8.11.2 Construction Noise Impact

The RBLs measured at Location 4 (Cummins Road) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for MP24 are shown in Table 8-11. Noise contours for daytime operation are shown on Figure 8-21. Noise contours for night time operation are shown on Figure 8-22.

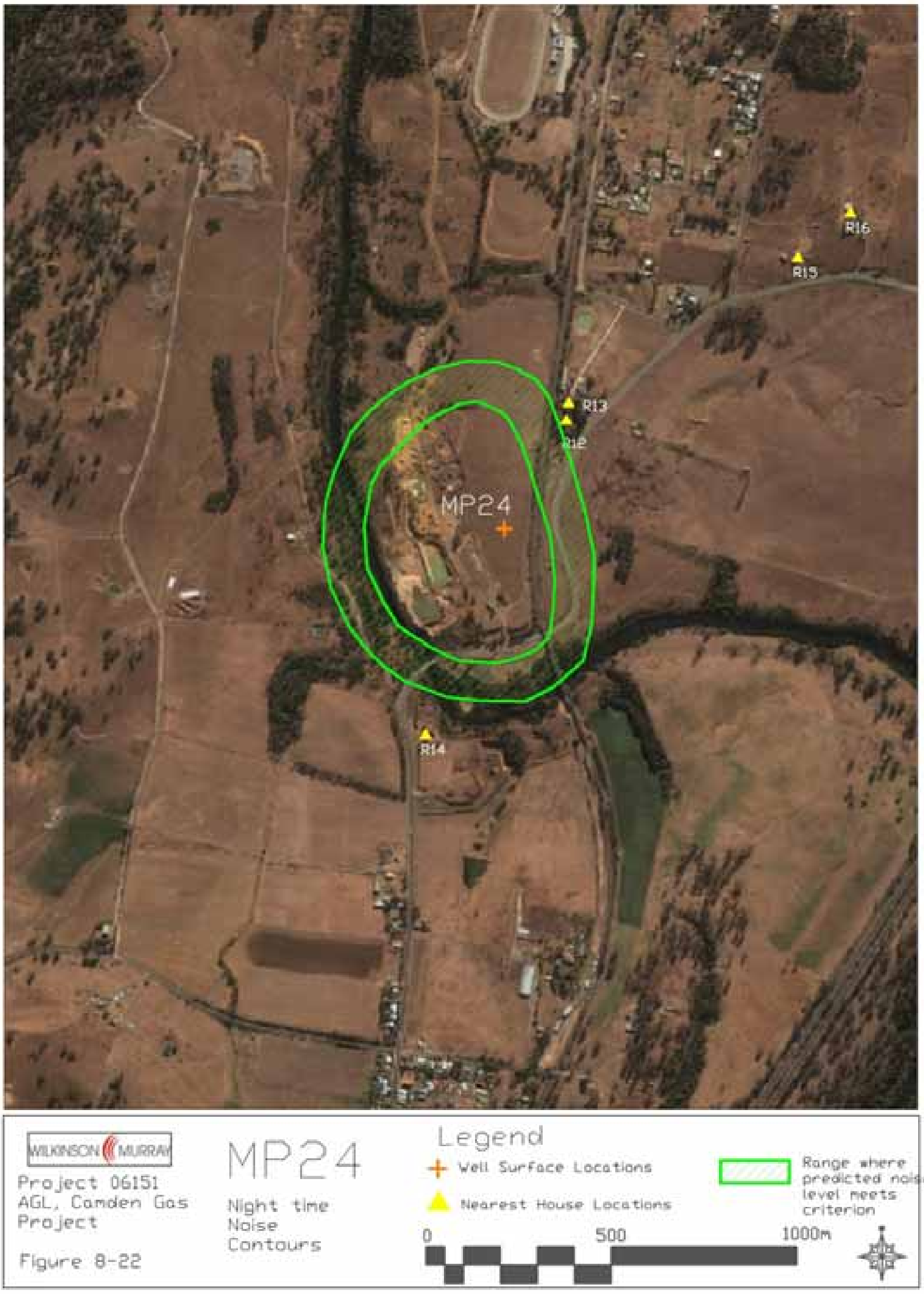
Table 8-11 Construction Noise – MP24 Well Surface Location

MP24		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		37	37	35	37
Noise Criteria L_{A10} dBA		42	42	40	42
Normal operation (2 pumps)	Predicted Noise Level at R14	44	44	45	44
	Compliance	☒	☒	☒	☒
Compliance Measure 1	Barriers to north and south, orient mud pumps west	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-21 Daytime Noise Contours – MP24

Figure 8-22 Night Time Noise Contours – MP24



8.12 Noise Impacts for MP33 Well Surface Location

8.12.1 Description of Surrounding Area

The proposed MP33 well surface location is in a rural area, along the western side of the M5 freeway, with only widely scattered residences. The nearest residences and their approximate distances from the well surface location are (with the designation as shown in the Figures below):

- R15, R16 - 1120m to north
- R17 > 900m to northeast
- R29 – 1130 m to northeast

8.12.2 Construction Noise Impact

The RBLs measured at Location 4 (Cummins Road) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for MP33 are shown in Table 8-12. Noise contours for daytime operation are shown on Figure 8-23. Noise contours for night time operation are shown on Figure 8-24.

Table 8-12 Construction Noise – MP33 Well Surface Location

MP33		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		37	37	35	37
Noise Criteria L_{A10} dBA		42	42	40	42
Normal operation (2 pumps)	Predicted Noise Level to all residences	<30	<30	<30	<30
	Compliance	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-23 Daytime Noise Contours – MP33

Figure 8-24 Night Time Noise Contours – MP33

8.13 Noise Impacts for SF04 Well Surface Location

8.13.1 Description of Surrounding Area

The proposed SF04 well surface location is located near the Jacks Gully Waste Management Facility. The nearest residence, and its approximate distances from the surface location is (with the designation as shown in the Figures below):

- R22 – 450m to north
- R26 – 460m to northwest (corner of Richardson Road and Springs Road)

8.13.2 Construction Noise Impact

The RBLs measured at Measurement Location 1 (St Thomas Church) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for SF04 are shown in Table 8-13. Noise contours for daytime operation are shown on Figure 8-25. Noise contours for night time operation are shown on Figure 8-26.

Table 8-13 Construction Noise – SF04

SF04		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		38	37	32	37
Noise Criteria L_{A10} dBA		43	42	37	42
Normal operation (2 pumps)	Predicted Noise Level to R22 & R26	55	55	55	55
	Compliance	☒☒	☒☒☒	☒☒☒	☒☒☒
Compliance Measure 1	Barriers to north, orient mud pump to south	☒	☒☒	☒☒	☒☒
Compliance Measure 2	1 Mud pump only	☒	☒	☒	☒
Compliance Measure 3	Acoustic enclosure on mud pumps	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-25 Daytime Noise Contours – SF04

Figure 8-26 Night Time Noise Contours – SF04

8.14 Noise Impacts for SF04A Well Surface Location

8.14.1 Description of Surrounding Area

The proposed SF04A well surface location is situated south of SF04 near the Jacks Gully Waste Management Facility and is one of the options for a single SF04 well surface location. The nearest residences and their approximate distances from the surface location are (with the designation as shown in the Figures below):

- R22 – 650m to north
- R26 – 610m to northwest (corner of Richardson Road and Springs Road)

Although SF04A is near the location for SF04, SF04A benefits from shielding by natural topography.

8.14.2 Construction Noise Impact

The RBLs measured at Measurement Location 1 (St Thomas Church) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for SF04A are shown in Table 8-14. Noise contours for daytime operation are shown in Figure 8-27. Noise contours for night time operation are shown on Figure 8-28.

Table 8-14 Construction Noise – SF04A

SF04A		Weekday (7am–6pm) & Saturday (7am–1pm)	Evening (6-10pm)	Night (10pm-7am)	Saturday (1pm–6pm) & Sunday (7am–6pm)
RBL		38	37	32	37
Noise Criteria L_{A10} dBA		43	42	37	42
Normal operation (2 pumps)	Predicted Noise Level to R22	34	34	35	34
	Compliance	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

Figure 8-27 Daytime Noise Contours – SF04A

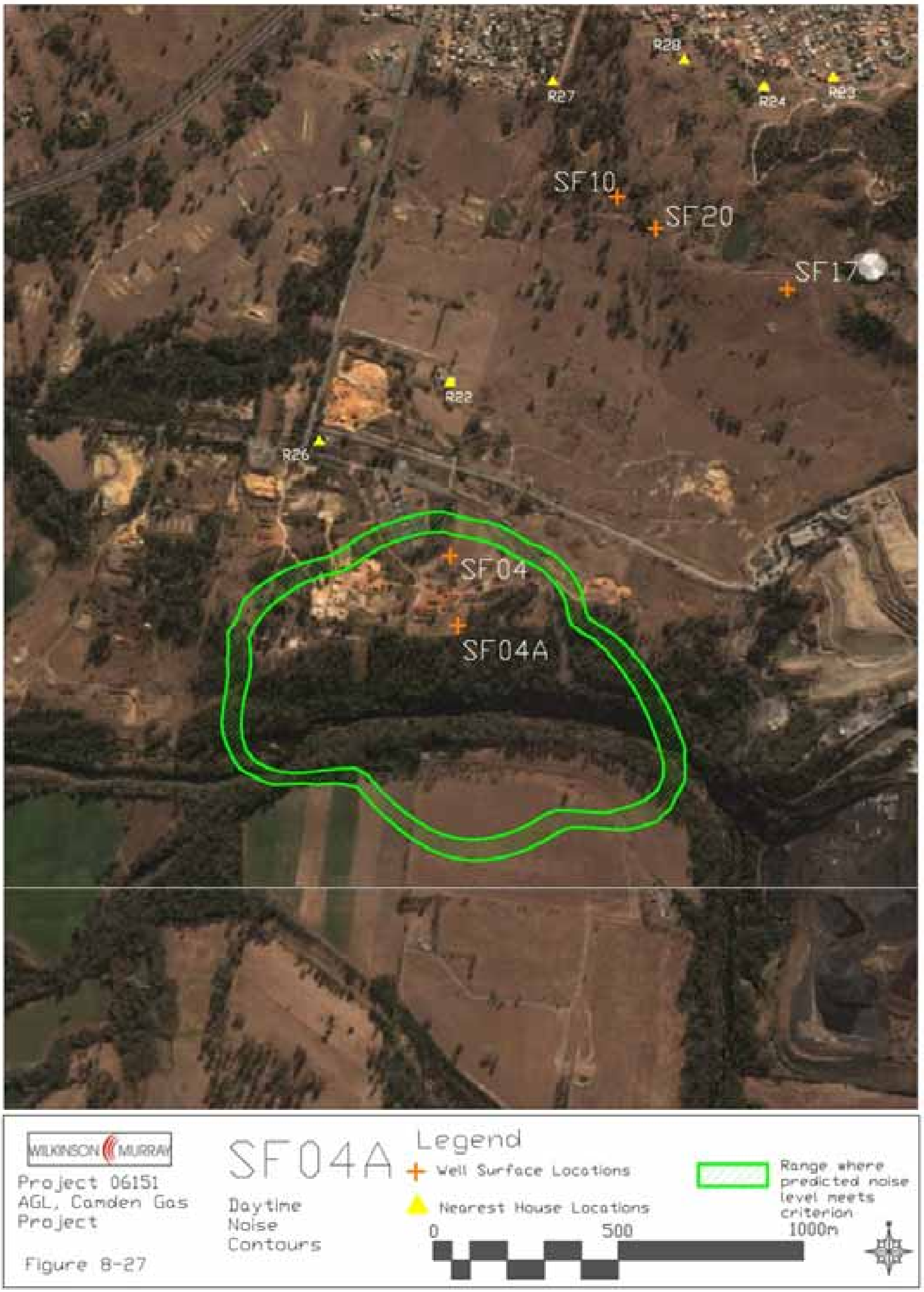
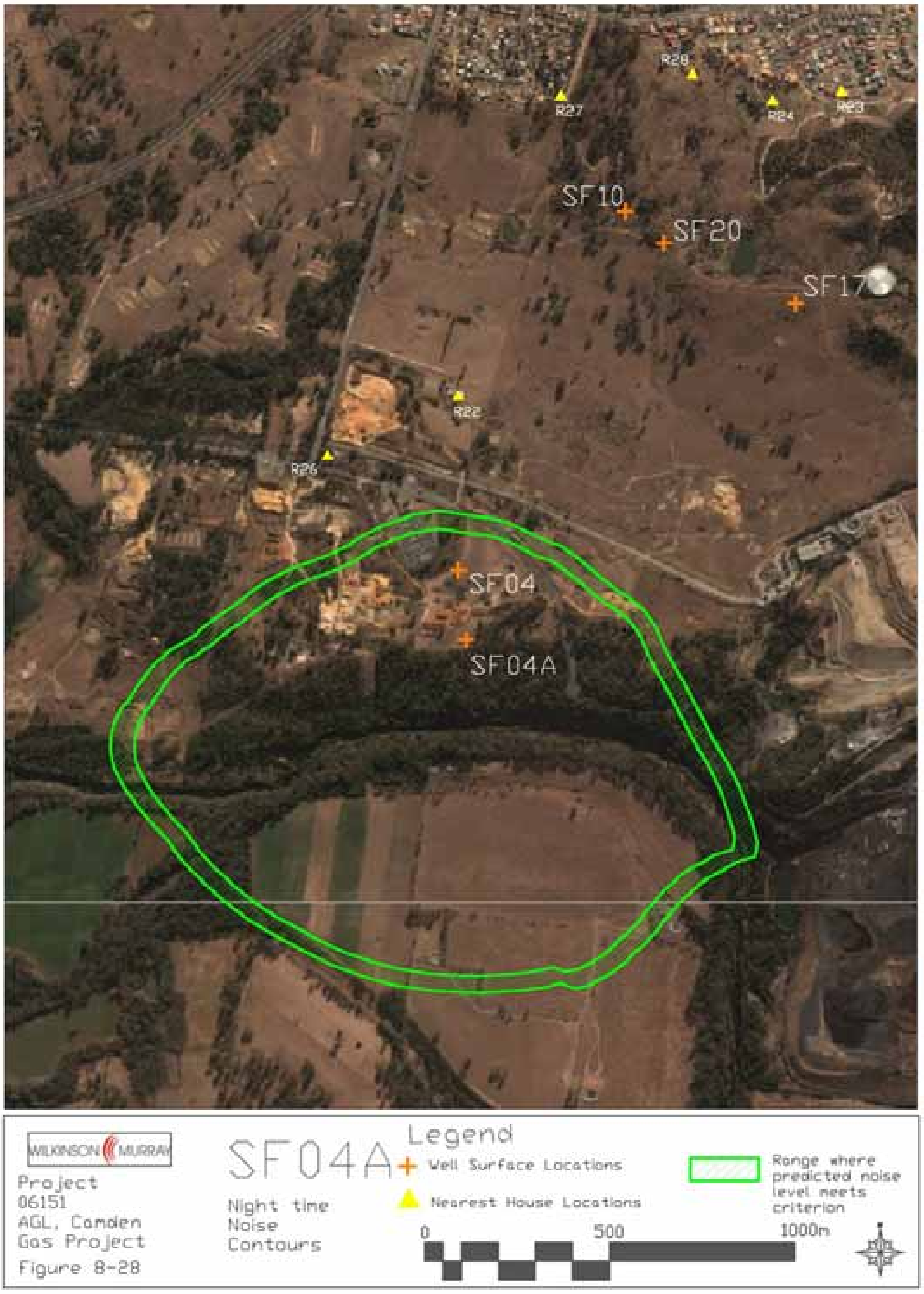


Figure 8-28 Night Time Noise Contours – SF04A



8.15 Noise Impacts for SF10 Well Surface Location

8.15.1 Description of Surrounding Area

The proposed SF10 well surface location is in a rural area south of the suburban area of Mount Annan. The noise impact at the suburban area is represented by the nearest residences – that is those most potentially impacted by noise from the drilling. These representative residences and their approximate distances from the surface location are (with the designation as shown in the Figures below):

- R24 – 480m to north east (Mount Annan suburban area)
- R27 – 340m to northwest
- R28 – 410m to north

Further from the well surface location are rural residences. The nearest is:

- R22 – 660m to southwest

8.15.2 Construction Noise Impact

The RBLs measured at Measurement Location 2 (Gundungurra Reserve) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for SF10 are shown in Table 8-15. Noise contours for daytime operation are shown on Figure 8-29. Noise contours for night time operation are shown on Figure 8-30.

Table 8-15 Construction Noise – SF10 Well Surface Location

SF10		Weekday (7am–6pm) & Saturday (7am–1pm)	Evening (6-10pm)	Night (10pm-7am)	Saturday (1pm–6pm) & Sunday (7am–6pm)
RBL		38	36	31	38
Noise Criteria L_{A10} dBA		43	41	36	43
Normal operation (2 pumps)	Predicted Noise Level to R27	54	54	56	54
	Compliance	☒☒	☒☒	☒☒☒	☒☒
Compliance Measure 1	Barriers to north, orient mud pumps south	☒	☒	☒☒☒	☒
Compliance Measure 2	1 Mud pump only – oriented to northwest.	☒	☒	☒	☒
Compliance Measure 3	Acoustic enclosure on mud pumps – barrier to northwest still required, maximum 5m from rig	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

8.15.3 Construction Noise Impact to Parks & Reserves

The well surface location is just within the southern boundary of the Gundungurra Reserve (the "area boundary" mentioned in the *INP* criteria). With acoustic enclosures on the mudpumps, and a northern acoustic barrier as described in Table 8-15, the L_{A10} 55dBA criterion will be achieved within 100m of the compound.

Figure 8-29 Daytime Noise Contours – SF10

Figure 8-30 Night Time Noise Contours – SF10

8.16 Noise Impacts for Well SF17 Well Surface Location

8.16.1 Description of Surrounding Area

The proposed SF17 well surface location is in a rural area south of the suburban area of Mount Annan. The noise impact at the suburban area is represented by the nearest residences – that is those most potentially impacted by noise from the drilling. These representative residences and their approximate distances from the well surface location are (with the designation as shown in the Figures below):

- R24 – 540m to north
- R23 – 580m to north

Further from the well surface location are rural residences. The closest is:

- R22 – 950m to southwest

8.16.2 Construction Noise Impact

The RBLs measured at Measurement Location 2 (Gundungurra Reserve) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for SF17 are shown in Table 8-16. Noise contours for daytime operation are shown in Figure 8-31. Noise contours for night time operation are shown in Figure 8-32.

Table 8-16 Construction Noise - SF17 Well Surface Location

SF17		**Weekday (7am–6pm) & Saturday (7am–1pm)**	**Evening (6-10pm)**	**Night (10pm-7am)**	**Saturday (1pm–6pm) & Sunday (7am–6pm)**
RBL		38	36	31	38
Noise Criteria L_{A10} dBA		43	41	36	43
Normal operation (2 pumps)	Predicted Noise Level to R24	33	33	35	33
	Compliance	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

8.16.3 Construction Noise Impact to Parks & Reserves

The well surface location is south of the William Howe Reserve. With an acoustic barrier on the north of the surface location the noise will be reduced to L_{A10} 55dBA approximately 120m north of the site. There will be some minor noise impact near the southern boundary of the Reserve, depending on the final location of the well surface location.

Figure 8-31 Daytime Noise Contours – SF17

Figure 8-32 Night Time Noise Contours – SF17

8.17 Noise Impacts for SF20 Well Surface Location

8.17.1 Description of Surrounding Area

The proposed SF20 well surface location is in a rural area south of the suburban area of Mount Annan. The noise impact at the suburban area is represented by the nearest residences – that is those most potentially impacted by noise from the drilling. These representative residences and their approximate distances from the surface location are (with the designation as shown in the Figures below):

- R24 – 470m to northeast
- R23 – 620m to northeast
- R27 – 470m to northwest
- R28 – 460m to north

Further from the well surface location than the urban area of Mount Annan there are some rural residences. The nearest is:

- R22 – 690m southwest

8.17.2 Construction Noise Impact

The RBLs measured at Measurement Location 2 (Gundungurra Reserve) are considered appropriate for assessment of noise impact at this surface location. Noise levels, assessments and compliance measures for SF20 are shown in Table 8-17. Noise contours for daytime operation are shown on Figure 8-33. Noise contours for night time operation are shown on Figure 8-34.

Table 8-17 Construction Noise – SF20 Well Surface Location

SF20		Weekday (7am–6pm) & Saturday (7am–1pm)	Evening (6-10pm)	Night (10pm-7am)	Saturday (1pm–6pm) & Sunday (7am–6pm)
RBL		38	36	31	38
Noise Criteria L_{A10} dBA		43	41	36	43
Normal operation (2 pumps)	Predicted Noise Level	57	57	57	57
	Compliance	☒☒☒	☒☒☒	☒☒☒	☒☒☒
Compliance Measure 1	Barriers to north and east, max 5m from rig	☑	☒	☒	☒
Compliance Measure 2	1 Mud pump only – oriented to south.	☑	☑	☑	☑

☑ complies
☒ non-compliance (<5dBA over criterion)
☒☒ non-compliance (5-10 dBA over criterion)
☒☒☒ non-compliance (> 10 dBA over criterion)

8.17.3 Construction Noise Impact to Parks and Reserves

The well surface location is within the southern section of the Gundungurra Reserve, and southwest of the William Howe Reserve. With an acoustic barrier on the north and east of the surface location the noise will be reduced to L_{A10} 55dBA approximately 120m of the site. There will be some noise impact within approximately 100m of the southern boundary of Gundungurra Reserve, depending on the final location of the well surface location. There may also be some impact in a small part of the William Howe reserve, depending on the final well surface location.

Figure 8-33 Daytime Noise Contours – SF20

Figure 8-34 Night Time Noise Contours – SF20

9 ASSESSMENT OF OPERATIONAL NOISE IMPACTS

9.1 Prediction & Assessment of Operational Noise

The prediction of operational noise from any well surface location is dependant on the following:

- Well head design;
- Source noise level;
- Number and type of wells at the surface location;
- Location and type of receivers;
- Any noise mitigation implemented for a particular well;
- The background noise level and assessment criteria; and
- Meteorological conditions.

These points are discussed further in the following sections.

9.2 Source Noise Levels

The proposal includes the operation of wells with different noise emission as described in Table 9-1.

Noise levels have been measured by Wilkinson Murray on a variety of producing wells. The source noise level depends on a number of factors including:

- Well head design, which is the critical issue in controlling noise from wells;
- Well productivity;
- Well maintenance;
- Free-flow or pump assisted;
- Directivity (wells can be up to 10dBA quieter on one side).

Table 9-1 Noise Levels of Representative Producing Gas Wells

Plant Description	Well ID	L_{eq} SWL (dBA)
Low Producing Well	EM11	49
	EM 12	53-57
Medium Producing Well	EM 14	73
	EM 15	72
		75
High Producing Well	EM 20	87
		77
		84
	GL 6	82
		80
Pump-Operated Well	MT 3	91
		94
		93

Plant Description	Well ID	L_{eq} SWL (dBA)
	EM 18	91
		91
		96
		85
	RP11	81
		93
Multiple Well Site	GL 2 & GL 12	75
		69
		76

All measurements were conducted using a Bruel and Kjaer Type 2260 Sound Level Meter. This sound level meter conforms to Australian Standard 1259 *Acoustics - Sound Level Meters* as a Type 1 Precision Sound Level Meter which has an accuracy suitable for field and laboratory use. The A-Weighting filter of the meter was selected and the time weighting was set to "Fast". The calibration of the meter was checked before and after the measurements with a Bruel and Kjaer Type 4231 sound level calibrator and no significant drift was noted.

The Bruel and Kjaer Type 2260 and Type 4231 have been laboratory calibrated within the previous two years in accordance with our in-house Quality Assurance Procedures.

Measurements were done at various distances appropriate to the source noise level and the site conditions. The measured sound pressure levels at various distances were used to determine the tabulated sound power level. Up to three measurements were taken at different directions from the wells to better calculate the overall sound power level. None of the measured wells were enclosed or had other acoustic treatment.

9.3 Location of Receivers

Based on currently available plans, it is expected that the Spring Farm and Menangle Park areas will change substantially during the lifetime of the proposed gas well surface locations from semi-rural to residential, industrial and commercial. The Development Concept Plan (DCP) for Spring Farm is known and the distance of residential boundaries to eventual well surface locations can be predicted with reasonable certainty.

It is expected that future residential boundaries will be approximately 30-40m from the SF04 and SF04A surface locations, 80-100m at SF17 and SF20, and 120m at SF10.

The planning for urban release at Menangle Park is less advanced and the distance between future development and well surface locations cannot be reasonably predicted. As noted in previous chapters, both the Spring Farm and Menangle Park areas are earmarked for future residential, commercial and industrial subdivisions. The change from the current semi-rural character will increase the background noise level at the operational stage of the project. As the background noise level increases with the progress of this development, the noise criteria could increase, especially during construction of the new suburbs and industrial precincts, hence the impact of the same operational noise from this project would be reduced.

9.4 Meteorological Conditions

Future urban areas could lie at a lower altitude than some of the wells surface locations at Spring Farm. As well as temperature inversions, drainage winds may need to be considered.

Drainage winds and inversion both enhance noise propagation, but possibly no more than the conservative default conditions of the *INP* that were used in this study for construction noise. In considering noise impact on future urban areas which lay below the well surface locations at Spring Farm the benefits of studying the meteorology could be considered against a conservative design of noise control that would work under all conceivable meteorological conditions as has been assessed in this report.

9.5 Operational Noise to Parks and Reserves

Several well surface locations are near of within areas reserved for passive recreation.

MP04 and MP05 will be 50-100m from the southern boundary of the Mount Annan Botanic Garden.

SF17 will be 50-100 m south of the Gundungurra Reserve. SF10 and SF20 are within the Gundungurra reserve.

As with the operational noise to residential receivers, the noise to parks and reserves should be assessed for each location, giving regard to location of the site with respect to the park boundary and the nature of the park. Once the noise source levels of the wells are known suitable noise controls can be designed. As shown in Section 5 the stringent residential noise criteria can be achieved at small distances from the well surface locations. The less stringent criterion for Parks and Reserves can also be achieved at suitable distances from the location.

9.6 Noise Mitigation Options

There are a variety of suitable noise mitigation measures that can be applied to operation of the gas well surface locations. They include (but are not restricted to):

- Well head design, including enclosure;
- Noise barriers for individual well heads;
- Noise barriers for well surface locations (a fence around it) – thus mitigating noise from all wells at a surface location;
- Enclosure of pumps/ generators and/ or separators;
- Replacement of diesel pumps/ generators with electric pumps/ generators.

The noise reduction provided by the different options should be designed for specific locations. For example a noise barrier around the final compound could reduce noise levels by up to 10dBA at some houses. If enclosures are preferred to noise barriers, they could easily be designed to have reductions up to 30dBA. Barriers and enclosures could be combined, thereby requiring only 10-20dBA reduction from the enclosure. A case by case approach to noise mitigation at each well surface location will ensure that noise criteria can be met whatever the future land use throughout the life of the project.

9.7 Examples of Operational Noise Mitigation

Four scenarios are considered to demonstrate the different noise mitigation requirements at different surface locations. The final topography of the well surface locations in relation to future residences is not taken into account and the 3°/ 100m temperature inversion is assumed in the following scenarios.

9.7.1 Scenario 1 - A medium producing well surface location at 40m from residences

A medium producing well surface location would have a total sound power level from six wells of 65-85dBA. At 40m from the boundary of the compound the noise level would be 25-45dBA. If it is assumed that the night time criterion at the residence is 36dBA, then the typical required noise reduction is 9dBA.

This reduction could be achieved by an acoustically treated 2m boundary fence. If the closest houses were two storey houses, then pumps/ generators may require individual treatment to reduce noise further and achieve criteria.

Occasionally a workover rig will come onto the site for maintenance works for a temporary period during daytime hours. Depending on the actual surface location, the criterion for the workover rig will be approximately 55dBA (that is background +20dBA as discussed earlier). A workover rig with sound power level (SWL) of 106 will have a noise level of approximately 66dBA at 40m. Any barrier around the site would reduce noise levels to below the criterion at ground floor residences.

9.7.2 Scenario 2 - A high producing well surface location with pumps / generators 40m from residences

This is the worst case scenario for any of the well locations, and would most likely never happen. A high producing well surface location with pumps would have a total sound power level from six well heads of 80-100dBA. At 40m from the boundary of the surface location the noise level would be 40-60dBA.

If it is assumed that the night time criterion at the residence is 36dBA, then the maximum required noise reduction is 24dBA.

It is extremely unlikely that all six wells would be pump assisted from an operational perspective, as high producing wells do not typically require pumps and it is also unlikely that pumps would be required at all wells at the same time. This scenario has been modelled to generate the highest possible operational noise impact in order to demonstrate the criteria can be met. Therefore this scenario assumes a pump at each well head with the pumps powered by diesel generators. The noisier wells at this surface location would require enclosures designed to achieve 24dBA noise reduction. This reduction could be achieved by a 2m boundary fence. This could be easily achieved with, for example, 2m steel (Colorbond) structure lined internally with plasterboard, the use of barriers for individual well heads, the use of electric generators, well head enclosures or acoustic treatment of generators.

The discussion for the workover rig is the same as in 9.7.1. A workover rig with sound power level (SWL) of 106 will have a noise level of approximately 66dBA at 40m.

9.7.3 Scenario 3 - A high producing well surface location at 120m from residences

A high producing well surface location would have a total sound power level from six well heads of 80-95dBA. At 120m from the boundary of the compound the noise level would be 30-45dBA.

If it is assumed that the night time criterion at the residence is 36dBA, then the typical required noise reduction is 9dBA.

This reduction could be achieved by a 2m boundary fence or enclosure of well heads.

The discussion for the workover rig is the same as in 9.7.1. A workover rig with sound power level (SWL) of 106 will have a noise level of approximately 56dBA at 120m. Any barrier around the compound would reduce noise levels to below the criterion and would be designed accordingly.

9.7.4 Scenario 4 - A medium producing well surface location at 300m from residences

A medium producing well surface location would have a total sound power level from six wellheads of 65-85dBA. At 300m from the boundary of the compound the noise level would be at most 28dBA.

No further noise reduction is required for this scenario. At this distance the noise would be increased during times of temperature inversion, but still would not exceed the noise criterion of 36dBA.

The discussion for the workover rig is the same as in 9.7.1. A workover rig with sound power level (SWL) of 106 will have a noise level of approximately 48dBA at 120m. This will meet the criterion at all surface locations. Any barrier around the compound would reduce noise levels.

9.7.5 Scenario 5 – A medium producing well within a remote section of a large reserve

The criterion for parks is L_{Aeq} 50dBA. A medium producing well surface location would have a total sound power level from six wellheads of 65-85dBA.

Depending on the layout of the site, the noise would be reduced to the criterion at approximately 20m from the boundary of the well surface location. A solid fence around the site would reduce noise to the criterion at 5m from the boundary.

9.7.6 Scenario 5 – A high producing well 120m from the boundary of a reserve

The criterion for parks is L_{Aeq} 50dBA. A high producing well surface location would have a total sound power level from six well heads of 80-95dBA. At 120m from the boundary of the well surface location noise level would be 30-45dBA. The criterion is met without further mitigation.

9.8 Meteorological Effects

As for construction noise, propagation of operational noise may be enhanced by meteorological conditions. Temperature inversion on winter nights could increase noise levels at residences, and the effect is most noticeable at residences at greater distances from the well surface locations. The increase in noise is typically less than 5dBA at residences less than 300m away from the source. As shown in Scenario 4 above, the worst case noise at 300m is 28dBA. If this were increased by temperature inversions it would still be below the noise criterion.

While temperature inversions should be considered when designing noise controls for a particular well surface location, they will in no case make noise control impractical.

9.9 Assessment of Sleep Disturbance from Operations

Noise levels generated by the proposed gas well surface locations are generally of a very steady and continuous nature and do not produce loud instantaneous noises with potential for sleep arousal and are well below sleep disturbance criteria. Meteorological effects would not increase maximum noise levels more than steady state noise levels, and would not lead to sleep disturbance events.

9.10 Decommissioning and Final Rehabilitation

The decommissioning and rehabilitation stage requires similar equipment to the workover stage. Hence the sound power level of the site would be approximately L_{A10} 106dBA (see Table 7-1). The decommissioning activities will take place during daytime hours and a Noise Abatement Plan would be prepared in advance of decommissioning.

The rehabilitation stage will require use of earthmoving machinery. Depending on the work required, the L_{A10} of the surface location would be 105-115dBA. The final site rehabilitation will also take place during daytime hours and a Noise Abatement Plan would be prepared prior to commencement of the final rehabilitation activity.

10 CONCEPT PLAN

10.1 Concept Plan Works

The works for Concept approval include:

- New well fields – works within the new well fields would involve the construction of well surface locations and associated infrastructure including gas gathering and water pipelines and access roads.
- Infill wells – with associated infrastructure (including gas gathering and water pipelines and access roads) to be located within existing well fields within Stage 2 where the gas reserve is not able to be accessed from existing well head locations.
- Upgrade of gas gathering lines – in some areas it is anticipated that the existing gas gathering pipework may not have sufficient capacity to handle increased production. Consequently there may be a need to increase the capacity of parts of the network to allow for this increased production. Increasing the capacity of the existing gas gathering pipework would most likely require the duplication ("twinning") of pipes within the affected sections of the gas gathering network. Duplication of the pipes would be carried out along existing gas gathering routes.
- Installation of infield compression – in order to maintain gas production from the gas plant, AGL may need to boost the pressure in the gathering system by in-field compression within the Stage 2 area prior to delivery to the gas plant. The method for providing in-field compression will be developed as the requirements within the system arise over time. Options include providing compression at existing wellhead locations or at distribution nodes within the gas gathering system; and
- Refracing – refracing of the wells may be required after a period of operation, and would involve a process not dissimilar to fracing of the wells, where the well is hydraulically fractured through the injection of a slurry of sand and water at sufficient pressure to create a conductive pathway into the coal reservoir. It is noted that refracing of the wells would only be undertaken where a production issue is identified, and is therefore unlikely to be undertaken at all well locations.

10.2 Concept Plan Noise Impact

With regard to the broader Stage 2 Concept area, the noise levels associated with the construction and operation of wells subject of this application cannot be accurately determined until further details of the proposed location of wells, and the ultimate distance to residences is known. Further, future background noise levels within this area cannot be accurately predicted due to the substantial changes to the character and density of development in the area likely to occur during the life of the Stage 2 Concept works. It is therefore difficult, if not impossible to definitively assess the noise impacts of the Concept works at this stage.

The detailed noise assessment undertaken in respect of the Spring Farm and Menangle Park project areas will be used to inform the location of well surface locations within the Stage 2 Concept area. Further detailed noise investigations will be undertaken in association with future separate assessment and approvals processes for this component of the project to confirm predictions in this EA.

Based upon the results of the noise assessment undertaken for the Spring Farm and Menangle Park project areas, the noise impacts of the Stage 2 Concept works are expected to be manageable and maintainable within acceptable limits with the application of appropriate mitigation measures. Section 8 of this report shows that even under worst-case conditions, the noise impacts of the proposed works would be manageable through the implementation of appropriate mitigation measures. A range of mitigation options will be considered and applied to each specific well surface location to ensure that noise criteria are met once background noise levels, construction and operational noise levels and distance to receivers is more accurately known.

Below are some recommendations from a noise perspective to be used in the preparation and design of future projects under the Stage 2 Concept Plan area:

- Well surface locations would be chosen in consideration of the proximity to nearest sensitive receivers and would take account of local topography and meteorological conditions which may affect the extent of noise impacts;
- The potential for noise impact would be considered in the preliminary planning phase of the project and noise minimisation will be built into the inherent project design; and
- The full range of available mitigation measures would be considered and applied where necessary to ensure that noise impacts can be maintained at an acceptable level.

11 CONCLUSION

11.1 Construction Noise

AGL requires construction for a period of up to 12 months, resulting in stringent noise criteria. Construction noise will be mitigated to meet the noise criteria. A range of mitigation options were described and will be implemented based on the needs at specific well surface locations.

Construction noise will not exceed the sleep disturbance criterion at any surface location. As there are low traffic volumes associated with the proposal, construction will not cause significant traffic on local roads. Construction traffic would cause an insignificant change to traffic on local roads, and would not result in any noise impact.

Because of the distance of the well surface locations to residences, construction will not cause excessive vibration at any location nor will there be significant night time traffic.

11.2 Operational Noise

Operational noise controls may be necessary at some locations. A range of controls have been described and will be implemented based on the need at specific well surface locations.

Operational noise will not exceed the criterion for sleep disturbance at any well surface location. This holds for both the existing land use and future urbanisation. The operation of the well surface locations does not require traffic except for routine visits of maintenance vehicles, and traffic noise will not be an issue.

The occasional visit to a surface location by a workover rig will result in temporarily elevated noise levels during daytime hours. With appropriate noise mitigation procedures employed this criteria will be met.

Operation of the wells will not cause a vibration issue at any receiver.

11.3 Concept Plan

Noise mitigation forms an integral part of the Concept plan for the project, which includes new well fields, infill wells, upgrade of gas gathering lines, installation of infield compression and refraccing.

As discussed previously, it is not possible at this stage to accurately assess the noise impacts and required mitigation for works subject of the Stage 2 Concept application. Further detailed noise assessment would be undertaken as part of subsequent project applications in order to identify potential impacts and appropriate mitigation as required.

A range of mitigation options will be considered and applied to each specific well surface location to ensure that noise criteria are met once background noise levels, construction and operational noise levels and distance to receivers is more accurately known.

11.4 Summary

The noise impact of the proposed construction and operation of gas well surface locations at various sites throughout Spring Farm and Menangle Park has been assessed. The construction phase of the proposed project will be the most significant from a noise perspective.

Construction and operational noise of the wells has been assessed on a site-by-site basis, ensuring the assessment criteria can be met at the most appropriate receivers in the vicinity of each well surface location.

Noise mitigation for the well fields in order to meet the criteria of the *INP* form part of the Concept Plan for the project.

Therefore, with appropriate mitigation and management, there is no impediment from a noise and vibration perspective to the development and operation of the Spring Farm and Menangle Park projects.

Note
All materials specified by Wilkinson Murray Pty Limited have been selected solely on the basis of acoustic performance. Any other properties of these materials, such as fire rating, chemical properties etc. should be checked with the suppliers or other specialised bodies for fitness for a given purpose.

Quality Assurance
We are committed to and have implemented AS/NZS ISO 9001:2000 "Quality Management Systems – Requirements". This management system has been externally certified and Licence No. QEC 13457 has been issued.

AAAC
This firm is a member firm of the Association of Australian Acoustical Consultants and the work here reported has been carried out in accordance with the terms of that membership.

Version	Status	Date	Prepared by	Checked by
Final	Final	4 July 2007	George Jenner	John Wassermann

APPENDIX A

GLOSSARY OF TERMS

GLOSSARY

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph overleaf, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

L_{A50} – The L_{A50} level is the noise level which is exceeded for 50% of the sample period. During the sample period, the noise level is below the L_{A50} level for 50% of the time.

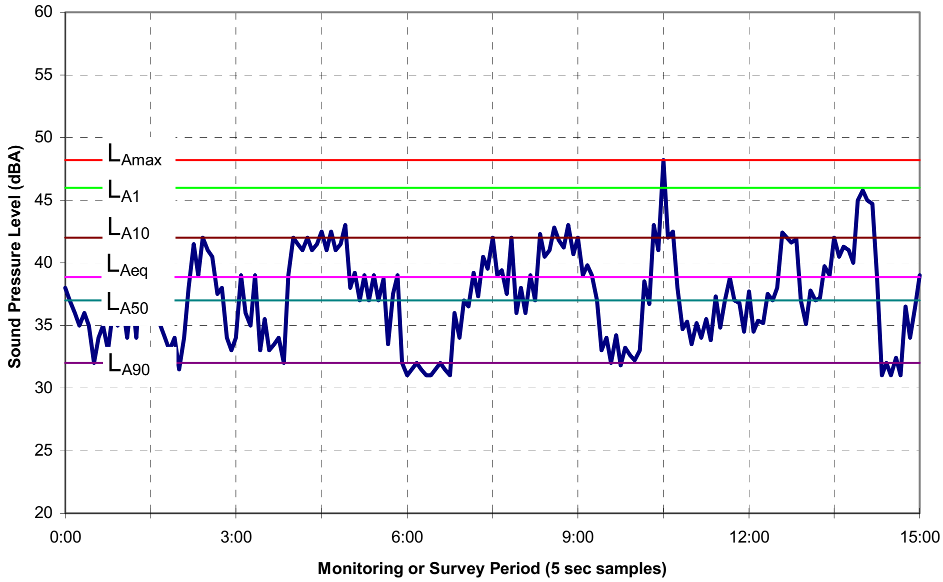
L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_W The L_w level (sometimes denoted SWL) is the sound power level of a noise source. It is intrinsic to the source and does not depend on the location of the source.

L_P – Sound pressure level. This is what we hear or measure. The sound pressure level of any source depends on the intrinsic L_W of the source and the distance from the source to the listener. Other factors, such as shielding and reflections can affect the eventual sound pressure level at the listener.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10^{th} percentile (lowest 10^{th} percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.



Sound Pressure Level (dBA)
60
55
50
45
40
35
30
25
20
LAmax
LA1
LA10
LAeq
LA50
LA90
0:00
3:00
6:00
9:00
12:00
15:00
Monitoring or Survey Period (5 sec samples)

APPENDIX B

NOISE MEASUREMENT RESULTS

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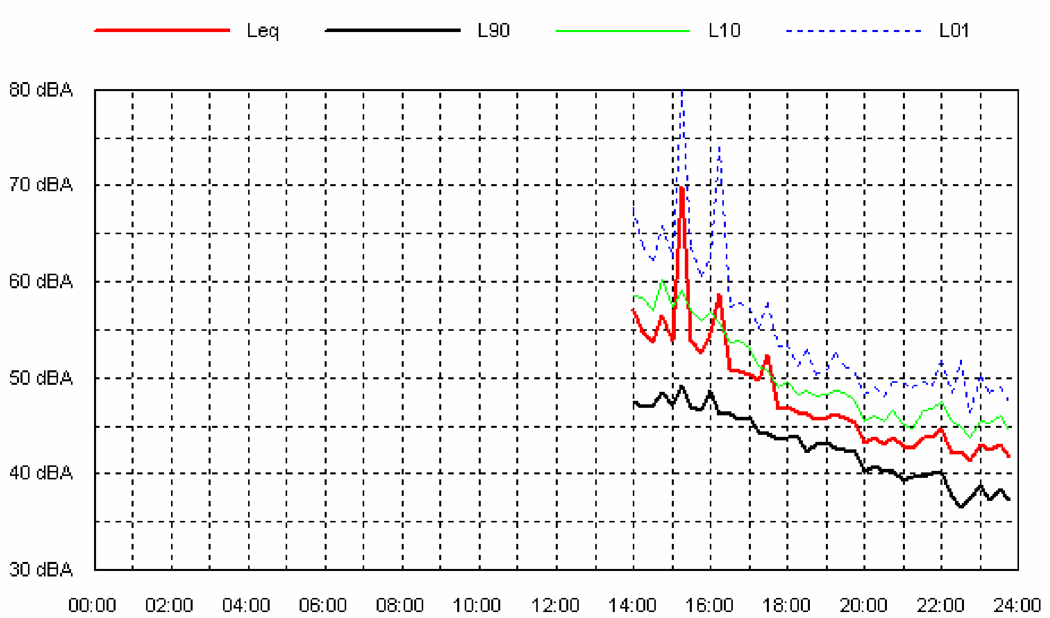
Tue 19 Sep 06



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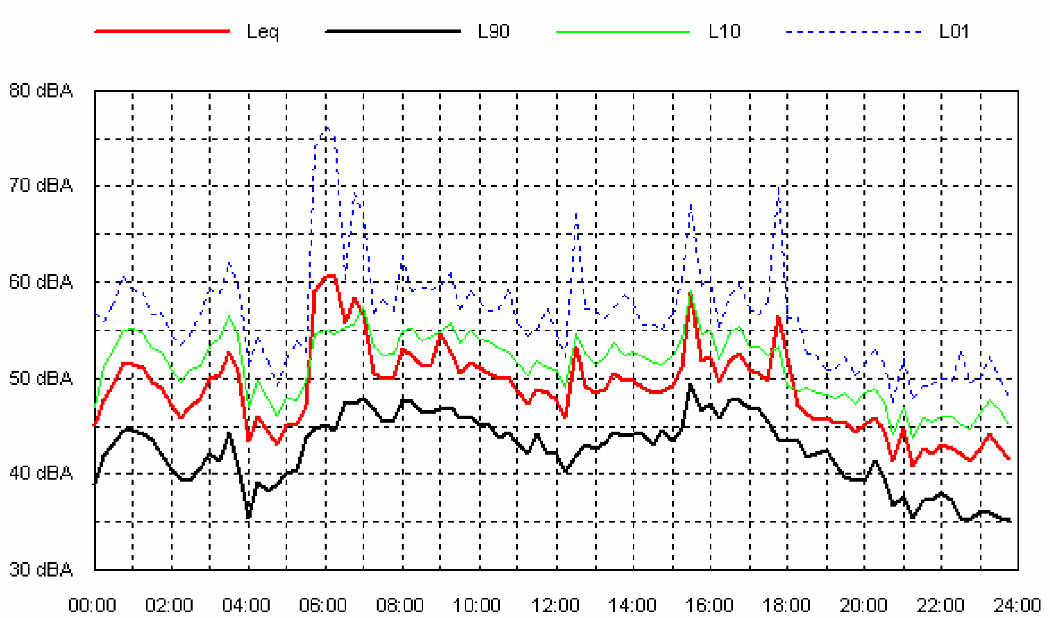

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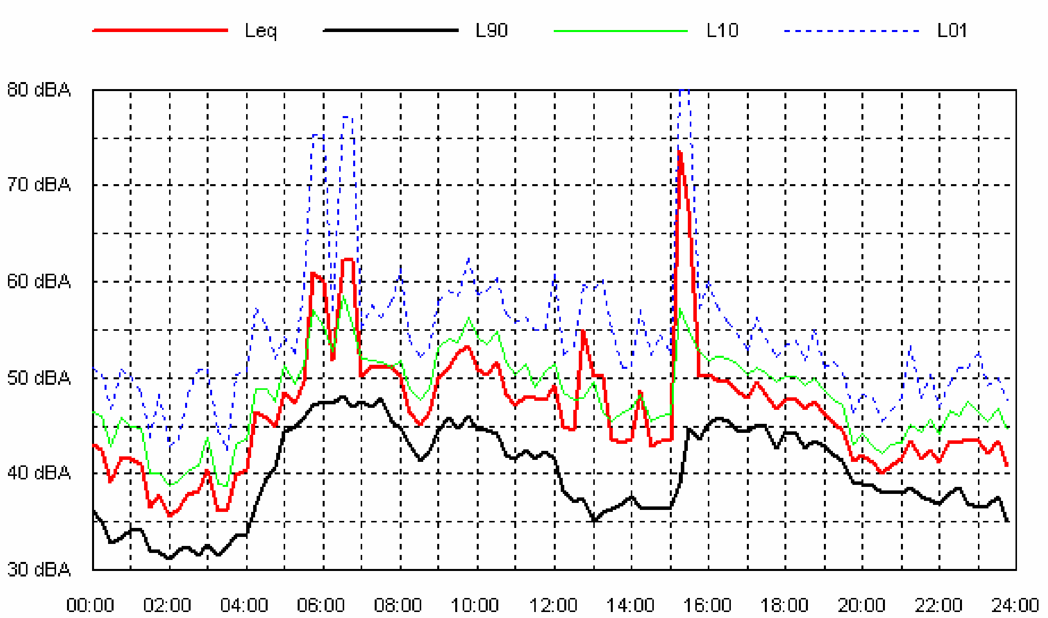

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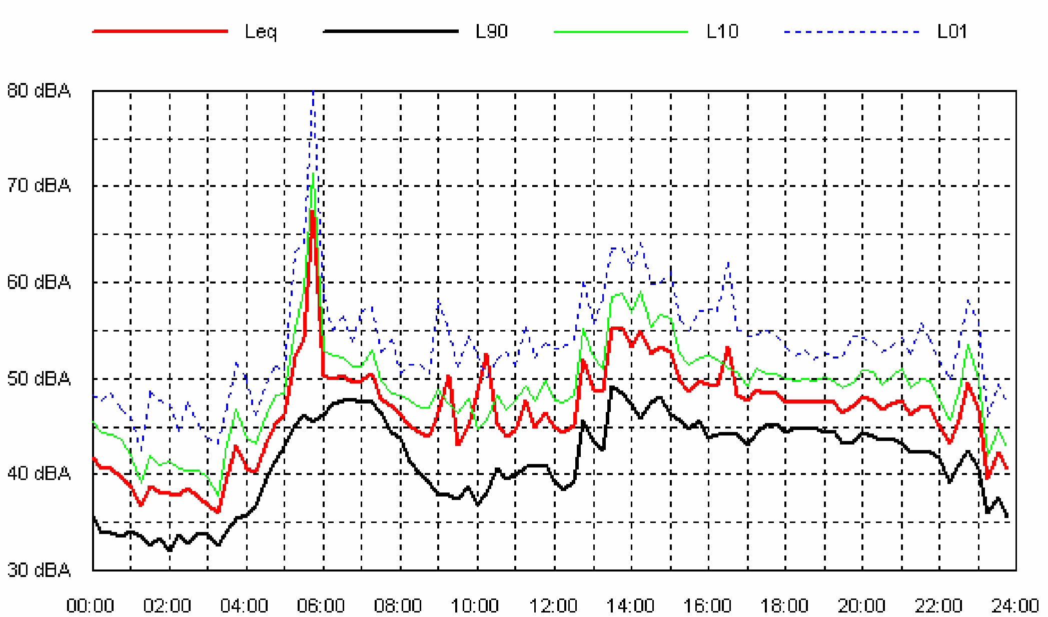

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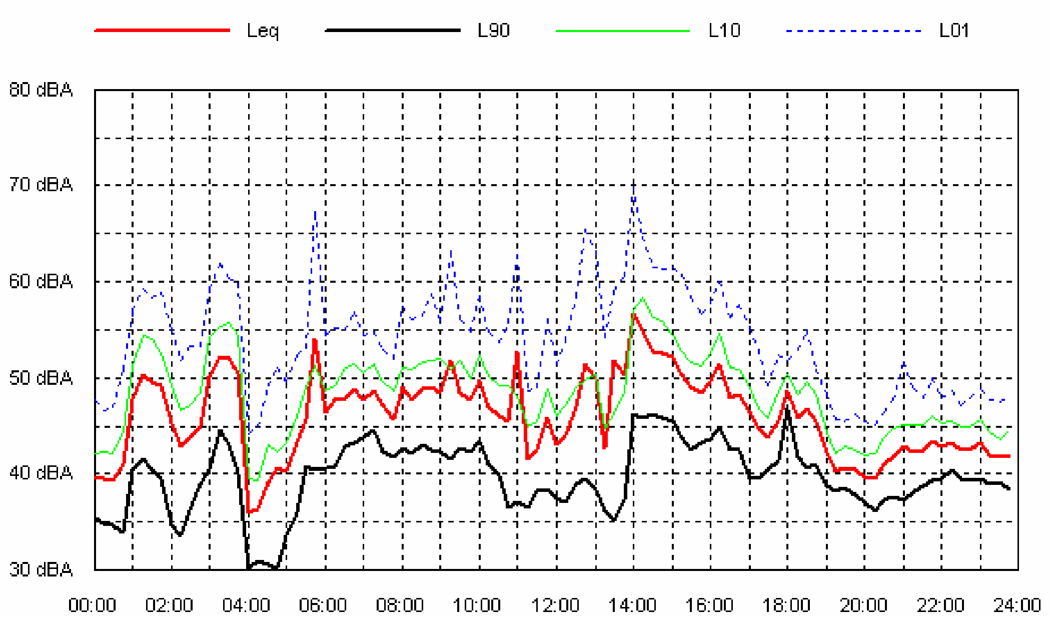

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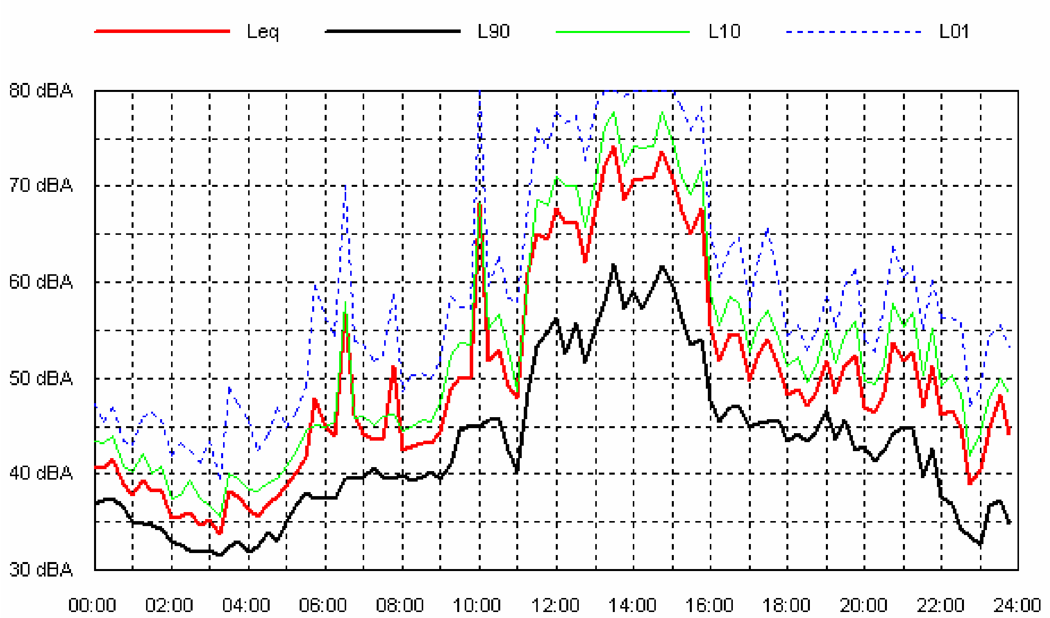

Location: St Thomas Church

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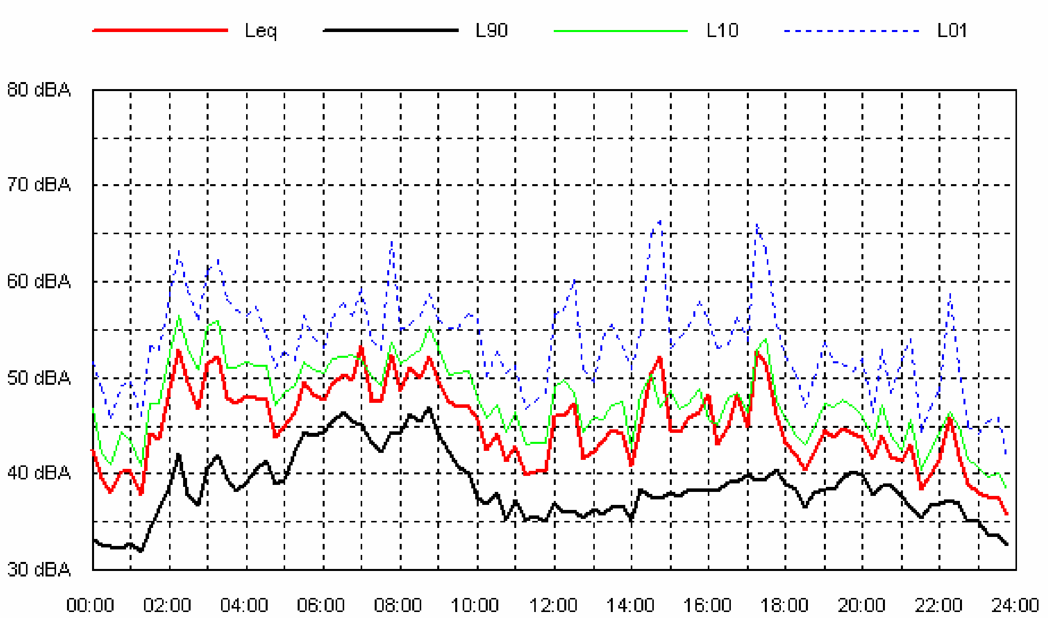

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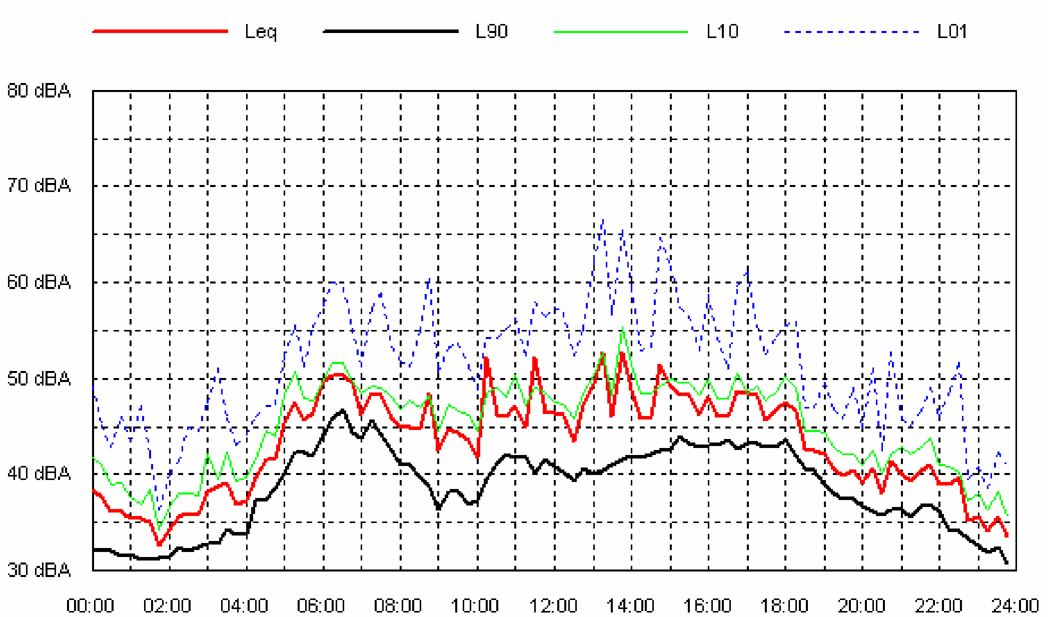

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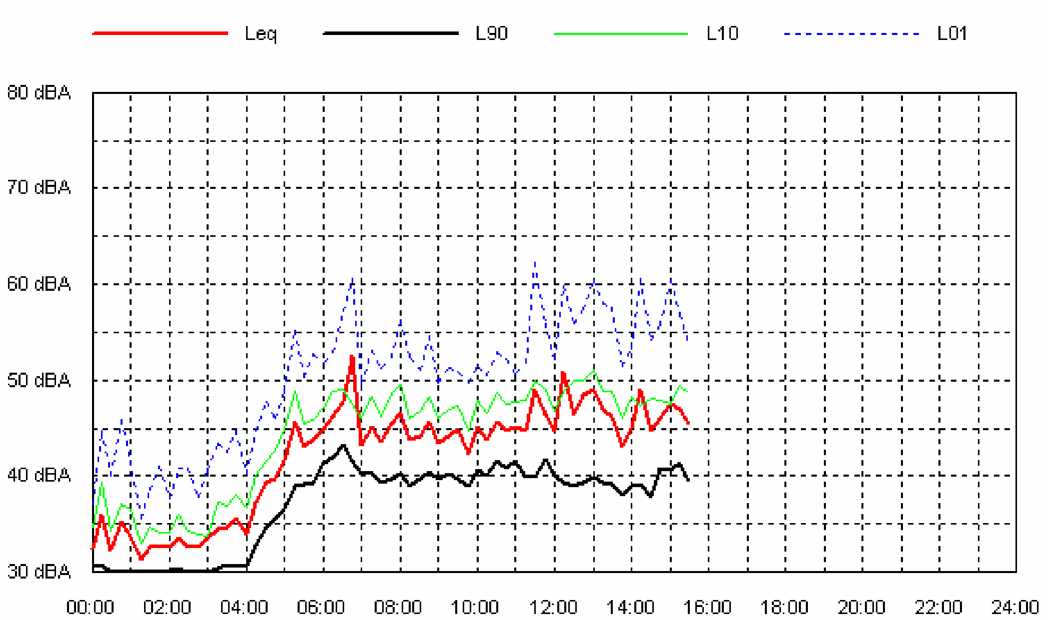

Location: Gundungurra Reserve

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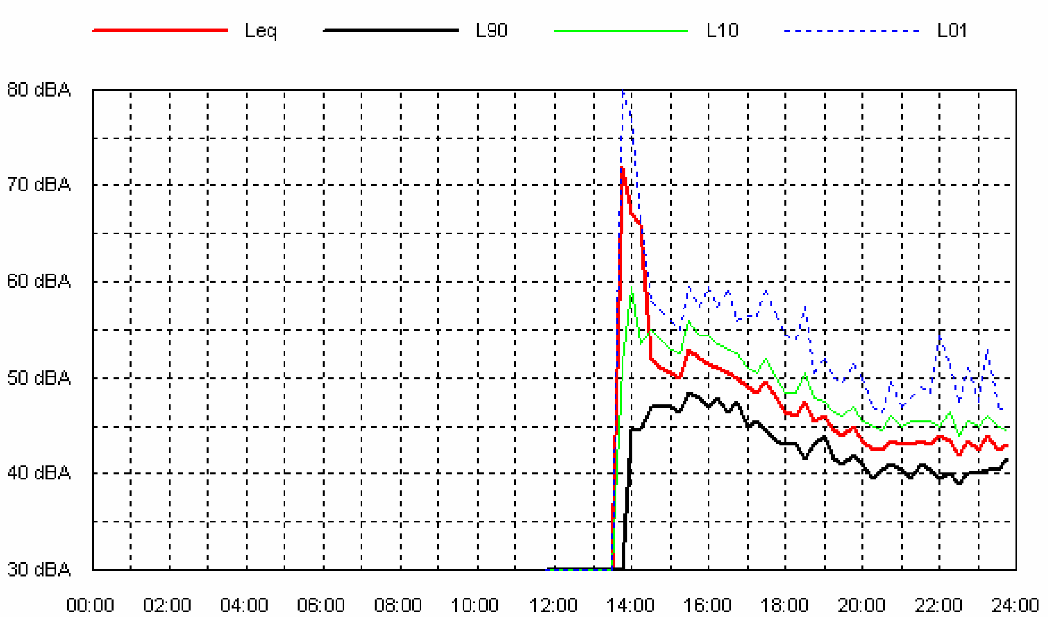

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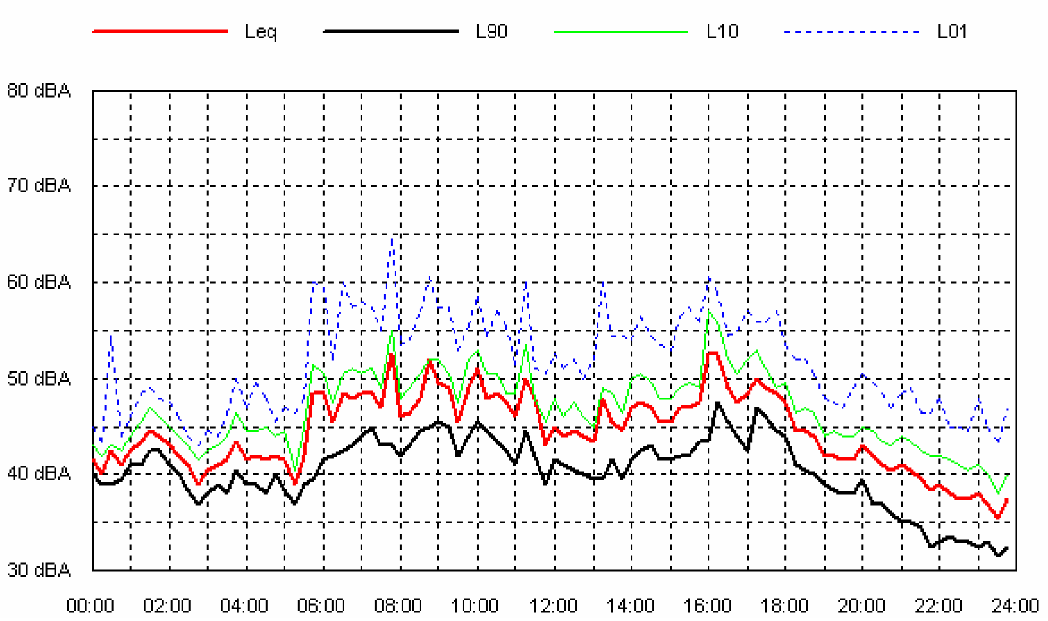

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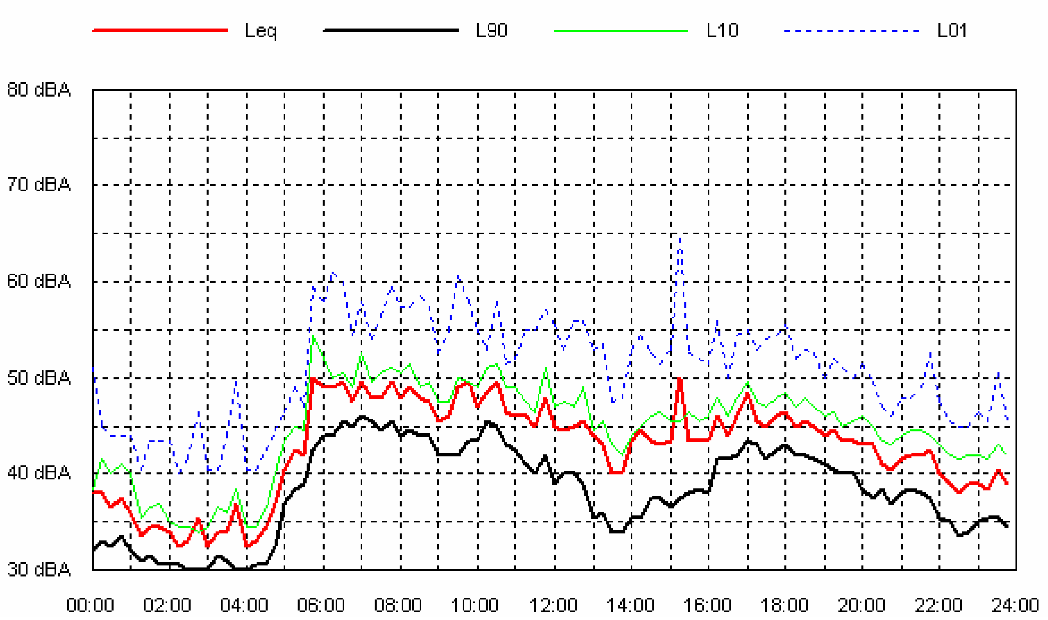

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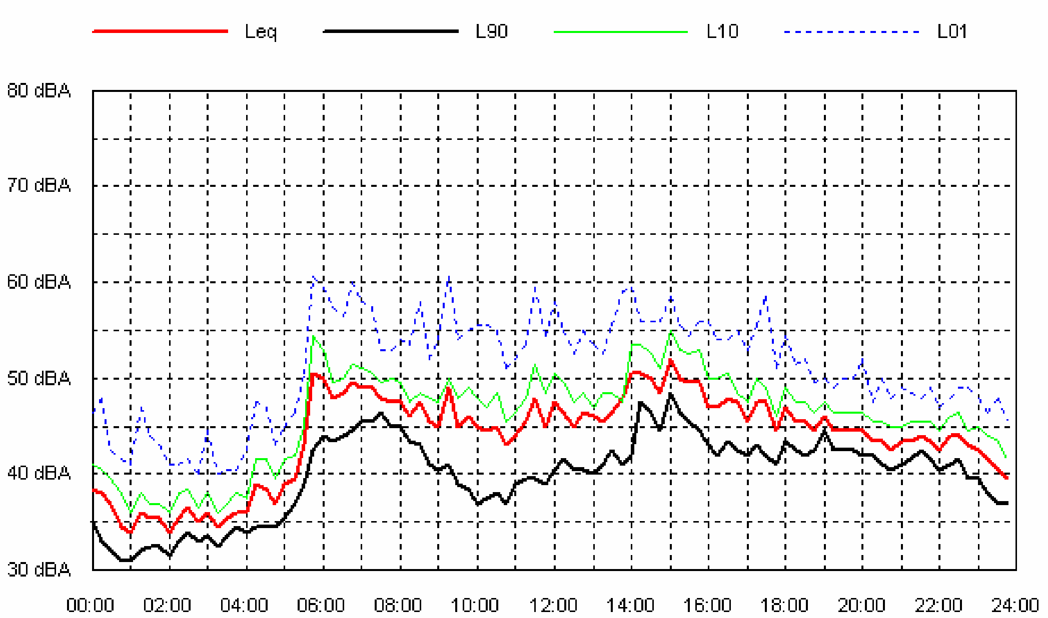

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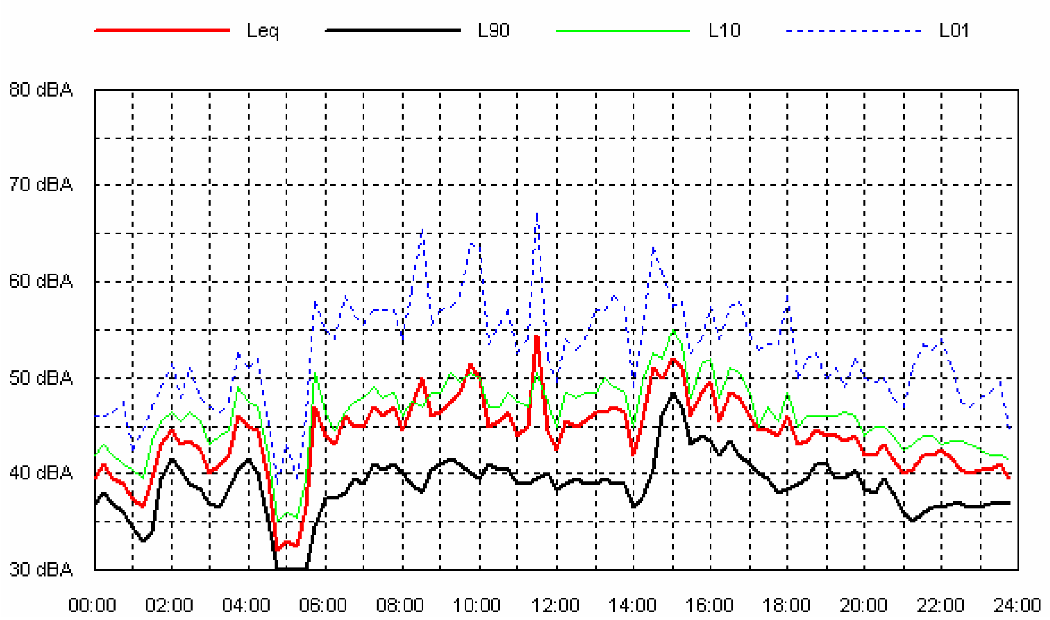

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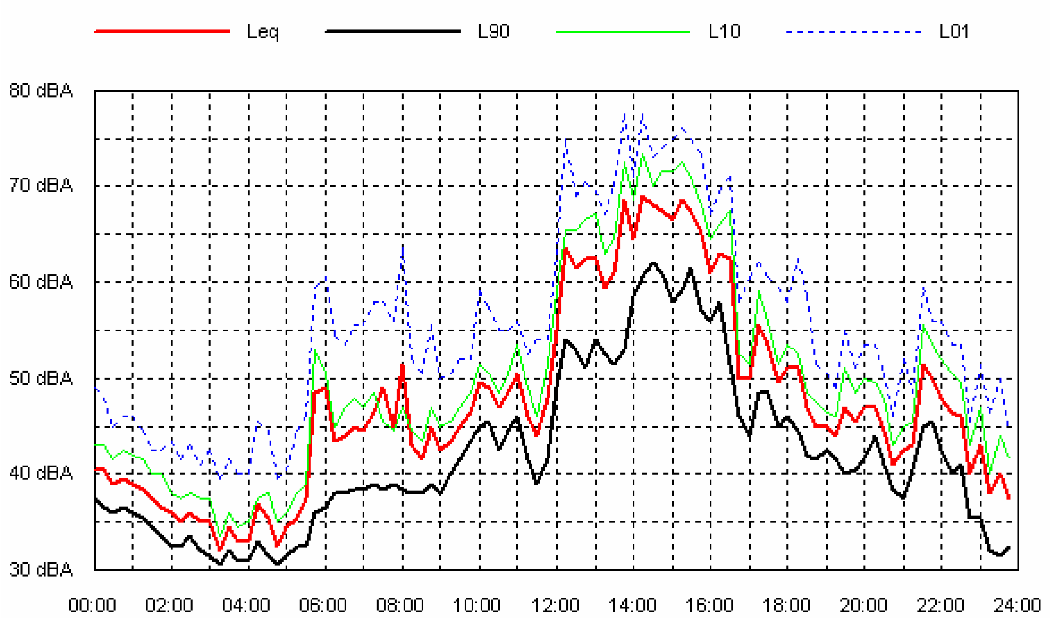

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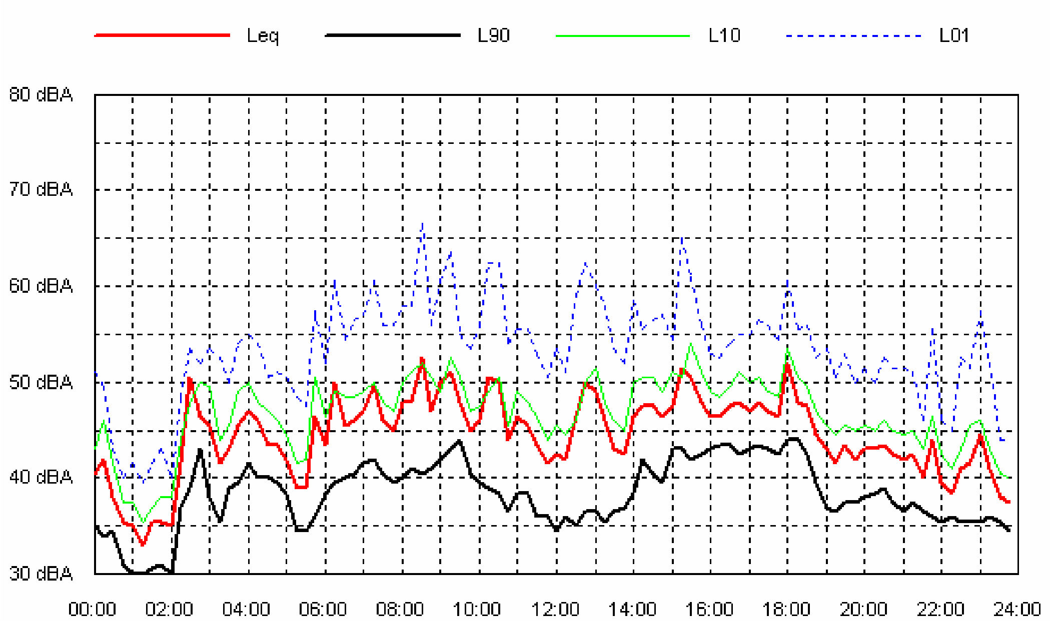

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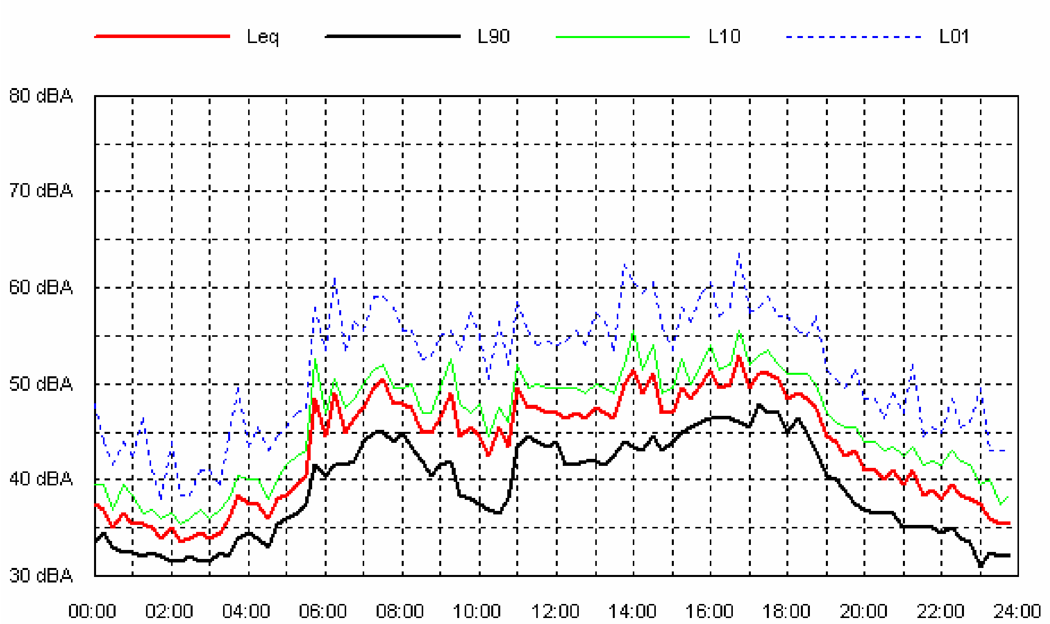

Location: Gundungurra Reserve

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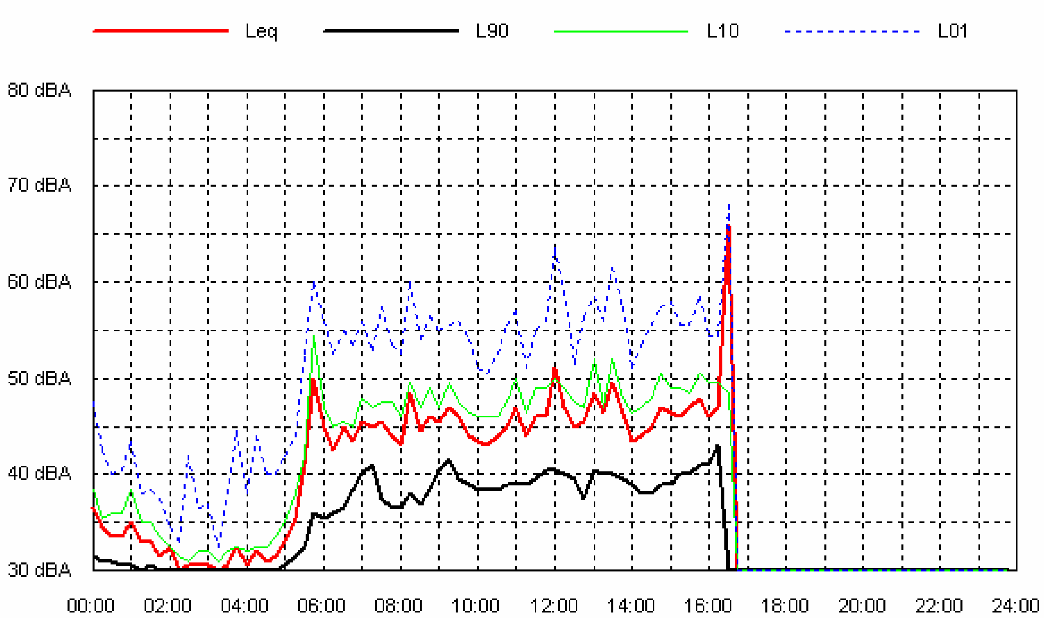

Location: Glenlee House, Menangle Park

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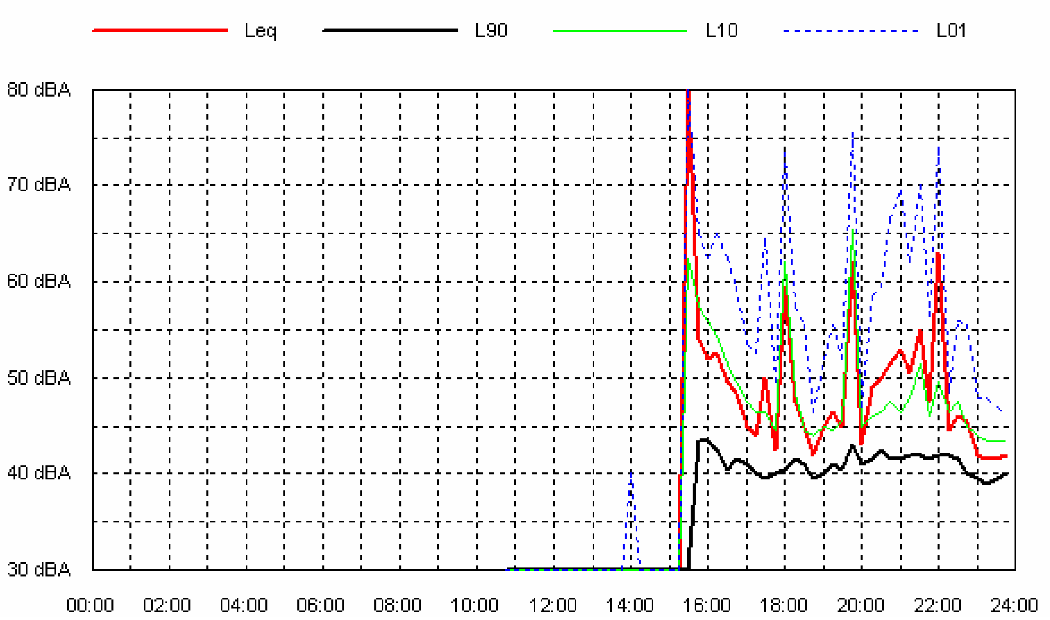

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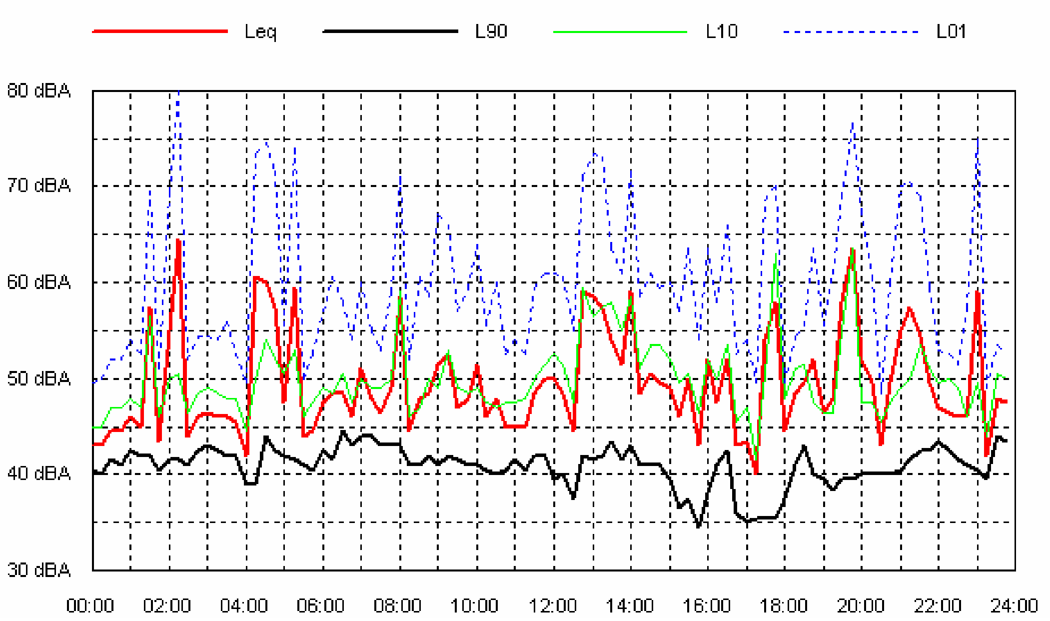

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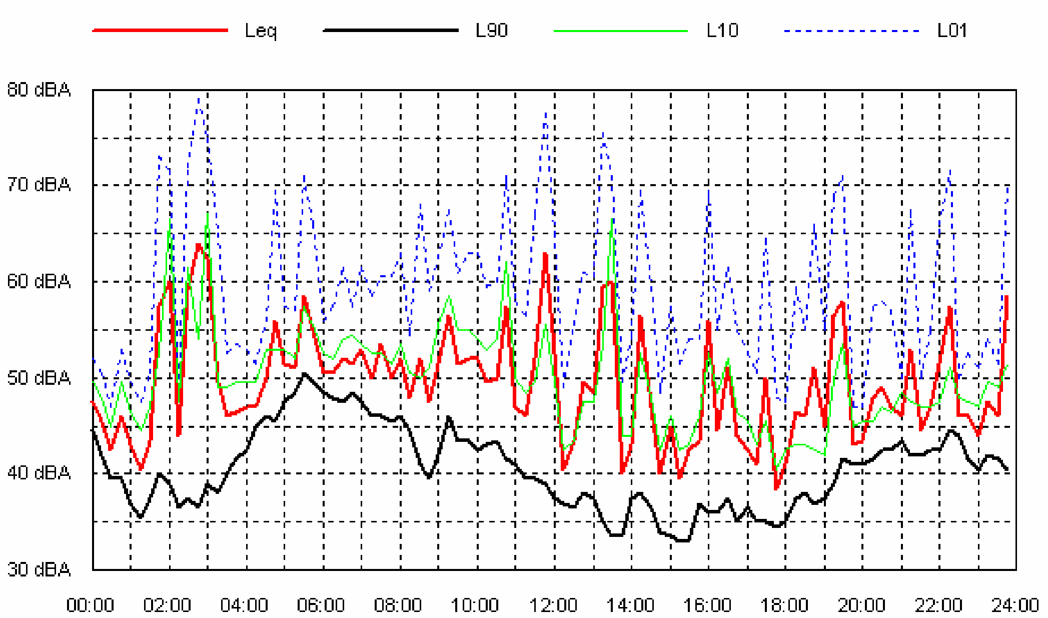

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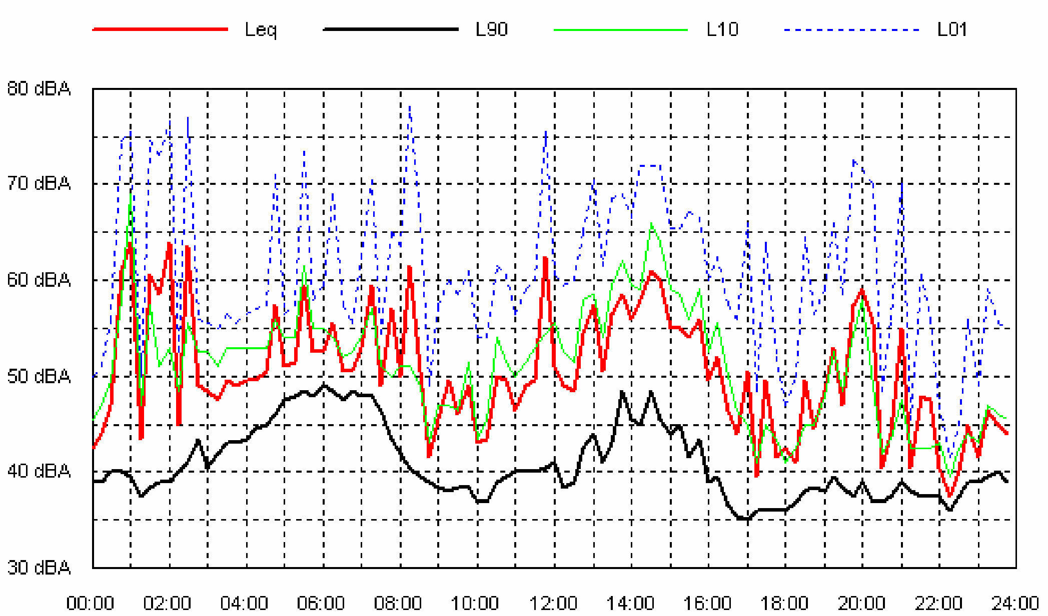

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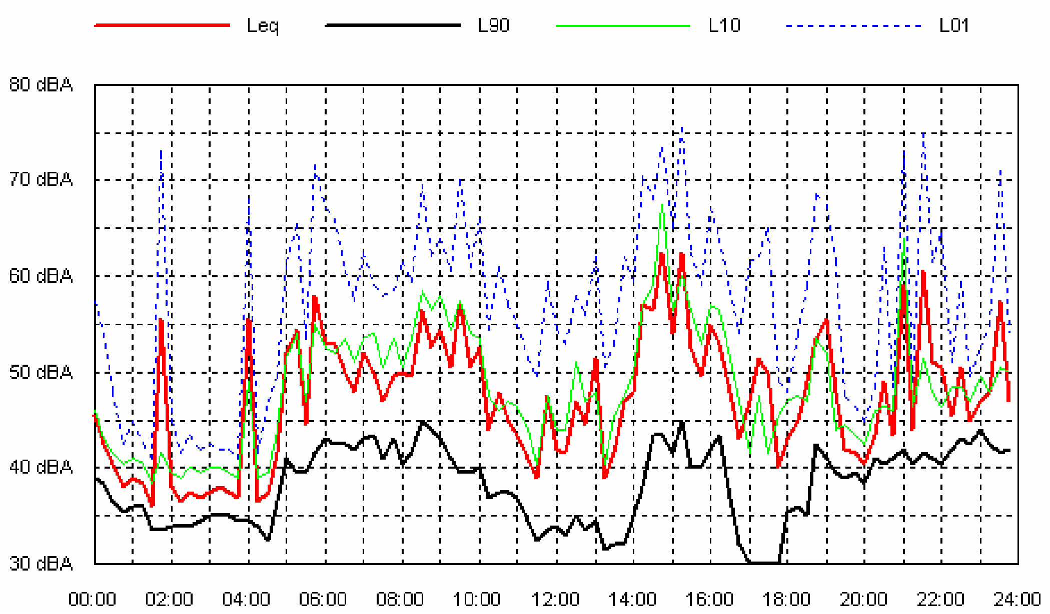

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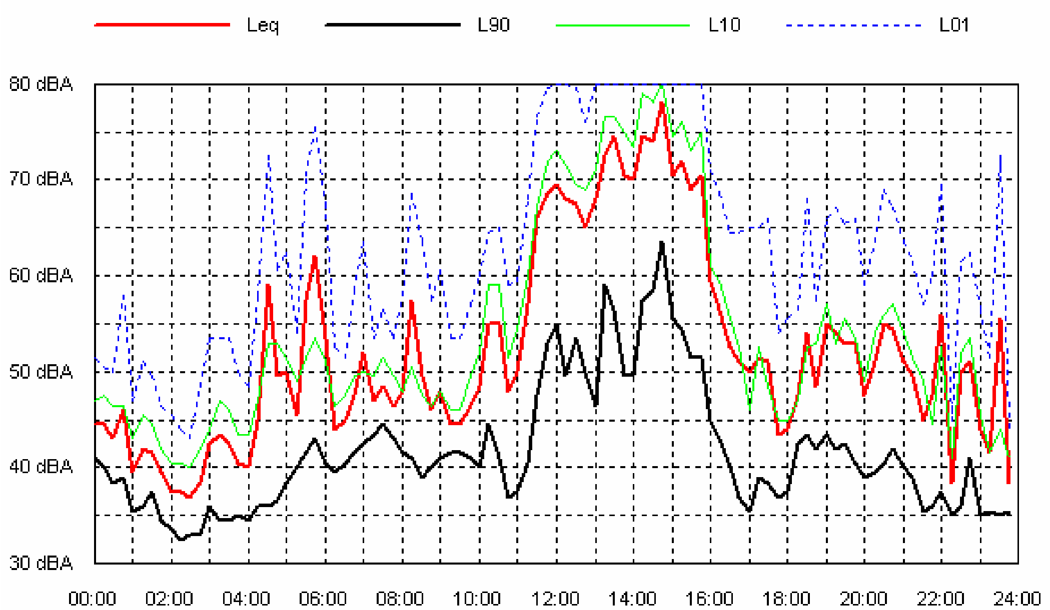

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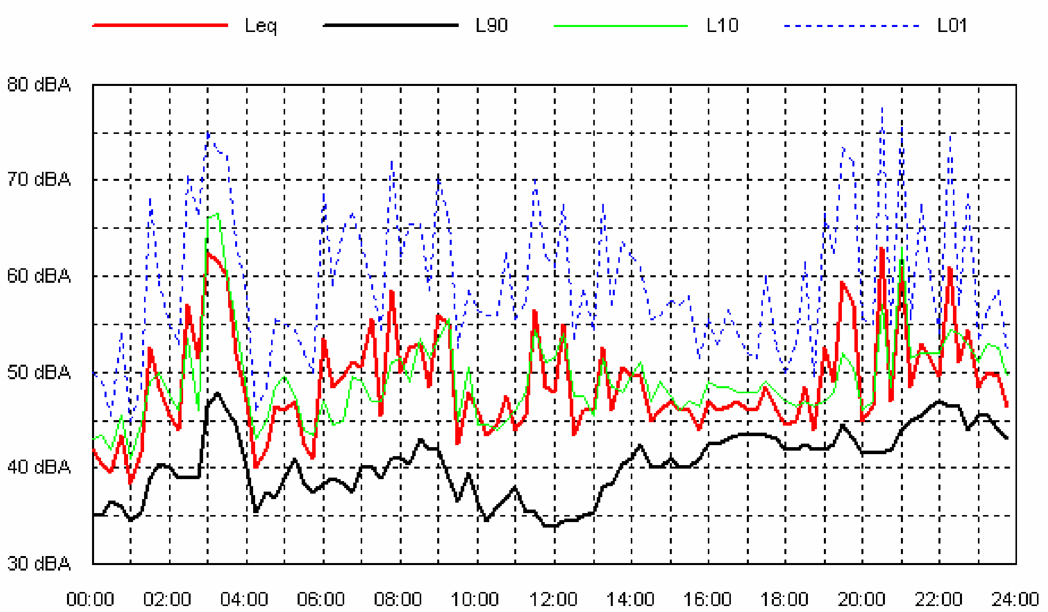

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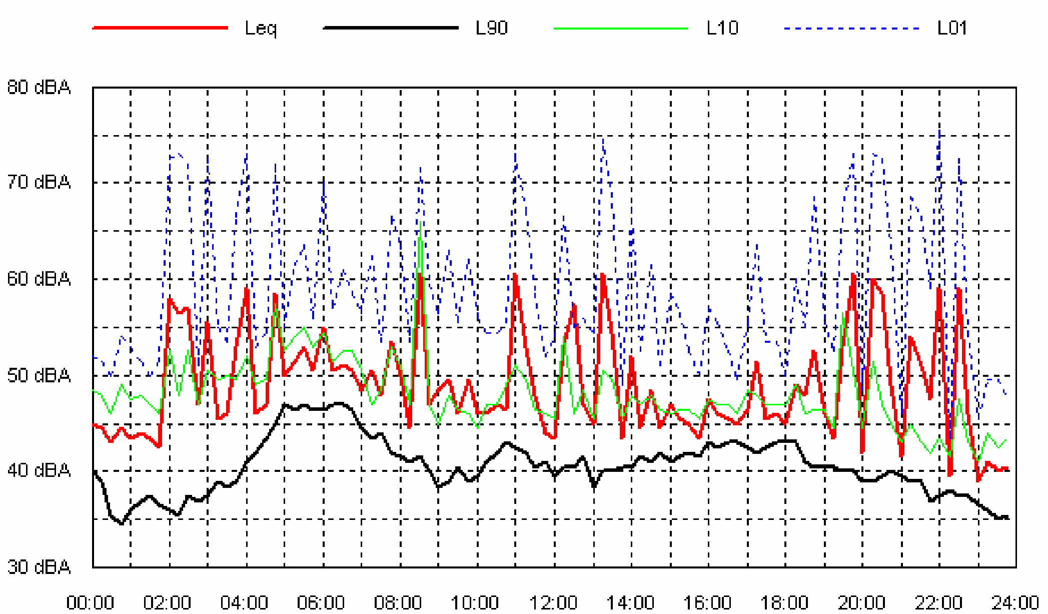

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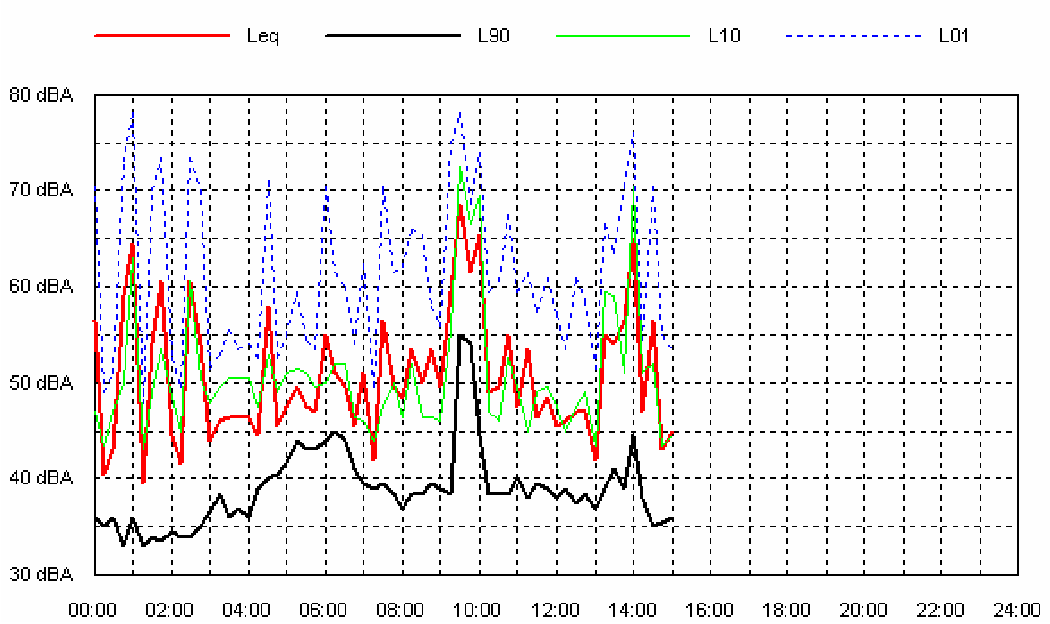

Location: Cummins Road

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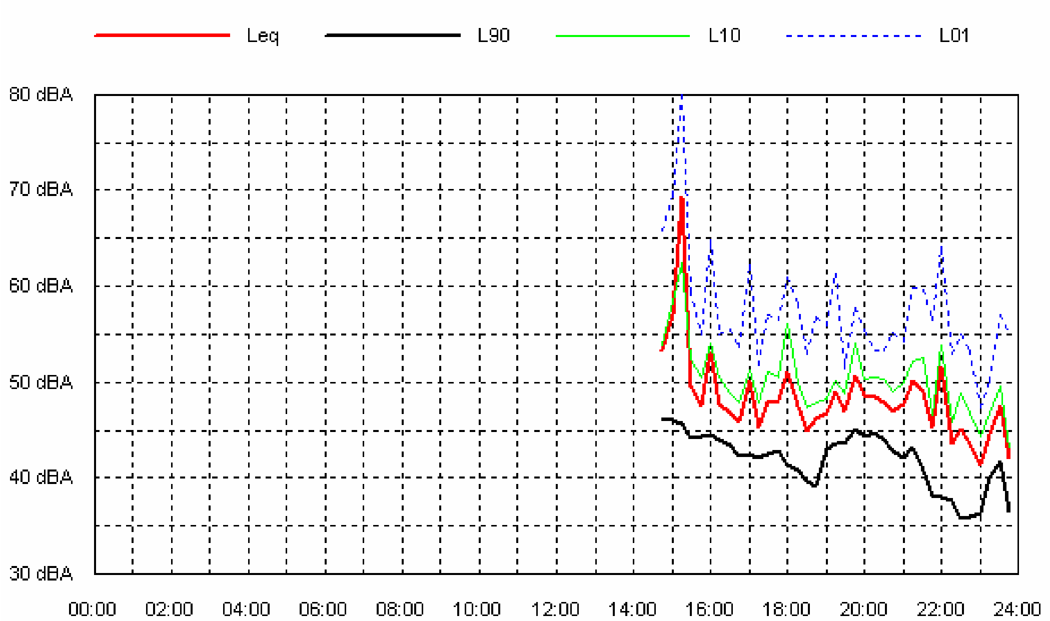

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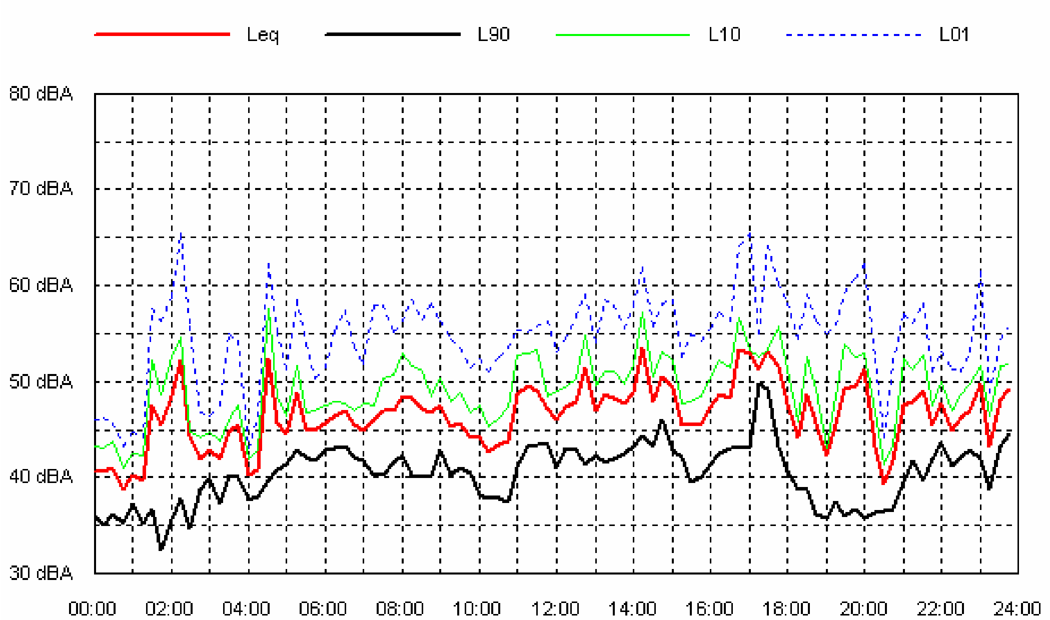

Location: Cummins Road

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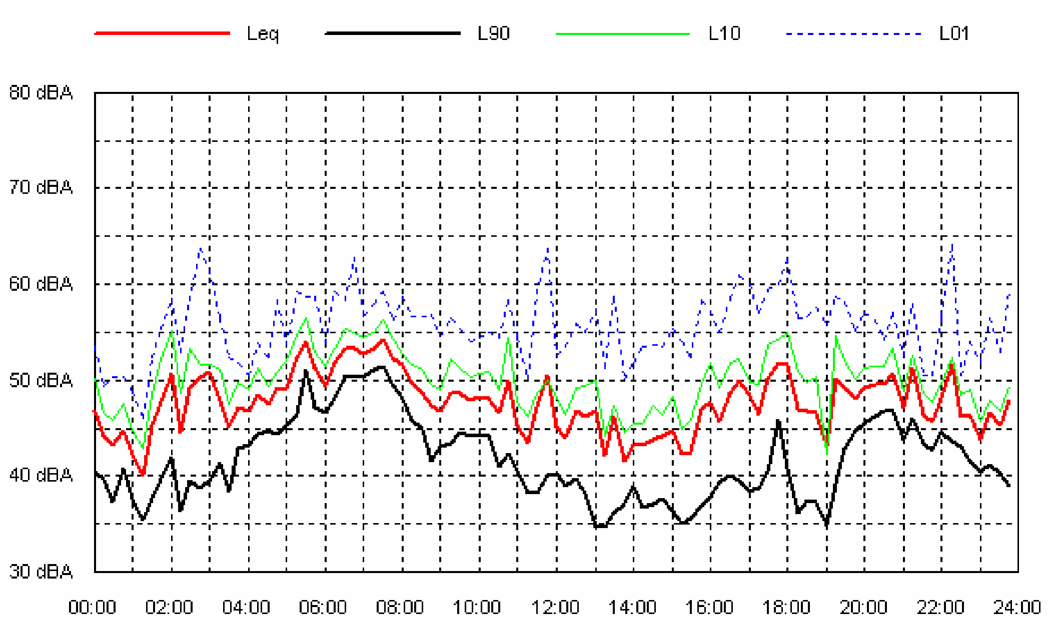

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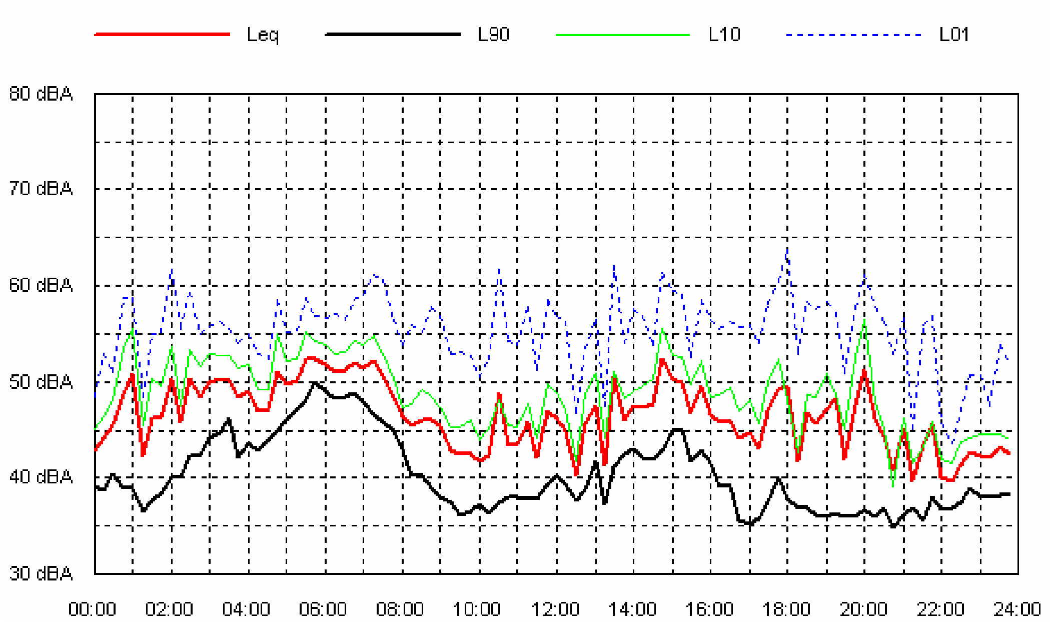

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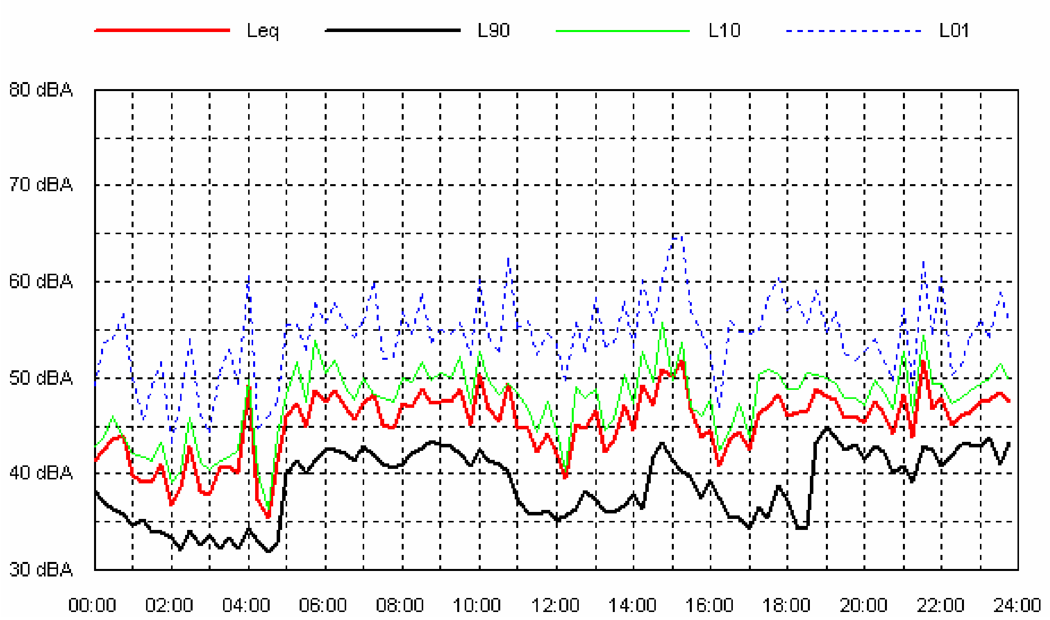

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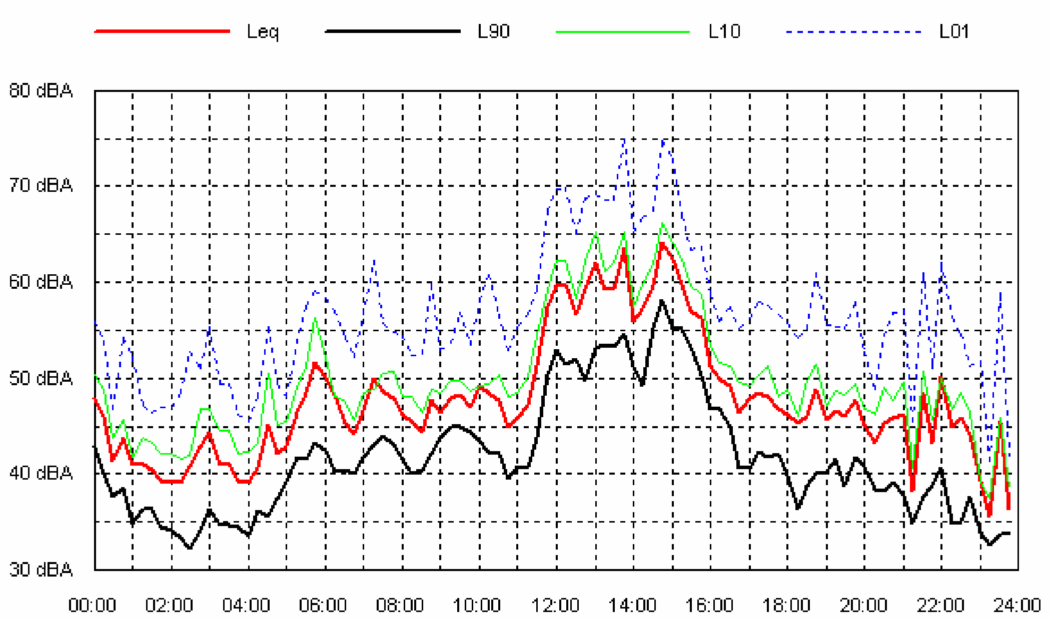

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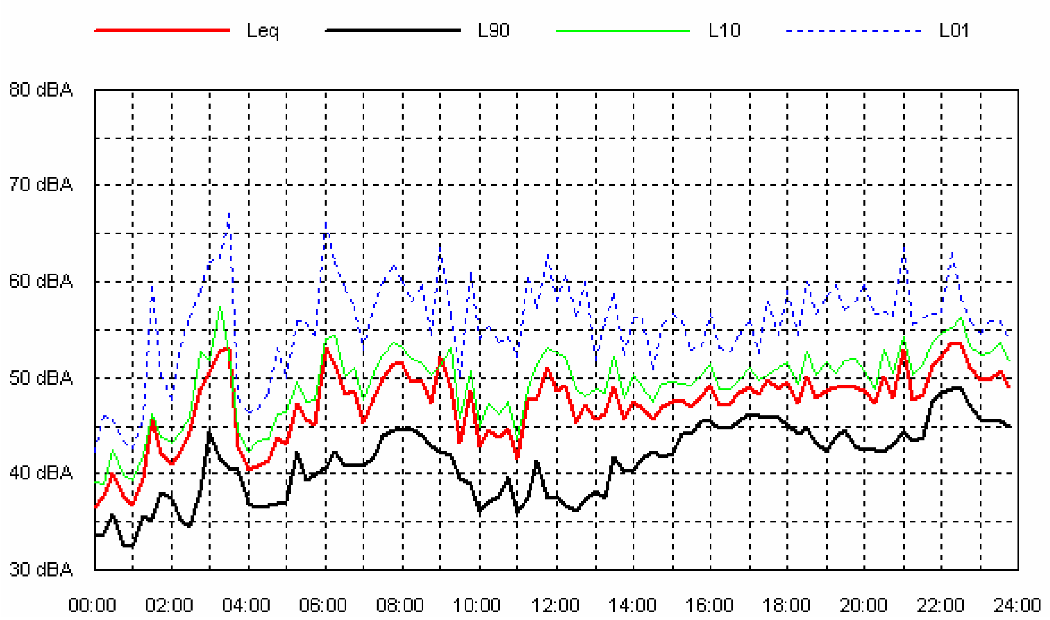

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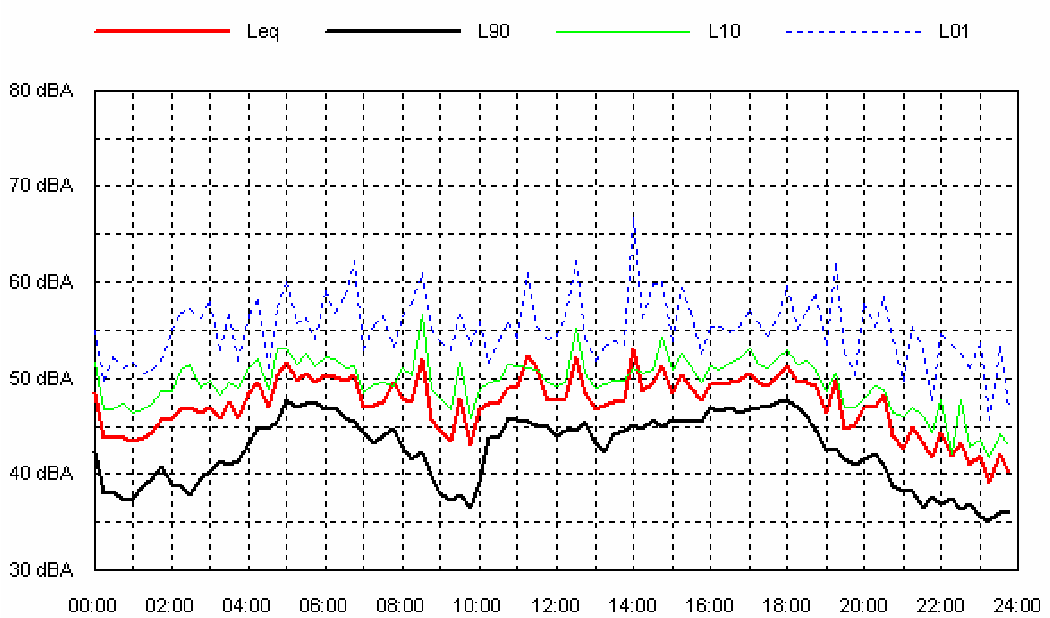

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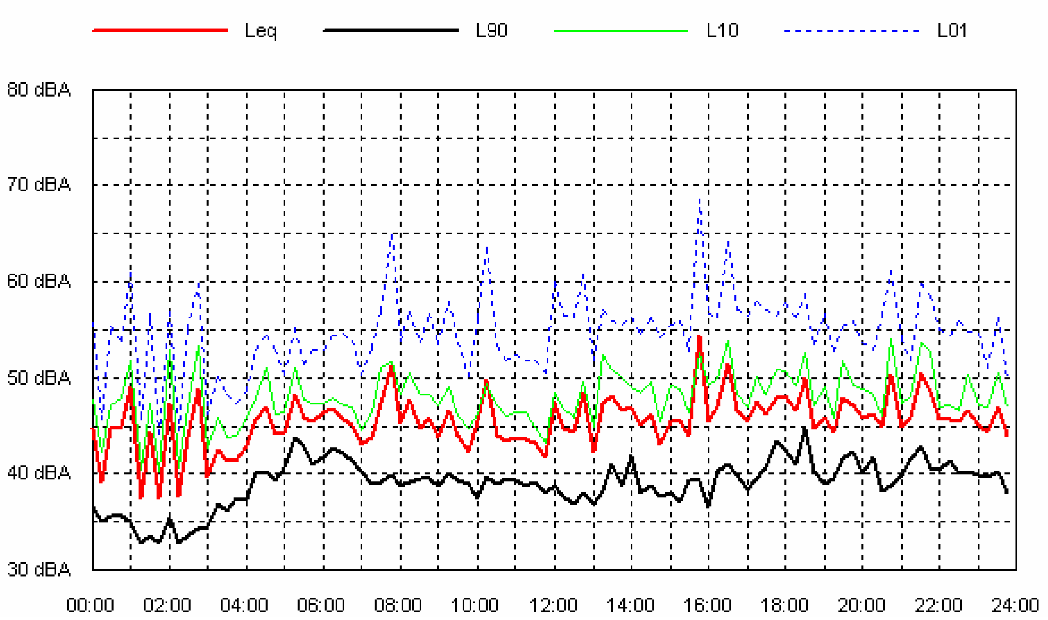

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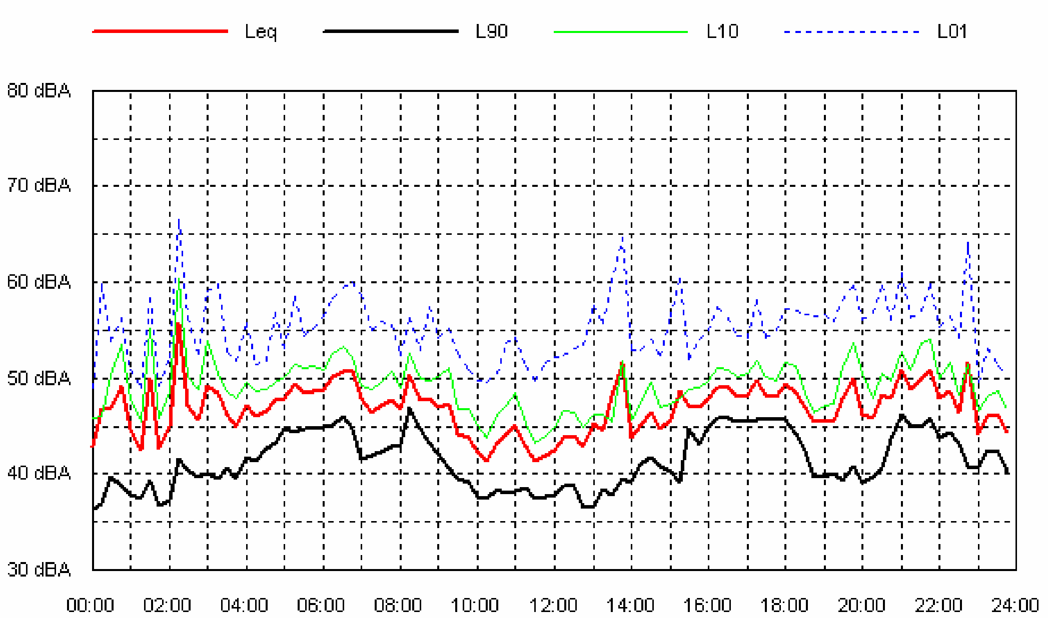

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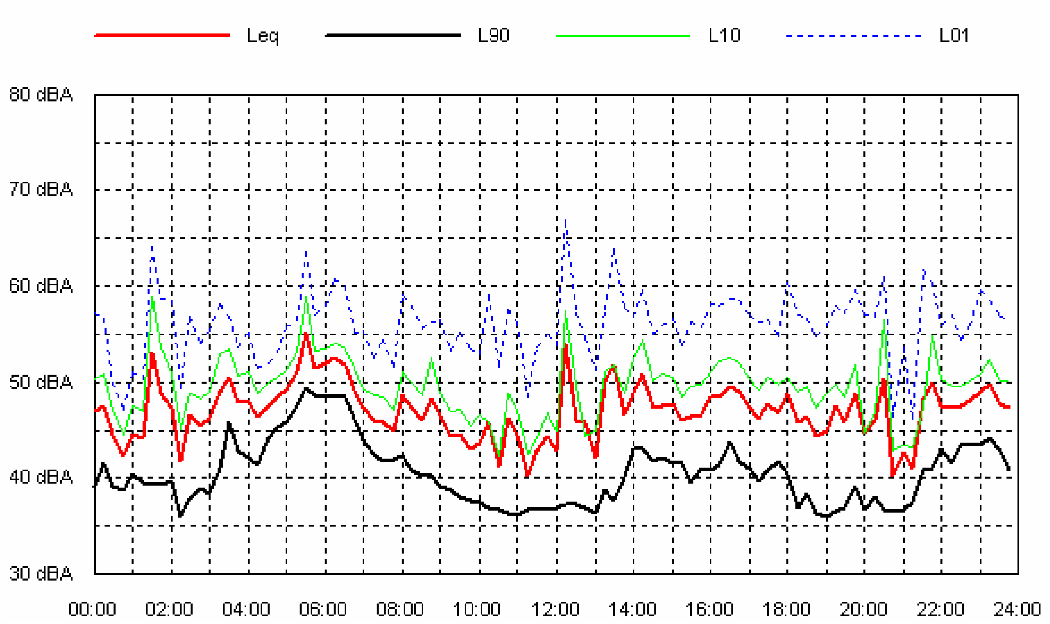

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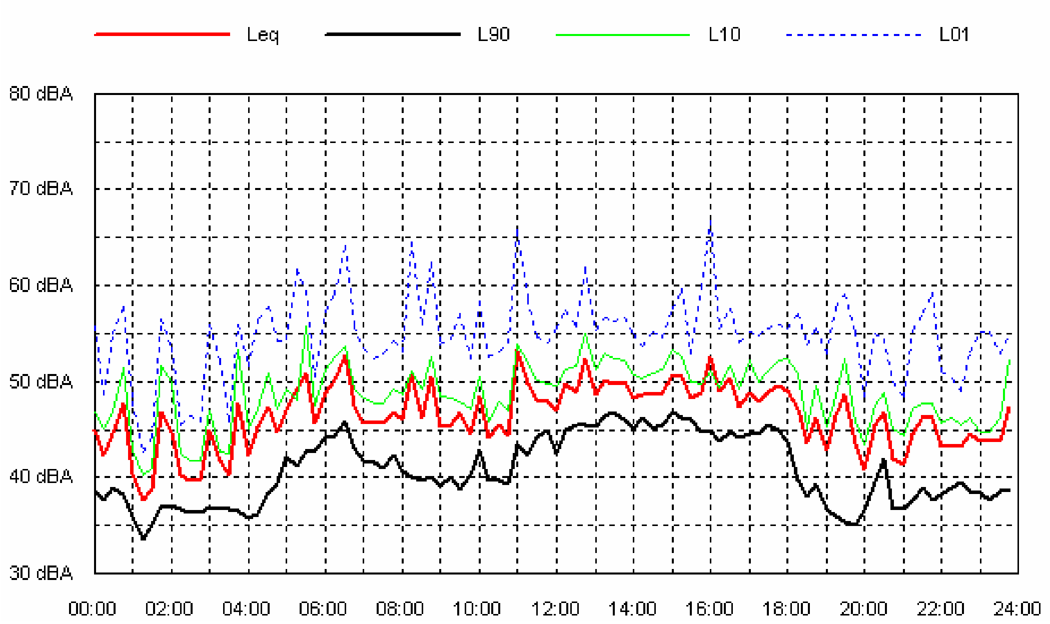

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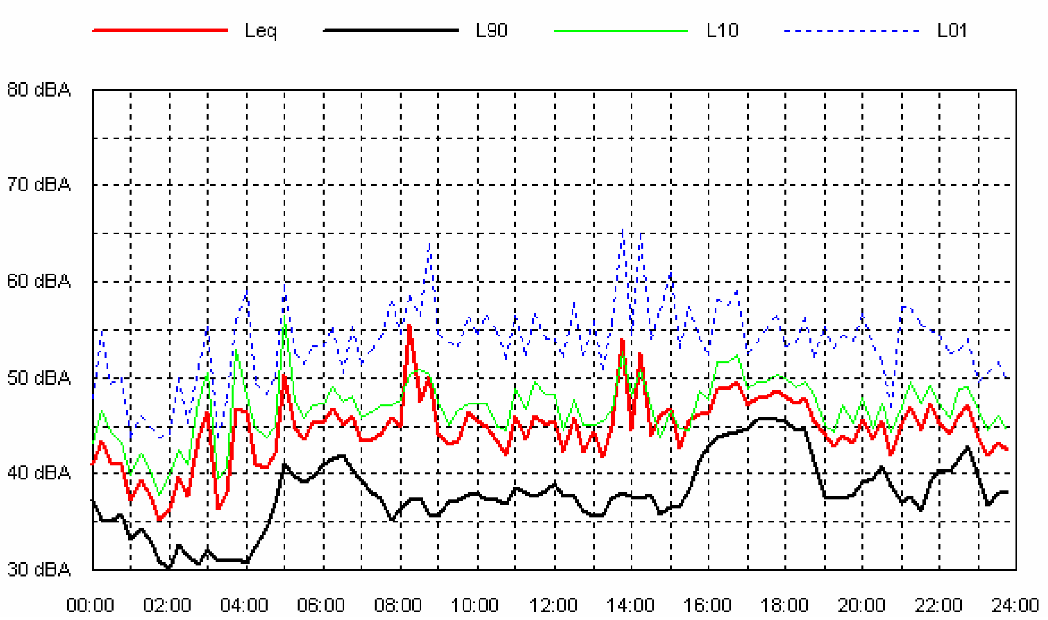

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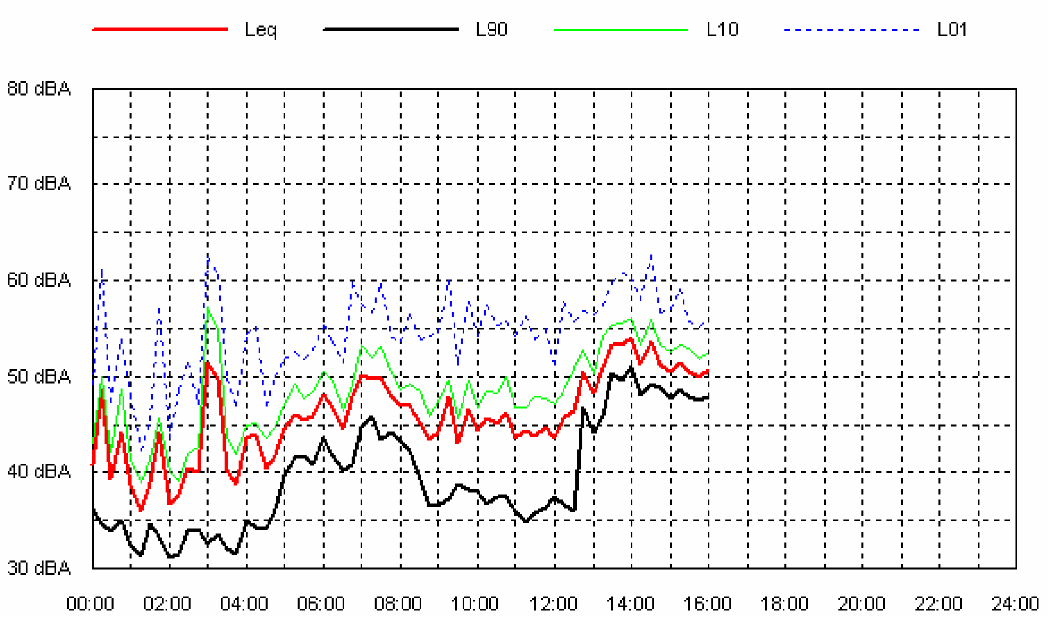
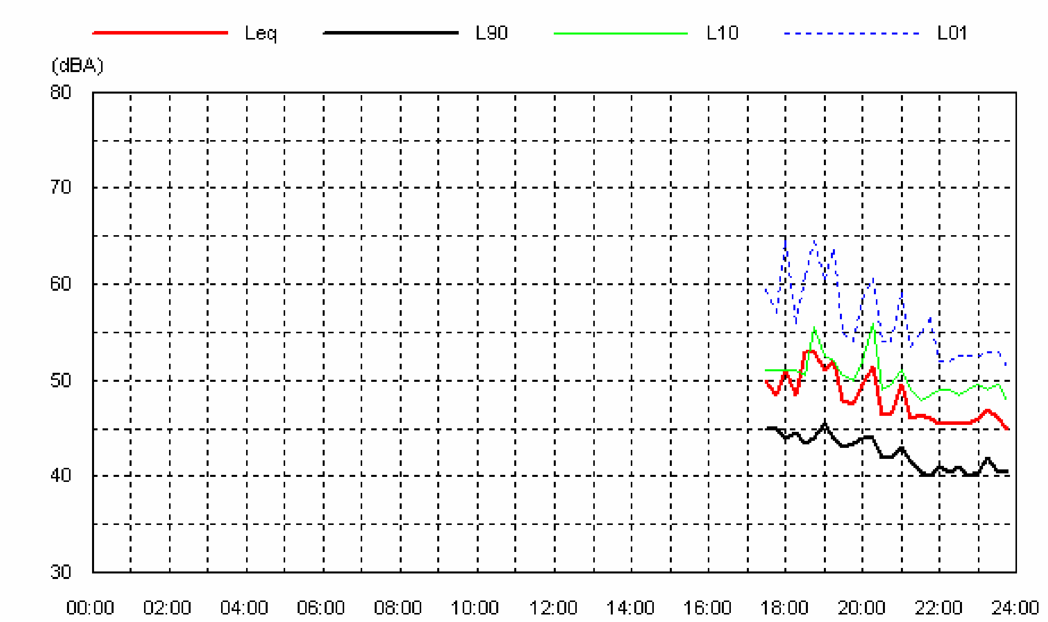


Location: Sugarloaf Well 2
Data shaded: Wind

Mon 18 Dec 06



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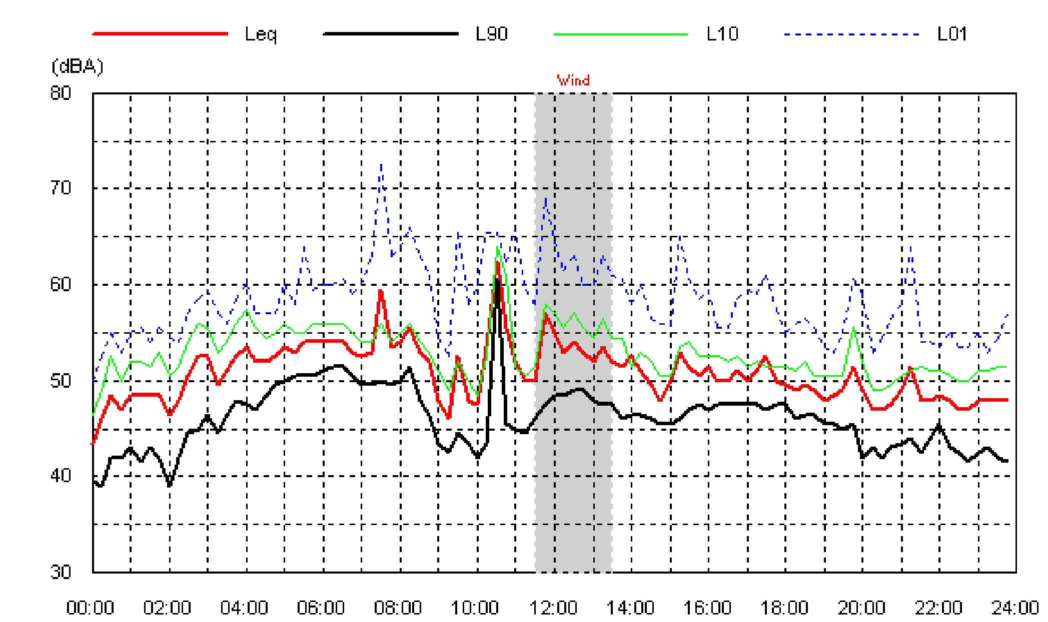
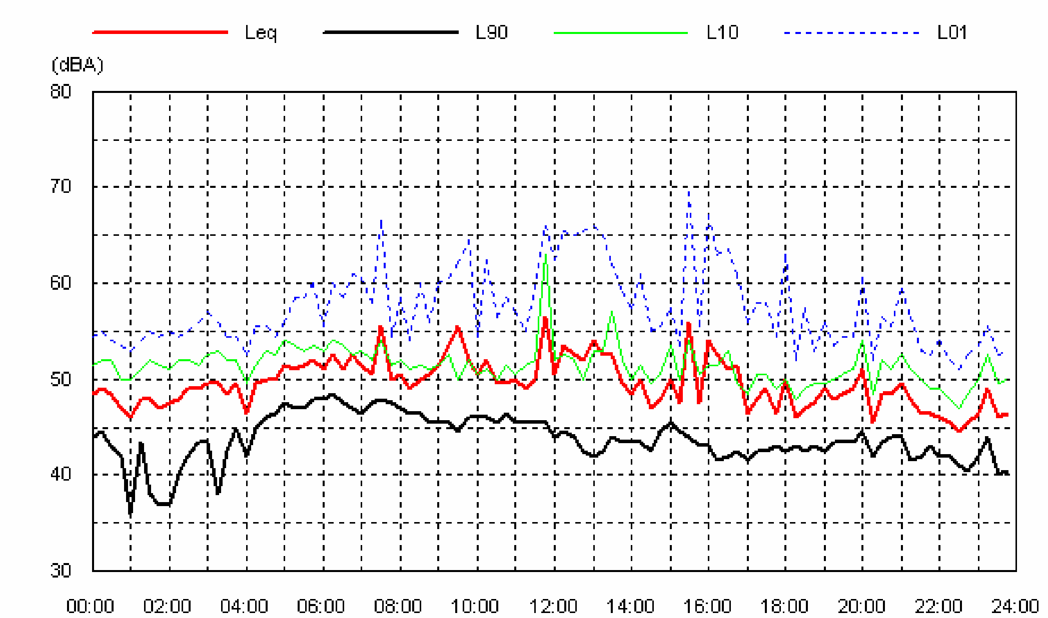


Location: Sugarloaf Well 2
Data shaded: Wind

Wed 20 Dec 06



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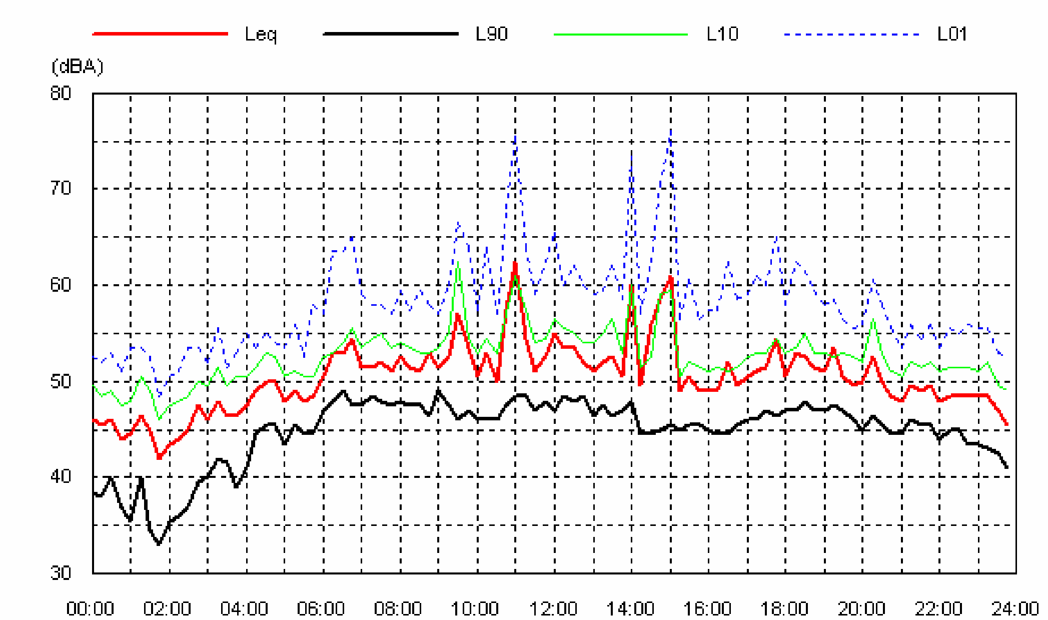

Location: Sugarloaf Well 2
Data shaded: Wind

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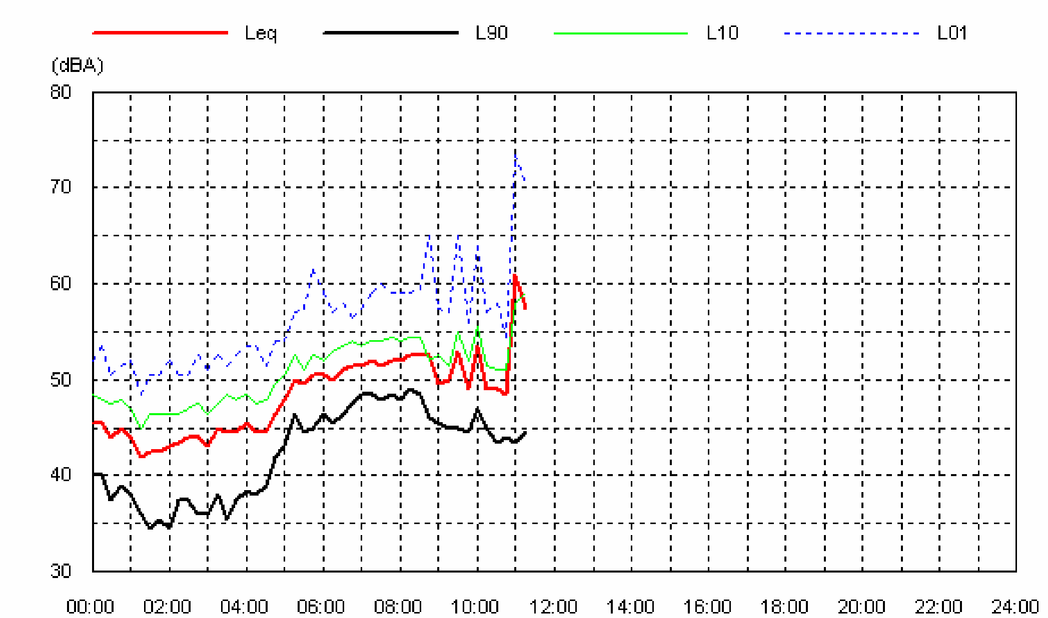

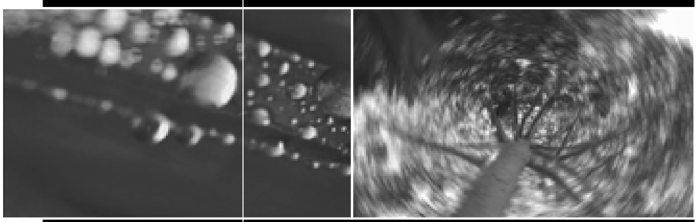

APPENDIX G

ECOLOGICAL ASSESSMENT

Ecological Assessment: Camden Gas Project
Stage 2 Concept Plan
Spring Farm and Menangle Park Project Areas

18 September 2007

Prepared for:
AGL Gas Production (Camden) Pty Ltd
72 Christie St
St Leonards

Report by:
HLA-Envirosciences Pty Limited (HLA ENSR)
ABN: 34 060 204 702
Level 5, 828 Pacific Highway Gordon NSW 2072
PO Box 726 Pymble NSW 2073
Ph: +61 2 8484 8999
Fax: +61 2 8484 8989

HLA Ref: S6056203_FFRPTFinal_18Sep07.doc

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DISTRIBUTION

Ecological Assessment: Stage 2 Camden Gas Project
Spring Farm and Menangle Park Project Areas
18 September 2007

Copies	Recipient	Copies	Recipient
1	**David Kelly** **AGL Gas Production (Camden) Pty Ltd** 72 Christie Street St Leonards NSW 2065		

This document was prepared for the sole use of AGL Gas Production (Camden) 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 (HLA ENSR) and AGL Gas Production (Camden) Pty Ltd.

By

HLA-Envirosciences Pty Limited (HLA ENSR)
ABN: 34 060 204 702
Level 5, 828 Pacific Highway Gordon NSW 2072
PO Box 726 Pymble NSW 2073

for **Evelyn Craigie**
Project Environmental Scientist

Technical Peer Reviewer: **Date:**

for	19 SEP 07
Michael England **National Practice Leader Environmental Planning**	

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CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

AGL Gas Production (Camden) Pty Limited (AGL) operates the Camden Gas Project (CGP), which is located 50 kilometres south west of Sydney in the Southern Coalfield of the Sydney Basin.

AGL is proposing to drill, test and operate gas wells at Spring Farm and Menangle Park. The project application also includes the construction of gas gathering lines, water drainage lines and access roads. Concurrent Concept approval is also being sought for future development of new well fields, infill wells and associated infrastructure (gathering lines, water drainage and access roads) along with post development activities.

An Environmental Assessment (EA) is being prepared on behalf of AGL to assess the potential environmental impacts of the proposed development and to support an application for approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act). HLA-Envirosciences Pty Limited (HLA ENSR) has prepared this ecological assessment to accompany the EA relating to Stage 2 of the CGP.

This ecological assessment relates to the proposed works within Spring Farm and Menangle Park for which Project approval is being sought. The Concept Plan is discussed in **Section 10**, as any activity covered by the Concept Plan will be subject to future application and a full impact assessment.

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2 PROJECT DESCRIPTION

2.1 Introduction

The Proponent, AGL, is seeking Concept approval for a range of works that are the remainder of development within the Stage 2 area of the CGP. Concurrent Project approval is also being sought for works within the proposed Spring Farm and Menangle Park well fields.

The ecological issues arising from the Concept Plan will be discussed in Chapter 9, however, it should be noted that any activity covered by the Concept Plan will be subject to future application and a full impact assessment, including an ecology assessment.

2.2 Overview of Proposed Activities

The works proposed in the Spring Farm and Menangle Park areas involve the construction and subsequent operation of a number of gas wells, together with associated infrastructure and post development activities to enable the extraction, collection and delivery of gas to the existing gas plant. **Figure 1** shows the regional location of the Spring Farm and Menangle Park areas.

The Project approval is being sought for the range of activities which can be divided into the following:

- Construction: The activities required to physically develop the wells and supporting infrastructure;
- Production: Production and delivery of gas from well surface locations to the RPGP via gas gathering lines for sale, including commissioning and maintenance activities;
- Post Development: Operational activities which may be needed to maintain production efficiency. These activities are proposed as part of the Concept Plan only and were not included as part of previous approvals in Stage 2. It is anticipated these activities may include the development of infill wells, upgrade of gas gathering lines, refracing (if required) and installation of infield compression; and
- Closure and Final Rehabilitation.

The application seeks approval for the construction of up to four surface well locations within the Spring Farm area and up to 12 surface well locations in the Menangle Park area. The proposed well surface locations are illustrated in **Figures 3** and **4** and for the purposes of this study are identified as follows:

- Spring Farm surface locations
  - SF04;
  - SF04A;
  - SF10;
  - SF17; and
  - SF20.
- Menangle Park surface locations
  - MP02;
  - MP03;

- MP04;
- MP05;
- MP06;
- MP11;
- MP19;
- MP22;
- MP21;
- MP23;
- MP24; and
- MP33.

Well surface locations SF04 and SF04A represent two alternatives for a single well surface location.

2.2.1 Gas Gathering System

The construction of the gas gathering lines typically involves survey and clearing (where required) of the route, trenching, pipe and tracer tape laying and backfilling, then rehabilitation and pipeline testing. Notification signposts are put in place to show the location of the gathering lines. A more detailed description of these works can be found in the EA. Water drainage lines may also be located with the gathering lines.

2.3 Location of Proposed Works

The area known as Spring Farm is located within the Camden LGA, approximately 65 km south west of Sydney. The Spring Farm area is located east of Camden and is situated south of the Camden by-pass. The Nepean River adjoins the south west boundary of the area, while the suburbs of Mount Annan, Narellan and Elderslie border the north / north eastern boundary of the area. Land in the area is allocated to support future urban development growth.

The Spring Farm Project Area is located between the existing well fields of Glenlee and the Elizabeth Macarthur Agricultural Institute to the south east and south west.

The Menangle Park area falls within the Campbelltown LGA. The land is situated to the southeast of the proposed Spring Farm area. The Menangle Park Project Area is bounded by the Hume Highway to the east, with the exception of a small portion of the study area which is situated east of the Hume Highway and north of Menangle Road. The Nepean River adjoins the western and southern boundaries of the area. The proposed works within the Spring Farm and Menangle Park areas are shown on **Figure 3** and **Figure 4** respectively.

The Environmental Assessment has used an “envelope” approach to the impact assessment which means that the highest impact activities are assessed even when these activities are not the most likely. The ecological assessment was undertaken in respect of the Spring Farm and Menangle Park Project areas. Within the two Project Areas, the ecological assessment focussed on a circle with a 200 metres radius around each proposed well surface location (the study area) and 25 metres either side of the proposed locations of the gas gathering lines and access roads (see **Figure 3** and **4**).

3 APPLICABLE POLICY AND LEGISLATION

3.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) sets out the requirements for 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). Matters of NES include wetlands of national importance, Commonwealth listed threatened species, threatened ecological communities and migratory species.

Approval from the Commonwealth is in addition to any approvals under NSW legislation and is triggered by a proposal which has the potential to have a significant impact on a matter of NES.

Cumberland Plain Woodland occurs in the project area and is an Endangered Ecological Community (EEC) listed under the provisions of the EPBC Act. The preferred habitat of one threatened fauna species and two threatened flora species listed under the provisions of the EPBC Act occurs in the project area (see **Tables 1 - 4**). Potential impacts to these matters are discussed in **Section 7**.

3.2 Environmental Planning and Assessment Act 1979

The EP&A Act and the EP&A Regulation provide the framework for environmental planning in NSW and include provisions to ensure that proposals which have the potential to impact the environment are subject to detailed assessment, and provide opportunity for public involvement.

Section 5A of the EP&A Act provides specific provisions for determining whether an activity will have a significant impact on threatened species, populations or ecological communities, or their habitats.

The threatened species and EECs that have been identified in the project area, or have potential habitat in the project area are listed in **Appendix A** and **B**. Potential impacts to these matters have been discussed in **Section 7**.

3.3 Threatened Species Conservation Act 1995

The objectives of the *Threatened Species Conservation Act 1995* (TSC Act) are to prevent the extinction and promote the recovery of threatened species, populations, ecological communities and critical habitat in NSW. It also aims to eliminate or manage key threatening processes, such as clearing of land and competition and grazing by the feral European rabbit. The schedules of the TSC Act provide lists of species, populations and ecological communities that are endangered, vulnerable or extinct. Actions that may impact on the threatened species, populations and ecological communities must be properly assessed.

The threatened species and EECs that have been identified in the project area, or have potential habitat in the project area are listed in **Appendix A** and **B**. Potential impacts to these matters have been discussed in **Section 7**.

3.4 Noxious Weeds Act 1993

In NSW, the *Noxious Weeds Act 1993* (NWA) is applicable to the notification and classification of noxious weeds. While the act is administered by the NSW Department of Primary Industries, Local Control Authorities (LCA) are responsible for implementing the act on private land, usually the local council. Under the Act, pest plants are classified into 5 categories:

- ***Classes 1 and 2***: "This plant must be eradicated form the land and the land kept free of the plant";
- ***Class 3***: "The plant must be fully and continuously suppressed and destroyed";
- ***Class 4***: "The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local authority"; and
- ***Class 5***: "The requirements in the *Noxious Weeds Act 1993* for a notifiable weed must be complied with".

The following declared weeds were recorded as being scattered across the study area:

- African Boxthorn (*Lycium ferocissimum*) – Class 4;
- Blackberry (*Rubus fruticosis*) – Class 4;
- Bridal Creeper (*Asparagus asparagoides*) – Class 4 and 5;
- Paterson's Curse (*Echium sp.*) – Class 4;
- Broad-leaf Privet (*Ligustrum lucidum*) – Class 4;
- Narrow-leaf Privet (*Ligustrum sinense*) – Class 4; and
- Willows (*Salix sp.*) – Class 5.

Two other species recorded in the study area are considered to be environmental weeds in the region, i.e. they are plants which reduce environmental values through their ability to invade bushland and compete with native flora; however, they are not declared weeds under the NWA. The environmental weeds recorded at the site include:

- African Olive (*Olea europaea*); and
- Moth Vine (*Araujia sericifolia*).

3.5 National Weeds Strategy

The *National Weeds Strategy* is a Federal strategy that was published in 1997, with a second edition being published in 1999. It aims to provide a coordinated approach to the management of weeds which affect Australia's productive capacity and natural ecosystems. The National Weeds Strategy Executive Committee was established in 1997 to identify Weeds of National Significance (WONS). Blackberry, Bridal Creeper and most Willow species are WONS.

The *National Weeds Strategy* does not create obligations for landholders; rather, it is an attempt to inform decision making with regards to weed control for State, Territory and Local weed authorities.

3.6 State Environmental Planning Policy 44 – Koala Habitat Protection

State Environmental Planning Policy 44 – Koala Habitat Protection (SEPP 44) aims to encourage conservation and management of koala habitat. The schedules of SEPP 44 provide a list of koala feed tree species and a list of local government areas (LGAs) in which koala habitat occurs. It defines core habitat value as areas which contain a resident koala population and potential koala habitat as areas in which the tree species listed in Schedule 2 comprise at least 15% of the total number of trees in the upper or lower strata of the tree component.

The Campbelltown and Wollondilly LGAs are listed in Schedule 1 of SEPP 44. *Eucalyptus tereticornis* (Forest Red Gum) occurs throughout the study areas and is listed in Schedule 2 of SEPP 44, however, the majority of the study areas are already cleared and the species occurs only as isolated individuals. As such, the area does not constitute potential or core koala habitat.

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4 METHODS

4.1 Review of Existing Information

A desktop review of available information was undertaken in respect of the existing environment, including a review of aerial photography, previous reports prepared for the area and NSW and Australian Government databases.

The Commonwealth Department of Environment and Heritage (DEH) online Protected Matters Search Tool was examined to obtain a list of matters of NES which may occur in the area. The NSW Department of Environment and Conservation (DEC, now the Department of Environment and Climate Change (DECC)) online Wildlife Atlas was also examined to obtain a list of threatened species (species listed as vulnerable or endangered) listed under the TSC Act previously recorded in a 20 km x 20 km grid centred on the two study areas.

Previous reports relating to the Project areas reviewed as part of this assessment include;

- *Spring Farm Urban Release Area Local Environment Study,* Camden Council, 2000;
- *Vegetation Assessment: Spring Farm Urban Land Release Area,* Anne Clements and Associates Pty Ltd, 2002;
- *Conservation Implementation Strategy: Spring Farm Urban Land Release Area,* Anne Clements and Associates Pty Ltd, 2002; and
- *Fauna and Fauna Habitat Study: Spring Farm Urban Release Area,* Conacher Travers, 2002.

Aerial photographs of the Spring Farm and Menangle Park Project areas are provided as **Figures 3** and **4** respectively.

4.2 Field Investigation

Field investigations were undertaken in late October and early November 2006 and early February 2007. The methods outlined below were applied to both the Spring Farm and Menangle Park Project areas. The field investigations focussed on the proposed well surface location, gas gathering lines and access road locations. The study area for each proposed well surface location comprised a circle with a 200 m radius, centred on the well surface location. In cases where the study area was intersected by a road, property boundary or railway line, the study area was reduced to fit within these borders as the final well location would not be placed beyond these barriers. Investigations were also undertaken 25 metres either side of the proposed locations for the gas gathering lines and access roads. Wells and associated infrastructure could therefore be located anywhere within these assessed areas in the knowledge that ecological impacts upon surrounding flora and fauna would be acceptable.

4.2.1 Fauna Habitat

The fauna values of the study areas were based upon an assessment of habitat quality and condition, including the following:

- The extent of fragmentation of habitat;
- The presence of key habitat features such as hollow-bearing trees, fallen logs, water bodies and the presence of shrub layers; and

- An assessment of whether the preferred habitat for the species listed in **Appendix A** and **B** was present.

Trapping and spotlighting was not undertaken as part of the fauna survey.

4.2.2 Flora

The flora investigation was based on an assessment of the following:

- Structural characteristics of the vegetation (based on life forms, approximate height and canopy cover);
- Groundcover characteristics;
- The condition of the vegetation, based on a subjective assessment of the degree of naturalness, level of disturbance and proportion of exotic flora present;
- Extent of weed species; and
- Dominant species in each structural component of the vegetation.

5 EXISTING ENVIRONMENT: CGP STAGE 2

The CGP Stage 2 area, shown in **Figure 2**, has undergone extensive clearing resulting from past and present land uses which include agriculture, residential, infrastructure and quarrying. This has resulted in a modified landscape, with much of the remaining native vegetation degraded and occurring in patches. Stands of native vegetation, including EECs occur scattered throughout the area. Remnants in varying condition of the following EECs occur in the area:

- Shale / Sandstone Transition Forest (Low Sandstone Influence);
- Shale / Sandstone Transition Forest (High Sandstone Influence);
- Cumberland Plain Woodland – Shale Hills Woodland;
- Cumberland Plain Woodland – Shale Plains Woodland;
- River-flat Eucalypt Forest on Coastal Floodplains – Alluvial Woodland;
- Riparian Forest;
- Moist Shale Woodland; and
- Elderslie Banksia Scrub.

Although much of the remnant vegetation is degraded, it provides habitat for a range of native species. This is particularly the case in the larger vegetation patches and the vegetation lining the Nepean River, which runs through the CGP Stage 2 area. Detailed descriptions of the existing environment at Spring Farm and Menangle Park are provided in the sections below.

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6 EXISTING ENVIRONMENT: SPRING FARM

6.1 Introduction

The majority of the Spring Farm Project Area has been cleared of vegetation as a result of past and present farming, coal washing and quarry activities. The region comprises good soils and a diverse ground cover of grasses and herbs, which have lead to extensive clearing for agricultural purposes (Keith, 2004). A vegetation corridor remains along the Nepean River and there are scattered vegetation stands throughout the paddocks and a few isolated remnant trees. The areas in which a diverse native groundcover, shrub and canopy layer occurs are very limited. The vegetation stands comprise both native and weed species and the majority of structural layers are dominated by one or two species.

The fragmented nature of the vegetation within the Spring Farm Project Area makes it more susceptible to edge effects, such as invasion of weeds, rubbish dumping and polluted stormwater. Current land uses in the project area and its vicinity, such as the presence of cattle and Jacks Gully Waste management Facility contribute to this susceptibility. Uncontrolled stormwater from some sources can increase the levels of nutrients in soil, affecting native vegetation, which is accustomed to low nutrient levels. There is a strong presence of rabbits, as evidenced by observation of numerous individuals, scats and burrows. Rabbits and other exotic fauna species compete with native species for food and habitat. Their prevalence, along with the pressures described above, has contributed to the overall reduction in quality of the vegetation and habitat of the Spring Farm Project Area.

The topography of the Spring Farm Project Area is undulating. Two of the well surface locations are located in Camden Council's Gundungurra Reserve, which has been set up to balance the open space and recreational needs with conservation of natural and cultural heritage values of the area. The reserve is proposed to play a role in the ongoing development of the Spring Farm Bush Corridor (SFBC); however, it has not been mapped as part of the corridor (Camden Council, 2004).

Database searches indicate that 35 threatened fauna species and 10 flora threatened flora species occur within a 20 km x 20 km area centred on the study area. A list of these species is provided in **Appendix A**. **Table 1** provides a list of flora species for which preferred habitat occurs within the project area. This includes one vulnerable and three endangered species, as listed under the TSC Act and one vulnerable and one endangered species listed under the EPBC Act.

A list of fauna species for which preferred habitat occurs in the project area is provided in **Table 2**. This includes eight vulnerable and two endangered species, as listed under the TSC Act and no vulnerable or endangered species listed under the EPBC Act.

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Table 1: Endangered Ecological Communities and flora species listed under Commonwealth and / or State legislation that have been recorded in a 20 km x 20 km search area centred on the site and have preferred habitat in the project area.

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Endangered Ecological Communities					
Cumberland Plain Woodland		TSC Act: E EPBC Act: E	Occurs on soils derived from Wianamatta Shale, and throughout the driest part of the Sydney Basin. Well adapted to drought and fire, and the understorey plants often rely on underground tubers or profuse annual seed production to survive adverse conditions.	✓	Yes
Elderslie Banksia Scrub		TSC Act: E	Occurs only on sand deposits on the old terraces deposited by ancient river systems of what is now the Nepean River, and requires deep sand soil to fully regenerate.	✓	Yes
River Flat Eucalypt Forest on coastal flood plains		TSC Act: E	Found on the river flats of the coastal floodplains. Can occur on smaller floodplains and river flats.	✓	Yes
Flora					
Matted Bush-pea	*Pultenaea pedunculata*	TSC Act: E1	Grows in dry sclerophyll forest and disturbed sites on a variety of soils on the South Coast and edge of the Southern Tableland, but with disjunct restricted populations on Wianamatta Shale on the Cumberland Plain in N.S.W.	✓	Yes (within 20 km x 20 km grid)[1]
Small-flower Grevillea	*Grevillea parviflora subsp. parviflora*	TSC Act: V EPBC Act: V	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	✓	Yes (within 20 km x 20 km grid)[1]
	Persoonia hirsuta subsp. hirsuta	TSC Act: E1	From Gosford to Royal National Park, below 300 m altitude.	✓	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Spiked Rice-flower	*Pimelea spicata*	TSC Act: E1 EPBC Act: E	Found on well-structured clay soils. On the inland Cumberland Plain sites it is associated with Grey Box and Ironbark.	✓	Yes (within 20 km x 20 km grid)[1]

Table 2: Fauna species listed under Commonwealth and / or State legislation that have been recorded in a 20 km x 20 km search area centred on the site and have preferred habitat in the project area.

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Gastropods					
Cumberland Plain Land Snail	*Meridolum corneovirens*	TSC Act:E1	Cumberland Plain Woodland, grassy open woodland. Under litter of bark, leaves and logs, soil around grass clumps.	✓	Yes (within 20 km x 20 km grid)[1]
Birds					
Bush Stone-curlew	*Burhinus grallarius*	TSC Act: E1	Inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber. Largely nocturnal, being especially active on moonlit nights.	✓	Yes (within 20 km x 20 km grid)[1]
Glossy Black-cockatoo	*Calyptorhyncus lathami*	TSC Act: V	Forests and woodlands with abundant casuarina trees, any of about five species.	✓	Yes (within 20 km x 20 km grid)[1]
Diamond Firetail	*Stagonopleura guttata*	TSC Act: V	Feeds on the ground. Grassy eucalypt woodland. Also open forest, mallee, Natural Temperate Grassland and secondary grassland derived from other communities. Often found in riparian areas, sometimes in lightly wooded farmland.	✓	Yes (within 20 km x 20 km grid)[1]
Hooded Robin	*Melanodryas cucullata*	TSC Act: V	Dry forests, woodlands, mallee, shrublands.	✓	Yes (within 20 km x 20 km grid)[1]
Barking Owl	*Ninox connivens*	TSC Act: V	Inhabits eucalypt woodland, open forest, swamp woodlands and, especially in inland areas, timber along watercourses. Denser vegetation is used occasionally for roosting. During the day they roost along creek lines, usually in tall understorey trees with dense foliage such as Acacia and Casuarina species, or the dense clumps of canopy leaves in large Eucalypts.	✓	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Powerful Owl	*Ninox strenua*	TSC Act: V	The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well.	✓	Yes (within 20 km x 20 km grid)[1]
Mammals					
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	TSC Act: V	Forages in eucalypt forests, mallee and open country. Roosts in tree hollows and has been found in the abandoned nests of Sugar Gliders.	✓	Yes (within 20 km x 20 km grid)[1]
Eastern Freetail-bat	*Mormopterus norfolkensis*	TSC Act: V	Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roost mainly in tree hollows but will also roost under bark or in man-made structures.	✓	Yes (within 20 km x 20 km grid)[1]
Koala	*Phascolarctos cinereus*	TSC Act: V	Inhabit eucalypt woodlands and forests.	✓	Yes (within 20 km x 20 km grid)[1]

TSC Act

V: Vulnerable - the species is likely to become endangered if threats continue.

E1: Endangered Species - the species is likely to become extinct in nature if threats continue, or its numbers are reduced to a critical level, or its habitat is reduced.

EPBC Act

E: Endangered – the species is facing a very high risk of extinction in the wild in the near future.

V: Vulnerable – the species is facing a high risk of extinction in the wild in the medium term future.

[1] Source: NPWS Online Atlas of NSW Wildlife

6.2 SF04 Well Surface Location Study Area

There are two alternatives for the SF04 surface location study area, SF04 and SF04A (see **Figure 3**). Based on constraints that are identified in this and other studies, the most appropriate of the two surface locations will be selected. Both surface locations are located in an area that has previously undergone sand quarrying activities and as such, there are existing roads and old stockpiles located throughout the study areas. An active sand quarry is located to the west of the study area.

6.2.1 Flora

The SF04 and SF04A study areas are located in areas that are largely cleared of vegetation. The only significant vegetation stand lies to the south east of SF04 and to the east of SF04A. It comprises Elderslie Banksia Scrub (EBS), which is an EEC described as critically endangered (NPWS, 2006). The vegetation that occurs within the study area is connected to a large vegetation corridor to the south, which runs along the Nepean River. It is surrounded by cleared land to the east, north and west, making it susceptible to edge effects, particularly the encroachment of weeds as these are abundant in the surrounding cleared areas. Much of the vegetation stand comprises regrowth with some remnant trees scattered throughout the area. The canopy is dominated by *Banksia integrifolia* ssp. *integrifolia* (Coast Banksia) with *Angophora subvelutina* (Broad-leaved Apple) and *Eucalyptus tereticornis* (Forest Red-gum). Much of the shrub layer comprises regrowth of these species and there is little groundcover.

An isolated stand of vegetation is located to the north west of SF04, comprising EBS regrowth and areas that have undergone rehabilitation.

6.2.2 Fauna Habitat

The vegetation which occurs in the study area is connected to a large vegetation corridor which runs along the Nepean River and large stands of vegetation to the south of the river. Within the study area, hollow bearing trees are scarce as much of the canopy layer comprises regrowth or trees which do not generally form hollows. Other key habitat features that are present include fallen logs and leaf litter. The vegetation stand has habitat value for a variety of species as it provides a food source and shelter. Its connectivity to a large tract of vegetation enhances its habitat value as a greater variety of species would be able to access the area and use its resources.

There is some isolated regrowth in the cleared areas of the study area which provide limited foraging and shelter opportunities, mainly for birds.

6.3 Access Road and Gas Gathering: SF04/ SF04A to GL06

The majority of the gas gathering and water pipeline from SF04/ SF04A to GL06 and the access road from Springs Road to SF04/ SF04A will follow an existing dirt road and the existing Glenlee Coal Washery road. Sections of it are located adjacent to a small area of the EBS described in **Section 5.2.1**. The remaining sections are proposed to go through cleared areas.

6.3.1 Flora

Much of the study area has been cleared to accommodate the quarrying activities. There are vegetation stands to the south, however, these are largely outside of the study area with the exception of a small section which the gas gathering and water pipeline will run alongside. This vegetation has been described in **Section 5.2.1** and comprises EBS, an EEC (see **Figure 3**). The vegetation which occurs at the eastern end of the study area comprises River Flat Eucalypt Forest which is also an EEC.

6.3.2 Fauna Habitat

The majority of the study area has been cleared and only provides limited habitat value for native fauna. Parts of the vegetation stands described in **Section 5.3.1** are included in the study area and these sections have potential habitat value, particularly as they are connected to a large vegetation corridor which runs along the Nepean River. Key habitat features that are present include fallen logs and leaf litter which provide shelter for animals such as reptiles and molluscs.

6.4 SF10 Well Surface Location Study Area

The SF10 study area is located in the Gundungurra Reserve on land which is gently undulating with drainage lines running through it. Existing residential housing is located to the north west.

6.4.1 Flora

The flora within the study area is degraded, largely comprising cleared areas with some stands of vegetation. The canopy layer makes up approximately 30% of the study area and includes some remnant Eucalypts growing to a height of approximately 30 metres. *Amyema miquelii* (mistletoe) occurs in the canopy species. The shrub layer covers approximately 60% of the study area and is dominated by *Bursaria spinosa,* a native shrub typical to Cumberland Plain Woodland (CPW) communities. The groundlayer is highly modified from its natural state and comprises a continuous layer of herbs and grasses, the majority of which are exotic species. The species diversity is limited in the shrub and canopy layers. Weed species within the study area include *Lycium ferocissimum* (African Boxthorn), *Verbena bonariensis* (Purple Top) and *Onopordum acanthium* (Scotch Thistle).

The vegetation within the study area is part of the Gundungurra Reserve; however, it is fragmented and does not connect to any significant areas of remnant vegetation. The condition of the vegetation is related to the previous grazing activities, which have ceased to occur since the land became part of the Gundungurra Reserve. It would appear that the shrub layer has benefited from this change, with the native shrub *Bursaria spinosa,* dominating the vegetation stands.

The assemblage of native species in the study area indicates it is CPW, although it is in a degraded state. The study area is part of a larger area of vegetation identified in a previous report, prepared by Anne Clements and Associates Pty Ltd, as meeting the criteria for CPW in terms of substrate and species composition under the TSC Act and EPBC Act. However, due to its degraded state and the presence of exotic species it is not considered likely to regenerate to achieve a ‘characteristic native understorey’ (Anne Clements and Associates Pty Ltd, 2003).

6.4.2 Fauna Habitat

Habitat value is mainly concentrated around the larger remnant trees, some of which contain hollows and have scattered logs and leaf litter around their bases. While such features are present, the isolated and fragmented nature of the vegetation reduces their value, making them less likely to support viable populations of native species. The lack of connectivity of the vegetation to significant areas of native vegetation means it would be difficult for less mobile species to make use of the habitat features within the study area. The hollows may provide habitat value for birds, bats and arboreal mammals. Both the native and exotic species which make up the shrub and groundlayer provide limited foraging and shelter opportunities, mainly for birds. Mistletoe was observed in some of the eucalypts and provides food for some bird species, particularly honeyeaters. The logs, fallen branches and patches of leaf litter provide potential habitat for ground dwelling reptiles, including skinks and snakes.

6.5 SF17 Well Surface Location Study Area

The study area for the SF17 surface location was truncated from the standard area (based on a circle with a 200 metre radius) due to the presence of a property boundary (see **Figure 3**). AGL advised that the well location would not occur beyond this boundary. The proposed well location is on a flat area which begins to slope towards the south approximately 10 metres from the proposed well surface location. AGL has advised that adjustments to the well surface location would not occur beyond the flat area. A dam is located in the study area, situated to the south west of the proposed well surface location.

6.5.1 Flora

The study area has been completely cleared of native trees and shrubs and comprises open pasture. The few shrubs that are present comprise the weed *Olea europaea* subsp. *africana* (African Olive). The groundcover contains some native grasses such as *Themeda australis* (Kangaroo Grass).

6.5.2 Fauna Habitat

The habitat value of the study area is very limited; however, there are species that would forage in the grass and the African Olive, such as grassland birds. The small dam is likely to provide a water source for native animals, however, its habitat value is limited as it does not contain any vegetation within or surrounding it.

6.6 SF20 Well Surface Location Study Area

The western half of the study area for the SF20 surface location overlaps with the eastern half of the study area for SF10, which has been described above. The remainder of SF20 is dominated by native and exotic grasses and African Boxthorn. The study area is in the Gundungurra Reserve and is located on gently undulating land with some drainage lines running through it. Existing residential housing is located to the north west.

6.6.1 Flora

There are some regrowth *Eucalyptus amplifolia* (Cabbage Gum) and *Eucalyptus moluccana* (Grey Box), with an average height of some 15 metres, covering approximately 10% of the study area. The shrub layer is dominated by African Boxthorn, growing to an average height of around 2 metres. The ground layer comprises a continuous cover of exotic grasses. Other species mainly comprise weeds and include *Senecio madagascariensis* (Fireweed), *Echium lycopsis* (Paterson's Curse), *Araujia sericifera* (Moth Vine), *Rubus fruticosis* (Blackberry) and Scotch Thistle.

The study area falls within the Gundungurra Reserve. It is also included in the vegetation that has been identified in a previous report as being degraded CPW (Anne Clements and Associates, 2003). In that report, the CPW is described as being in a degraded state with the presence of exotic species making it unlikely to regenerate to achieve a ‘characteristic native understorey’ (Anne Clements and Associates Pty Ltd, 2003).

6.6.2 Fauna Habitat

The study area contains few key habitat features such as hollow bearing trees and leaf litter. Habitat features present in the study area include fallen logs, a thick groundcover and native and exotic plant species bearing fruit. Such features can provide foraging opportunities and shelter for common native birds, reptiles and small mammals. Whilst these habitat features are present, their value is reduced as a result of the fragmented nature of the vegetation and its isolation from areas of significant remnant vegetation.

6.7 Access Road: Jacks Gully Waste Management Facility road to SF17 and SF20

The access road from the Jacks Gully Waste Management Facility access road to SF17 and SF20 is proposed to run along an existing road, the length of which has been developed to varying degrees. As shown in **Figure 3**, there are two section of the access road with one section leading towards SF20 and the other heading east towards SF17. The initial section of road, from the Jacks Gully Waste Management Facility road to the cattle yards, is a dirt road with some sections of gravel. Beyond the cattle yards, the road is less developed, being visible but overgrown with grass. The construction access road is proposed to follow this same path.

6.7.1 Flora

Much of the access road passes through cleared paddocks. With the exception of some tree and shrub stands, the vegetation within 25 metres of each side of the road comprises only pasture grasses. The road passes through a patch of shrubs that comprise both *Bursaria spinosa* (a native) and African Boxthorn (a weed). A stand of four remnant *Corymbia gummifera* (Red Bloodwood) is located immediately adjacent to the existing road.

6.7.2 Fauna Habitat

Habitat features in the road corridor are restricted to the shrub patches and the remnant eucalypts. The isolated nature of this vegetation reduces its quality as habitat, with only highly mobile species, such as birds, able to make use of them. There may also be some foraging value for grassland birds in the cleared areas which characterise much of the road corridor.

6.8 Access Road and Gas Gathering: SF17 to SF20 and SF10

The access road from SF17 to SF20 and SF10 is proposed to follow an existing fenceline where there is a track that is used as a walking and motorbike track. The study area for the gas gathering and water pipelines from SF20 to SF10 largely falls within the same corridor as that of the access road between SF20 and SF10.

6.8.1 Flora

The identified route for the proposed access road and gas gathering and water pipelines is along an existing road. The majority of the vegetation on either side of the cleared track comprises African Olive and African Boxthorn. Some Eucalypt species are located immediately adjacent to the proposed track and further afield within the study area.

6.8.2 Fauna Habitat

The study area contains little habitat value in terms of key habitat features. It contains a thick groundcover which may provide foraging opportunities and shelter for common birds, reptiles and small mammals. The native canopy species and exotic shrub species would provide foraging opportunities for birds, arboreal mammals and bats when they are flowering. Threatened species which may use these habitats are shown in **Table 2**.

6.9 Gas Gathering and Water Pipeline: SF17 to Jacks Gully Waste Management Facility

The study corridor passes through undulating cleared paddocks. The vegetation comprises pasture grasses and some scattered African Olive. Its habitat value is limited and its use would be restricted to common birds and reptiles which may pass through the area.

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7 EXISTING ENVIRONMENT: MENANGLE PARK

7.1 Introduction

The landscape of the Menangle Park Project Area is similar to the Spring Farm Project area in that the majority of it has been cleared to accommodate agricultural, sand quarrying and coal mining land uses. The remaining vegetation within the Menangle Park Project area is fragmented and isolated from significant areas of remnant native vegetation, reducing its habitat value. The fragmented nature of the vegetation in the study area makes it more susceptible to edge effects, such as invasion of weeds, rubbish dumping and polluted stormwater.

The areas in which a diverse native groundcover, shrub and canopy layer occur are very limited with the majority of vegetation stands being dominated by one or two species.

There is a large weed presence and a very strong rabbit presence. Much of the land is currently used for horse agistment. As seen in **Figure 4**, sections of the project area are highly disturbed as a result of sand quarrying and coal mining activities.

A list of species listed under the provisions of the TSC Act, which have been recorded within a 20 km x 20 km area centred on each well surface location, has been provided in **Appendix B**. Species listed under the provisions of the EPBC Act which may occur or for which habitat may occur in the study area have also been provided in **Appendix B**.

Eucalyptus tereticornis is a koala feed tree listed in Schedule 2 of SEPP 44 – Koala Habitat. The species is scattered throughout the Project area, occurring only as isolated individuals. As such, the Project area does not contain potential or core koala habitat, as defined by SEPP 44 and **Section 3.4**.

Database searches indicate that 35 threatened fauna species and 10 flora threatened flora species occur within a 20 km x 20 km area centred on the study area. A list of these species is provided in **Appendix B**. **Table 3** provides a list of flora species for which preferred habitat occurs within the project area. This includes one vulnerable and three endangered species, as listed under the TSC Act and one vulnerable and one endangered species listed under the EPBC Act.

A list of fauna species for which preferred habitat occurs in the project area is provided in **Table 4**. This includes eight vulnerable and two endangered species, as listed under the TSC Act and no vulnerable or endangered species listed under the EPBC Act

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Table 3: Flora species listed under Commonwealth and / or State legislation that have been recorded in a 20 km x 20 km search area centred on the site and have preferred habitat in the project area.

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Matted Bush-pea	*Pultenaea pedunculata*	TSC Act: E1	Grows in dry sclerophyll forest and disturbed sites on a variety of soils on the South Coast and edge of the Southern Tableland, but with disjunct restricted populations on Wianamatta Shale on the Cumberland Plain in N.S.W.	✓	Yes (within 20 km x 20 km grid)[1]
Small-flower Grevillea	*Grevillea parviflora subsp. parviflora*	TSC Act: V EPBC Act: V	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	✓	Yes (within 20 km x 20 km grid)[1]
	Persoonia hirsuta subsp. hirsuta	TSC Act: E1	From Gosford to Royal N.P., below 300 m altitude.	✓	Yes (within 20 km x 20 km grid)[1]
Spiked Rice-flower	*Pimelea spicata*	TSC Act: E1 EPBC Act: E	Found on well-structured clay soils. On the inland Cumberland Plain sites it is associated with Grey Box and Ironbark.	✓	Yes (within 20 km x 20 km grid)[1]

Table 4: Fauna species listed under Commonwealth and / or State legislation that have been recorded in a 20 km x 20 km search area centred on the site and have preferred habitat in the project area.

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
FAUNA					
Gastropods					
Cumberland Plain Land Snail	*Meridolum corneovirens*	TSC Act:E1	Cumberland Plain Woodland, grassy open woodland. Under litter of bark, leaves and logs, soil around grass clumps.	✓	Yes (within 20 km x 20 km grid)[1]
Birds					
Bush Stone-curlew	*Burhinus grallarius*	TSC Act: E1	Inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber. Largely nocturnal, being especially active on moonlit nights.	✓	Yes (within 20 km x 20 km grid)[1]
Glossy Black-cockatoo	*Calyptorhyncus lathami*	TSC Act: V	Forests and woodlands with abundant casuarina trees, any of about five species.	✓	Yes (within 20 km x 20 km grid)[1]
Diamond Firetail	*Stagonopleura guttata*	TSC Act: V	Feeds on the ground. Grassy eucalypt woodland. Also open forest, mallee, Natural Temperate Grassland and secondary grassland derived from other communities. Often found in riparian areas, sometimes in lightly wooded farmland.	✓	Yes (within 20 km x 20 km grid)[1]
Hooded Robin	*Melanodryas cucullata*	TSC Act: V	Dry forests, woodlands, mallee, shrublands.	✓	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Barking Owl	*Ninox connivens*	TSC Act: V	Inhabits eucalypt woodland, open forest, swamp woodlands and, especially in inland areas, timber along watercourses. Denser vegetation is used occasionally for roosting. During the day they roost along creek lines, usually in tall understorey trees with dense foliage such as Acacia and Casuarina species, or the dense clumps of canopy leaves in large Eucalypts.	✓	Yes (within 20 km x 20 km grid)[1]
Powerful Owl	*Ninox strenua*	TSC Act: V	The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well.	✓	Yes (within 20 km x 20 km grid)[1]
Mammals					
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	TSC Act: V	Forages in eucalypt forests, mallee and open country. Roosts in tree hollows and has been found in the abandoned nests of Sugar Gliders.	✓	Yes (within 20 km x 20 km grid)[1]
Eastern Freetail-bat	*Mormopterus norfolkensis*	TSC Act: V	Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roost mainly in tree hollows but will also roost under bark or in man-made structures.	✓	Yes (within 20 km x 20 km grid)[1]
Koala	*Phascolarctos cinereus*	TSC Act: V	Inhabit eucalypt woodlands and forests.	✓	Yes (within 20 km x 20 km grid)[1]

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7.2 MP02 Well Surface Location Study Area

A railway line runs through the study area of MP02. The well would not be located to the south of the railway line and as such, the study area has been reduced to reflect this. The study area does not currently have specific use, however, it was formerly used for grazing and the makeup of the vegetation reflects this (see **Figure 4**). The well surface location slopes very gently with a southerly aspect. A drainage line is located in the eastern section of the study area.

7.2.1 Flora

Overall, the vegetation at MP02 is degraded. Native tree and shrub species have regrown after having been cleared, however, the study area is dominated by weeds. A significant canopy cover is lacking, comprising only a line of eucalypts in the north western extremities of the study area and a stand of *Acacia decurrens* (Sydney Green Wattle). The canopy trees make up approximately 15% of the study area with the eucalypts growing to a height of approximately 20 metres and the Sydney Green Wattle growing to approximately 5 metres. The shrub layer is dominated by African Olive, with some *Bursaria spinosa* also present. There is a continuous grass cover comprising both native and exotic species.

The weed species present include *Sida rhombifolia* (Paddy's Lucerne), African Olive, Blackberry, Scotch Thistle, Patersons Curse and Fireweed.

7.2.2 Fauna Habitat

Key habitat features such as hollow bearing trees are lacking in the study area. There are some scattered fallen logs and birds were observed in the tree canopy. The weed species such as African Olive provide a source of food and shelter for birds. The grass areas also provide foraging and sheltering opportunities for some birds, small mammals and reptiles.

The habitat value of the study area is reduced due to its fragmented and modified state. Mobile species such as birds would be able to use the study area; however, it would be difficult for the study area and its surrounds to support viable populations of species due to its degraded nature and the presence of a barrier to animal movement in the form of the railway line.

7.3 Access Road to MP02 and MP03

Access to MP02 and MP03 is via an existing ARTC road which is accessed from the road network of the University of Western Sydney. The road runs alongside a railway track.

7.3.1 Flora

Vegetation is generally restricted to the northern side of the road as the southern side runs along the railway track for most of its length and has been cleared of canopy species, comprising only scattered shrubs and grass cover. Vegetation to the north of the road is patchy and largely lacks a canopy layer. The understorey is dominated by weeds such as African Olive and the grass cover comprises both native and exotic species.

7.3.2 Fauna Habitat

The weed species such as African Olive provide a source of food and shelter for birds. A large dam is located to the north of the road which provides a water source for a variety of species and comprises potential habitat for common waterbirds and amphibians. It does not constitute the preferred habitat for the threatened species listed in **Table 2**.

The habitat value of the study area is reduced due to its fragmented and modified state. Mobile species such as birds would be able to use the study area; however, it would be difficult for the study area and its surrounds to support viable populations of species due to its degraded nature and the presence of a barrier to animal movement in the form of the railway line.

7.4 MP03 Well Surface Location Study Area

The MP03 study area is located in close proximity to the proposed MP02 well surface location study area and as such, shares many of its features in terms of topography and landscape features. This study area is reduced to a smaller area than the standard circle of 200 metre radius due to the presence of the railway line and a road to the west (see **Figure 4**). An existing underground gas pipe runs parallel to this road. Much of the study area is on a slope with a southerly aspect, however, the proposed well location is situated on a flat area at the base of the slope.

7.4.1 Flora

The MP03 study area has been cleared in the past and the vegetation that is currently present is disrupted by the presence of an existing access road, the underground gas pipe and its associated right of way. Canopy species are restricted to a hilltop in the north eastern section of the study area, reaching an average height of around 20 metres and covering approximately 5% of the study area. Some smaller Acacia species, reaching an average height of some 5 metres are scattered throughout the study area. African Olive dominates the study area and the shrub layer. The ground cover comprises native and exotic grasses.

7.4.2 Fauna Habitat

The habitat features of the study area are very similar to those of the MP02 study area. The trees and shrubs that are present, along with the thick ground cover, would provide foraging, roosting and shelter opportunities for a variety of species. The lack of connectivity of the vegetation in the study area to other areas of significant vegetation restricts the species that could use the study area to those that are more mobile, such as birds. The study area contains potential habitat for some of the threatened species listed in **Table 2**, however, habitat quality is reduced due to the presence of the railway line and the road. Native species may use the study area, however, it is unlikely to support viable populations of native species.

7.5 MP04 Well Surface Location Study Area

The MP04 study area is reduced by the presence of the railway line and a water supply channel / canal (see **Figure 4**).

7.5.1 Flora

The MP04 study area forms part of a large paddock in which horses are kept. As a result of past clearing activities and the presence of the horses, the study area lacks structural diversity, comprising only a canopy layer and a degraded groundlayer. Canopy trees include *Eucalyptus crebra* (Narrow-leaved Ironbark), Cabbage Gum and Grey Box. African Boxthorn dominates the shrub layer, which lacks native species. Native regrowth has occurred in the vicinity of the large remnant trees. The remnant trees and stands of regrowth cover approximately 40% of the study area and are an average height of about 30 metres.

7.5.2 Fauna Habitat

Despite the degraded nature of the study area, key habitat features are present, generally in the vicinity of the remnant trees. There are hollows in the larger trees, fallen logs scattered around their bases and patches of leaf litter. While these features are likely to provide a habitat for birds, arboreal mammals, reptiles and bats, their isolated nature precludes them from supporting viable populations of a diverse range of species.

7.6 Access Road: MP04 to Glenlee Road

The topography of the road corridor is undulating, sloping with a westerly aspect and becoming flat towards Glenlee Road. There is an existing dirt road on the flat area of the proposed road corridor, while the remaining areas are completely cleared with the exception of pasture grasses. The access road would pass around the existing vegetation and south to Glenlee Road. Once past the vegetation within the MP04 study area, there are only some isolated paddock trees within 25 metres of either side of the proposed road.

7.7 Gas Gathering: Menangle Road

The gas gathering and water pipeline is proposed to run along Menangle Road, from an underbore (in the vicinity of MP02) to the intersection of Menangle Road and Glenlee Road. The study area lies between Menangle Road and a residential area to the east.

7.7.1 Flora

Vegetation occurs in patches along the road verge. The vegetation stands are isolated due to their location between the road to the west and residential areas to the east. Much of the vegetation comprises weeds, being dominated by African Olive. Native species present include *Bursaria spinosa* in the shrub layer and remnant and regrowth eucalypts.

The species assemblage in some sections of the study area indicates the vegetation is CPW; however, it is dominated by weeds and highly degraded due to its isolation.

7.7.2 Fauna Habitat

The vegetation has the potential to provide habitat for native species due to the presence of large, hollow bearing eucalypts and a dense shrub layer. The habitat value of the study area is reduced due to its location beside a busy road and a residential area, making it likely to provide habitat only for more mobile species such as birds.

7.8 Gas Gathering and Access: Glenlee Road

The gas gathering pipeline is proposed to run alongside Glenlee Road. The road verge in the section between Menangle Road and the Glenlee Road bridge (over the Hume Highway) is narrow, being approximately 2 – 3 m. From the road bridge towards the west, the road verge widens considerably, being up to 10 m.

7.8.1 Flora

Approximately 40% of the study area contains a canopy layer comprising mature and regrowth native species such as Grey Box. The understorey is dominated by African Olive with some native species occurring such as regrowth *Acacia implexa.* The vegetation occurs almost entirely in the section of the study area between Menangle Road and the road bridge. The study area passes through the northern end of a large vegetation stand immediately to the east of the road bridge. While the vegetation stand is in good condition, the section in which the gas gathering pipeline is proposed to go through has been disturbed by the presence of Glenlee Road, along which the gas gathering pipeline will run. The species assemblage in this section of the study area indicates the vegetation comprises CPW.

To the west of the Hume Highway road bridge there is very little vegetation. A ground cover is present comprising a mixture of native and exotic species. Some isolated eucalypts are scattered along the road verge.

7.8.2 Fauna Habitat

The vegetation has the potential to provide habitat for native species due to the presence of large eucalypts and a dense shrub layer in sections of the study area. The habitat value of much of the study area is reduced due to its location beside a road.

7.9 Gas Gathering: MP03 to MP04

The gas gathering line options between MP03 and MP04 form a triangle which crosses the Hume Highway in two places (see **Figure 4**). One option runs along the railway line between MP03 and MP04 while the other option runs south along the Hume Highway from MP03 before crossing the Hume Highway to MP04. The area is highly disturbed as it has been cleared and accommodates a major road (the Hume Highway), a truck stopping bay and a railway line. The study area contains vegetation patches which are dominated by African Olive with some scattered native species. This vegetation structure is likely to provide habitat for more mobile species such as birds.

7.10 Gas Gathering: MP05 to MP04

The gas gathering and water pipelines are proposed to be located along the southern side of the railway line, as shown in **Figure 4**. The study area passes through paddocks which are currently being used for horse agistment. The land is flat to gently undulating and contains scattered vegetation stands.

7.10.1 Flora

The land within the 50 metre study area corridor has been cleared, however, there are vegetation stands remaining which contain remnant native species. The remnant species include Cabbage Gum, Grey Box and Narrow-leaved Ironbark. Stands of regrowth have occurred in the vicinity of the remnant trees. The shrub layer is degraded, comprising weed species such as Blackberry and African Olive. The ground layer is also degraded and comprises pasture grasses.

7.10.2 Fauna Habitat

The study area contains key habitat features such as hollow bearing trees, scattered logs and patches of leaf litter. These features are generally concentrated around the remnant Eucalypts. The habitat value is reduced due to the lack of connectivity with other areas of significant remnant vegetation, however, the key habitat features may provide habitat for lizards, birds, bats and arboreal mammals. Some of the threatened species listed in **Table 2** have the potential to use these habitat features, for example, the Yellow-bellied Sheathtail Bat and the Eastern Freetail Bat use tree hollows for roosting.

7.11 MP05 Well Surface Location Study Area

The study area of MP05 is very much reduced as it is located within a triangle bounded by three railway lines (see **Figure 4**). The study area is highly degraded as it has been cleared, levelled and filled. There is very little vegetation and that which exists comprises weed species such as African Olive. The habitat value of the study area is extremely limited.

7.12 MP06 Well Surface Location Study Area

The MP06 study area is located on a gentle westerly slope, which becomes flatter in the vicinity of the proposed well location. An existing gravel road dissects the study area and this road will be used as the access road for the well. A small dam is located in the north eastern section of the study area from which a drainage line runs to the south west.

7.12.1 Flora

The vegetation of the MP06 study area is restricted to the vicinity of the water bodies described above. There is also a stand of eucalypts in the western section of the study area. The area has very little structural diversity, with the majority of the vegetation comprising remnant and regrowth canopy trees and a degraded groundcover. The vegetation in the vicinity of the water bodies comprises eucalypts and *Casuarina glauca* (Swamp Oak), while the vegetation stand in the western section of the study area mainly comprises Cabbage Gum. Such lack of species diversity is likely a result of the area having been cleared, with the exception of some remnant Cabbage Gum from which the regrowth has occurred. The few shrubs in the study area are African Olive.

7.12.2 Fauna Habitat

The remnant trees and the water bodies in the study area provide potential habitat for a variety of species, with key habitat features including hollow bearing trees, scattered logs and branches and patches of leaf litter providing potential habitat for birds, reptiles and small mammals. The vegetation surrounding and within the small dam and the drainage line provides foraging and sheltering opportunities. The dam itself provides habitat for common frogs, reptiles and aquatic birds.

The quality of the habitat in the study area is somewhat reduced due to its isolation, making it difficult for viable populations to establish.

7.13 Access Road and Gas Gathering: MP06 to MP05

The access road and gas gathering lines are proposed to be located along an established gravel and dirt road. The area within the 50 metres wide study area corridor adjacent to the existing road has been cleared and comprises a groundcover with some scattered African Olive. The groundcover and the African Olive may provide foraging opportunities and shelter for small birds.

7.14 Access Road: MP06 to MP11

The access road from MP06 to MP11 is proposed along an existing gravel road. The area within the study corridor has been cleared, comprising groundcover and some scattered African Olive.

7.15 MP11 Well Surface Location Study Area

The MP11 study area is dissected by the railway line and as such, the study area has been reduced from the standard 200 metre radius circle (see **Figure 4**). It is located on flat land with a drainage line running from the north to the south east of the well surface location.

7.15.1 Flora

The majority of the study area has been cleared, leaving a groundcover of pasture grasses. Some of the weed species in the cleared area include Paterson's Curse, Fireweed and Scotch Thistle. A stand of vegetation is located in the south west of the study area, lining the drainage corridor. It is the western limit of a vegetation corridor lining the drainage area which continues towards the south east and runs through the MP19, MP21, MP22 and MP23 study areas. The canopy layer covers approximately 5% of the study area and comprises Swamp Oak and Willow growing to an average height of around 8 metres. The shrub layer is sparse and is entirely comprised of weeds species such as Blackberry and African Boxthorn. *Asparagus asparagoides* (Bridal Creeper) is also present in the vegetated area. The presence of horses and rabbits in the study area have resulted in a highly degraded groundlayer.

7.15.2 Fauna Habitat

The study area has very limited habitat value due to the lack of features such as hollow bearing trees, fallen logs and native vegetation. The canopy species present in the study area, such as Swamp Oak, generally do not form hollows. Species likely to use the study area for foraging or sheltering purposes are restricted to birds which feed and shelter in the Blackberry and the Swamp Oak. This may include the threatened Glossy Black-cockatoo, which may occasionally feed on the Swamp Oak.

7.16 Gas Gathering and access: Racecourse Avenue to MP11

The gas gathering and water pipelines are proposed to be located along an existing dirt road which is proposed as an access road, adjacent to the railway line. The study area has been cleared and comprises a degraded groundcover of mainly weed species. There is vegetation within 50 metres of the proposed gas gathering and water pipeline, however, it is situated within the railway easement and as such, is outside the study area.

7.17 MP19 Well Surface Location Study Area

The study area is flat with a drainage line running through the southern section of the well surface location, which contained water at the time of the site investigation. There is also a small dam close to the centre of the study area.

7.17.1 Flora

The vegetation in the study area is restricted to the drainage line, with the remainder being cleared paddocks with one isolated paddock tree. The canopy layer exclusively comprises Swamp Oak growing to an average height of some 9 metres and covering approximately 25% of the study area. The shrub layer comprises weed species such as African Olive, Blackberry and African Boxthorn. While the vegetation along the drainage line is in good condition, the lack of structural and species diversity indicates that overall, it is degraded.

7.17.2 Fauna Habitat

The presence of the small dam containing reeds and the dense tree cover close to the edge of the water provides habitat, mainly for birds, reptiles and frogs. The dam does not constitute the preferred habitat for the threatened species listed in **Table 2**. The Swamp Oak lining the drainage line would provide foraging and shelter opportunities for some bird species. The Glossy Black-cockatoo is a threatened species (see **Table 2**) that may occasionally feed on Swamp Oak.

7.18 Access Road: Glenlee Road to MP19

The access road from Glenlee Road to MP19 is one option for accessing MP19. The proposed access road is located on a slope with a southerly aspect, as shown in **Figure 4**. The area is highly degraded as it has been cleared and horses are kept in the paddock. Additionally, there is a strong rabbit presence. The area within the 50 metres wide study area corridor has been cleared and comprises only a degraded groundcover with some scattered African Olive and Boxthorn. The groundcover and the shrub species may provide limited foraging opportunities and shelter for small birds.

7.19 Access Road and Gas Gathering: MP11 to MP19

The access road and gas gathering line are proposed to follow an existing dirt road which is located in a gently undulating area. The area within the 50 metres wide study area corridor has been cleared and comprises only a degraded groundcover of exotic species.

7.20 MP22 Well Surface Location Study Area

The Hume Highway runs through the MP22 study area, reducing it from the standard area based on a 200 metre radius around the well surface location, as shown in **Figure 4**. The drainage line that runs through the MP19 study area also runs through the MP22 study area. A small dam is located in the study area.

7.20.1 Flora

The MP22 study area contains vegetation in the vicinity of the drainage line. Other sections of the study area contain vegetation stands and there are also isolated paddock trees. The vegetation which is in the vicinity of the drainage line contains structural and species diversity, with remnant and regrowth canopy species present, along with a shrub layer and a continuous groundcover. The canopy species covers approximately 50% of the study area and species include Grey Box and Swamp Oak, growing to an average height of around 25 metres. The other vegetation stands mainly comprise regrowth and the isolated paddock trees include Grey Box and Cabbage Gum. The shrub layer mainly comprises weed species including Blackberry, African Olive and African Boxthorn.

The species assemblage indicates the vegetation is CPW. The canopy layer is in good condition, however, the shrub and groundlayers are degraded. This is largely due to the small size of the vegetation patches and the presence of horses and rabbits in the study area. The vegetation community towards the eastern section of the study area, along the drainage line, is likely to have once comprised RFEF, however, it is now highly degraded with very limited species and structural diversity.

7.20.2 Fauna Habitat

Habitat features are restricted to vegetation stands which occur as scattered patches throughout the study area and along the drainage line. The canopy species provide habitat for birds, arboreal mammals and bats. The fallen logs and patches of leaf litter provide habitat for reptiles and potentially for *Meridolum corneovirens* (Cumberland Plain Land Snail). The small dam in the study area may provide habitat value for frogs, reptiles and aquatic birds, however, its habitat potential is reduced as vegetation does not occur within or surrounding it. The canopy layer provides foraging and sheltering opportunities and, particularly in and around the large remnant eucalypts, there are fallen logs, branches and scattered patches of leaf litter.

7.21 MP23 Well Surface Location Study Area

The MP23 study area is dissected by the Hume Highway and as such, its area is reduced (see **Figure 4**). It is located on flat land and includes the easternmost end of the vegetation corridor described in **Section 6.10**.

7.21.1 Flora

The MP23 study area comprises both cleared areas, with a native and exotic groundcover and stands of native vegetation. The native vegetation stands comprise Grey Box and Cabbage Gum and cover approximately 40% of the study area. The canopy comprises some remnant trees with the remainder being regrowth. The average height of the trees is some 20 metres. The shrub layer contains some Acacia species, however, it is mainly comprised of weeds, particularly Blackberry.

The species assemblage indicates the vegetation is CPW, however, it is highly degraded, particularly in the shrub and ground layers. This is largely due to the small size of the vegetation patches and the presence of horses and rabbits in the study area.

7.21.2 Fauna Habitat

The habitat value of the study area is fairly limited as there are few remnant trees in which features such as hollows have developed. The native vegetation does provide foraging and shelter opportunities for birds, bats and arboreal mammals. The weed species, such as Blackberry, also provide food and shelter for bird species.

7.22 MP21 Well Surface Location Study Area

Much of the MP21 study area overlaps with that of MP22. The study area is located in a gently undulating area. The drainage line described in the above sections also runs through this study area. The ground is littered with rabbit burrows.

7.22.1 Flora

The majority of the study area has been cleared, containing only a grassy cover and scattered weeds such as Blackberry, African Olive and African Boxthorn. The vegetation in the vicinity of the drainage line contains structural and species diversity, with remnant and regrowth native canopy species present, along with a shrub layer and a continuous groundcover. The canopy species cover approximately 50% of the study area and species include Grey Box and Swamp Oak, growing to an average height of about 25 metres.

The species assemblage indicates the vegetation is CPW. The canopy layer is in good condition, however, the shrub and groundlayer are degraded. This is largely due to the small size of the vegetation patches and the presence of horses and rabbits in the study area. The vegetation community towards the eastern section of the study area, along the drainage line, is likely to have once comprised RFEF, however, it is now highly degraded with very limited species and structural diversity.

7.22.2 Fauna Habitat

The canopy layer provides foraging and shelter opportunities and, particularly in and around the large remnant eucalypts, there are tree hollows, fallen logs, branches and scattered patches of leaf litter. These features provide foraging and shelter opportunities for common birds, bats and arboreal mammals. Features such as tree hollows are the preferred habitat of threatened species such as the Yellow-bellied Sheathtail-bat and the Eastern Freetail-bat.

7.23 Gas Gathering and Access Road: MP19, MP21, MP22 and MP23

This gas gathering lines will go through cleared areas and areas containing vegetation. The proposed route is located on flat land.

7.23.1 Flora

Sections of the vegetation within 50 metres of the proposed access road contain structural and species diversity, with remnant and regrowth canopy species present, along with a shrub layer and a continuous groundcover. Other sections contain a canopy of remnant trees scattered amongst regrowth and a weedy shrub layer. Species include Grey Box, Cabbage Gum, Swamp Oak, Blackberry, African Olive and African Boxthorn.

The species assemblage in some sections of the proposed access road indicate the vegetation is CPW. The canopy layer is in good condition, however, the shrub and groundlayers are degraded. This is largely due to the small size of the vegetation patches and the presence of horses and rabbits in the study area. There are also stands of RFEF, however, it is now highly degraded with very limited species and structural diversity.

7.23.2 Fauna Habitat

The canopy species provide habitat for birds, arboreal mammals and bats. The fallen logs and patches of leaf litter provide habitat for reptiles and potentially for *Meridolum corneovirens* (Cumberland Plain Land Snail).

The habitat value of the study area is reduced due to its lack of connectivity with significant patches of remnant vegetation, making it unlikely to support viable populations of native species.

7.24 MP24 Well Surface Location Study Area

The MP24 study area was significantly reduced due to the presence of the railway line to the east, a quarry to the west and Menangle Road to the south (see **Figure 4**). The study area is located on flat land.

7.24.1 Flora

The study area has been completely cleared of vegetation with only a degraded groundcover remaining. This has resulted from clearing and the presence of horses in the paddock.

7.24.2 Fauna Habitat

The habitat value of the well surface location is extremely limited. Grassland birds may visit the area to forage in the grass, although this is quite degraded and unlikely to provide much food.

7.25 Access Road: MP19 to MP22

The proposed access road is shown in **Figure 4**, which illustrates that sections of it will be located in the vicinity of the drainage line that runs through this area, going through both cleared land and stands of vegetation.

7.25.1 Flora

The majority of the study corridor is located in cleared paddocks. The vegetation along the drainage line comprises stands of RFEF, however, it is now highly degraded with very limited species and structural diversity.

7.25.2 Fauna Habitat

The Swamp Oak lining the drainage line would provide foraging and shelter opportunities for some bird species. The Glossy Black-cockatoo is a threatened species (see **Table 2**) that may occasionally feed on Swamp Oak.

7.26 Access Road: Cummins Road to MP21 and MP23

The proposed access road runs east from Cummins Road towards MP21 and MP23. The road passes through gently undulating, cleared paddocks with some isolated mature eucalypts and stands of vegetation remaining.

7.26.1 Flora

The majority of the study area comprises cleared paddocks with only a grassy groundcover remaining. There are isolated mature eucalypts and stands of vegetation which cover less than ten percent of the study area. The vegetation stands have a healthy canopy layer, however, they are lacking in structural diversity due to the degraded nature of the shrub and groundlayers. The degraded condition of the understorey is likely due to the presence of stock in the past, the presence of rabbits and the isolated nature of the vegetation stands.

The species assemblage indicates the vegetation is CPW, however, it is degraded, particularly in the shrub and ground layers. **Figure 6** shows the distribution of the vegetation communities in the study area.

7.26.2 Fauna Habitat

The isolated mature eucalypts and the canopy trees within the vegetation stands provide foraging and shelter opportunities, particularly in and around the large remnant eucalypts which are likely to contain key habitat features such as tree hollows, fallen logs and leaf litter. These features provide foraging and shelter opportunities for common birds, bats and arboreal mammals. Features such as tree hollows are the preferred habitat of threatened species such as the Yellow-bellied Sheathtail-bat and the Eastern Freetail-bat.

7.27 Access Road: Menangle Road to MP24

Parts of the proposed access road from Menangle Road to MP24 are proposed to be located along an existing dirt road. The majority of the proposed route will be in a paddock to the north of Menangle Road that is completely cleared of vegetation, with only pasture grasses remaining.

7.28 Gas Gathering: MP24 to Menangle Road

A section of the proposed gas gathering and water pipeline follows the same route as the access road from Menangle Road to MP24, described above in **Section 7.24** and shown in **Figure 4**. The remainder of the gas gathering and water pipeline is proposed to extend across Menangle Road and towards the northeast where it will meet existing pipelines. This section runs alongside Menangle Road through cleared road verge and cleared paddocks with very limited ecological value. Within the 50 m study area, there is a revegetated area.

7.29 MP33 Well Surface Location Study Area

The MP33 study area has been reduced by the presence of the Hume Highway to the east and a property boundary to the south, over which the well will not be located. The study area is on undulating land with a drainage line running from east to west through its centre.

7.29.1 Flora

The majority of the study area has been cleared and has been used for horse agistment. There are small patches of vegetation in the study area, however, these comprise weed species such as *Ligustrum lucidum* (Broad-leaf Privet), *Ligustrum sinense* (Narrow-leaf Privet) and Blackberry. These vegetation stands are dominated by Broad-leaf Privet.

7.29.2 Fauna Habitat

There is very little fauna habitat in this study area. The stands of Broad-leaf Privet are used by birds for foraging and shelter; however, they would not support any viable populations within themselves.

7.30 Access Road: Menangle Road to MP33

The paddock through which the access road and gathering pipeline from Menangle Road to MP33 is proposed has been cleared. There are some isolated paddock trees and stands of Broad-leaf Privet, as well as a drainage line which the access road and gathering pipeline will cross.

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8 POTENTIAL IMPACTS

8.1 Introduction

In determining the potential ecological impacts associated with the well surface locations, gas gathering and water pipelines and access roads, the following factors have been assessed:

- The potential impact on species that are listed under the provisions of the TSC Act and EPBC Act;
- The potential impact on populations that are listed under the provisions of the TSC Act;
- The potential impact on endangered ecological communities (EEC) that are listed under the provisions of the TSC Act and EPBC Act; and
- Key threatening processes.

Potential impacts can include direct disturbance or removal of native flora, fauna and ecological communities. It can also include more indirect impacts in which habitats are disturbed or modified, affecting the ability of flora and fauna to maintain viable populations. Disturbances to habitat include clearing of native vegetation, particularly hollow bearing trees, removal of logs and leaf litter and allowing contaminated runoff to enter water bodies.

8.2 Well Surface Location – Construction and Operation

Potential impacts in the well study areas are likely to be minimal as the wells have been sited in areas that are already cleared and degraded. Furthermore, AGL has indicated that even within the construction footprint, mature trees would not be felled and the majority of the ground cover will remain. Thus, impacts to native flora and fauna and will be minimal and key habitat features will remain undisturbed. Due to other constraints, such as archaeological or geological constraints, the well surface locations may be shifted within the 200 metre radius circle. The final well surface locations will take account of identified ecologically sensitive areas, such as those containing CPW, and would be located to avoid these areas. Where native vegetation communities are present within the study area, the final surface well locations will be sited to avoid these. The presence of so much cleared and degraded land in the study areas means ecologically sensitive areas are easily avoided.

Some of the major factors that impact upon native flora and fauna are already occurring in the project areas. This includes processes such as land clearing, which has occurred extensively throughout the project areas and establishment of weeds and introduced fauna. The isolated and fragmented nature of the remaining vegetation makes it prone to further degradation resulting from edge effects, encroachment of weed and pest species and increased nutrient levels from urban runoff. The works associated with well installation are unlikely to add to these impacts as clearing of native vegetation is not likely to be required.

8.3 Access Roads and Gas Gathering Lines

The potential impacts associated with construction and operation of the access roads and gas gathering and water pipelines are very similar to those associated with well installation. As the access roads and gas gathering lines are proposed to be located along existing roads or cleared areas, there is likely to be minimal clearing required. Potential impacts from construction of access roads are associated with the removal or disturbance of some trees. The removal and disturbance of trees should be avoided where possible but even removal of some trees would not represent a significant impact to the ecological communities present in the project areas.

There are some examples where the roads and gas gathering are proposed to cross drainage lines or swampy areas, which may lead to degradation of the drainage line and the habitat surrounding it.

8.4 Impacts to Threatened Species, Populations and Endangered Ecological Communities

The threatened species tables (**Tables 1 – 4**) identify the species for which habitat occurs in the Spring Farm and Menangle Park Project areas. While potential habitat occurs in the study area for a variety of species, it is unlikely that viable populations of native species are supported as the vegetation is fragmented and lacks connectivity to areas of significant remnant vegetation. Furthermore, as the proposed works would occur in areas that are already disturbed, further disturbance to areas containing potential habitat for threatened species, such as areas containing native vegetation stands, would be avoided.

Three EECs have been identified as occurring in the Project areas; EBS, CPW and RFEF. The proposed works have been situated to avoid areas of vegetation and as such, areas containing EBS, CPW and RFEF will be avoided. Mature trees and other vegetation occurring within the construction footprint would not require clearing and as such, impacts to EECs are likely to be avoided.

There are no threatened populations, as listed in Schedule 1 of the TSC Act, which occur in either of the Project areas.

8.5 Key Threatening Processes

The proposed works do not constitute a Key Threatening Processes (KTP) and are unlikely to increase the impact of an existing KTP. Existing KTPs at the Spring Farm and Menangle Park Project areas are:

- Clearing of native vegetation; and
- Competition and grazing by the feral European rabbit.

The occurrence of these KTPs has resulted in the degraded nature of the vegetation and landscape in the project areas. The proposed works would be undertaken in areas that are already disturbed and further clearing is unlikely to be required. The works are also unlikely to increase the impact of the feral European rabbit, which is already well established in the area.

8.6 SEPP 44 – Koala Habitat Protection

Eucalyptus tereticornis (Forest Red Gum) occurs throughout the study areas and is listed in Schedule 2 of the SEPP. The majority of the study areas are already cleared and the Forest Red Gum occurs only as isolated individuals. As such, the area does not constitute potential or core koala habitat.

8.7 Summary of Potential Impacts at Each Study Area

8.7.1 Spring Farm Project Area

Table 5: Summary of Potential Impacts - Spring Farm Project Area

Site ID	Potential Impacts	Impacts Avoidable
SF04/SF04A	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
Access Road and Gas Gathering and Water Pipeline: SF04/SF04A to GL06	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities can be avoided.
SF10	Clearing of native vegetation. Habitat modification.	The prevalence of the common native shrub *Bursaria spinosa* means it will be hard to avoid clearing some individuals. The species is not protected by threatened species legislation and is widespread in the project areas.
SF17	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
SF20	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
Access Road: Jacks Gully Waste Management Facility road to SF17 and SF20	Remnant trees located immediately adjacent to existing road and traffic may cause disturbance.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
Access Road and Gas Gathering and Water Pipeline: SF17 to SF20 and SF10	Remnant trees located immediately adjacent to existing road and traffic may cause disturbance.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
Gas Gathering and Water Pipeline: SF17 to Jacks Gully Waste Management Facility	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A

The works are proposed to be undertaken in areas that have been substantially modified from their original condition and the ecological values have been greatly reduced. The proposed works involve minimal modification of the existing environment and thus, would not result in a significant impact to the remaining ecological values in the study areas.

8.7.2 Menangle Park Project Area

Table 6: Summary of Potential Impacts - Menangle Park Project Area

Site ID	Potential Impacts	Impacts Avoidable
MP02	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
Access Rd to MP02 and MP03	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
MP03	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
MP04	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
Access Road: MP04 to Glenlee Rd	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
Gas Gathering and Water Pipelines: Menangle Road	Clearing of native vegetation. Habitat modification.	Yes – fragmented and degraded nature of vegetation, particularly the understorey, means sensitive areas and mature native vegetation can be avoided.
Gas Gathering and Water Pipelines: Glenlee Road	Clearing of native vegetation. Habitat modification.	In sections where the road verge is narrow it is likely that individual native trees will be removed unless gathering is placed under the bitumen.
Gas Gathering and Water Pipelines: MP03 to MP04	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
Gas Gathering and Water Pipelines: MP05 to MP04	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
MP05	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A

Site ID	Potential Impacts	Impacts Avoidable
MP06	Clearing of native vegetation. Habitat modification. Contaminated runoff affecting water bodies.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided. Standard erosion and runoff control measures would prevent impacts to water bodies.
Access Rd and Gas Gathering and Water Pipelines: MP06 to MP05	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
Access Rd: MP06 to MP11	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
MP11	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
Gas gathering and water pipeline and access road: Racecourse Ave to MP11	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
MP19	Clearing of native vegetation Contaminated runoff affecting water bodies.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided. Standard erosion and runoff control measures would prevent impacts to water bodies.
Access Road: Glenlee Road to MP19	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
Access Road and Gas Gathering: MP11 to MP19	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
MP22	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and areas containing the preferred habitat of threatened species such as the Cumberland Plain Land Snail can be avoided.

Site ID	Potential Impacts	Impacts Avoidable
MP23	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
MP21	Clearing of native vegetation Contaminated runoff affecting water bodies.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided. Standard erosion and runoff control measures would prevent impacts to water bodies.
Gas Gathering and Water Pipelines and access road: MP19 to MP21, MP22 and MP23	Clearing of native vegetation. Habitat modification.	Yes – fragmented and degraded nature of vegetation, particularly the understorey, means sensitive areas can be avoided and areas containing the preferred habitat of threatened species such as the Cumberland Plain Land Snail can also be avoided.
MP24	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
Access Rd: Cummins Rd to MP21 and MP23	Clearing of native vegetation. Habitat modification.	Yes – presence of extensive cleared areas within the study area means native vegetation communities and key habitat areas or features can be avoided.
Access Rd: Menangle Rd to MP24	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
Gas Gathering and Water Pipelines: MP24 to underbore	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
MP33	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A
Access Rd: Menangle Rd to MP33	The ecological value of the study area is already greatly reduced. Further impacts are unlikely.	N/A

The works are proposed to be undertaken in areas that have been substantially modified from their original condition and the ecological values have been greatly reduced. The presence of extensive cleared areas within each study area means that the final surface well locations can be placed to avoid sensitive ecological values. The proposed works involve minimal modification of the existing environment and thus, would not result in a significant impact to the remaining ecological values in the study areas.

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9 MITIGATION MEASURES

9.1 Introduction

It is anticipated that the impacts associated with the proposed works will be minimal. In order to manage the works to prevent further degradation to the remaining native vegetation and habitats within the Spring Farm and Menangle Park Project areas, the following mitigation measures are recommended:

- Keep the construction footprint to a minimum;
- Avoid spread of weeds by ensuring vehicles remain on designated roads;
- If an animal is inadvertently injured, call WIRES or a local wildlife care group;
- If well locations are changed within the 200 metre radius circular study area, place the new location in an area that is already cleared, avoiding areas containing native vegetation;
- Rehabilitate the construction footprint using endemic species; and
- Enhance local environmental values by rehabilitating in accordance with best practice guidelines such as *Recovering Bushland on the Cumberland Plain* (DEC, 2005) and applicable local management plans such as the *Gundungurra Reserve Plan of Management* (Environmental Partnership Pty Ltd, 2004).

9.2 Further Mitigation Measures

The following additional mitigation measures are appropriate for implementation at certain study areas:

- Avoid clearing of native vegetation, particularly remnant trees, EBS and CPW;
- Install erosion and sediment control measures around all construction work and (where appropriate) adjacent to roads to prevent contaminated runoff entering water bodies and affecting their health; and
- Clearly identify or fence off significant habitat trees and endangered ecological communities (EECs).

Table 7: Study Areas for Which Additional Mitigation Measures Apply

Further Mitigation Measure	Applicable Study Areas
Avoid clearing of native vegetation, particularly remnant trees, EBS and CPW.	SF04/SF04A, SF10, SF20, MP02, MP03, MP04, MP06, MP19, MP22, MP23, MP21
	Access Road and Gas Gathering and Water Pipeline: SF04/SF04A to GL06
	Access Road: Jacks Gully Waste Management Facility road to SF17 and SF20
	Access Road: MP04 to Glenlee Road
	Gas Gathering and Water Pipeline: Menangle Road
	Gas Gathering and Water Pipelines: Glenlee Road

Further Mitigation Measure	Applicable Study Areas
	Gas Gathering and Water Pipelines: MP05 to MP04
	Access Road: MP19 to MP22
	Gas Gathering and Water Pipelines: MP19, MP22, MP23, MP21
	Access Road: Cummins Rd to MP21 and MP23
Install erosion and sediment control measures around all construction work and (where appropriate) adjacent to roads to prevent contaminated runoff entering water bodies and affecting their health	Around all construction work
Clearly identify or fence off significant habitat trees and EECs.	SF10, SF20, MP02, MP03, MP04, MP06, MP19, MP22, MP23, MP21
	Access Road: Jacks Gully Waste Management Facility road to SF17 and SF20
	Access Road: MP04 to Glenlee Road
	Gas Gathering and Water Pipeline: Menangle Road
	Gas Gathering and Water Pipelines: Glenlee Road
	Gas Gathering and Water Pipelines: MP05 to MP04
	Access Road: Cummins Rd to MP21 and MP23
	Gas Gathering and Water Pipelines: MP19, MP22, MP23, MP21

10 STAGE 2 CONCEPT PLAN

Gas wells proposed as part of the Concept Plan, which can be allocated into three groups as follows:

- New well fields in areas identified as Spring Farm, Menangle Park, Mount Gilead and Kay Park Stage II (see **Figure 2**).
- Co-locating new wells within the pad of existing wells in existing well fields within Stage 2 to access additional resource from currently disturbed areas through the installation of a new well head and bore; and
- Infill wells with associated infrastructure (including gas gathering and water pipelines and access roads) to be located within existing well fields within Stage 2 where the gas reserve is not able to be accessed from existing well head locations.

Approval is also sought for the subsequent production and transportation of gas from new well surface locations to the RPGP.

Concept Plan approval is also sought for post development operational activities including upgrading of existing gas gathering lines, the installation of in-field compression and refracing of existing and new wells. These activities were not detailed as part of previous approvals within Stage 2, and are required to ensure the efficiency of gas production is maintained.

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Figures

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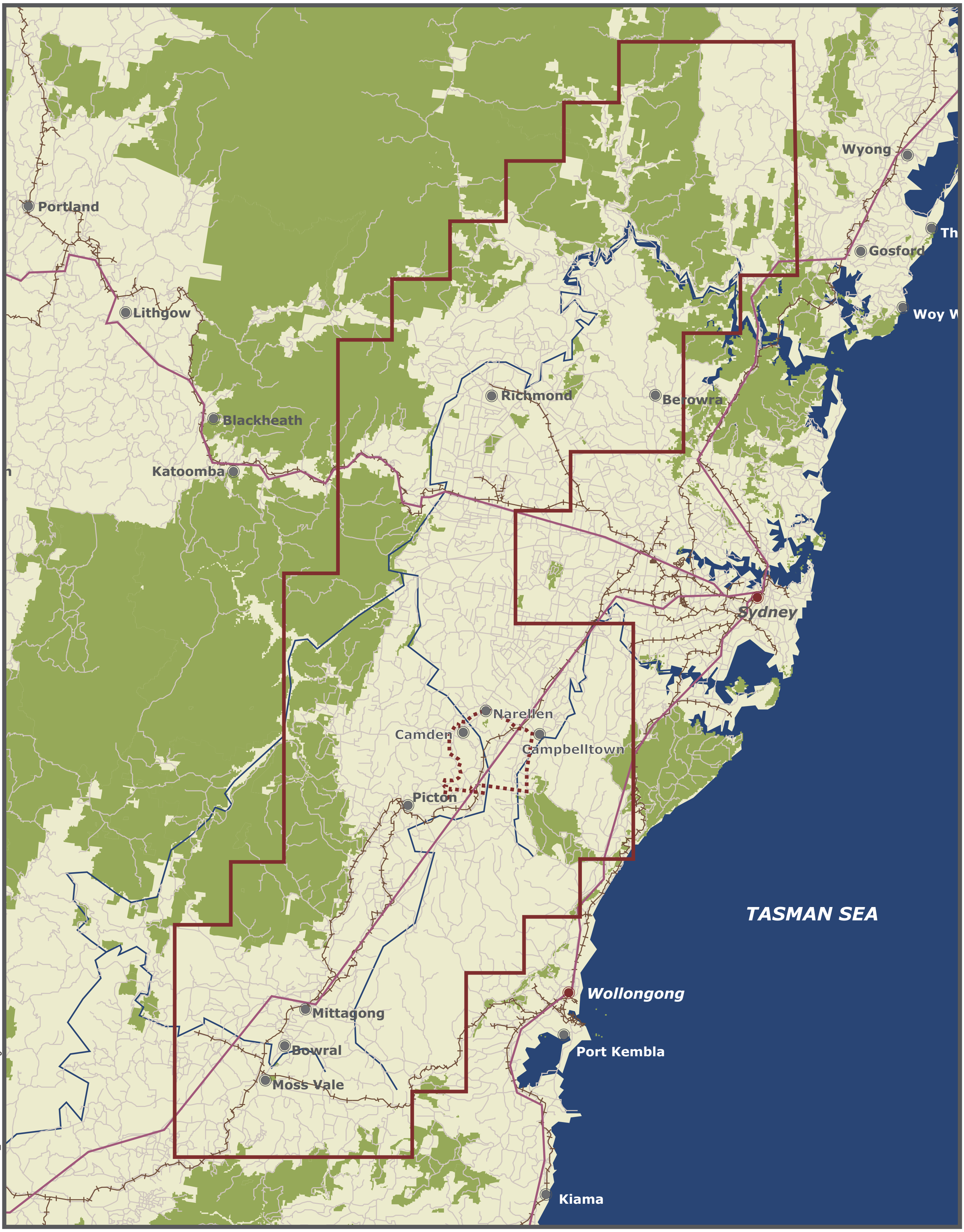

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Figure 1

Stage 2 Concept Area Within PEL 2

Ecology Assessment -

Expansion of Stage 2 of the Camden Gas Project

- PEL Boundary
- Stage 2 Concept Area boundary
- Highway
- Road
- Rail
- River
- National Parks Estate

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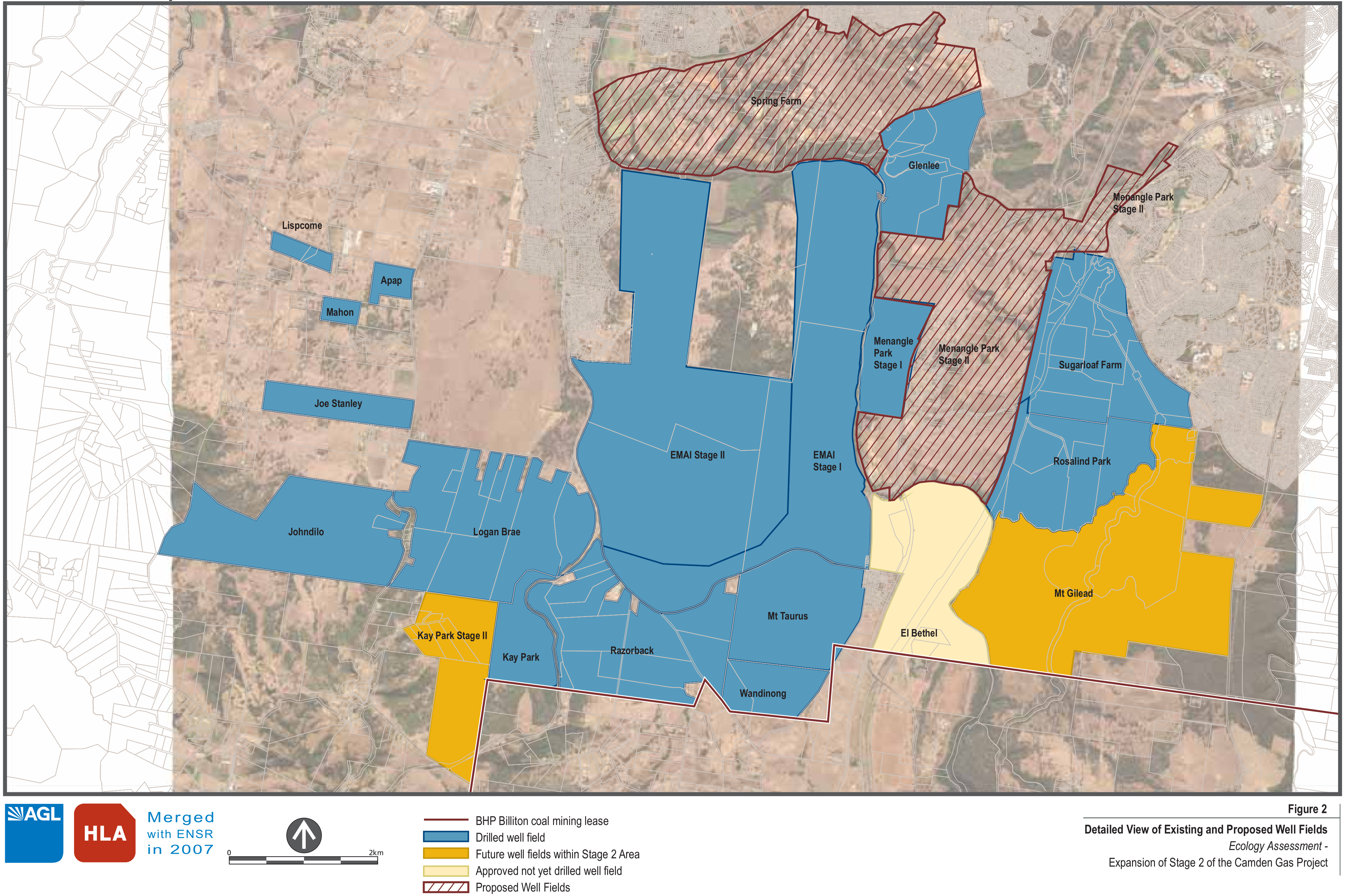

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Figure 2

Detailed View of Existing and Proposed Well Fields

Ecology Assessment -

Expansion of Stage 2 of the Camden Gas Project

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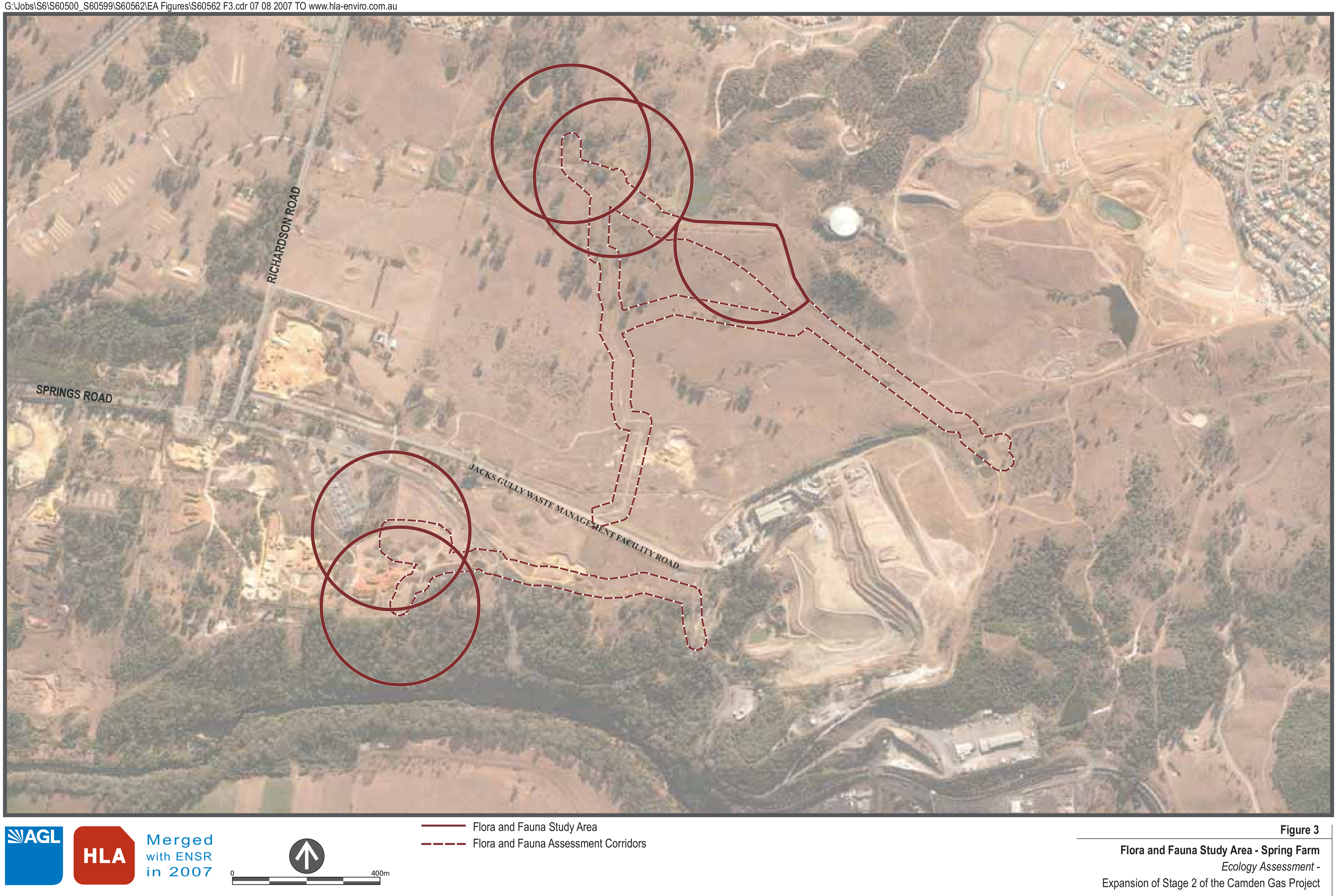

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Figure 3

Flora and Fauna Study Area - Spring Farm

Ecology Assessment -

Expansion of Stage 2 of the Camden Gas Project

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Flora and Fauna Assessment Study Area
Flora and Fauna Assessment Corridors

0 500m

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Figure 4

Flora and Fauna Study Area - Menangle Park (North)

Ecology Assessment -

Expansion of Stage 2 of the Camden Gas Project

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Merged with ENSR in 2007

0 400m

Flora and Fauna Assessment Study Area
Flora and Fauna Assessment Corridors

Figure 5

Flora and Fauna Study Area - Menangle Park (South)

Ecology Assessment -

Expansion of Stage 2 of the Camden Gas Project

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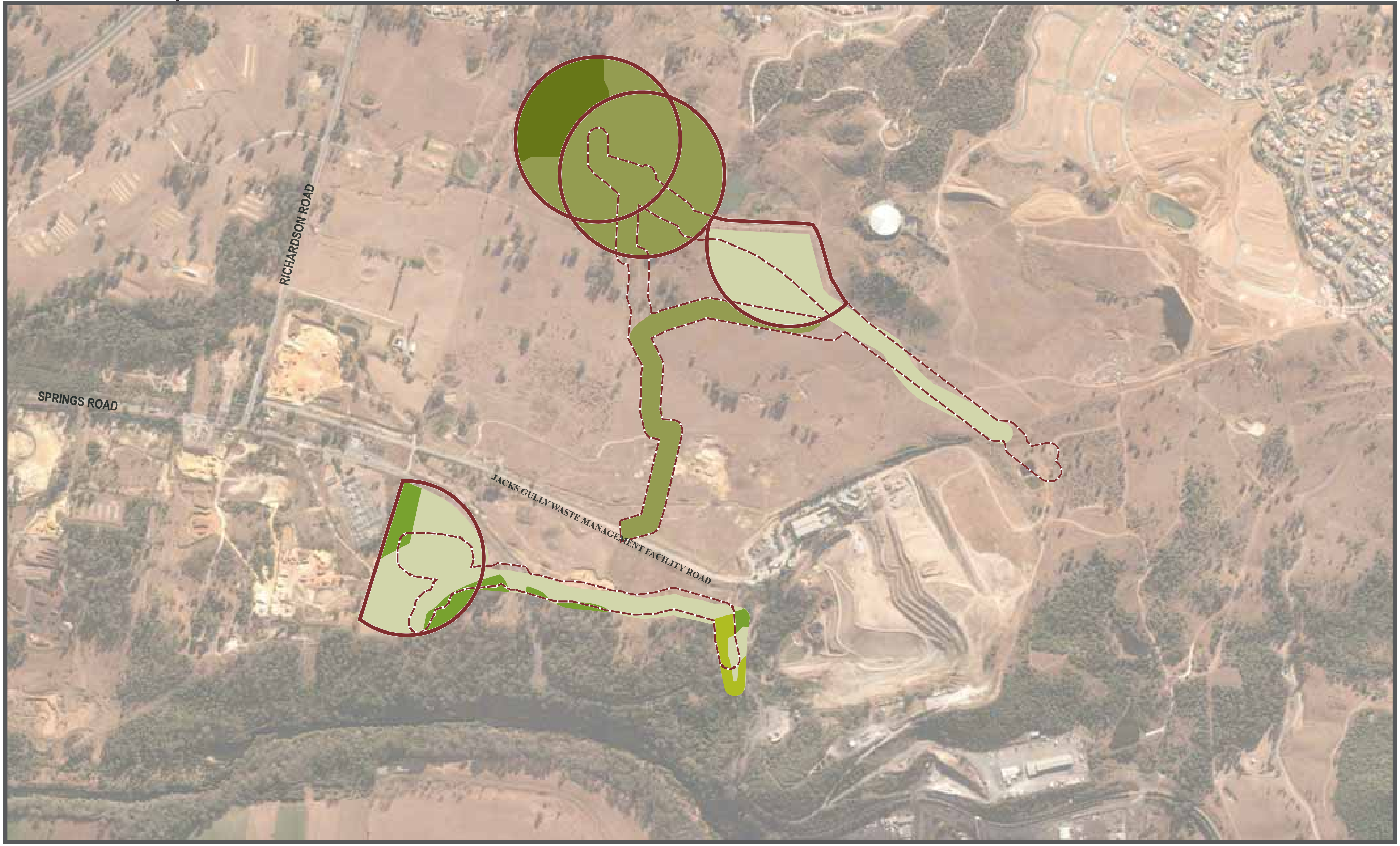

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0 400m

- Flora and Fauna Study Area
- Flora and Fauna Assessment Corridors
- Exotic Vegetation Assemblage - predominantly cleared
- Exotic Vegetation Assemblage - isolated remnant paddock trees/ native vegetation stands
- Cumberland Plain Woodland - degraded
- Elderslie Banksia Scrub
- River Flat Eucalypt Forest - degraded

Figure 6

Vegetation Communities - Spring Farm

Ecology Assessment -

Expansion of Stage 2 of the Camden Gas Project

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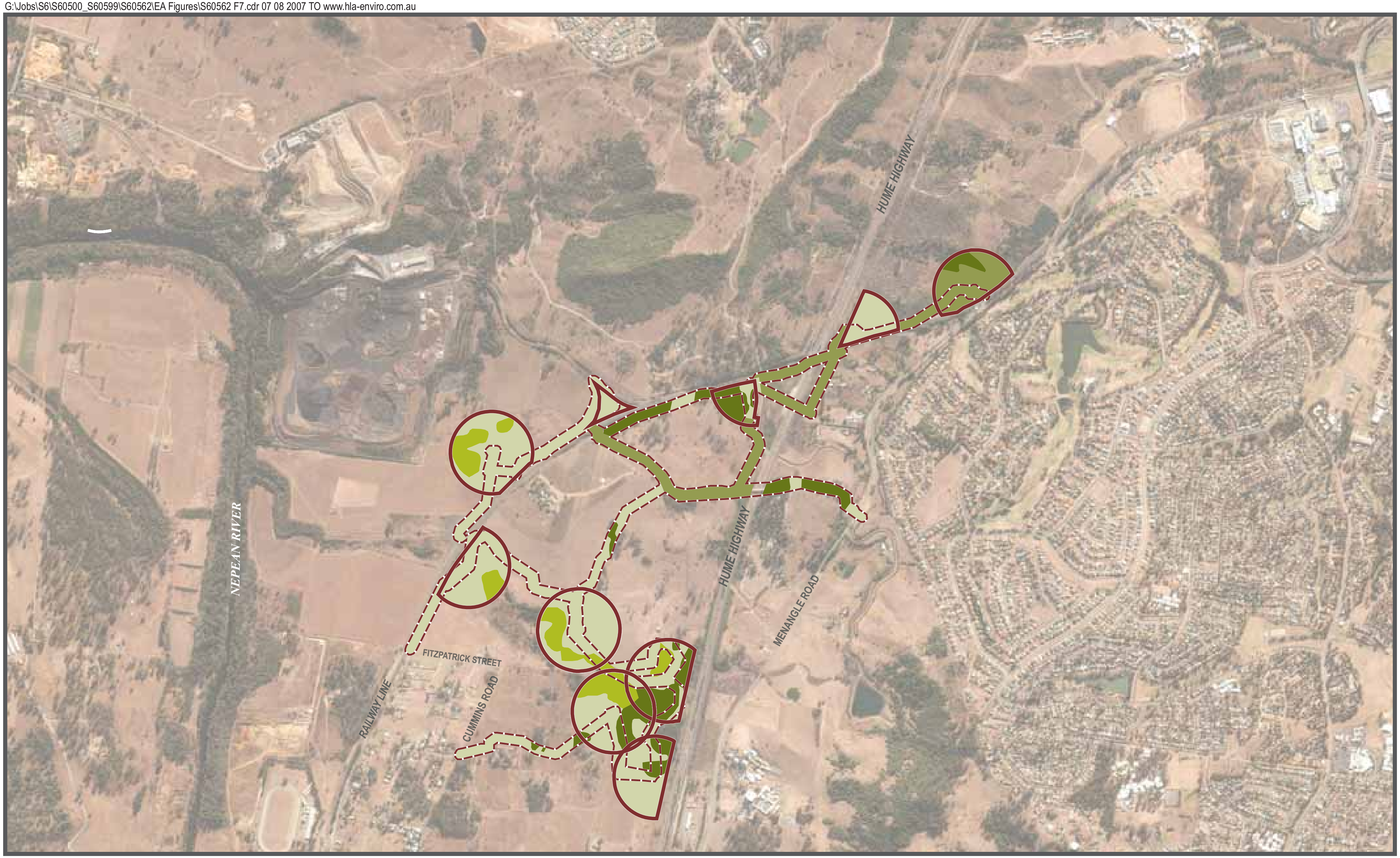

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Figure 7

Vegetation Communities - Menangle Park (North)

Ecology Assessment -

Expansion of Stage 2 of the Camden Gas Project

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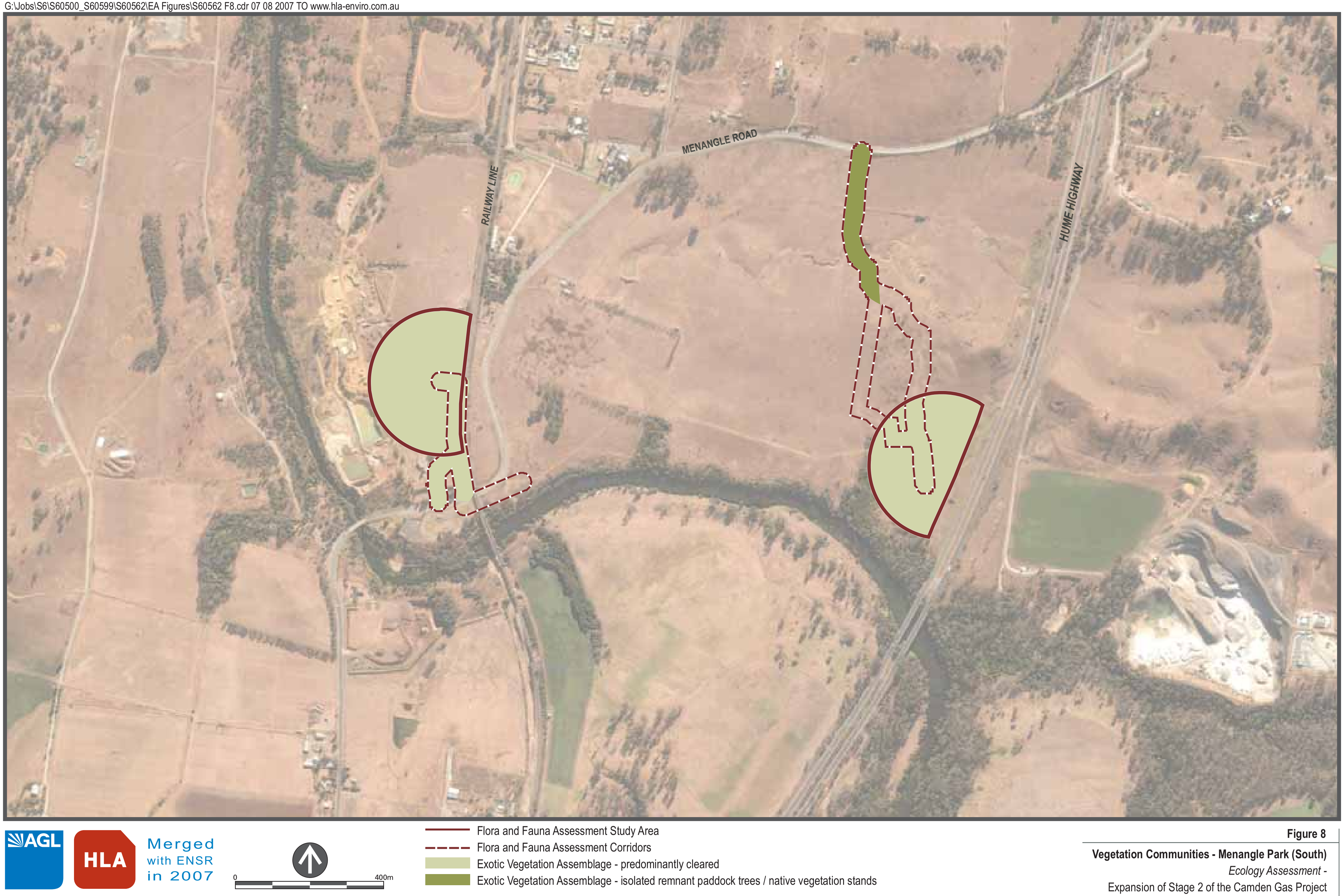

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Figure 8

Vegetation Communities - Menangle Park (South)

Ecology Assessment -

Expansion of Stage 2 of the Camden Gas Project

Appendix A: Threatened Species Table: Spring Farm

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Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
FAUNA					
Gastropods					
Cumberland Plain Land Snail	*Meridolum corneovirens*	TSC Act:E1	Cumberland Plain Woodland, grassy open woodland. Under litter of bark, leaves and logs, soil around grass clumps.	✓	Yes (within 20 km x 20 km grid)[1]
Ray-finned Fishes					
Macquarie Perch	*Macquaria australasica*	EPBC Act: E	Macquarie perch are found in both river and lake habitats, especially the upper reaches of rivers and their tributaries.	N	
Australian Grayling	*Prototroctes maraena*	EPBC Act: V	Clear, gravel-bottomed habitats but also muddy-bottomed, heavily silted habitats.	N	
Frogs					
Giant Burrowing Frog	*Heleioporus australiacus*	TSC Act: V EPBC Act: V	Heath, woodland and open forest with sandy soils.	N	Yes (within 20 km x 20 km grid)[1]
Green and Golden Bell Frog	*Litoria aurea*	EPBC Act: V	Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (Typha spp.) or spikerushes (Eleocharis spp.). Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow (Gambusia holbrooki), have a grassy area nearby and diurnal sheltering sites available.	N	
Reptiles					
Broad-headed Snake	*Hoplocephalus bungaroides*	TSC Act: E1	Shelters in windblown sandstone caves or beneath slabs resting on bare rock along cliff edges. Ascends into hollows of nearby eucalypts in summer.	N	Yes (within 20 km x 20 km grid)[1]
Rosenberg's Goanna	*Varanus rosenbergi*	TSC Act: V	Found in heath, open forest and woodland. Associated with termites, the mounds of which this species nests in; termite mounds are a critical habitat component.	N	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Birds					
Speckled Warbler	*Pyrrholaemus sagittatus*	TSC Act : V	Ground dwelling, eucalypt dominated communities with grassy understorey, often on rocky ridges or in gullies. Scattered native tussock grasses, sparse shrub layer, some eucalypt regrowth and open canopy. Requires large, relatively undisturbed remnants.	N	Yes (within 20 km x 20 km grid)[1]
Blue-billed Duck	*Oxyura australis*	TSC Act: V	Aquatic – deep water in large permanent wetlands and swamps with dense aquatic vegetation.	N	Yes (within 20 km x 20 km grid)[1]
Freckled Duck	*Stictonetta naevosa*	TSC Act: V	Permanent freshwater swamps and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. During drier times move to lakes, reservoirs, farm dams and sewage ponds.	N	Yes (within 20 km x 20 km grid)[1]
Bush Stone-curlew	*Burhinus grallarius*	TSC Act: E1	Inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber. Largely nocturnal, being especially active on moonlit nights.	✓	Yes (within 20 km x 20 km grid)[1]
Gang-gang Cockatoo	*Callocephalon fimbriatum*	TSC Act: V	Summer: tall mountain forests and woodlands, particularly heavily timbered and mature wet sclerophyll forests. Winter: drier more open eucalypt forests and woodlands, often found in urban areas.	N	Yes (within 20 km x 20 km grid)[1]
Glossy Black-cockatoo	*Calyptorhyncus lathami*	TSC Act: V	Forests and woodlands with abundant casuarina trees, any of about five species.	✓	Yes (within 20 km x 20 km grid)[1]
Brown Treecreeper	*Climacteris picumnus*	TSC Act: V	Eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges.	N	Yes (within 20 km x 20 km grid)[1]
Diamond Firetail	*Stagonopleura guttata*	TSC Act: V	Feeds on the ground. Grassy eucalypt woodland. Also open forest, mallee, Natural Temperate Grassland and secondary grassland derived from other communities. Often found in riparian areas, sometimes in lightly wooded farmland.	✓	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Regent Honeyeater	*Xanthomyza phrygia*	TSC Act: E1 EPBC Act: E	The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers of mature trees, high canopy cover and abundance of mistletoes.	N	Yes (within 20 km x 20 km grid)[1]
Hooded Robin	*Melanodryas cucullata*	TSC Act: V	Dry forests, woodlands, mallee, shrublands.	✓	Yes (within 20 km x 20 km grid)[1]
Swift Parrot	*Lathamus discolor*	TSC Act: E1 EPBC Act: E	Winter flowering eucalypts: Eucalyptus robusta, Corymbia maculata, C. gummifera, E. albens.	N	Yes (within 20 km x 20 km grid)[1]
Australian Painted Snipe	*Rostratula australis*	EPBC Act: V	Shallow inland wetlands, either freshwater or brackish, that are either permanently or temporarily filled.	N	
Barking Owl	*Ninox connivens*	TSC Act: V	Inhabits eucalypt woodland, open forest, swamp woodlands and, especially in inland areas, timber along watercourses. Denser vegetation is used occasionally for roosting. During the day they roost along creek lines, usually in tall understorey trees with dense foliage such as Acacia and Casuarina species, or the dense clumps of canopy leaves in large Eucalypts.	✓	Yes (within 20 km x 20 km grid)[1]
Powerful Owl	*Ninox strenua*	TSC Act: V	The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well.	✓	Yes (within 20 km x 20 km grid)[1]
Mammals					
Eastern Pygmy-possum	*Cercartetus nanus*	TSC Act: V	Found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest.	N	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	TSC Act: V	Forages in eucalypt forests, mallee and open country. Roosts in tree hollows and has been found in the abandoned nests of Sugar Gliders.	✓	Yes (within 20 km x 20 km grid)[1]
Eastern Freetail-bat	*Mormopterus norfolkensis*	TSC Act: V	Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roost mainly in tree hollows but will also roost under bark or in man-made structures.	✓	Yes (within 20 km x 20 km grid)[1]
Squirrel Glider	*Petaurus norfolcensis*	TSC Act: V	Inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas. Prefers mixed species stands with a shrub or Acacia midstorey.	N	Yes (within 20 km x 20 km grid)[1]
Spotted-tail Quoll	*Dasyurus maculatus maculatus (SE mainland population)*	EPBC Act: E	Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites.	N	
Brush-tailed Rock-wallaby	*Petrogale penicillata*	EPBC Act: V	Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north.	N	
Long-nosed Potoroo (SE mainland)	*Potorous tridactylus tridactylus*	EPBC Act: V	Inhabits coastal heaths and dry and wet sclerophyll forests. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature.	N	
Koala	*Phascolarctos cinereus*	TSC Act: V	Inhabit eucalypt woodlands and forests.	✓	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Grey-headed Flying-fox	*Pteropus poliocephalus*	TSC Act: V EPBC Act: V	Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy.	N	Yes (within 20 km x 20 km grid)[1]
Large-eared Pied-bat	*Chalinolobus dwyeri*	TSC Act: V EPBC Act: V	Roosts in caves, found in well-timbered areas containing gullies.	N	Yes (within 20 km x 20 km grid)[1]
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	TSC Act: V	Prefers moist habitats, with trees taller than 20 m. Generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings.	N	Yes (within 20 km x 20 km grid)[1]
Eastern Bent-wing Bat	*Miniopterus schreibersii oceanensis*	TSC Act: V	Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Hunt in forested areas, catching moths and other flying insects above the tree tops.	N	Yes (within 20 km x 20 km grid)[1]
Large-footed Myotis	*Myotis adversus*	TSC Act: V	Roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface.	N	Yes (within 20 km x 20 km grid)[1]
Greater Broad-nosed Bat	*Scoteanax rueppellii*	TSC Act: V	Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Although this species usually roosts in tree hollows, it has also been found in buildings. Forages after sunset, flying slowly and directly along creek and river corridors at an altitude of 3 - 6 m. Open woodland habitat and dry open forest suits the direct flight of this species.	N	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
FLORA					
Thick-lipped Spider-orchid	*Caladenia tessellata*	EPBC Act: V	Grows in sheltered moist places in forests and scrubs, especially in stony laterites on coastal tops.	N	
White-flowered Wax Plant	*Cynanchum elegans*	TSC Act: E1 EPBC Act: E	Usually occurs on the edge of dry rainforest vegetation. Other associated vegetation types include littoral rainforest	N	Yes (within 20 km x 20 km grid)[1]
Matted Bush-pea	*Pultenaea pedunculata*	TSC Act: E1	Grows in dry sclerophyll forest and disturbed sites on a variety of soils on the South Coast and edge of the Southern Tableland, but with disjunct restricted populations on Wianamatta Shale on the Cumberland Plain in N.S.W.	✓	Yes (within 20 km x 20 km grid)[1]
Camden White Gum	*Eucalyptus benthamii*	TSC Act: V EPBC Act: V	Requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Occurs in open forest.	N	Yes (within 20 km x 20 km grid)[1]
Small-flower Grevillea	*Grevillea parviflora subsp. parviflora*	TSC Act: V EPBC Act: V	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	✓	Yes (within 20 km x 20 km grid)[1]
Basalt Pepper-cress	*Lepidium hyssopifolium*	EPBC Act: E	Woodland or dry sclerophyll forest on sandstone and on heavier, well drained, loamy, gravely soils.	N	
	Persoonia hirsuta subsp. hirsuta	TSC Act: E1	From Gosford to Royal N.P., below 300 m altitude.	✓	Yes (within 20 km x 20 km grid)[1]
	Persoonia bargoensis	EPBC Act: V	Woodland or dry sclerophyll forest on sandstone and on heavier, well drained, loamy, gravely soils.	N	

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Brown Pomaderris	*Pomaderris brunnea*	TSC Act: V EPBC Act: V	Grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines.	N	Yes (within 20 km x 20 km grid)[1]
Spiked Rice-flower	*Pimelea spicata*	TSC Act: E1 EPBC Act: E	Found on well-structured clay soils. On the inland Cumberland Plain sites it is associated with Grey Box and Ironbark.	✓	Yes (within 20 km x 20 km grid)[1]

TSC Act

V: Vulnerable - the species is likely to become endangered if threats continue.

E1: Endangered Species - the species is likely to become extinct in nature if threats continue, or its numbers are reduced to a critical level, or its habitat is reduced.

EPBC Act

E: Endangered – the species is facing a very high risk of extinction in the wild in the near future.

V: Vulnerable – the species is facing a high risk of extinction in the wild in the medium term future.

[1] Source: NPWS Online Atlas of NSW Wildlife

Appendix B: Threatened Species Table: Menangle Park

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Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
FAUNA					
Gastropods					
Cumberland Plain Land Snail	*Meridolum corneovirens*	TSC Act:E1	Cumberland Plain Woodland, grassy open woodland. Under litter of bark, leaves and logs, soil around grass clumps.	✓	Yes (within 20 km x 20 km grid)[1]
Ray-finned Fishes					
Macquarie Perch	*Macquaria australasica*	EPBC Act: E	Macquarie perch are found in both river and lake habitats, especially the upper reaches of rivers and their tributaries.	N	
Australian Grayling	*Prototroctes maraena*	EPBC Act: V	Clear, gravel-bottomed habitats but also muddy-bottomed, heavily silted habitats.	N	
Frogs					
Giant Burrowing Frog	*Heleioporus australiacus*	TSC Act: V EPBC Act: V	Heath, woodland and open forest with sandy soils.	N	Yes (within 20 km x 20 km grid)[1]
Green and Golden Bell Frog	*Litoria aurea*	EPBC Act: V	Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (Typha spp.) or spikerushes (Eleocharis spp.). Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow (Gambusia holbrooki), have a grassy area nearby and diurnal sheltering sites available.	N	
Reptiles					
Broad-headed Snake	*Hoplocephalus bungaroides*	TSC Act: E1	Shelters in windblown sandstone caves or beneath slabs resting on bare rock along cliff edges. Ascends into hollows of nearby eucalypts in summer.	N	Yes (within 20 km x 20 km grid)[1]
Rosenberg's Goanna	*Varanus rosenbergi*	TSC Act: V	Found in heath, open forest and woodland. Associated with termites, the mounds of which this species nests in; termite mounds are a critical habitat component.	N	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Birds					
Speckled Warbler	*Pyrrholaemus sagittatus*	TSC Act : V	Ground dwelling, eucalypt dominated communities with grassy understorey, often on rocky ridges or in gullies. Scattered native tussock grasses, sparse shrub layer, some eucalypt regrowth and open canopy. Requires large, relatively undisturbed remnants.	N	Yes (within 20 km x 20 km grid)[1]
Blue-billed Duck	*Oxyura australis*	TSC Act: V	Aquatic – deep water in large permanent wetlands and swamps with dense aquatic vegetation.	N	Yes (within 20 km x 20 km grid)[1]
Freckled Duck	*Stictonetta naevosa*	TSC Act: V	Permanent freshwater swamps and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. During drier times move to lakes, reservoirs, farm dams and sewage ponds.	N	Yes (within 20 km x 20 km grid)[1]
Bush Stone-curlew	*Burhinus grallarius*	TSC Act: E1	Inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber. Largely nocturnal, being especially active on moonlit nights.	✓	Yes (within 20 km x 20 km grid)[1]
Gang-gang Cockatoo	*Callocephalon fimbriatum*	TSC Act: V	Summer: tall mountain forests and woodlands, particularly heavily timbered and mature wet sclerophyll forests. Winter: drier more open eucalypt forests and woodlands, often found in urban areas.	N	Yes (within 20 km x 20 km grid)[1]
Glossy Black-cockatoo	*Calyptorhyncus lathami*	TSC Act: V	Forests and woodlands with abundant casuarina trees, any of about five species.	✓	Yes (within 20 km x 20 km grid)[1]
Brown Treecreeper	*Climacteris picumnus*	TSC Act: V	Eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges.	N	Yes (within 20 km x 20 km grid)[1]
Diamond Firetail	*Stagonopleura guttata*	TSC Act: V	Feeds on the ground. Grassy eucalypt woodland. Also open forest, mallee, Natural Temperate Grassland and secondary grassland derived from other communities. Often found in riparian areas, sometimes in lightly wooded farmland.	✓	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Regent Honeyeater	*Xanthomyza phrygia*	TSC Act: E1 EPBC Act: E	The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers of mature trees, high canopy cover and abundance of mistletoes.	N	Yes (within 20 km x 20 km grid)[1]
Hooded Robin	*Melanodryas cucullata*	TSC Act: V	Dry forests, woodlands, mallee, shrublands.	✓	Yes (within 20 km x 20 km grid)[1]
Swift Parrot	*Lathamus discolor*	TSC Act: E1 EPBC Act: E	Winter flowering eucalypts: Eucalyptus robusta, Corymbia maculata, C. gummifera, E. albens.	N	Yes (within 20 km x 20 km grid)[1]
Australian Painted Snipe	*Rostratula australis*	EPBC Act: V	Shallow inland wetlands, either freshwater or brackish, that are either permanently or temporarily filled.	N	
Barking Owl	*Ninox connivens*	TSC Act: V	Inhabits eucalypt woodland, open forest, swamp woodlands and, especially in inland areas, timber along watercourses. Denser vegetation is used occasionally for roosting. During the day they roost along creek lines, usually in tall understorey trees with dense foliage such as Acacia and Casuarina species, or the dense clumps of canopy leaves in large Eucalypts.	✓	Yes (within 20 km x 20 km grid)[1]
Powerful Owl	*Ninox strenua*	TSC Act: V	The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well.	✓	Yes (within 20 km x 20 km grid)[1]
Mammals					
Eastern Pygmy-possum	*Cercartetus nanus*	TSC Act: V	Found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest.	N	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	TSC Act: V	Forages in eucalypt forests, mallee and open country. Roosts in tree hollows and has been found in the abandoned nests of Sugar Gliders.	✓	Yes (within 20 km x 20 km grid)[1]
Eastern Freetail-bat	*Mormopterus norfolkensis*	TSC Act: V	Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roost mainly in tree hollows but will also roost under bark or in man-made structures.	✓	Yes (within 20 km x 20 km grid)[1]
Squirrel Glider	*Petaurus norfolcensis*	TSC Act: V	Inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas. Prefers mixed species stands with a shrub or Acacia midstorey.	N	Yes (within 20 km x 20 km grid)[1]
Spotted-tail Quoll	*Dasyurus maculatus maculatus (SE mainland population)*	EPBC Act: E	Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites.	N	
Brush-tailed Rock-wallaby	*Petrogale penicillata*	EPBC Act: V	Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north.	N	
Long-nosed Potoroo (SE mainland)	*Potorous tridactylus tridactylus*	EPBC Act: V	Inhabits coastal heaths and dry and wet sclerophyll forests. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature.	N	
Koala	*Phascolarctos cinereus*	TSC Act: V	Inhabit eucalypt woodlands and forests.	✓	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Grey-headed Flying-fox	*Pteropus poliocephalus*	TSC Act: V EPBC Act: V	Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy.	N	Yes (within 20 km x 20 km grid)[1]
Large-eared Pied-bat	*Chalinolobus dwyeri*	TSC Act: V EPBC Act: V	Roosts in caves, found in well-timbered areas containing gullies.	N	Yes (within 20 km x 20 km grid)[1]
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	TSC Act: V	Prefers moist habitats, with trees taller than 20 m. Generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings.	N	Yes (within 20 km x 20 km grid)[1]
Eastern Bent-wing Bat	*Miniopterus schreibersii oceanensis*	TSC Act: V	Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Hunt in forested areas, catching moths and other flying insects above the tree tops.	N	Yes (within 20 km x 20 km grid)[1]
Large-footed Myotis	*Myotis adversus*	TSC Act: V	Roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface.	N	Yes (within 20 km x 20 km grid)[1]
Greater Broad-nosed Bat	*Scoteanax rueppellii*	TSC Act: V	Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Although this species usually roosts in tree hollows, it has also been found in buildings. Forages after sunset, flying slowly and directly along creek and river corridors at an altitude of 3 - 6 m. Open woodland habitat and dry open forest suits the direct flight of this species.	N	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
FLORA					
Thick-lipped Spider-orchid	*Caladenia tessellata*	EPBC Act: V	Grows in sheltered moist places in forests and scrubs, especially in stony laterites on coastal tops.	N	
White-flowered Wax Plant	*Cynanchum elegans*	TSC Act: E1 EPBC Act: E	usually occurs on the edge of dry rainforest vegetation. Other associated vegetation types include littoral rainforest	N	Yes (within 20 km x 20 km grid)[1]
Matted Bush-pea	*Pultenaea pedunculata*	TSC Act: E1	Grows in dry sclerophyll forest and disturbed sites on a variety of soils on the South Coast and edge of the Southern Tableland, but with disjunct restricted populations on Wianamatta Shale on the Cumberland Plain in N.S.W.	✓	Yes (within 20 km x 20 km grid)[1]
Camden White Gum	*Eucalyptus benthamii*	TSC Act: V EPBC Act: V	Requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Occurs in open forest.	N	Yes (within 20 km x 20 km grid)[1]
Small-flower Grevillea	*Grevillea parviflora subsp. parviflora*	TSC Act: V EPBC Act: V	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	✓	Yes (within 20 km x 20 km grid)[1]
Basalt Pepper-cress	*Lepidium hyssopifolium*	EPBC Act: E	Woodland or dry sclerophyll forest on sandstone and on heavier, well drained, loamy, gravely soils.	N	
	Persoonia hirsuta subsp. hirsuta	TSC Act: E1	From Gosford to Royal N.P., below 300 m altitude.	✓	Yes (within 20 km x 20 km grid)[1]
	Persoonia bargoensis	EPBC Act: V	Woodland or dry sclerophyll forest on sandstone and on heavier, well drained, loamy, gravely soils.	N	
Brown Pomaderris	*Pomaderris brunnea*	TSC Act: V EPBC Act: V	Grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines.	N	Yes (within 20 km x 20 km grid)[1]

Common Name	Scientific Name	Status	Preferred Habitat	Preferred Habitat on Site	Known Records
Spiked Rice-flower	*Pimelea spicata*	TSC Act: E1 EPBC Act: E	Found on well-structured clay soils. On the inland Cumberland Plain sites it is associated with Grey Box and Ironbark.	✓	Yes (within 20 km x 20 km grid)[1]

TSC Act

V: Vulnerable - the species is likely to become endangered if threats continue.

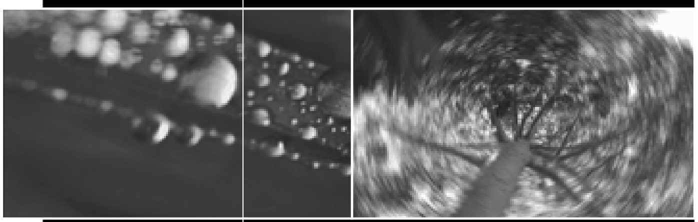
E1: Endangered Species - the species is likely to become extinct in nature if threats continue, or its numbers are reduced to a critical level, or its habitat is reduced.

EPBC Act

E: Endangered – the species is facing a very high risk of extinction in the wild in the near future.

V: Vulnerable – the species is facing a high risk of extinction in the wild in the medium term future.

[1] Source: NPWS Online Atlas of NSW Wildlife



APPENDIX H

ABORIGINAL HERITAGE ASSESSMENT

Aboriginal Heritage Assessment: Camden Gas Project Stage 2 Concept Plan Spring Farm and Menangle Park Project Areas

September 2007

Prepared for:

AGL Gas Production (Camden) Pty Ltd
72 Christie Street
St Leonards NSW 2065

Report by:

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HLA Ref: Appendix J_FINALHERITAGERPT_Sept07

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DISTRIBUTION

Aboriginal Heritage Assessment: Camden Gas Project, Stage 2 Concept Application, Spring Farm and Menangle Park Project Areas

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for

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1 INTRODUCTION

HLA-Envirosciences Pty Limited (HLA ENSR) has prepared an Aboriginal heritage assessment to accompany an Environmental Assessment (EA) relating to Stage 2 of the Camden Gas Project (CGP). The EA is being prepared for AGL Gas Production (Camden) Pty Ltd (AGL) and is seeking Concept Plan approval to develop further well fields and infill wells supported by associated infrastructure, together with post development activities including the installation of in-field compression, upgrade of gas gathering lines and undertaking refracing in Stage 2 of the CGP. In addition, concurrent Project approval is being sought for proposed works, involving the development of wells, gas gathering lines, access roads and water transfer pipelines (where required) within the Spring Farm and Menangle Park areas.

The EA is being prepared for consideration under the provisions of Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Aboriginal heritage assessment relates to the proposed works within Spring Farm and Menangle Park for which Project approval is being sought (i.e. the development of well surface locations, access roads, gas gathering lines and water transfer pipelines). In addition, further generic management strategies and mitigation measures based on this study are provided for the Stage 2 Concept approval.

Specifically, the main aims of the study are to identify and record the extent and nature of Aboriginal archaeological potential within the study areas, by:

- the validation of known sites and/ or items within the study area through archaeological survey;
- an archaeological survey of the study area to locate additional sites and/or items;
- an assessment of the study area to delineate areas of high archaeological sensitivity or potential;
- consultation with the relevant local Aboriginal community groups;
- assessing the potential impacts of the proposed development on known archaeological materials and areas of archaeological potential within the study area;
- assessing the significance of archaeological material identified; and
- presenting recommendations for the management of and/or mitigation of construction impact to the archaeological resource identified.

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2 PROJECT DESCRIPTION

2.1 Introduction

The Proponent is seeking Concept Plan approval for a range of works relating to the remainder of development within the Stage 2 area of the CGP. Concurrent Project approval is also being sought for works within the proposed Spring Farm and Menangle Park well fields.

The Concept Plan proposal relates to the area identified in **Figure 1** and **Figure 2**.

2.2 Overview of Proposed Activities

The works proposed in the Spring Farm and Menangle Park areas involve the construction and subsequent operation of a number of gas wells, together with associated infrastructure and post development activities to enable the extraction, collection and delivery of gas to the gas plant.

Project approval is being sought for the range of activities which can be divided into the following:

- Construction: The activities required to physically develop the wells and supporting infrastructure;
- Production: Production and delivery of gas from well surface locations to the gas plant via gas gathering lines for sale, including commissioning and maintenance activities;
- Post Development: Operational activities which may be needed to maintain production efficiency. These activities are proposed as part of the Concept Plan only and were not included as part of previous approvals in Stage 2. It is anticipated these activities may include the development of infill wells, upgrade of gas gathering lines, refracing (if required) and installation of infield compression; and
- Closure and Final Rehabilitation.

The application seeks approval for the construction of up to four well surface locations within the Spring Farm area and up to 12 well surface locations in the Menangle Park area. Well surface locations SF04 and SF0A represent two alternatives for a single well surface location. The proposed well surface locations are illustrated in **Figures 3** and **4** and for the purposes of this study are identified as follows:

- Spring Farm surface locations
  - SF04;
  - SF04A
  - SF10;
  - SF17; and
  - SF20.
- Menangle Park surface locations
  - MP02;
  - MP03;
  - MP04;

- MP05;
- MP06;
- MP11;
- MP19;
- MP21;
- MP22;
- MP23;
- MP24; and
- MP33.

2.2.1 Gas Gathering System

The construction of the gas gathering lines typically involves survey and clearing (where required) of the route, trenching, pipe and tracer cable and marker tape laying and backfilling, then rehabilitation and pipeline testing. Notification signposts are put in place to show the location of the gathering lines. A more detailed description of these works can be found in the EA. Water transfer lines may also be located with the gathering lines.

2.3 Location of Proposed Works

The proposed area which is the subject of the Concept application (further development within Stage 2) is situated approximately 65 kilometres south-west of Sydney in the Camden, Campbelltown and Wollondilly LGAs.

The Nepean River runs through the project area, from the south to the north-western corner of the Stage 2 area. The area extends from the suburbs of Narellan and Currans Hill in the north to south of Menangle, extending across to Glen Alpine and Ambervale in the east, and Camden in the west (see **Figure 2**), and incorporates the areas of Spring Farm and Menangle Park.

Concurrent Project approval is being sought for the construction of well surface locations and the installation of access roads, gas gathering and water pipelines within Spring Farm and Menangle Park (see **Figures 3**, **4** and **5**).

The area known as Spring Farm is located within the Camden LGA, approximately 65 km south west of Sydney. The Spring Farm area is located east of Camden and is situated south of the Camden by-pass. The Nepean River adjoins the south west boundary of the area, while the suburb of Spring Farm borders the north / north eastern boundary of the area. Land in the area is allocated to support future urban, commercial and industrial development growth.

The Spring Farm area is located between the existing well fields of Glenlee and EMAI to the south east and south west.

The Menangle Park area falls within the Campbelltown LGA. The land is situated south east of the proposed Spring Farm well field. The Menangle Park area is bounded by the Hume Highway to the east, with the exception of a small portion of the field which is situated east of the Hume Highway and north of Menangle Road. The Nepean River forms the western and southern boundaries of the area. The proposed works within the Spring Farm and Menangle Park areas are shown on **Figure 3** and **Figures 4** and **5** respectively.

The indigenous heritage assessment has used an “envelope” approach to the impact assessment which means that the highest impact activities are assessed even when these activities are not the most likely. Within the two Project Areas, the ecological assessment focussed on a circle with a 200 metres radius around each proposed well surface location (the study area) and 25 metres either side of the proposed locations of the gas gathering lines and access roads.. The scope of the study area is far greater than the area required for each well surface location, gas gathering lines and access roads, therefore it allows for flexibility of construction and production operations, which would allow the selection of well surface locations to avoid areas of Indigenous heritage sensitivity.

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3 APPLICABLE POLICY AND LEGISLATION

3.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) sets out the requirements for the approval of the Commonwealth Minister for the Environment and Water Resources for actions that may have a significant impact on matters of National Environmental Significance (NES). Matters of NES include World Heritage Properties and National Heritage Places.

Approval from the Commonwealth is in addition to any approvals under NSW legislation and is triggered by a proposal which has the potential to have a significant impact on a matter of NES.

3.2 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 Aboriginal 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 Aboriginal 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 Aboriginal 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 Water Resources (DEW).

3.3 Environmental Planning and Assessment Act 1979

The *Environmental Planning & Assessment Act 1979* (EP&A Act) requires that consideration be given to environmental impacts as part of the land use planning process. In NSW, environmental impacts include cultural heritage impacts.

This project is being assessed under Part 3A of the EP&A Act which provides an approvals regime applying to all major projects. Major projects are defined under State Environmental Planning Policy (Major Projects) 2005 (SEPP 2005).

Part 3A applies to all projects where the Minister has the approval role. Under Part 3A, the Minister can issue a project approval or a concept approval. Both maintain the requirement for consultation with the community and relevant State Government agencies, but the requirement for certain other permits and licences is removed.

Section 75B(2) of the EP&A Act makes provision for 'major projects' to be identified through various means, including by way of declaration as a listed project in State Environmental Planning Policy (Major Projects) 2005 (SEPP 2005), or by notice in the Gazette.

Schedule 1 of SEPP 2005 identifies classes of development which are defined as 'major projects' and includes projects related to petroleum (oil, gas and coal seam methane), within certain local government areas including Camden, Wollondilly and Campbelltown City.

The proposal involves the development of well surface locations for coal seam methane extraction within Stage 2 of the CGP which is situated in the Camden, Campbelltown and Wollondilly LGAs. Therefore the proposal falls within the definition under Group 6 of Schedule 1 of SEPP (Major Projects) 2005 and the Minister for Planning is the approval authority.

Importantly for this study, under Section 75U (1) (d) of Part 3A, the proponent is not required to obtain certain permits under the NPW Act, specifically:

- The following authorisations are not required for an approved project (and accordingly the provisions of any Act that prohibit an activity without such an authority do not apply):
- a permit under section 87 or a consent under section 90 of the National Parks and Wildlife Act 1974

A section 87 permit (also known as a Preliminary Research Permit or PRP) is a permit issued by DEC for the undertaking research into identified Aboriginal objects while a section 90 consent (also known as a Consent to Destroy or CD) is a permit issued by DEC for the destruction of Aboriginal objects. Generally both approvals require the preparation of work methodologies such as a research methodology for a PRP and a work methodology for a CD which involve approval or endorsement from both DEC and the Aboriginal communities. PRPs and CDs are generally required for projects undertaken under Parts 4 and 5 of the EP&A Act.

Under Part 3A of the EP&A Act, the proponent is required to prepare a Statement of Commitments, in accordance with the Director-General's Environmental Assessment Requirements (EARs). The Statement of Commitments will then form part of the overall Project Approval. As such AGL will be required to fully implement these commitments during and following the proposal. Recommendations of this report should be inserted into this Statement of Commitments.

While the Sections 87 and 90 of the NPW Act do not apply in the case of this proposal, it is recommended that the intent of those sections of the Act be retained in the Statement of Commitments. Hence, Section 4.3 seeks to acknowledge the relevance and intent of the Act by placing them in a Part 3A framework.

3.4 National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* (NPW Act) 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 NPW Act (as amended), 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". This definition technically would seem to exclude PADs as they are not proven to be deposits, objects or material evidence, as defined under the NPW Act. Instead they are potential archaeological sites whose legislative protection relies on a demonstration of their Aboriginal cultural origin, something that can only be ascertained through further archaeological investigation.

The most relevant section of the legislation is section 90, which deals with the destruction of Aboriginal objects and states:

- Destruction etc of Aboriginal objects or Aboriginal places
    - 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.

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 or not an Aboriginal object or place was going to be destroyed, defaced, damaged or desecrated. 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.

Please note, in this project Section 87 and 90 permits are not required, since the project is being undertaken under Part 3A of the EP&A Act, (see Section 3.3).

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4 METHODOLOGY

4.1 Aboriginal Community Consultation

In response to two 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 requirements have expanded and developed on the current guidelines (*Aboriginal Cultural Heritage Standards and Guidelines*, DEC 1997), making the consultation process longer and more thorough.

Given the extensive literature, existing information of the relevant Aboriginal groups in the area, and the involvement of these groups in previous AGL projects, HLA ENSR was familiar with the relevant Aboriginal groups, and hence undertook the following steps with regard to this project.

- Contacted the DEC's Executive Director Operations, Cultural Heritage Division;
- Contacted the Tharawal Local Aboriginal Land Council (TLALC) to identify their interest in the project and any other relevant Aboriginal groups;
- Contacted the Cubbitch Barta Native Title Claimants (CBNTC) to identify their interest in the project and any other relevant Aboriginal groups;
- Searched the Native Title Tribunal to identify possible Native Title holders;
- Searched the Office of Registrar of Aboriginal Corporations; and
- AGL advertised for registrations of interest in relevant newspapers on 8 February 2005 as part of the wider project.

Both TLALC and CBNTC were contacted regarding their interest in the project, and asked to identify any further relevant Aboriginal stakeholders. Both organisations expressed an interest in being involved, and identified no further stakeholders.

A Native Title search of the Camden and Campbelltown LGAs identified two current claim applications for the Gundugarra Tribal Council Aboriginal Corporation #6 (NC 97/7) and the Darug Tribal Aboriginal Corporation (NC 97/8). These claims fall outside of the boundaries of the study area, predominantly being made on areas closer to the Blue Mountains, so neither of these groups was contacted. The CBNTC claim (NC 98/20) is shown to have been discontinued on the Native Title Tribunal website, and hence was not found in the search.

No response was received from the DEC or the Register of Aboriginal Corporations.

The two groups who registered their interest sent representatives to participate in the survey. The CBNTC representative was Glenda Chalker and Donna Whillock took part for TLALC. The survey was carried out by Glenda Chalker, Donna Whillock, Aaron Clifton (AGL) and Clayton Fredericksen (HLA ENSR) on 26 and 27 November (Menangle Park project area) and 9 November 2006 (Spring Farm project area). Dominic Steele Consulting Archaeology and the above representatives of the groups and Tom Lawler from AGL undertook further survey work in both Project areas on 2 February 2007.

A subsequent site visit of two gas gathering lines, at Glenlee Road East and Menangle Road, and between MP24 and the existing valve pit, was undertaken with Alan Williams (HLA ENSR), Glenda Chalker and Donna Whitlock on 4 July 2007.

A copy of comments received from Cubbitch Barta Native Title Claimants is provided in Appendix B.

All groups who registered their interest will be provided a copy of this report for comment, and will continue to be involved in the ongoing development of the Camden Gas Project.

4.2 Review of Existing Information

A desktop review of available information was undertaken in respect of the existing environment, including a review of aerial photography, previous reports prepared for the area and NSW and Australian Government databases.

Five previous investigations have recently been undertaken that incorporate a large portion of the Menangle Park and Spring Farm Project areas. These documents are reviewed and utilised throughout this document to provide a more comprehensive picture of the archaeological potential of these areas, and assist in developing both Conceptual and Project management and mitigation measures. The five reports are:

- HLA-Envirosciences Pty Limited (2004) Indigenous Heritage Assessment: Menangle Park Re-zoning. *A report prepared for APP Corporation Pty Limited;*
- McDonald, J. (2004) Additional Archaeological Assessment of Indigenous Heritage Issues: Menangle Park Re-zoning. *A report prepared for APP Corporation Pty Limited;*
- Godden Mackay Logan (2002) *Spring Farm Urban Release Area Heritage Assessment;*
- Dallas, M, and Irish, P. (2001) *Aboriginal Archaeological Assessment Spring Farm Urban Release Area;* and
- Patterson Britton & Partners (2000) Spring Farm Urban Release Area Local Environment Study. *A report for Camden Council.*

4.3 Field Investigation

The aim of the field survey was to ascertain whether the proposed development would impact upon either previously identified or unrecorded Aboriginal heritage sites. The survey was to focus on:

- 17 well surface locations - Spring Farm (5) two of which were assessed as options for a single well surface location and Menangle Park (12). An approximate 200 metre radius footprint around each well surface location was inspected[1];
- Approximately 25 metres on either side of the routes of underground gas gathering line that will link the surface wells were inspected;
- Proposed and existing routes of access tracks to facilitate construction of the gathering lines. Usually, but not always, the tracks ran roughly parallel line to the gas gathering lines along the same route. Approximately 25 metres on either side of the access tracks were inspected.

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[1] An additional two gas gathering lines at Glenlee East and Menangle Road, and MP24 to the existing valve pit, was subsequently undertaken by HLA ENSR and the Aboriginal communities on 4 July 2007.

This approach to the assessment will allow flexibility for the well surface locations to be sited anywhere within these assessed areas in the knowledge that Aboriginal heritage would not be unacceptably impacted.

Previous surveys have identified flaked stone as the major signature of former Aboriginal use of this landscape. The following characteristics were used in the assessment presented here to discriminate rock that was manufactured into stone tools, or to identify rock present as the by-product of tool manufacture:

- Flakes: possess all or a combination of the following attributes – percussion bulb, eraillure scar, striking platform, ringcracks (from hammer striking the core).
- Cores: display single or multiple negative flake scars, but with no positive flake scars.
- Retouched flakes: flakes with microflaking (i.e. retouch) along one or more margins. Flaking tends to be more regular than through treadage or most forms of usewear.
- Flaked pieces: pieces that do not possess any of the attributes of cores or flakes but are nevertheless the result of human action, usually the by-product of tool manufacture or core preparation.

Lithology is also important in discriminating rock imported by people from that occurring naturally as background. Previous studies have identified a range of siliceous rock types in this area. For simplicity (following HLA 2004) siliceous rocks other than chert, silcrete and quartz are defined by the term ***fine-grained siliceous rock (FGS)***, which includes such types as mudstone (orange/dark brown bands, cream, yellow/cream mottled), tuff (brown, orange/red, cream), and siliceous tuff (grey, cream/yellow, yellow/grey, cream/grey/pink/red). ***Chert*** is a siliceous sedimentary fine-grained rock composed of micro-organisms or precipitated silica grains; and can be multi-coloured to grey or white/yellow. ***Silcrete*** is a quartz-rich sedimentary rock; often red to pink and sometimes with quartz inclusions. ***Quartz*** is a medium-grained rock that is easily recognisable by a structure consisting of tightly interlocking grains of quartz, like a 3-D jigsaw puzzle; and is usually white to translucent. A fourth category recognised here is ***volcanic***, which consists of metamorphic rock that is often grey in colour.

The field investigation itself consisted of a pedestrian traverse of the proposed well surface locations and proposed and existing access tracks, and the proposed gathering lines. This was done by reference to aerial photographs provided by AGL, with Aaron Clifton (AGL) providing on-the-ground instruction over the various routes and route options. Most well locations were marked by wooden pegs, which facilitated the inspection of these areas.

4.4 Assessment of Archaeological Sensitivity

The assessment of archaeological sensitivity is a way of gauging, from available evidence, which sectors within a survey area are more archaeologically “valuable” than others (where “value” is measured as the relative potential to provide information on past Aboriginal occupation or land use of an area). Assessment of sensitivity is made on the basis of 1) the presence of known surface archaeological materials, 2) the probability of undetected surface archaeological materials, 3) the probability of subsurface archaeological materials, and 4) terrain nature and integrity. Information on pre-recorded sites and sites identified in this assessment is used in combination with observations of terrain nature and integrity to assess archaeological sensitivity. Sensitivity can be rated in terms of low, moderate or high, as set out below:

Low Archaeological Sensitivity	Areas where archaeological material is unlikely to occur. This can be due to the landscape being unsuitable for human occupation, or to the landscape being heavily modified in recent history by European activity.
Moderate Archaeological Sensitivity	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.
High Archaeological Sensitivity	Areas known or likely to contain archaeological materials. The terrain remains largely undisturbed, and sites are known to occur in this context in high concentrations or as a wide range of types.

Assessments of archaeological sensitivity have become standard in archaeological reporting in NSW. Assessments of this kind have previously been carried out for Menangle Park (HLA (2004: 76ff, McDonald 2004: 13). Importantly, some of the proposed gas gathering lines and access tracks will pass through or nearby areas previously designated as possessing high archaeological sensitivity (refer McDonald 2004: 17).

5 EXISTING ENVIRONMENT

5.1 General

The Stage 2 area of the CGP is located in the Camden area of the NSW east coast within the Cumberland lowlands. The area's landform is characterised by low lying gently undulating plains and rolling low hills and rises with the Nepean River being the dominant feature of the landscape. Much of the area has been cleared of the natural vegetation with grazing practices common in the landscape.

The Spring Farm project area is located on the northern terraces of the Nepean River and on the western slopes of the low hills which border the Mount Annan Botanical Gardens and the William Howe Reserve (CC, 2000). The Spring Farm project area has a predominantly south western aspect with views across the extensive Nepean River floodplains. Landform is gently undulating with steeper sections to the east of the site reaching elevations of up to 170m AHD. Generally the land falls away to the Nepean River in the south with an extensive floodplain adjacent to the river.

Drainage lines of the Spring Farm project area flow in a westerly direction in meandering patterns joining the Nepean River at the western boundary. Several modifications have occurred to the landscape since European settlement including the formation of large dams, roadways, sand mining sites and residential areas. Much of the site has been cleared of vegetation for grazing and farming purposes with a noted remnant vegetation corridor in the vicinity of the Nepean River and extending along Jacks Gully. Sand mining and intensive activities have altered the landscape creating depressions, exposed areas and gully systems. The area does not contain distinctive landform features (i.e. prominent hills) with roadways, sand mining activities and river flats providing the variability to the undulating landscape.

The Menangle Park project area is located on the eastern floodplain and terraces of the Nepean River. The area has a predominantly westerly aspect with landform relatively low. Generally the Menangle Park area falls within the Nepean River floodplain.

Drainage within the area tends to the west joining the Nepean River. As in the Spring Farm landscape, modifications have occurred to the landscape since European settlement including the formation of large dams, roadways, sand mining sites and residential areas with much of the area cleared of vegetation for grazing and farming purposes. Remnant vegetation is primarily located in the riparian corridor of the Nepean River. Sand mining is not as prominent in the Menangle Park landscape as in the Spring Farm landscape with dominant landform feature restricted to roadways, floodplains and low hills.

5.2 Geology and Soils

The Wollongong – Port Hacking Geological Series Sheet (reference 9029 – 9129) indicates that the Stage 2 area is underlain by Triassic Age Bringelly Shales of the uppermost formation of the Wianamatta Group (Hazelton and Tille, 1990). Quaternary alluvium gravels, deposits and sands are present around the Nepean River flats and lower slopes, comprising of mainly silica sand with high clay content. The quaternary deposits provide evidence of landscape forming features when the Nepean River was flowing at higher levels. A few small locations of Tertiary sand mineral deposits are scattered around the Stage 2 area with the most prominent location to the north of the Spring Farm area.

A review of the Soil Landscapes of the Wollongong – Port Hacking 1: 100 000 Sheet indicates that the two main natural soil landscapes occurring on the Stage 2 area are Blacktown and

Theresa Park, with pockets of Luddenham, Monkey Creek and Hawkesbury Landscapes and isolated areas of disturbed terrain. The Soil Landscapes are summarised in **Table 1** below.

Table 1: Soil Landscapes

Soil Landscape	Characteristics	Occurrence
Blacktown	• Residual landscape • Gently undulating rises on Wianamatta Group shale • Broad round crests and ridges with gently inclined slopes • Local relief 10-30 m • Slopes generally <5% but up to 10% • Almost completely cleared of vegetation • Red and Brown Podzolic Soils on crests, upper slopes and well drained areas • Yellow Podzolic and Soloths on lower slopes and in drainage lines	• Stage 2 • Spring Farm • Menangle Park
Theresa Park	• Fluvial landscape • Floodplain and terraces of the Nepean River • Local relief up to 60m • Slopes generally <5% but up to 10% • Almost completely cleared of vegetation • Red Earths and Red Podzolic Soils on terraces and Prairie Soils on the floodplain	• Stage 2 • Spring Farm • Menangle Park
Luddenham	• Erosional landscape • Undulating to rolling low hills on Wianamatta shale • Local relief 50-80m • Slopes 5-20% • Narrow ridges, hillcrests and valleys • Extensively cleared open forest • Brown Podzolic and Massive Earthy Clay on crests • Red Podzolic Soils on upper slopes • Yellow Podzolic and Prairie Soils on lower slopes and near drainage lines	• Small areas of Stage 2 • Small pocket of east Spring Farm • Small pockets of east Menangle Park

Soil Landscape	Characteristics	Occurrence
Hawkesbury	• Colluvial landscape • Rugged rolling to very steep hills • Local relief 100-200m • Slopes >25% • Surface rock >50% • Narrow crests and ridges • Narrow incised valleys • Steep sideslopes with narrow rocky benches • Lithosols / Siliceous Sands associated with rock outcrop • Earthy Sands and Yellow Earths on benches • Yellow and Red Podzolic Soils on valley flats	• Stage 2 • Menangle Park around the Nepean River
Monkey Creek	• Fluvial landscape • Floodplains, valley flats and drainage depressions of the Cumberland Plain • Yellow Podzoic Soils and Solodic Soils on floodplains and valley flats • Alluvial Soils and Gleyed Podzolic Soils in poorly drained depressions	• South western areas of Stage 2
Disturbed Terrain	• Occurs within other landscapes and has been disturbed through human activities • Original soils have been removed • Most areas are levelled	• Isolated areas of Stage 2

5.3 Aboriginal History

Traditional Aboriginal occupation of the study area and surrounding region was well established prior to the arrival of European settlers. At the time of European contact, the Aboriginal population for the Sydney region has been estimated as being between 5,000 and 8,000 people, of which about 1,000 were living in the Liverpool and Campbelltown areas (Murray & White 1988). Early European settlers referred to the Aboriginal people who lived in the Campbelltown region as the Cow-pastures tribe. This was because the Europeans named the area the "Cow-pastures", due to it being the location of a wild herd of cattle. Anthropologists have concluded that the tribes in this area spoke the Dharawal[2] language and that their territory covered a region from Botany Bay, south to the Shoalhaven River and inland to Camden.

According to Liston (1988:49) the Dharawal travelled widely through the country of the Hawkesbury-Nepean River system, occasionally leaving their own territory to visit other Aboriginal groups at Prospect, Parramatta and Windsor, east to Botany Bay and as far north as Broken Bay, west to Bathurst and south-west to Lake Bathurst. Whilst the Aboriginal people of the Appin / Campbelltown / Cow-pastures district were mainly the Dharawal speaking tribes, the

[2] In modern times, the term Dharawal has been modified to *Tharawal.*

Gundungurra (an uplands tribe from west of the Wollondilly, Wingecarribee and Nattai Rivers) sometimes migrated into the Cow-pastures (Camden Crier 1983:12).

One of the most interesting pieces of physical evidence from this earlier period of European and Aboriginal interaction was a site known as Bull's Cave. Prior to the movement of settlers into the region, two bulls and four cows wandered south to the grazing land of the Menangle-Camden area. These animals were sketched on the wall of a sandstone shelter, known as Bull's Cave. It is known that this sketch pre-dates 1795 (Liston 1988:50).

However, visits to the district by Europeans were rare until the early I800s when attempts were made to domesticate the wild cattle of the Cow-pastures and the opening up of forest lands prompted new farming settlements. By November 1810, when Macquarie visited Minto and the Cow-pastures, the district was already under the plough with fields of wheat and grazing sheep and cattle (Liston 1998:50). There are several accounts of contact between members of the Dharawal and early European settlers. Early explorers, including convict stockman John Warby and a prominent grant holder Charles Throsby, established close working relationships with the Dharawal. Explorer Hamilton Hume (1777-1873) also explored the district in the company of the Dharawal.

Further information comes from Moloney, who has written an account of his personal recollections of the Campbelltown district, specifically his family ties to Menangle Park. Moloney's experiences extend back to the 1870s, while his family has been associated with Menangle since 1854. He states:

> *"The Aboriginals of the area were few in number and I will refer to them individually, but visits from Wollongong and Kiama tribes were frequent and, as they trekked to and from Sydney, generally made a call at the old home in which I was born"*
>
> (Moloney, 1854:5)

Moloney also provides details of several individual members of the Dharawal including an Aboriginal woman named Nellie, who made frequent visits to the Menangle Park area. Moloney relays the story of Nellie meeting an Aboriginal man (named Johnnie) who was working on the Taber property. Nellie and Jonnie subsequently left Menangle when his tribe moved away.

There are no reports of violent contact between the Dharawal and the Europeans settlers in Campbelltown before 1810. However, in the following decade, with the declaration of the Districts of Airds & Appin, the flow of settlers and subsequent land pressures dramatically increased. Some have described conflict as inevitable between such vastly different cultures (Botanic Gardens Trust, 2003), while environmental issues such as land pressure and the severe droughts of 1814-16 would have exacerbated the situation. Articles in the Sydney Gazette during this time (such as those published on 18 June 1814) reported "unhappy conflicts" between settlers and Aboriginal groups in Bringelly, Airds and Appin, and the adjoining districts. These reports indicate that both settlers and Aboriginal lives had been lost. At this time, Governor Macquarie warned settlers not to take the law into their own hands. However, by 1816, the European settlers considered all the Cow-pastures tribes to be hostile, despite a number of Aboriginal groups within the area not being engaged in violent activity.

The Appin Massacre of 1816 is widely regarded as a critical turning point in the conflicts of the 1810s, and subsequently led to severe impacts on the Aboriginal people of Campbelltown and Camden and a disruption to the traditional Dharawal way of life. A review of Sydney Gazette articles dating from 1816 outlines a conflict between European settlers and Aborigines along the Nepean River during January 1816. Five white men were killed in the incident, and some farmers in the surrounding area abandoned their farms. While there is no evidence that the Dharawal played an aggressive role in the encounter, Governor Macquarie ordered a detachment of troops to the area. In early 1816, Captain Wallis led a punitive expedition that surprised an Aboriginal encampment, killing at least fourteen and taking five prisoners.

After the 1816 conflicts, the Dharawal remained south of the Nepean River in the Cow-pastures district (including Mount Annan) under the tacit protection of the Macarthur family (Botanic Gardens Trust, 2003). In March 1818, James Meehan marked out some land on the Macarthur's Camden estate for Aborigines who wanted to live there under the protection of the Macarthurs' (Liston 1988:55).

Sources indicate that the Dharawal population was quite small by 1816, as many had succumbed to smallpox, influenza and other introduced diseases which had a profound effect on their lives before the armed conflicts took place. McGill (1994) reports a severe drought between 1814 and 1816 further exasperated the Dharawal as their already constrained food supplies were depleted through competing land pressures. The Dharawal numbers were further depleted by the 1820 influenza epidemic, and between 1835 and 1845 the official number of Aborigines in the Campbelltown District fell from 20 to none, although it is clear from later records that a number of Dharawal did survive (Botanic Gardens Trust, 2003).

There is some evidence of surviving Dharawal people at this time from the Sydney Gazette 1828 Sketch of "Ager Cottage" at Leumeah made by John Scarr (owner) published in the paper. The article and picture imply that there were still a considerable number of Aboriginal people located around the cottage, and hence within the district at this time.

The removal of their traditional hunting grounds for pastoral land and the dispersion of people in the years following the conflicts of 1816 resulted in less Dharawal actually remaining in the district. Although corroborees were held at Camden in the 1850s, the gatherings comprised a number of tribes (including the remaining Dharawal) (Botanic Gardens Trust, 2003). European settlement continued to grow within the Campbelltown district as a result of developments including the opening of a railway station in 1858, further depleting the traditional land of the Dharawal.

5.4 Archaeological Context

The archaeological background section outlines the known Aboriginal and historic sites and other studies undertaken in the area. This section will then provide site predictions for the study area in question.

5.4.1 Archaeology of the Cumberland Plain

The Cumberland Plain has been subject to numerous archaeological investigations. Most of this research relates directly to recent development within the Cumberland Plain, which has been identified as a major area for urban expansion within Sydney. A major stimulus for research has been the Rouse Hill Infrastructure Project (RHIP), which resulted in numerous studies throughout the Rouse Hill, Kellyville, Parklea and the Baulkham Hills area.

The numerous archaeological studies within the Cumberland Plain, and more specifically the intensive archaeological works in advance of the RHIP, have consisted of both landscape survey and excavation. These studies have increased the level of archaeological knowledge of site distribution and composition within the Cumberland Plain. The relatively high level of archaeological excavation has also enabled a high level of understanding of the subsurface archaeological potential of the Cumberland Plain. A large number of these studies have addressed the issue of site distribution within the Cumberland Plain for specific site types. Occupation sites (artefact scatters, isolated finds) are the most numerous known site type within the Cumberland Plain, and a number of early models have been developed to identify patterns in the distribution of occupation sites.

These models have become increasingly more refined as the results of the RHIP archaeological works have broadened the archaeological knowledge of the region. Many of the early models are now considered inadequate to describe the characteristics of sites and to predict site locations and/or variability as they were based on limited surface materials (Brayshaw and McDonald 1993; McDonald 2001b). McDonald (1998) has outlined a comprehensive model for site type and distribution within the Cumberland Plain. This model was initially developed for the RHIP but contains elements that are applicable across the Cumberland Plain. This model contains a number of generalised statements and specific predictions about site distribution within the Cumberland Plain. The statements of this model made by McDonald (1998:13-14) are:

- most areas — even those with sparse or no surface manifestations — contain subsurface archaeological materials;
- where open sites are found in aggrading and stable landscapes, some are intact and have the potential for internal structural integrity. Sites in alluvium posses the potential for stratification;
- contrary to earlier models for open sites, many sites contain extremely high artefact densities, with variability appearing to depend on the range of activity areas and site types present;
- the complexity of the archaeological record is far greater than had previously been identified on the basis of surface recordings and limited test excavations. Intact knapping floors, backed blade manufacturing sites, heat treatment locations, a number of specialised tool types and generalised camp sites were all located;
- two Early Bondaian sites (between 5000 and 3000 before present) provide a context for some backed blade manufacture; and,
- gross site patterning is identifiable on the basis of environmental factors: sites on permanent water are more complex (i.e., they represent foci for larger groups or repeated use for smaller groups over a long period of time) than sites on ephemeral or temporary water lines.

The specific predictions of this model made by McDonald (1998:15-16) are that the size (density and complexity) of archaeological features will vary according to the permanence of water (i.e. stream order), landscape unit and proximity to lithic resources in the following way:

a. in the headwaters or upper tributaries (first order creeks) archaeological evidence will be sparse and represent little more than a background scatter;

b. in the middle reaches of tributaries (second order creeks) will be archaeological evidence for sparse but focused activity (i.e., one-off camp locations, single episode knapping floors);

c. in the lower reaches of tributaries creeks (third order creeks) will be archaeological evidence for more frequent occupation. This will include repeated occupation by small groups, knapping floors (perhaps used and reused) and evidence of more concentrated activities.

d. on major creek lines (fourth order) will be archaeological evidence for more permanent or repeated occupation. Sites will be complex and may even be stratified;

e. creek junctions may provide the loci for site activity; the size of the confluence (in terms of stream ranking nodes) could be expected to influence the size of the site;

f. ridge top locations between drainage lines will usually contain limited archaeological evidence although isolated knapping floors or other forms of one-off occupation may be in evidence in such a location;

- naturally outcropping silcrete will have been exploited and evidence for extraction activities (decortication, testing and limited knapping) would be found in such locations;
- sites in close proximity to an identified stone source would cover a range of size and cortex characteristics. As one moves away from the resource, the general size of artefacts in the assemblage should decrease, as should the percentage of cortex;
- On the margins of the shale plain, a further element can be added to this model. Where sandstone features occur (either overhangs or platforms) these may have provided a focus for a number of activities, either camping or art production (for the former) or the production / sharpening of axes (for the latter). Sandstone platforms have also been used for the production of art (i.e., engravings) although these are very rare on the margins of the Plain.

The above predictions have been directed towards identifying the surface distribution of artefactual material. However, the high level of archaeological excavation within the Cumberland Plain has enabled a more sophisticated understanding of the subsurface potential of the area. The archaeological works of the Rouse Hill Test Excavation Program (McDonald 1998:13) stated that of the 61 excavated sites containing subsurface materials, 17 had no visible artefacts on the surface prior to excavation. McDonald (1998:13) also identified that the ratio of recorded surface artefacts to excavated artefacts throughout the Cumberland Plain was 1:25. This indicates that subsurface materials may be in areas with no surface artefacts, and that subsurface deposits are likely to be more substantial than surface deposits. This also indicates that known sites are likely to contain a number of subsurface artefacts, and that surface materials may not characterise a site (McDonald, 1998:13).

For example, McDonald (2001b) conducted a salvage excavation of six occupation sites along four creek lines within the area, Second Ponds Creek, Cattai Creek, Smalls Creek and Caddies Creek. None of the areas had surface archaeological materials but they were previously identified as potential archaeological deposits (PADs). The excavation program recovered a total of 33,337 artefacts, from an area of 482m^2. Following this study, McDonald (2001b:ii) proposed that the earliest occupation of the Sydney region focused on the Hawkesbury-Nepean River and that this may have occurred as early as 20,000 years ago.

Archaeological excavations within the Cumberland Plain have also revealed a number of significant and/or older sites within the area. To date, the oldest known site within the area is c.7000 years ago (Dallas 1988 cited in Mills 2000: 9). Other sites have been dated at Plumpton Ridge (2500 years old), Second Ponds Creek (700 years old) and Quakers Hill (3500 years old) (see *ibid).* Although no Pleistocene dates (over 10,000 years) are known within the Cumberland Plains, sites within the Blue Mountains have been dated to c.20,000 years ago (see Mills 2000a: 9). It can be assumed that the Cumberland Plain was occupied by this time, if not earlier, and that the lack of dated Pleistocene sites within the Cumberland Plain has been attributed to the difficulties of dating older sites rather than the lack of occupation (Mills, 2000a: 9).

5.4.2 Archaeology of the Stage 2 Concept Study Area

A number of archaeological studies have been undertaken in areas adjacent to and within the Stage 2 study area. Dibden (2003a:16) provides a useful grouping of existing reports according to the type of landscape covered by the study. This classification of reports according to landscape is summarised in **Table 2 .**

Table 2: Previous Studies conducted adjacent to and within the Stage 2 Concept Study Area Grouped by Landscape.

Author/s	Year	Publication Title
McDonald, J. and Brayshaw, H.	1983	Archaeological survey of a proposed soil extraction site at Menangle Park (NPWS #568)
McDonald, J.	1990	Archaeological survey at Menangle Park NPWS #2038)
Corkhill, T. and Edgar, B.	1991	Archaeological investigation at sites Menangle Park1, Menangle Park2 and Menangle Park3. Menangle Park, NSW (NPWS#2149)
Knight and Kohen	2000	Archaeological survey of the proposed new extraction area - Racecourse Road, Menangle Park, NSW (NPWS#97942)
Dibden,J.	2002a	Glenlee Coal Bed Methane Project — Archaeological and Heritage Assessment
Dibden, J.	2002b	Glenlee Coal Bed Methane Project Stage 2 — Archaeological and Heritage Assessment at Glenlee, near Camden, New South Wales
Dibden, J.	2003a	Camden Gas Project Stage 2- Camden NSW Archaeological and Heritage Assessment
Dibden, J.	2003b	Camden Gas Project Stage 2. Five gas production well sites and associated gathering system, Menangle Park, NSW (NPWS#98667)
Lee and Somer	1999	A report on the archaeological assessment of Menangle and Menangle Park, Sydney Water Sewerage Scheme
Byrne, D.	1994	Archaeological Survey at Spring Farm, Elderslie, NSW.
McDonald, J.	1992	Archaeological survey at Spring Farm Camden.
Patterson Britton & Partners	2000	Spring Farm Urban Release Area Local Environmental Study
Dallas, M. and Irish, P.	2001	Aboriginal Archaeological assessment Spring Farm Urban Release Area
Godden Mackay Logan	2002a	Spring Farm Urban Release Area Heritage Assessment
Rich, E.	1985a	An Archaeological survey of proposed topsoil extraction part portion 17, Parish of Narellan, County of Cumberland.
Rich, E.	1985b	An Archaeological survey of proposed sand extraction Somerset Park Estate, Camden.
Baker, N.	1999	Local Environmental Study for Camden Council
Bonhomme, T.	1986	An assessment of archaeological sites at Narellan, near Campbelltown, NSW.
Corkhill, T.	1992	Survey for Aboriginal archaeological sites at Narellan Vale NSE.
Corkhill, T.	1994	Survey for Aboriginal archaeological sites at Mount Gilead, NSW.
Crew	1989	An archaeological survey of a proposed subdivision of Lot 204, Mt Annan, near Campbelltown, NSW
Dallas, M.	1985	An archaeological survey of Glen Alpine Campbelltown, NSW.

Author/s	Year	Publication Title
Dallas, M.	1986	Archaeological survey of the Land and Housing Corporation project 217 - St Helens Park south of Campbelltown, NSW
Heritage Concepts	2006	Aboriginal and Historic Cultural Heritage Assessment – MacArthur Substation, Menangle Park

Menangle Park

In 1990 an investigation was undertaken by McDonald (1990) covering the majority of the Menangle Park Urban Release Area east of the railway line. Two artefact scatters were found Menangle Park 1 (52-2-1597) and Menangle Park 2 (52-2-1598). Subsurface testing was recommended at these two locations and later reported on by Corkhill and Edgar (1991). McDonald (1990:5-8) reviewed the results of archaeological surveys and excavations to the north of the study area and the Cumberland Plain which demonstrated that subsurface deposits of archaeological material existed in landscapes comparable to the locations of Menangle Park 1 and Menangle Park 2. In the subsequent report by Corkhill and Edgar (1991) on the results of the subsurface testing it was shown that the predictions for buried deposits of archaeological material made by McDonald (1990) were correct.

Recent archaeological survey work by Dibden (2002a, 2002b, 2003a and 2003b) covered most of the current study area to cover proposed gas wells and gathering lines. When the surveys were undertaken these locations were pegged. In Section 5 Dibden (2003a:13) states "Gas well production sites were located in the field by flagged pegs. Pipeline routes were identified in the field by recourse to detailed photographic records supplied by Sydney Gas". Pegs demarcating well site locations were observed during the course of the current study. In addition to these areas Dibden (2003a:14) also inspected areas of exposure wherever feasible. A detailed listing of survey coverage and rates of exposure is provided in Appendix 1 of the 2003a report (Dibden 2003a: Appendix 1) and a discussion of effective survey coverage presented in Section 8.3. It is clear that like other surface surveys the effective coverage achieved during the survey was comparatively low (0.865% of the total survey area) (Dibden 2003a:50).

An Aboriginal heritage assessment was undertaken by HLA ENSR in relation to the Menangle Park Release Area in 2004. A total of 21 archaeological sites were identified during the course of the survey. All recorded sites in the study area are flaked stone artefact scatters and isolated finds of stone artefacts. Site distribution patterns according to terrain unit were recorded and are summarised in **Table 3 .**

Table 3: Site Distribution according to Terrain Unit - Menangle Park

Terrain Unit	Number of Sites	% of Sites	Number of Artefacts	% of Artefacts
Extremely Low Relief Slopes	10	45.5%	77	66.4%
Very Low Relief Slopes	7	31.8%	25	21.5%
Low Relief Slopes	5	22.7%	14	12.1%
Total	**22**		**116**	

While the coverage of the survey area was representative of all types of terrain the effectiveness of the survey was constrained by varying rates of exposure and groundcover. A strong relationship between exposure through human activities and subsequent erosion and artefact detection was observed, which according to HLA ENSR (2004), suggests that the results are biased towards opportunistic uncovering of buried archaeological material. This is a significant limitation on the discovery of site distribution patterns. Also of note was the absence of artefactual material in all stable landforms where human action has not exposed the lower parts of the A soil horizon. The possibility that buried material is more widespread than surface indications has important implications for the reliability of the known patterning of site distribution as an indicator of the actual dispersal of archaeological sites.

On the basis of this assessment, six zones were identified within the terrain units according to the probability of surface and/or subsurface archaeological material existing. A rating of high, moderate, low or nil archaeological sensitivity was assigned to each zone. These ratings reflect the division of the landscape into two sections upon which the predictive model of landscape sensitivity is based. Areas of high sensitivity are restricted to the accretionary context of the extremely low relief slopes of the Nepean River floodplain while the stable and eroding slopes of the very low and low relief slopes contain zones of moderate sensitivity. Areas of low and nil sensitivity reflect the impact of recent land use on sections of all three terrain units rather than the original distribution of archaeological material. To assist in the selection of areas for conservation, aerial photography was used to identify areas of restricted land use impact where the probability for buried potential archaeological deposits (PADs) is high.

Spring Farm
A large portion of the Spring Farm Urban Release Area was surveyed by Byrne (1994). Two open camp sites consisting of artefact scatters and one PAD were identified. As part of the Spring Farm Urban Release Area Local Environment Study (LES) (Patterson Britton & Partners, 2000) additional artefact scatters were identified as well as a scarred tree.

Throughout the Spring Farm Urban Release Area, archaeologically sensitive areas or landscapes have been identified based on their association with second order (or higher) streams, prominently elevated areas, and prominently elevated areas close to the river. Based on these criteria the following areas were identified as potentially sensitive in regard to Aboriginal sites in the Aboriginal archaeological study undertaken by AMBS (in Patterson Britton and Partners, 2000):

- The central Spring Creek banks;
- The south eastern elevated points overlooking the Nepean River;
- The vegetated banks of the Nepean River; and
- The crest just north of the Jacks Gully Waste Management Facility.

Several archaeological sites are known to exist in the vicinity of the subject site. These are outlined in **Table 4** .

Table 4: Site Distribution according to Terrain Unit - Spring Farm

Landform Group	Site Type
Spring Creek	Scarred Tree
Spring Creek	Artefact Scatter
Nepean River	Stone Artefact
Nepean River	Artefact Scatter
Nepean River	Artefact Scatter
Nepean River	Canoe Tree
Nepean River	Artefact Scatter

Landform Group	Site Type
Crest North of Jacks Gully	Artefact Scatter
Gully south of Gundungurra Reserve	Artefact Scatter

In addition to these sites, a PAD was identified as part of the LES study (Patterson Britton & Partners 2000). The PAD is located on an elevated spur of Nepean River alluvium to the east of the Spring Creek Dam. This area remains undisturbed and lies above flood-prone land along the river. It is considered to have moderate to high archaeological potential. All archaeological sites/items are located within relatively undisturbed areas, which are defined as archaeologically sensitive.

Generally it is considered that areas that have been subject to substantial sand mining activity or other activities associated with massive surface and subsurface disruption have no potential to contain significant undisturbed archaeological sites. In areas that have been partially mined or farmed, archaeological potential exists but at a lower scale. Sand mining activities particularly in the southern half of the Spring Farm area have resulted in significant disturbance to the study area.

Godden Mackay Logan (2002a) provided a review of the Patterson Britton & Partners LES (2000) to develop a statement of archaeological significance for the subject site. The study area and associated archaeological sites and potential sites are significant as;

> *"Given the depleted nature of the Aboriginal archaeological resource, the extant sites and areas of archaeological potential represent an important scientific resource in their ability to demonstrate local Aboriginal prehistory and occupation and resource use along the Nepean. The known sites and areas of potential archaeological deposit also represent an important resource to the local Aboriginal community in terms of their potential to demonstrate considerable length of occupation and continuing association with the area."*
>
> *(Godden Mackay Logan 2002a:51)*

Dallas and Irish (2001) provided a review of both the works of Byrne (1994) and AMBS (in Patterson Britton & Partners, 2000). Additional survey work revisited known archaeological sites and identified additional sites (all sites located within the study area are listed in **Table 4** above). The authors present a table of archaeological potential according to landscape unit, with attendant management recommendations (see **Table 5**).

Table 5: Archaeological potential according to terrain unit- Spring Farm

Landscape Unit	General description and Distribution in Study area	Archaeological Management Requirements
Flood Plain/ Alluvial Terrace	This area covers most of the southern portion of the study area and has been subjected to sand mining and extensive cultivation.	Survey/Test Excavation in unmined areas
River Bank /Major Creek Banks	Nepean River and Spring Creek.	Field survey prior to proposed works and site preservation and conservation.
Hillslope/ Minor Creek Lines	The low undulating hills covering the majority of the northern section of the study area, and the Spring Creek tributary creek lines.	Test Excavation

Landscape Unit	General description and Distribution in Study area	Archaeological Management Requirements
Gully	Jacks Gully.	Test Excavation
Ridgetop/Crests	Crests either side of Jacks Gully and low crests in the north and the east of the study area.	Test Excavation and site preservation and conservation.

Razorback
Dominic Steele Consulting Archaeology (2005*a*) conducted an Aboriginal heritage assessment for several well site locations in the Razorback area as part of the Stage 2 Camden Gas Project. Overall the majority of the Razorback area failed to reveal evidence of past Aboriginal occupation, owing to the poor nature of archaeological visibility across the study area.

A total of four archaeological sites and six isolated finds were recorded. All Aboriginal finds were flaked stone tools made from a variety of raw materials, including quartz, mudstone, tuff and silcrete. As was the case with the Menangle Park studies conducted by HLA ENSR (2004), the majority of identified finds have been located on the surfaces of existing tracks and/or other disturbed land forms. The majority of terrain investigated was located in disturbed contexts situated some distance to the south and west of the Nepean River.

Dominic Steele Consulting Archaeology (2005*a*) suggests that although areas away from the Nepean River (and along the margins of lesser water courses) may have been subject to frequent Aboriginal visitation, the lack of substantial archaeological deposits in these areas suggests any visits were likely to have been short term or transitory in nature. Sites located within the Razorback area are deemed unlikely to contain substantial and/or intact archaeological remains. Further, it is considered likely that archaeological material will consist of isolated and/or low density artefact scatters that will occur predominantly in disturbed contexts.

Elizabeth Macarthur Agricultural Institute
Dominic Steele Consulting Archaeology (2005*b*) also conducted an Aboriginal heritage assessment for several well site locations in the Elizabeth Macarthur Agricultural Institute (EMAI) area, located adjacent to the Razorback area. A total of eight open camp sites were identified, along with several isolated finds, a scar tree and a PAD. As with the Razorback area most of the recorded finds were located on the surfaces of existing tracks and/or other disturbed landforms. Similar to the conclusions drawn for the Razorback area, the majority of terrain investigated was composed of disturbed contexts situated some distance to the south and west of the Nepean River.

5.4.3 Known Aboriginal Sites in the Stage 2 Concept Study Area

HLA ENSR undertook a search of the AHIMS for all sites within a 20 km radius of the study area on 28 August 2006. This revealed a total of 136 previously recorded sites within the area. Approximately 78 % (106) of sites are defined as open camp sites comprising stone artefact scatters (AFT) or isolated finds. The few remaining archaeological site types are recorded as scar trees (TRE) (10.3% or 14 sites), potential archaeological deposits (PAD) (7.3 % or 10 sites), and rockshelter art and/or deposits (4.4% or 6 sites).

Within and in close proximity to the Stage 2 Concept Area itself 48 sites have been previously recorded and entered onto the AHIMS database. Site coordinates (GDA datum, transformed by algorithm from AGD) and types are presented in **Table 6** below *(NB: coordinates not included in accordance with Aboriginal community requests)*:

Table 6: Previously Identified Aboriginal sites within the Stage 2 Concept Area

Site I.D.	Locality	Site Features	Site Type
52-2-0911	Stage 2 Concept Area	AFT	Open Camp Site
52-2-0914	Spring Farm Project Area	AFT	Open Camp Site
52-2-0915	Spring Farm Project Area	AFT	Open Camp Site
52-2-0916	Spring Farm Project Area	AFT	Open Camp Site
52-2-0917	Spring Farm Project Area	AFT	Open Camp Site
52-2-0918	Spring Farm Project Area	AFT	Open Camp Site
52-2-1219	Stage 2 Concept Area	AFT	Open Camp Site
52-2-1597	Menangle Park Project Area	AFT	Open Camp Site
52-2-1598	Menangle Park Project Area	AFT	Open Camp Site
52-2-1607	Menangle Park Project Area	AFT	Open Camp Site
52-2-1887	Spring Farm Project Area	AFT	Open Camp Site
52-2-1888	Spring Farm Project Area	AFT	Open Camp Site
52-2-2116	Stage 2 Concept Area	AFT	Open Camp Site
52-2-2270	Spring Farm Project Area	AFT	Not provided
52-2-2271	Stage 2 Concept Area	AFT	Not provided
52-2-2272	Spring Farm Project Area	AFT	Not provided
52-2-2274	Menangle Park Project Area	AFT	Not provided
52-2-2275	Stage 2 Concept Area	AFT	Not provided
52-2-2276	Spring Farm Project Area	AFT	Not provided
52-2-2277	Menangle Park Project Area	AFT	Not provided
52-2-2278	Stage 2 Concept Area	AFT	Not provided
52-2-2279	Spring Farm Project Area	AFT	Not provided
52-2-2280	Menangle Park Project Area	AFT	Not provided
52-2-2281	Menangle Park Project Area	AFT,TRE	Not provided
52-2-2289	Menangle Park Project Area	AFT	Not provided
52-2-2338	Stage 2 Concept Area	PAD	Not provided
52-2-3045	Stage 2 Concept Area	AFT	Not provided
52-2-3046	Stage 2 Concept Area	AFT	Not provided
52-2-3047	Stage 2 Concept Area	AFT	Not provided
52-2-3048	Stage 2 Concept Area	AFT	Not provided
52-2-3049	Stage 2 Concept Area	AFT	Not provided
52-2-3050	Stage 2 Concept Area	AFT	Not provided
52-2-3057	Stage 2 Concept Area	AFT	Not provided
52-2-3058	Stage 2 Concept Area	AFT	Not provided
52-2-3059	Stage 2 Concept Area	AFT	Not provided
52-2-3060	Spring Farm Project Area	AFT	Not provided
52-2-3189	Spring Farm Project Area	AFT	Not provided

Site I.D.	Locality	Site Features	Site Type
52-2-3238	Spring Farm Project Area	TRE	Not provided
52-2-3239	Stage 2 Concept Area	AFT	Not provided
52-2-3240	Stage 2 Concept Area	TRE	Not provided
52-2-3255	Spring Farm Project Area	AFT	Not provided
52-2-3256	Spring Farm Project Area	AFT	Not provided
52-2-3257	Spring Farm Project Area	AFT	Not provided
52-2-3258	Spring Farm Project Area	AFT	Not provided
52-2-3260	Spring Farm Project Area	AFT	Not provided
52-2-3261	Spring Farm Project Area	AFT	Not provided
52-2-3262	Spring Farm Project Area	AFT	Not provided
52-2-3266	Spring Farm Project Area	PAD	Not provided

Not included on the database are 12 sites recorded at Menangle Park in 2004 (HLA 2004: 57ff). All are artefact scatters or isolated finds. In total therefore, 60 sites were known to exist, or have previously existed, in the Stage 2 Concept study area before the onset of the survey discussed in this report. Almost all are sites represented as stone artefactual material. The locations of previously recorded sites are illustrated in **Figure 2** and **Figure 3**.

Dominic Steele Consulting Archaeology undertook an archaeological survey of part of the Stage 2 study area in February 2007, after the completion of the HLA ENSR assessment presented in this report. This survey targeted proposed activity location at Menangle Park (MP24 and MP33) and Spring Farm (SF04 and SF04A). The survey found no evidence of Aboriginal archaeological sites in the inspected areas of either Menangle Park or Spring Farm, and concluded that "the likelihood for substantial and intact Aboriginal archaeological deposits to survive at each site was considered to be relatively unlikely" (Dominic Steele Consulting Archaeology 2007: 29). The report resulting from the Dominic Steele Consulting Archaeology survey is appended to this report as **Appendix A**.

More recently, a study undertaken by Heritage Concept (2006) in Menangle Park, not far from the proposed location of MP04, identified several heritage sites. Importantly for this study, several isolated finds, predominantly in erosion scars and upon vehicle tracks, were identified within the curtilage of a proposed substation to the west of the M5 and south of the Main Southern Railway. Subsequently, the report splits much of this area into three PADs, which encompasses parts of MP04 and the indicative access road options leading to it. Furthermore, isolated finds IF 1 and 2 are located in multiple locations depending upon the figure referenced in the document (see Heritage Concepts, 2007, Figures 6.1 and 6.2 for contrasting locations), some of which are in the 200m study area surveyed for MP04.

5.5 Results of Field Investigation

The archaeological field survey of the study area was conducted by Clayton Fredericksen (HLA ENSR), Glenda Chalker (CBNTC), and Donna Whillock (TLALC), accompanied by Aaron Clifton (AGL). On 26 and 27 October 2006 inspection was made of the Menangle Park area, and on 9 November 2006 the Spring Farm area was inspected. Dominic Steele Consulting Archaeology, the abovementioned groups and Tom Lawler of AGL completed further inspections on 2 February 2007. A subsequent visit was undertaken for two further gas gathering lines by Alan Williams (HLA ENSR), Glenda Chalker (CBNTC), and Donna Whillock (TLALC) was undertaken on 4 July 2007. The survey method is outlined in **Section 4.3**.

The location of all identified sites and artefact finds was recorded using a Garmin eTrex GPS and employing the MGA94 coordinate system. The use of a handheld GPS means an error of between approximately 4m and 8m in spatial accuracy must be expected. Site location was also facilitated by the use of large scale A3 aerial photographs (provided by AGL) of the Menangle Park and Spring Farm areas. The following notes were taken for each site:

- GPS coordinates and description of location;
- Site extent, measured by pacing and orientating using compass;
- Site condition (intact, eroding, disturbed);
- Artefact description (approximate size or size range of artefacts, type, lithology as estimated by eye observation of grain and colour); and
- Digital photography (location of photograph through GPS coordinates and orientation of photograph by compass bearing).

In line with DEC recommendations, the context of each site was also recorded. This took the form of observations of the local site environment and landscape condition. Special attention was given to factors which may have contributed to the observed status of the site, such as erosion through vegetation removal, stock grazing, farm track use, etc.

While the well surface locations were looked at in detail, the wider Stage 2 Concept Area was also considered during the field investigation to consider the types of landforms and areas archaeological sites may occur. Based on existing environmental information and the physical inspection, it was considered that sites routinely occurred upon elevated areas and major creek lines (typically second order or higher), with other low relief areas and lower order creeks having a lesser potential.

5.6 Sites Identified

The survey revealed 25 archaeological sites. Of these, four were probably recorded during earlier surveys. Discounting these four sites, the survey collected information on 21 previously unrecorded Aboriginal sites – 13 in the Spring Farm area and 8 in the Menangle Park area (**Figure 5** and **6**).

Table 7 and **Table 8** present information on the 21 Indigenous heritage sites located through the field investigations. Please note, as requested by the Aboriginal communities involved, no GPS co-ordinates of specific locations have been provided in this document. General locations have been shown in **Figures 5** and **6**, while specific locations have been provided to the Aboriginal communities and AGL separately to this document.

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Table 7: Spring Farm Sites located for Stage 2 of the CGP.

Site ID[3]	Site Type	Description	Potential Surface/Subsurface deposits
S1	Artefact scatter	Surface scatter of stone flakes on access track. In secondary context lying on subsoil. **Note that previously recorded AHIMS site, #52-2-3256, is located nearby**.	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)
S2	Isolated find	Single mudstone flake on surface of access track. In secondary context lying on subsoil. Spatially associated with the dispersed distribution that includes S3, S4, S5, S6 and S7.	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)
S3	Artefact scatter	Surface scatter of eight small quartz flakes and flaked pieces (none larger than 10mm) on access track. Scatter is 15m long in disturbed context. Spatially associated with the dispersed distribution that includes S2, S4, S5, S6 and S7. **Note that previously recorded AHIMS site, #52-2-3261, is located nearby**.	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)
S4	Artefact scatter	Dispersed scatter of three silcrete flakes spread across 6m of surface of access track. One piece is a transverse fractured blade segment. All pieces occur in disturbed context. Spatially associated with a dispersed distribution that includes S2, S3, S5, S6 and S7.	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)
S5	Isolated find	Two flakes (one chert and one silcrete) two metres apart on surface of access track in disturbed context. Spatially associated with a dispersed distribution that includes S2, S3, S4, S6 and S7.	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)
S6	Isolated find	One flaked piece with no diagnostic attributes. Material is silcrete and measures approximately 10x10mm. Present on surface of access track in secondary context. Spatially associated with a dispersed distribution that includes S2, S3, S4, S5 and S7.	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)

[3] Site ID refers to numbers that have been assigned to archaeological sites by the authors, and do not relate to the proposed well locations IDs.

Site ID[3]	Site Type	Description	Potential Surface/Subsurface deposits
S7	Isolated find	One flake of grey chert measuring approximately 10x10mm. Present on surface of access track in secondary context. Spatially associated with a dispersed distribution that includes S2, S3, S4, S5 and S6.	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)
S8	Artefact scatter	Scatter of flaked material on crest of prominent hill, approximately 10m from large wooden power pylons. Scatter is 2x5m in extent and consists of one chert flake (grey), one quartz flake, and four silcrete flakes (red). Flakes no larger than 15x15mm. The chert piece is a transversely snapped blade with possible unifacial retouch. Artefacts are eroding from the verge of the access track and in disturbed context. 10m east of the main scatter is a single exhausted core of silcrete, measuring 30x30mm. S8 is spatially associated with dispersed distribution that includes S9 and S10. **(Plate 1)**	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)
S9	Isolated find	Single silcrete flake measuring 30x30mm. Prominent bulb and striking platform; no retouch. Present on surface of track. Nearby on the track is a partially buried piece of silcrete potentially flaked. S9 is spatially associated with dispersed distribution that includes S8 and S10.	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)
S10	Isolated find	Single silcrete flake measuring 20x30mm. Distinct platform and negative scars on dorsal surface. Eroding from surface of access track. S10 is spatially associated with dispersed distribution that includes S8 and S9. **(Plate 2)**	Potential for other surface material within the vicinity. Intact subsurface deposits likely off the area of track disturbance (refer to **Section 7.1** for recommendations)
S11	Artefact scatter	Dispersed scatter of twelve quartz and silcrete flakes and flaked pieces over an area of approximately 10x10m. More flakes likely to be present. Scatter is present on a prominent erosion feature on the northern slope of a low ridge. No topsoil present and artefacts are lying on exposed subsoil in association with lateritic pebbles. **(Plates 3 and 4)**	High potential for more surface artefacts, and for subsurface material away from (particularly upslope of) the erosion feature (refer to **Section 7.1** for recommendations)
S12	Isolated find	Silcrete flaked piece located on surface of access track. No diagnostic attributes. Associated with track gravel and possibly re-deposited with the gravel. **(Plate 5)**	Low potential for surface or subsurface deposits
S13	Isolated find	Silcrete flaked piece located on surface of access track. No diagnostic attributes. Associated with track gravel and possibly redeposited with the gravel. Six metres south on track is a small quartz flaked piece. **(Plate 5)**	Low potential for surface or subsurface deposits

Table 8: Menangle Park Sites located for Stage 2 of the CGP.

Site ID	Site Type	Description	Potential Surface/Subsurface deposits
M1	Artefact scatter	Flakes and other artefacts over an area approximately 30x100m. Scatter is discontinuous, with occasional artefacts widely dispersed. Artefacts include chert and quartz flakes, hammerstone, chert core, and a flake from volcanic material. This area previously identified as a PAD extending approximately 300x1100m (HLA 2004). **The western end of the site previously recorded by HLA (2004) as artefact scatter MPRP8**. (**Plates 6** and **7**)	Very high potential for subsurface deposits. Site is on what appears to be consolidated sand that is eroding in places. Artefacts visible in erosion areas.
M2	Artefact scatter	Five flakes (two quartz and three silcrete) dispersed over an area of approximately 5m. The flakes are small (largest is 10x20mm) and visible eroding out of a farm track.	Flakes are probably in secondary context, having eroded from the upslope side of the track (approx 0.5m high and sloping). Above this scarp is a 20x30m level area, the possible original locality of this material. High potential for associated surface deposits in this area, given ongoing erosion from upslope.
M3	Artefact scatter	Six flaked pieces (one quartz flake, one silcrete flake, four quartz shatter). Pieces are small (no larger than 5 x 5mm) and visible eroding out of a farm track.	Pieces are probably in secondary context, having eroded from the upslope side of the track (approx 0.5m high and sloping). High potential for associated surface deposits in this area, given ongoing erosion from upslope.
M4	Isolated find	Isolated silcrete flake measuring approximately 10x20mm. This piece is elongated with a distinct striking platform. Visible in disturbed context on farm track with natural ironstone gravel.	Flake is in disturbed context, possibly introduced with track gravel but more likely eroded from the upslope side of the track. High potential for associated surface deposits in this area, given ongoing erosion from upslope.

Site ID	Site Type	Description	Potential Surface/Subsurface deposits
M5	Artefact scatter	Silcrete core (20x20mm) silcrete flake, and a quartz flake. Artefacts are eroding downslope toward access track. **(Plate 8)**	The artefacts are on the surface of the upslope verge of the track, formed when the track was cut down. Evidence of fluvial erosion with no A Horizon present. Artefacts probably derive from upslope on a level area adjacent to the track. In eroded context. Potential for other eroded surface deposits.
M6	Isolated find	Large grey fine-grained flake in association with rail ballast. Unlikely to have eroded onto track as here the track is level with surrounding land. Probably introduced with ballast. **(Plate 9)**	None
M7	Isolated find	Large grey fine-grained flake in association with rail ballast. Unlikely to have eroded onto track as here the track is level with surrounding land. Probably introduced with ballast.	None
M8	Artefact scatter	Seven flakes (six silcrete and one quartz) scattered along verge of access track for approximately 30m. Individual finds except four silcrete flakes which form a cluster. All pieces are lying on top of or embedded into clay subsoil horizon. Clearly in secondary depositional context. **Note that previously recorded AHIMS site, #52-2-2277, is located nearby**. **(Plate 10).**	The artefacts are on the surface of the upslope verge of the track, formed when the track was cut down. No A Horizon is present. Artefacts probably derive from upslope on a level area adjacent to the track. In eroded context. Potential for other eroded surface deposits.

Site detectability is influenced by surface visibility. In the study area this was variable. Along current farm tracks, proposed as future access ways, low or absent vegetation cover facilitated easy identification of sites **(Plate 5)**. However, easements on either side of access tracks and proposed gathering lines were often under ungrazed tussock and pasture, which limited the ability to survey for surface exposures in these areas **(Plate 11)**. High tussock and woodland vegetation also hindered ground visibility in places, notably in the area encompassing the proposed Menangle Park well surface locations MP21 and 23 and in the area around the proposed Spring Farm well surface location SF10 **(Plate 12)**. The survey would not have identified all surface sites within the development that were concealed by vegetation cover. It is perhaps no coincidence that the majority of sites recorded were identified in erosion features **(Plate 3)** and on existing tracks where the vegetation cover was absent or denuded **(Plate 1)**. The identified sites may therefore be interpreted as a sample of the range and density of archaeological material present at localities within the proposed development area.

5.7 Assessment of Archaeological Sensitivity

While the survey was restricted to pre-defined transect lines and well locations, the collected data supports the predictions made by previous investigators of the correlation between specific landscape features and site distribution, particularly in regard to the Menangle Park area. Here much of the northwest and south of the area has been identified as possessing high archaeological sensitivity (HLA 2004: Figure 9), land that includes medium to low elevation terrain along tributaries of the Nepean River. The newly recorded sites at Menangle Park cluster in the low lying and medium elevation terrain within some 500 m of tributaries. Here two site clusters can be identified in the vicinity of the MP19, MP21 and MP22 well surface locations; and near well surface locations MP02 and MP03 **(Figure 6)**. At Spring Farm the presence of medium elevation terrain in proximity to water also seems to be a major factor in site distribution. Two obvious concentrations of sites are apparent. One is in the area of SF10 on low land at the end of a ridge near a formerly watered area. The other is near the ridge crest overlooking former wetlands, between the SF17 and SF20 well surface locations.

Based on these findings and the wider archaeological literature of the Stage 2 Concept area, a relative assessment of archaeological sensitivity can be made for the Spring Farm and Menangle Park areas to be impacted by the gas gathering lines, well surface locations, and access roads, and more generally for the wider Stage 2 Concept area. Areas of archaeological sensitivity are identified below.

High Archaeological Sensitivity

- Stage 2 Concept Area:
  - all areas near major creek lines (second order or higher) and elevated areas, particularly those near creeks. Specific examples include areas near the Nepean River and its associated banks and nearby elevated areas, Central Springs Creek banks and the crest north of Jack's Gully Waste Management Facility;
- Spring Farm:
  - 1) low lying land around SF10, with identified sites S1, #52-2-3256, S2, S3, #52-2-3261, S4, S5, S6, S7, #52-2-3260, and #52-2-3238; and
  - 2) high ridge between SF17 and SF20, with identified sites S8, S9, and S10. In these locations, artefact densities appear to be high and, although layers present in disturbance of the access track and verge, there is a likelihood of undisturbed contexts nearby, especially near

ridge crests and level areas where erosion has not been so pronounced.

- Menangle Park:
  - areas encompassed by low lying and medium elevation land in the vicinity of MP19, MP21, and MP22 with identified sites M1/MPRP8, M2, M3, M4, M10, MPRP11, and #52-2-1598. This has been previously suggested as an area of high sensitivity and the presence of relatively undisturbed lowland deposits and level areas on medium elevation terrain within close proximity to a stream system point to high archaeological potential.

Moderate Archaeological Sensitivity

- Stage 2 Concept Area:
  - all areas found on first order creeks or erosion channels, and areas a reasonable distance from higher course creeks, such as the Nepean River;
- Spring Farm:
  - the area of proposed access route and gathering line that encompasses site S11. This land is low lying to medium elevation terrain presenting a low ridge between two lowlands, to the east and west. The potential for archaeological sites is relatively high although erosion is visible on ridge slopes. Sites are possibly not as intensively distributed as the area to the northwest, and identified above as highly sensitive.
- Menangle Park:
  - medium elevation terrain between well surface locations MP02 and MP03, with identified sites M5, M6, M7, and M8/#52-2-2277. Here there are scattered artefacts in disturbed contexts, possibly deriving from *in situ* deposits to the immediate north (upslope) of the access track, where the terrain is relatively level.

Low Archaeological Sensitivity

- Stage 2 Concept Area:
  - areas of substantial erosion, steep terrain, slopes, and previous natural or man-made impacts, including access roads, infrastructure services, and residential development[4];
- Spring Farm:
  - remaining areas investigated as part of this study, not outlined in the high and moderate sensitive areas above.
- Menangle Park:
  - remaining areas investigated as part of this study, not outlined in the high and moderate sensitive areas above, MP04, MP06, MP05, MP11, MP23, MP24, MP33.

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[4] While it is acknowledged that numerous sites are located upon existing impacts, this is largely due to good visibility and exposure rather than the site distribution. Furthermore, the archaeological integrity and sensitivity of these types of sites is considered low due to the substantial impacts that have occurred to the landscape in these areas.

6 POTENTIAL IMPACTS

6.1 Stage 2 Concept Approval

This report considers both the impacts of the Concept approval for Stage 2 and the Project approval for Spring Farm and Menangle Park. **Table 9** provides a summary of the wider generic impacts in relation to the installation of gas wells and associated infrastructure if the works proceed without any further mitigation measures.

The potential impacts to archaeological sites are outlined in some detail in **Table 9** and fall into four main activities - construction, production, post development activities, and closure and final rehabilitation. While all the activities have the potential to impact archaeological sites (if present), the first stage (construction), which typically involves the preparation and installation of drill pads, access roads and gas gathering lines, has the most potential to remove and/or destroy archaeological sites currently within the nominated well surface locations. Once an archaeological site has been disturbed or destroyed, subsequent activities in relation to heritage are largely irrelevant.

It must be noted, however, that existing farm tracks will typically be utilised where possible as access roads for the construction and maintenance of gathering lines and well surface locations. Artefacts have been recorded on these tracks in a state of disturbance from natural erosion and vehicle traffic. Use of existing tracks will not greatly further compromise the already disturbed archaeological integrity of these sites. On the other hand, if there is a requirement to widen or otherwise improve the traversability of these tracks, as might be required for heavy machinery egress, then there is a threat to potentially undisturbed deposits that might exist immediately beyond the present track boundaries. This is particularly a risk for those areas identified in this report as possessing high or moderate archaeological sensitivity.

Table 9: Generic Potential Impacts to Archaeological Sites based on Activities

Proposed Activity	Potential Impacts
• Construction (including preparation and construction of drill pads, access roads, and gas gathering lines); • Production (including operation, maintenance and access to the wells); • Post Development Activities (including upgrades and further installations); and • Closure and Final Rehabilitation (including removal of wells and associated equipment and earthworks)	Direct impact to archaeological sites through the movement of topsoil and subsoil during construction and rehabilitation of drill pads, access roads and gas gathering lines. Indirect or accidental impacts may also occur with the potential for equipment being located or placed outside the areas previously investigated.

6.2 Project Approvals

Based on the activities outlined in **Table 9** , it seems likely that any Aboriginal sites within the proposed impact areas have the potential to be destroyed unless mitigation measures are applied. Sites located on the periphery of the activities may be retained and/or un-impacted depending on the management systems put in place.

Without mitigation measures, the following sites may be impacted by construction, production, post development, and closure and final rehabilitation activities (**Figures 5** and **6**):

- Spring Farm
  - S1, #52-2-3256, S2, S4, S5, S6, S7, #52-2-3258, #52-2-3238, #52-2-3260, S9, S10, S11, S12 and S13.
- Menangle Park
  - M2, M3, M4, M5, M6, M7, M8, MPRP1, MPRP11, #52-2-2281, #52-2-2274.

This Indigenous Heritage Assessment has been undertaken using an 'envelope approach' whereby environmental impacts are assessed within a 50 m radius of the indicative well surface location within Spring Farm and within 100 m of the indicative well surface location for Menangle Park to establish the potential impacts of the proposed works within this broader area. Therefore, the final selected wellhead location could be anywhere within that 50 m or 100 m radius dependant upon environmental constraints. The flexibility of this approach would enable identified archaeological sites to be avoided during the project, which would minimise potential impacts.

6.2.1 Summary of Potential Sites Affected

Spring Farm Project Area

Table 11: Summary of Potential Impacts - Spring Farm Project Area

Development	Sites Potentially Impacted by Proposed Well Site Activities
SF10 and proposed gas gathering line and access road within well surface location study area	S1, #52-2-3256, S2, S4, S5, S6, S7, #52-2-3258
SF20 and proposed gas gathering line and access road within well surface location study area	S2, S4, S5, S6, S7, #52-32-3238, #52-2-3260, S8
SF17 and proposed gas gathering line and access road within well surface location study area	S9, S10
Gathering and Water Pipeline SF17 to existing system (GL02)	S11
Jacks Gully Waste Management Facility Road north to SF17	S12, S13,
SF04 and proposed gas gathering line and access road	No sites predicted to be impacted
SF04A and proposed gas gathering line and access road	No sites predicted to be impacted

Menangle Park Project Area

Table 12: Summary of Potential Impacts - Menangle Park Project Area

Development	Sites Potentially Impacted by Proposed Well Site Activities
MP02	M6, M7, M8, #52-2-2277
MP03	M5
MP04 and gas gathering lines to MP05	IF 1 and 2 (recorded by Heritage Concepts)
Access Road: MP04 to Glenlee Road	#52-2-2281, #52-2-2274
MP06	MPRP1
Access Road and Gas Gathering Pipeline: MP06 to MP05	MPRP1
Gas Gathering lines and acces roads: MP11 to MP19	M2, M3, M4, MPRP11
Access Road: MP33	#52-2-4597
Gas gathering lines along Glenlee Road East and Menangle Road, and MP 24 to the valve pit	No sites predicted to be impacted
MP05, MP11, MP22, MP23, and associated access roads and gas gathering lines (excluding those outlined above).	No sites predicted to be impacted
MP19	No sites predicted to be impacted

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7 MITIGATION MEASURES

This section provides mitigation measures for both the Concept Approval for Stage 2 and the Project Approval of Spring Farm and Menangle Park.

7.1 Concept Approval

The following measures are recommended for the Stage 2 Concept approval:

- For all proposed well surface locations, gas gathering lines and access roads, AGL should prepare and implement an Aboriginal Heritage Management Plan, in consultation with DECC and the relevant Aboriginal communities. The plan should be submitted to the Director-General prior to commencing construction works and include:
  - a detailed description of the measures that would be implemented for salvage, relocation or mapping of archaeological objects within the proposed development footprints: and
  - sections on the project background, environmental context and site setting, archaeological background, and management measures and protocols.

7.2 Project Approval

As outlined in **Section 6**, several Aboriginal sites have the potential to be impacted through the installation of well surface locations, gathering lines and access roads in Spring Farm and Menangle Park (**Figures 5** and **6**).

7.2.1 General

The following general recommendations are made:

- For all proposed well surface locations, gas gathering lines and access roads, AGL should prepare and implement an Aboriginal Heritage Management Plan, in consultation with DECC and the relevant Aboriginal communities. The plan should include:
  - a detailed description of the measures that would be implemented for salvage, relocation or mapping of archaeological objects within the proposed development footprints; and
  - sections on the project background, environmental context and site setting, archaeological background, and management measures and protocols.
- A statement for the protection of any Aboriginal skeletal remains uncovered during development should be placed in the Aboriginal Heritage Management Plan. Aboriginal skeletal remains are protected under the NPW Act and if remains are identified during development then all works must stop and contact with the NSW Police, DECC and the NSW Coroners Office immediately initiated. Management actions for any Aboriginal skeletal material should be developed in conjunction with DECC, the Aboriginal communities and trained archaeologists. Management options could include preservation *in situ*, or detailed excavation and recording followed by retrieval. In relation to the latter, consideration must be given to the ultimate location of the remains before they are retrieved.

- All contractors should be made aware of the Aboriginal Heritage Management Plan and associated safeguards prior to commencing site works.

7.2.2 Spring Farm Project Area

Table 10 provides specific mitigation measures for each of the proposed activities within Spring Farm.

Table 10: Spring Farm Mitigation Measures

Development	Archaeological Sites within the Study Area	Mitigation Measures
SF10 and proposed gas gathering line and access road	S1, #52-2-3256, S3, #52-2-3261, S2, S4, S5, S6, S7	All archaeological sites are located in the southwestern quadrant of the study area. While the proposed well surface location is not likely to impact the archaeological sites present, the construction footprint may. Therefore, the proposed construction footprint should be constrained to the northern and eastern sections of the study area. The proposed access road will currently impact S7. To avoid this impact, the access road should be moved north and eastwards of its current location. The proposed gas gathering line will also impact S7 and falls very close to S5 and S6. The gas gathering pipeline should be moved north and eastwards within the study area, if possible, from its present location. Given the density and proximity of archaeological sites within this study area, consideration should be given to fencing or identifying (through flagging, etc) prior to the proposed development. The Project would develop a Cultural Heritage Management Plan, which would outline the appropriate procedures for manoeuvring of gas gathering lines with respect to Cultural Heritage management. For example, where sites are identified either through the risk assessment and/or site visit, consideration should first be given to relocation of the well site and/or ancillary infrastructure to an area not identified as possessing Aboriginal heritage sites. Should this not be possible, mitigation of site damage or destruction should be undertaken. Mitigation measures should include the detailed recording, collection, excavation (if required), documenting and/or relocation of the site prior to any proposed impacts by a professional archaeologist in conjunction with Aboriginal community representatives.

Development	Archaeological Sites within the Study Area	Mitigation Measures
SF20 and proposed gas gathering line and access roads	S2, S4, S5, S6, S7, #52-32-3238, #52-2-3260, S8	Archaeological sites are present within the study area in the western, southern and southeastern quadrants. While the proposed well surface location is not likely to impact the archaeological sites present, the construction footprint may. Therefore, the proposed construction footprint should be constrained to the northern and eastern sections of the study area. The access road will currently impact S7, S8, S9, S10 and #52-2-3238. To avoid this impact, the east-west access road should be moved northwards of its current location, and the north-south access road should be moved westwards (between #52-2-3260 and #52-2-3238). The proposed gas gathering line will also impact S7 and potentially S8 and S9. The gas gathering pipeline should be moved north within the study area, if possible, of its present location to avoid these sites. Given the density and proximity of archaeological sites within this study area, consideration should be given to fencing or identifying (through flagging, etc) prior to the proposed development. The Project would develop a Cultural Heritage Management Plan, which would outline the appropriate procedures for manoeuvring of gas gathering lines with respect to Cultural Heritage management.
SF17 and proposed gas gathering line and access road	S9, S10	S9 and S10 are situated on the western edge of the study area upon the access track. Currently, the development of the well surface location should not impact these sites. Due to the potential for subsurface archaeological deposits in this location, the access track and gas gathering line should seek to use the existing access track, and fence off or flag S9 and S10 to ensure their conservation. The Project would develop a Cultural Heritage Management Plan, which would outline the appropriate procedures for manoeuvring of gas gathering lines with respect to Cultural Heritage management. Due to the land availability constraints to the north of the access track to avoid identified sites, the implementation of appropriate mitigation measures contained within the Cultural Heritage Management Plan would be considered appropriate.
Gathering and Water Pipeline to SF17 to existing gathering system	#52-2-0918, S11	S11 is unlikely to be impacted by the proposed development, but is within the buffer zones. Hence, in the location of S11, the activities should either be moved southwards, or the site should be made known to the construction team before activities occur in this area. #52-2-0918 is located upon the proposed access track. The track in this location should be moved southwards in this area.

Development	Archaeological Sites within the Study Area	Mitigation Measures
Jack Gully Waste Management Facility Road north to SF17	S12, S13	Currently, the proposed access road will impact S12 and S13. Both sites are disturbed isolated finds upon the access track. Given the disturbed nature of these sites, their removal should be considered, rather than the relocation of the track to undisturbed soil profiles nearby. These measures would be discussed with the Tharawal Local Aboriginal Land Council (TLALC) and Cubbitch Barta Native Title Claimants (CBNTC).
SF04 and proposed gas gathering line and access road	No sites predicted to be impacted	No archaeological requirements
SF04A and proposed gas gathering line and access road	No sites predicted to be impacted	No archaeological requirements

7.2.3 Menangle Park Project Area

Table 11 provides specific mitigation measures for each of the proposed activities within Menangle Park.

Table 11: Menangle Park Mitigation Measures

Development	Archaeological Sites within the Study Area	Mitigation Measures
MP02	M6, M7, M8, #52-2-2277	The proposed well location and gas gathering lines will currently impact M6, M7, M8 and #52-2-2277, all of which are situated in the centre and southwestern quadrant of the study area. The proposed access track currently has no heritage issues. To avoid impacting these sites, the well location (and associated construction zone) needs to be moved north and eastwards within the study area, if possible, of its present location. Alternatively, the appropriate mitigation of the four archaeological sites should be undertaken prior to the development. Based on the physical description of the sites (Table 8), mitigations are likely to be limited to surface collections. The Project would develop a Cultural Heritage Management Plan, which would outline the appropriate procedures for manoeuvring of gas gathering lines with respect to Cultural Heritage management
MP03	M5	M5 is currently located in the east quadrant of the study area, and will be impacted by the proposed gas gathering line, and potentially by the construction footprint. To avoid impacts, the gas gathering line should be moved northwards of its current location, and the construction footprint should be limited in its eastern extent. Fencing or flagging the site before development, should also be considered.

Development	Archaeological Sites within the Study Area	Mitigation Measures
MP04 and gas gathering lines to MP05	IF 1 and 2 (recorded by Heritage Concepts)	MP04 and gas gathering lines to MP05 would potentially impact upon IF 1 and 2 (as recorded by Heritage Concepts). Due to the unknown actions or timetable of potential test excavations in this vicinity, consultation with the landowner is required. Upon receipt of available information regarding the status of IF 1 and 2, appropriate mitigation measures would be outlined in the Cultural Heritage Management Plan.
Access Road: MP04 to Glenlee Road	#52-2-2281, #52-2-2274	#52-2-2281 is currently within the 25m area assessed for the proposed access road, while #52-2-2274 will be directly impacted through its construction. The extent of these sites (which were not investigated) is unknown, but based on conversations with the Aboriginal communities it is perceived to be extensive. In relation to #52-2-2281, the proposed route may occur unchanged, but the site would need to be identified (and potentially fenced off) to the construction team involved. #52-2-2274 will require the relocation of the road westwards to avoid impact. Regardless of these proposed mitigation measures, supervision of activities in this area should occur with appropriate salvage or route relocation occurring as necessary during reconstruction. The Project would develop a Cultural Heritage Management Plan, which would outline the appropriate procedures for manoeuvring of gas gathering lines with respect to Cultural Heritage management. As referred to previously, potential test excavations may occur in the vicinity of MP04 as a result of an indigenous assessment undertaken for an adjacent development (refer Heritage Concepts, 2006). Appropriate mitigation measures for this vicinity would be outlined in the Cultural Heritage Management Plan.
MP06	MPRP1	MPRP1 is located on the southeast edge of the study area. The site will not be impacted by the proposed gas well location or construction footprint.

Development	Archaeological Sites within the Study Area	Mitigation Measures
Access Road and Gas Gathering Pipeline: MP06 to MP05	MPRP1	MPRP1 is located adjacent the railway within MP06's study area. The site is within the buffer zone of both the proposed gas gathering line and access road in this location. At this stage, the site appears to be un-impacted by the proposed development, but is very close to both activities. To avoid impacting this site, consideration should be given to moving the gathering and access northwards (to bisect the well location directly). Alternatively, fencing off the site and advising the construction team of its presence during construction may suffice.
Gas Gathering Pipeline and access road: MP11 to MP19	M2, M3, M4, MPRP11	Four archaeological sites are currently located on the proposed gas gathering line and proposed access track between MP11 and MP19. All sites are disturbed low concentration artefact scatters or isolated finds, and consideration to salvaging them prior to development, rather than an alteration of the services into undisturbed areas should be given. Alternatively, the services should be moved either northwards or southwards of their current locations.
Access Road: MP33	#52-2-1597	#52-2-1597 is located outside the proposed access routes study area, but construction teams should be advised of the site prior to development.
Gas gathering lines between Glenlee Road East and Menangle Road, and MP 24 to the valve pit	No sites predicted to be impacted	No archaeological requirements
MP05, MP11, MP22, MP23, and associated access roads and gas gathering lines (excluding those outlined above).	No sites predicted to be impacted	No archaeological requirements
MP19	No sites predicted to be impacted	No archaeological requirements
Access Road: MP21 to 23	No sites predicted to be impacted	No archaeological requirements

8 CONCLUSION

The Indigenous Heritage assessment relates to the proposed works within Spring Farm Project Area and Menangle Park Project Area as well as the Stage 2 Concept Area. The works associated with the proposal, including the development of well surface locations, access roads, gas gathering lines and water transfer pipelines have the potential to impact Aboriginal sites within the Project Areas. However, the flexibility of the ‘envelope approach’ and the recommended Aboriginal Heritage Management Plan adopted for the proposed project discussed in **Section 6.2** enables Aboriginal sites and areas of archaeological sensitivity to be managed.

This Indigenous Heritage Assessment recommends that AGL prepare and implement an Aboriginal Heritage Management Plan, in consultation with DECC and the relevant Aboriginal communities, and to the satisfaction of the Director-General for affected well surface locations, gathering lines and access roads. This plan should be in a similar format and contain similar content of previous Plans undertaken by AGL at nearby EMAI and Razorback. Further management strategies and mitigation measures are provided in **Section 6.1** for the proposed well surface locations, gas gathering lines and access roads within the Stage 2 Concept Area.

The future development plans for Spring Farm and Menangle Park, including the approved DCP for Spring Farm, will affect these sites into the future, despite actions recommended in this report designed to manage and protect the sites identified and this needs due consideration.

The flexibility of the ‘envelope approach’ together with the implementation of appropriate mitigation measures as recommended in this report would minimise potential impacts to Indigenous heritage within the Concept and Project Areas such that there would be no impediment to the development of the CGP.

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Figures

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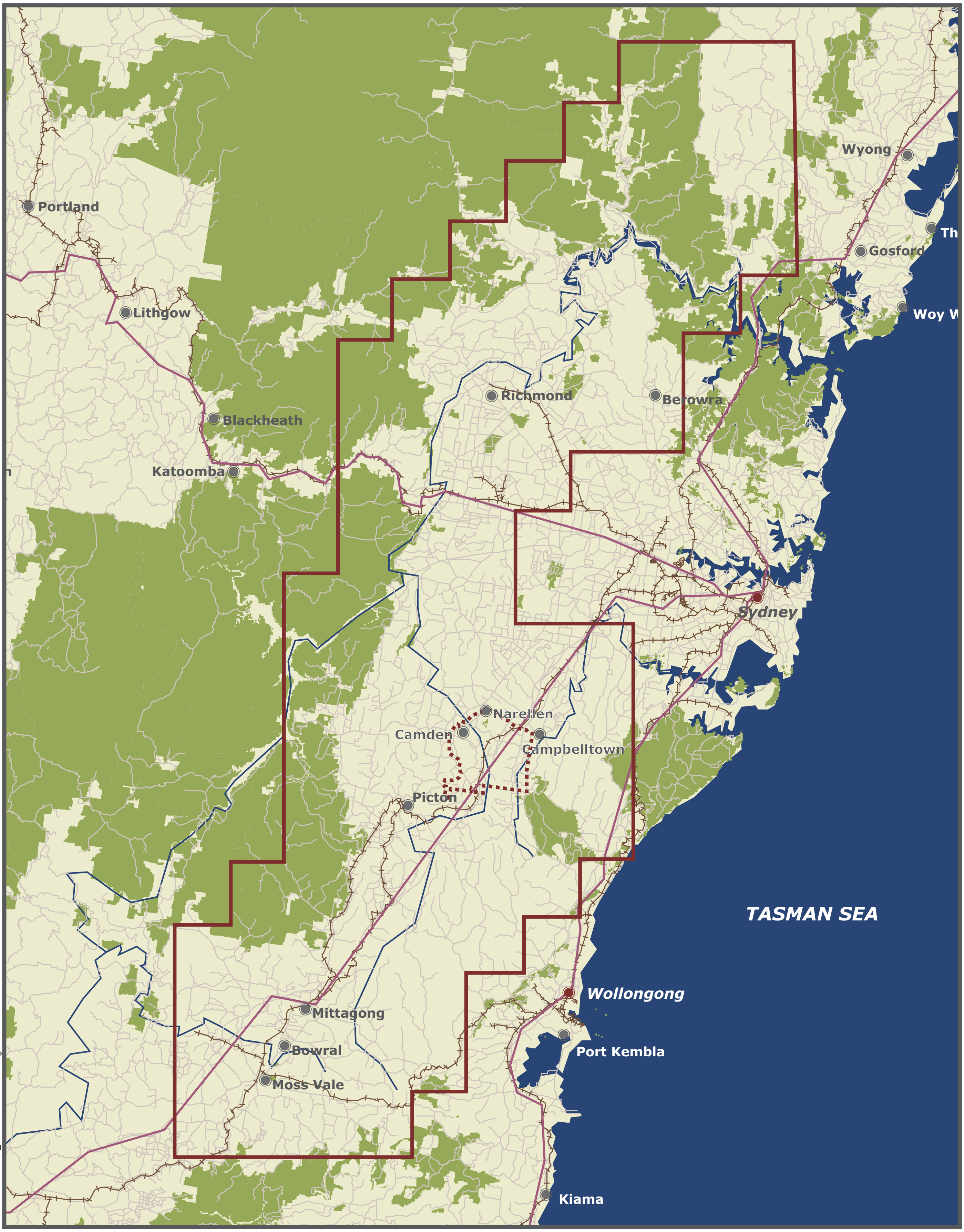

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- PEL Boundary
- Stage 2 Concept Area boundary
- Highway
- Road
- Rail
- River
- National Parks Estate

Figure 1

Stage 2 Concept Area Within PEL 2

Aboriginal Heritage Assessment -

Expansion of Stage 2 of the Camden Gas Project

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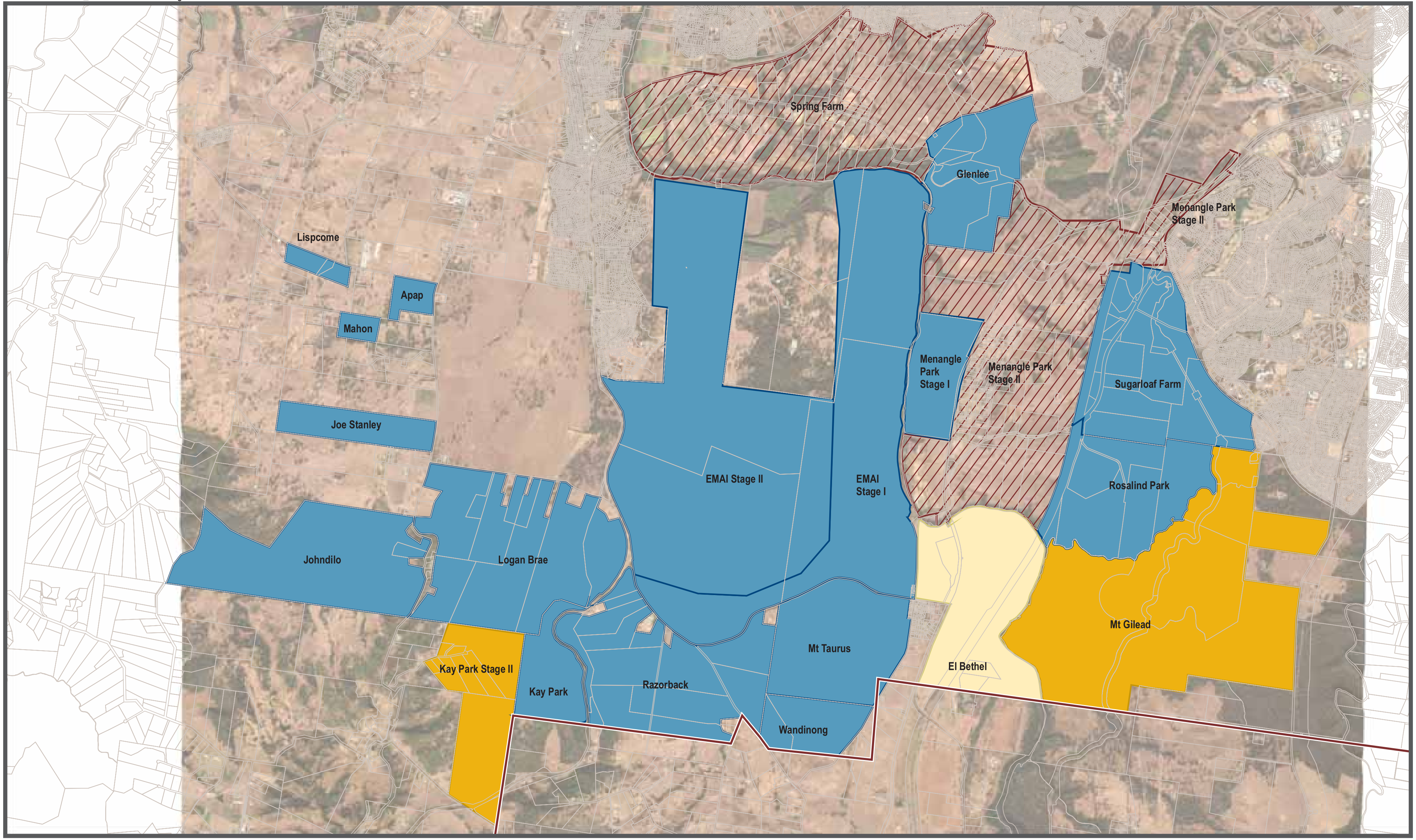

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0 2km

- BHP Billiton coal mining lease
- Drilled well field
- Future well fields within Stage 2 Area
- Approved not yet drilled well field
- Proposed Well Fields

Figure 2

Detailed View of Existing and Proposed Well Fields

Aboriginal Heritage Assessment -

Expansion of Stage 2 of the Camden Gas Project

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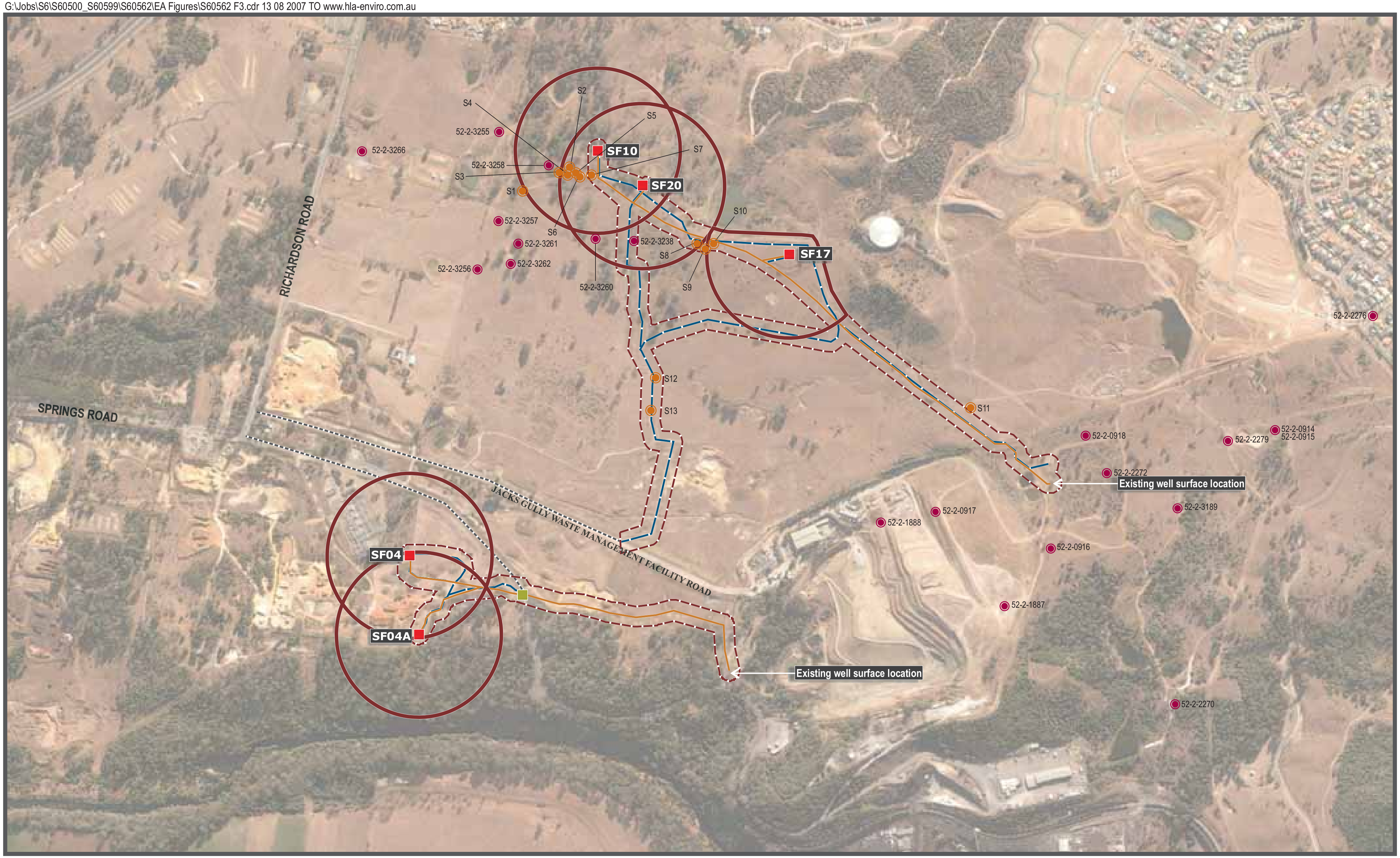

Well surface location assessment area
Infrastructure assessment corridor
Access road
Existing access road
Proposed gathering pipeline
Proposed well surface location
Gathering underbore location
Pre-recorded archaeological sites (November 2006)
Archaeological sites (November 2006)

AGL | HLA | Merged with ENSR in 2007

Figure 3

Location of Recorded AHIMS Sites and Identified Survey Sites - Spring Farm

Aboriginal Heritage Assessment -

Expansion of Stage 2 of the Camden Gas Project

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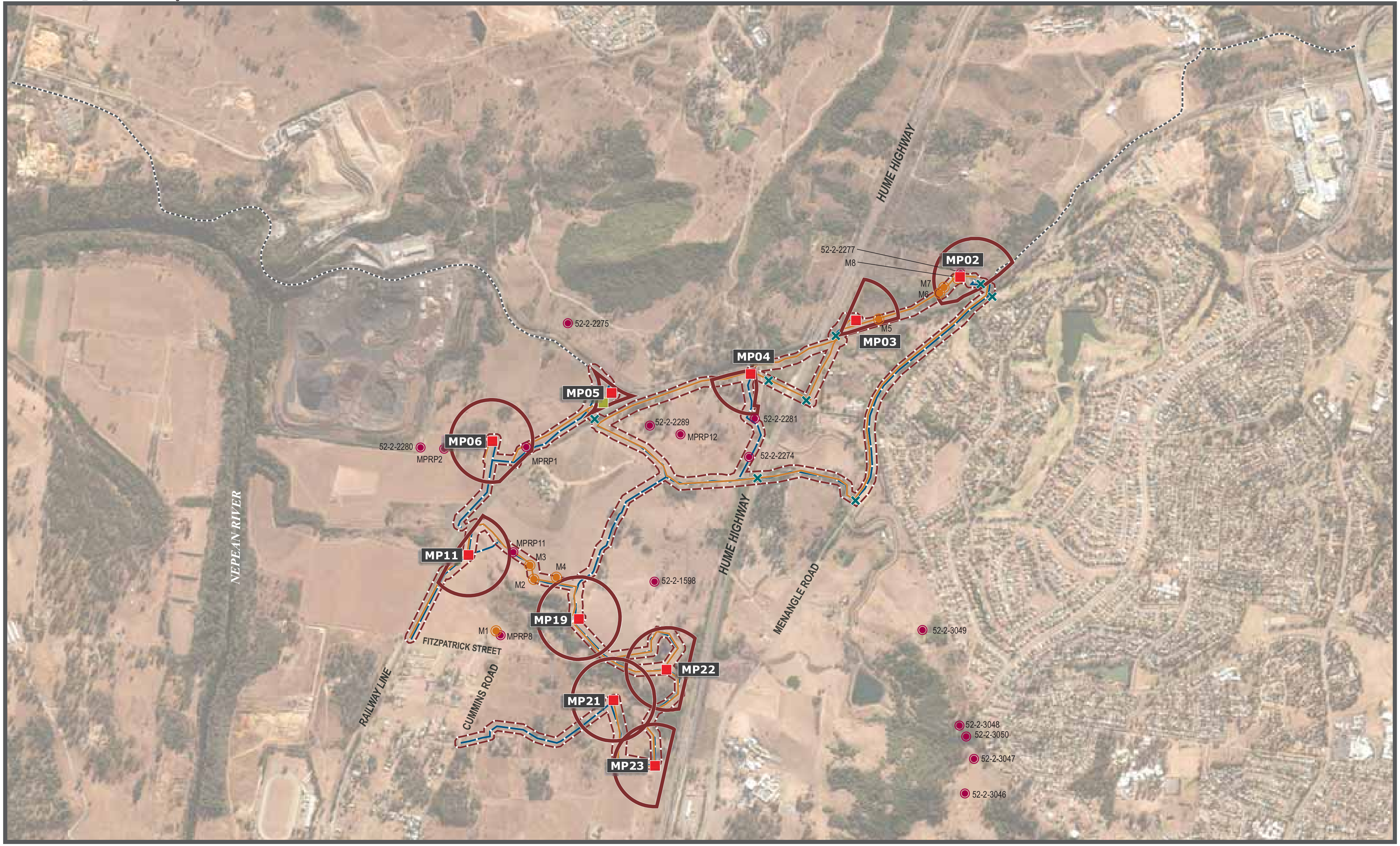

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Figure 4

Location of Recorded AHIMS Sites and Identified Survey Sites - Menangle Park (North)

Aboriginal Heritage Assessment -

Expansion of Stage 2 of the Camden Gas Project

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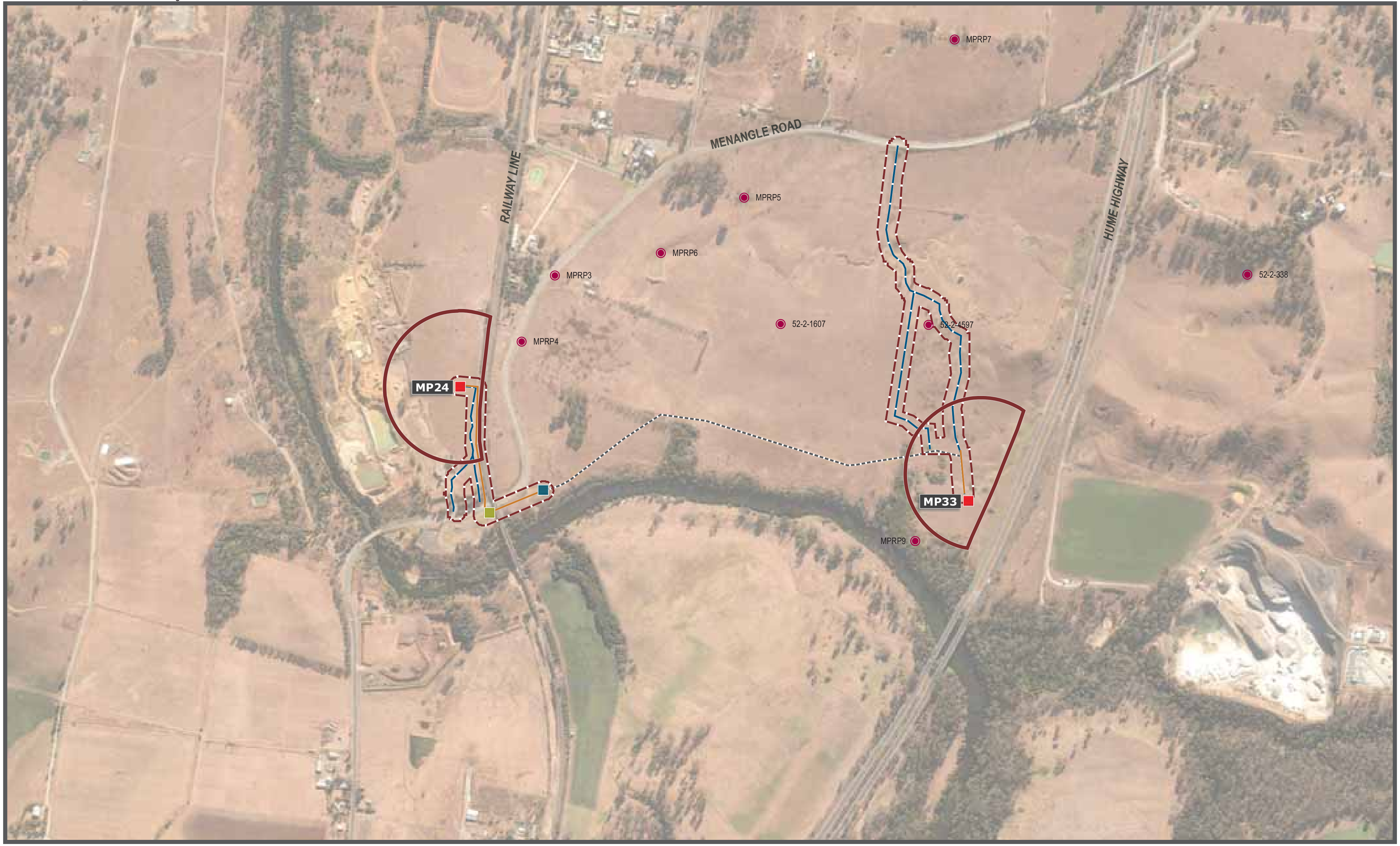

Merged with ENSR in 2007

0 400m

- Well surface location assessment area
- Infrastructure assessment corridor
- Access road
- Existing access road
- Proposed gathering pipeline
- Proposed well surface location
- Gathering underbore location
- Existing valve pit
- Pre-recorded archaeological sites (November 2006)

Figure 5

Location of Recorded AHIMS Site - Menangle Park (South)

Aboriginal Heritage Assessment -

Expansion of Stage 2 of the Camden Gas Project

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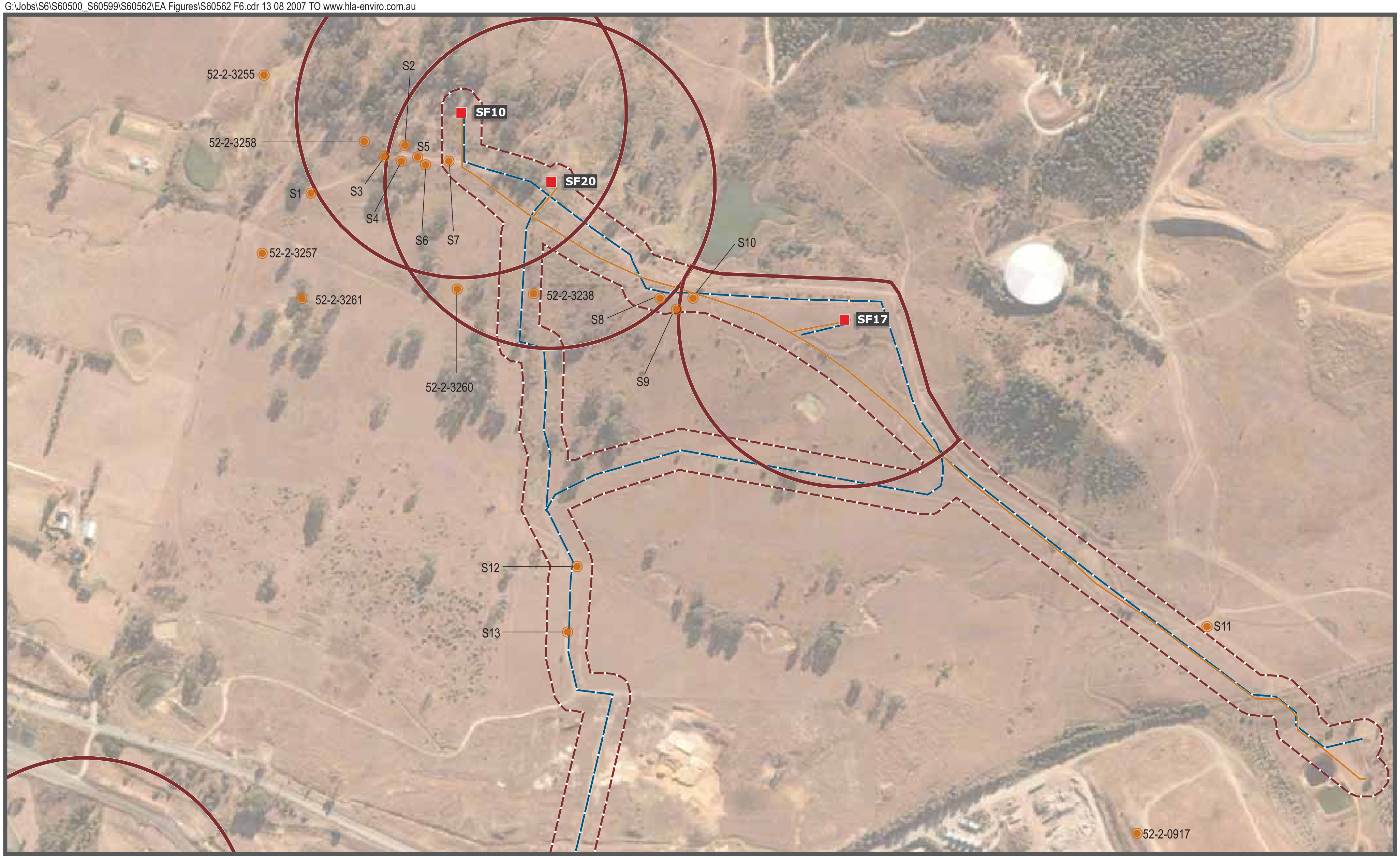

Merged with ENSR in 2007

0 400m

Well surface location assessment area
Infrastructure assessment corridor
Access road
Existing access road
Proposed gathering pipeline
Proposed well surface location
Archaeological sites likely to be impacted

Figure 6

Archaeological Sites within Construction or Production Areas - Spring Farm

Aboriginal Heritage Assessment -

Expansion of Stage 2 of the Camden Gas Project

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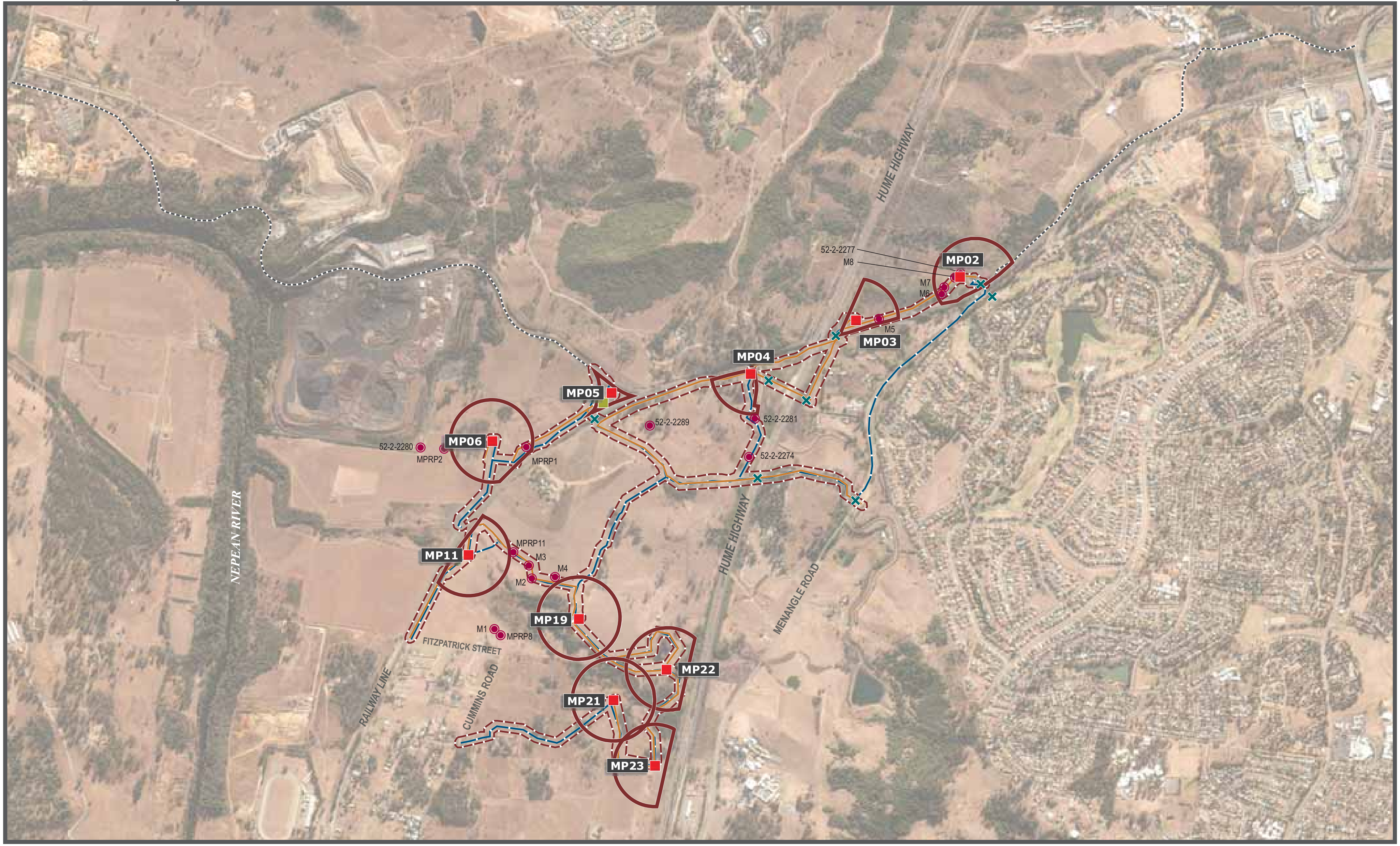

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Figure 7

Archaeological Sites within Construction or Production Areas - Menangle Park (North)

Aboriginal Heritage Assessment -

Expansion of Stage 2 of the Camden Gas Project

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AGL | HLA Merged with ENSR in 2007

0 200m

- Well surface location assessment area
- Infrastructure assessment corridor
- Access road
- Proposed gathering pipeline
- Proposed well surface location
- Gathering underbore location
- Existing valve pit
- Archaeological sites likely to be impacted

Figure 8

Archaeological Sites within Construction or Production Areas - Menangle Park (South)

Aboriginal Heritage Assessment -
Expansion of Stage 2 of the Camden Gas Project

Plates

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Plate 1: Site S8, looking east. Note vegetation cover either side of farm track

Plate 2: Site S10, silcrete flake

Plate 3: Site S11, on western side of ridge looking to the east

Plate 4: Site S11, flaked chert pieces

Plate 5: Proposed Central Access Track looking to the southeast

Plate 6: Site M1 looking to the southeast across previously identified PAD

Plate 7: Hammerstone on surface of M1

Plate 8: Site M5, silcrete core and quartz flake

Plate 9: Site M6, possibly flaked stone imported with road ballast

Plate 10: Site M8, quartz flaked piece embedded in subsoil

Plate 11: View to the northwest in vicinity of Site S11 (visible as eroded patch in centre of picture), showing route of proposed gathering line this side of fenceline

Plate 12: Proposed Well Surface Location SF10

Appendix A: Aboriginal Cultural Heritage Survey and Assessment Report Spring Farm and Menangle Park Project Areas, by Dominic Steele Consulting Archaeology, 2007

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REPORT CONTENTS

REPORT CONTENTS CONT)

1.0 Introduction

1.1 Background

AGL Gas Production (Camden) Pty Limited and *Sydney Gas (Camden) Operations Pty Limited* are currently in a joint venture arrangement known as the *Camden Gas Project Joint Venture – Stage II* (CGPJV – Stage II) extracting coal-bed methane gas from the Illawarra Coal Measures that underlie a series of properties that surround the Township of Menangle in the Camden region of New South Wales. Located approximately 60km to the south west of Sydney, the general location of the study area is illustrated in **Figure 1**

Operational gas fields in Camden include those at Menangle Park and Spring Farm that are situated approximately 3km to the north and 7km to the north-west of the Menangle Township respectively.

The Development Proponents (CGPJV) are presently seeking approval to establish two new gas production wells, access roads and gas gathering systems at Menangle Park (coded MP24 and MP34/33), along with two new wells, gathering lines and access routes at Spring Farm (coded SF04 and SF04A) for the delivery of additional gas to the Rosalind Park Gas Plant. The preferred locations of these proposed activity areas are illustrated in **Figure 2** and **Figure 3** respectively, and are described below.

This report presents the results of an *Aboriginal Cultural Heritage Survey and Assessment* program that has been completed for the proposal in partnership with the *Tharawal Local Aboriginal Land Council* and the *Cubbitch Barta Native Title Claimants Aboriginal Corporation*, and has been prepared to ensure future works do not have an adverse impact upon the Aboriginal cultural heritage values of the lands concerned.

1.2 The Proposal

1.2.1 Introduction

The proposed works at the locations illustrated in **Figures 2** and **3** will require a variety of activities to be completed over a series of consecutive construction stages. Each of these phases will result in varying levels of disturbance that have the potential to impact upon previously documented and/or as yet undetected Aboriginal archaeological sites, objects and areas of possible Aboriginal cultural heritage sensitivity.

The nature and scope of future works proposed to be implemented at Menangle Park and Spring Farm are described below.

1.2.2 Proposed Well Sites

The proposed new well sites at Menangle Park and Spring Farm are to be located within previously cleared paddocks that have long histories of pasture improvement and ongoing use for a range of agricultural activities that include vegetation clearance, animal grazing and soil tilling. The wells, gathering lines and access routes at Spring Farm are also proposed to be sited within land that has been subject to extensive excavation and grading works in recent years associated with the operation of an adjacent waste management facility.

The four proposed well site locations have been selected from a consideration of a number of environmental factors including landform, topography, and subsurface geology. As described below, the preferred well sites are to be located in previously disturbed areas in order to reduce future disturbance to existing landforms, and a number of these sites therefore as a result retain limited Aboriginal archaeological potential.

The proposed well sites will each occupy an area measuring approximately 70m by 100m, and will include a drill pit measuring up to 25m by 25m (that would be excavated to a depth of approximately 2m) for the purposes of retaining drilling cuttings and associated water.

The well sites would initially be fenced to define the precise area of operations, and would be subsequently reduced in size when the required construction works at the well-head are completed at a time where there remained only the need to secure the operational components of the facility.

At the completion of future drilling at the locations indicated in **Figures 2** and **3**, necessary surface infrastructure at the well-heads would be installed, after which time the sites would be rehabilitated and the area of the fenced enclosures would be subsequently reduced as per previous gas extraction projects completed in the Camden region.

1.2.3 Proposed Gas Gathering Systems

The proposed gas gathering systems for the Menangle Park and Spring Farm projects would comprise the creation of additional low pressure networks of polyethylene pipes to connect the new production wells to existing gathering lines for the delivery of gas to the Rosalind Park Gas Plant. These works would variously entail a combination of the following:

- Excavation of narrow trenches for the installation of pipes generally extending to a depth of between 0.75m to 1.0m below existing ground levels.
- Where practicable, the preferred alignments would follow existing (and disturbed) road surfaces (particularly at SF04, SF04A and MP24), road verges and property boundaries (along fence lines etc) that retain limited subsurface integrity as a result of past grading works and ongoing impacts from vehicle traffic.
- Excavation would be undertaken via machine, and pipe diameters at the well sites would generally range between 90mm and 110mm. Where pipes approach main trunk lines, needed pipe diameters would be within the order of 160mm to 315mm.

1.2.4 Proposed Access Roads

Preferred access routes to the proposed well sites would generally follow pre-existing graded and unsealed vehicle access tracks and sealed roads, and their future use during construction phases would therefore result in limited impacts.

1.3 Statutory Protection for Aboriginal Cultural Heritage

1.3.1 Introduction

Two principal pieces of legislation provide automatic statutory protection for Aboriginal heritage and the requirements for its management in New South Wales. These are the *National Parks and Wildlife Act* (NPWS Act) of 1974, and the *Environmental Planning and Assessment Act* (EP&A Act of 1979).

The implications of these statutory provisions within the context of the current project (particularly NPWS Act) are reviewed below.

1.3.2 NPWS Act 1974

The *National Parks & Wildlife Act* (1974) provides statutory protection for all Aboriginal 'objects' (consisting of any material evidence of the Aboriginal occupation of NSW) under Section 90 of the Act, and for 'Aboriginal Places' (areas of cultural significance to the Aboriginal community) under Section 84. Aboriginal objects are afforded automatic statutory protection in NSW whereby it is an offence to:

> *'damage, deface or destroy Aboriginal sites without the prior consent of the Director-General of the National Parks and Wildlife Service' (*now the DEC*).*

The Act defines an Aboriginal 'object' as:

> *'any deposit, object or material evidence (not being a handicraft for sale) relating to indigenous and non-European habitation of the area that comprises New South Wales, being habitation before or concurrent with the occupation of that area by persons of non-Aboriginal European extraction, and includes Aboriginal remains'.*

The protection provided to Aboriginal objects applies irrespective of the level of their significance or issues of land tenure. However, areas are only gazetted as Aboriginal Places if the Minister is satisfied that sufficient evidence exists to demonstrate that the location was and/or is, of special significance to Aboriginal culture.

1.3.3 EP&A Act 1979

In contrast with the NPWS Act, the EP&A Act is designed more specifically to cater for heritage issues within the context of new development projects and is closely linked with the process of preparing environmental impact studies. This act has three main parts of direct relevance to Aboriginal cultural heritage. Namely, Part III which governs the preparation of planning instruments, Part IV which relates to development assessment process for local government (consent) authorities and Part V which relates to activity approvals by governing (determining) authorities.

Part III deals primarily with development planning in which sites and places sacred or significant to Aboriginal communities are to be assessed and are to be taken into consideration in initial studies. Guidelines are available on the preparation of planning instruments such as *State Environmental Planning Policies* (SEPP's, REPs and LEPs) that explicitly list Aboriginal sites and places of significance as values which should be assessed as part of initial planning studies.

Part IV deals with decisions to be made within the context of development applications. The *Department of Environment & Conservation* is an approving body under Part V of the EP&A Act and will require formal consideration of a variety of cultural and community factors. These may variously include potential impact to significant anthropological, archaeological, cultural and historical values, and these will typically be addressed through a *Review of Environmental Factors* (REF).

1.3.4 Implications for the Current Project

Damage, destruction or removal of any Aboriginal 'places' or 'objects' is only permitted where a Permit or Consent has been issued by the Director-General of the DEC according to Sections 87 and 90 of the *NSW National Parks & Wildlife Act 1974* (as amended).

NPWS Permits and Consents are only granted where sufficient information is supplied in written form to the Director-General of the DEC from Aboriginal stakeholders, archaeologists and developers that demonstrate accuracy and transparency in the site assessment process and the good faith intended by each of these parties in applying for consent to either move, disturb and/or destroy statutorily protected objects. Best practice advocates that development impact to documented and/or potential sites of Aboriginal cultural heritage sensitivity be avoided where practicable and/or mitigated at the minimum, and that all decisions made for either course of action be made consequent to direct guidance provided by Aboriginal stakeholders.

1.4 Report Objectives & Scope

The objectives of this study have been to provide an *Aboriginal Cultural Heritage Survey and Assessment* of the locations illustrated in **Figures 2** and **3** that may be affected by the future Menangle Park and Spring Farm gas extraction projects as detailed in **Section 1.2** and described further in **Section 5.0**.

1.4.1 Aboriginal Community Consultation

- To maintain active consultation throughout the course of the two projects with the *Tharawal Local Aboriginal Land Council* (TLALC) and the *Cubbitch Barta Native Title Claimants Aboriginal Corporation* (CBNTCAC).
- Aboriginal community liaison for the broader Camden Gas Stage II Project (of which this study forms an ongoing component) was initiated by *Sydney Gas Limited* at an early stage of the planning process in 2002 and 2003. This included a program of public notification and consultation being completed according to current DEC consultation guideline requirements in February 2005.

- To incorporate into the assessment process of the proposed works in the locations illustrated in **Figures 2** and **3** the views, possible concerns, and recommendations provided by the TLALC and the CBNTCAC.

1.4.2 Background Research and Assessment

- To undertake background research into the location and nature of any previously recorded Aboriginal archaeological sites that may be present either within the boundaries of the proposed activity areas illustrated in **Figures 2** and **3** and/or in the immediate vicinity.
- From this targeted archaeological review, to prepare a predictive model describing the archaeological sensitivity of the proposed activity locations and to assess the potential for unrecorded Aboriginal sites or objects to occur within the locations that may be affected by future works (see **Section 1.2**).

1.4.3 Field Inspection and Recording

- To undertake an archaeological survey of the proposed activity areas in partnership with the TLALC and the CBNTCAC.
- To identify and record any Aboriginal archaeological sites or objects that may be located during the field survey and to assess their significance.

1.4.4 Analysis, Assessment and Reporting

- To report on the outcomes of the consultation undertaken with the TLALC and the CBNTCAC for the Menangle Park and Spring Farm projects, the results of the field survey, and to prepare an Aboriginal archaeological assessment for the proposals that meets the requirements of the *NSW NPWS Aboriginal Cultural Heritage Standards & Guidelines Kit* (September 1997).
- To provide appropriate management options and recommendations for the mitigation of future impacts to any documented Aboriginal sites that may be located during the survey in particular, and to guide the management of the potential archaeological resource that may be identified in general relative to the works proposed for the Menangle Park and Spring Farm projects.

1.5 Aboriginal Community Consultation and Site Inspection

An ongoing program of Aboriginal community consultation, archaeological survey, assessment and reporting for the broader Camden Gas Stage II Project (of which the proposed works outlined above form a part) has been undertaken in partnership with the *Tharawal Local Aboriginal Land Council* (TLALC) and the *Cubbitch Barta Native Title Claimants Aboriginal Corporation* (CBNTCAC) since 2001.

Liaison for the Stage II Project was first initiated at the preliminary planning stage in 2001 by *Sydney Gas Operations Pty Limited.* The Aboriginal community consultation subsequently included a process of public notification completed according to the requirements of the DEC *Interim Community Consultation Requirements for Applicants* guidelines introduced in January 2005 when the current works were confirmed by the Development Proponents.

No additional Aboriginal community groups beyond the TLALC and the CBNTCAC registered an interest in being involved in the consultation/assessment process for the project at that time (February 2005), and no additional response from any other Aboriginal community organisation have been received to the present by the Development Proponents.

Following confirmation of the project specifications that are the subject of this report between October 2006 and January 2007, Dominic Steele of *Dominic Steele Consulting Archaeology* (DSCA) contacted the TLALC and the CBNTCAC and the nature and scope of the proposed works were discussed.

Representatives of DSCA subsequently undertook a series of targeted field surveys of the proposed activity locations at Menangle Park (MP24 and MP33/34) and Spring Farm (SF04 and SF04A) on the 2nd of February 2007 in association with the TLALC (represented by Mrs Donna Whillock) and the CBNTCAC (represented by Mrs Glenda Chalker).

These field inspections were also attended by a representative of *AGL Gas Production (Camden) Pty Limited* who assisted in providing on-the-ground advice about the nature and location of the proposed works at each location.

The draft results of the February 2007 field survey, along with the conclusions and recommendations documented in this report, were duly forwarded to the TLALC and the CBNTCAC for review and comment at the completion of the fieldwork.

The TLALC and CBNTAC have indicated in principle support for the findings, conclusions and recommendations documented in this report and will shortly forward their respective *Aboriginal Cultural Heritage Statements* for the proposal to the Development Proponent for inclusion into this document (see **Appendix 1** and **2**).

1.6 Report Structure

This report presents the following:

- An introduction to the Menangle Park and Spring Farm Projects (**Section 1.0**).
- A description of the environmental context of the two study areas including their geology, topography, vegetation and soils. This information has been adapted from a number of previous studies completed to date in the local landscape as detailed in **Section 8.0** of this report.
- A review of previous Aboriginal archaeological studies undertaken in the local landscape, and a prediction of the types of archaeological evidence that may be present within the boundaries of the proposed Menangle Park and Spring Farm activity areas (**Section 3.0**).

- The methods employed to survey and record each of the proposed activity areas that are the subject of this report (**Section 4.0**).
- A review of the observations recorded during the site survey completed for Menangle Park and Spring Farm in February 2007, and the results of the field inspections for each locality (**Section 5.0**).
- A discussion of the results and conclusions that have been developed for the two projects and an evaluation of the Aboriginal archaeological sensitivity of each of the proposed activity areas. This is presented in the form of a *Statement of Heritage Impact* (**Section 6.0**).
- The provision of Aboriginal archaeological management recommendations and advice relative to the specific Menangle Park and Spring Farm locations outlined above (**Section 7.0**).
- References cited in this report (**Section 8.0**).
- Supporting documentation including copies of the *Aboriginal Cultural Heritage Statements* prepared by the *Tharawal Local Aboriginal Land Council* and the *Cubbitch Barta Native Title Claimants Aboriginal Corporation* for the projects to be forwarded shortly to the Development Proponent (see **Appendices 1** and **2**).

1.7 Authorship & Acknowledgements

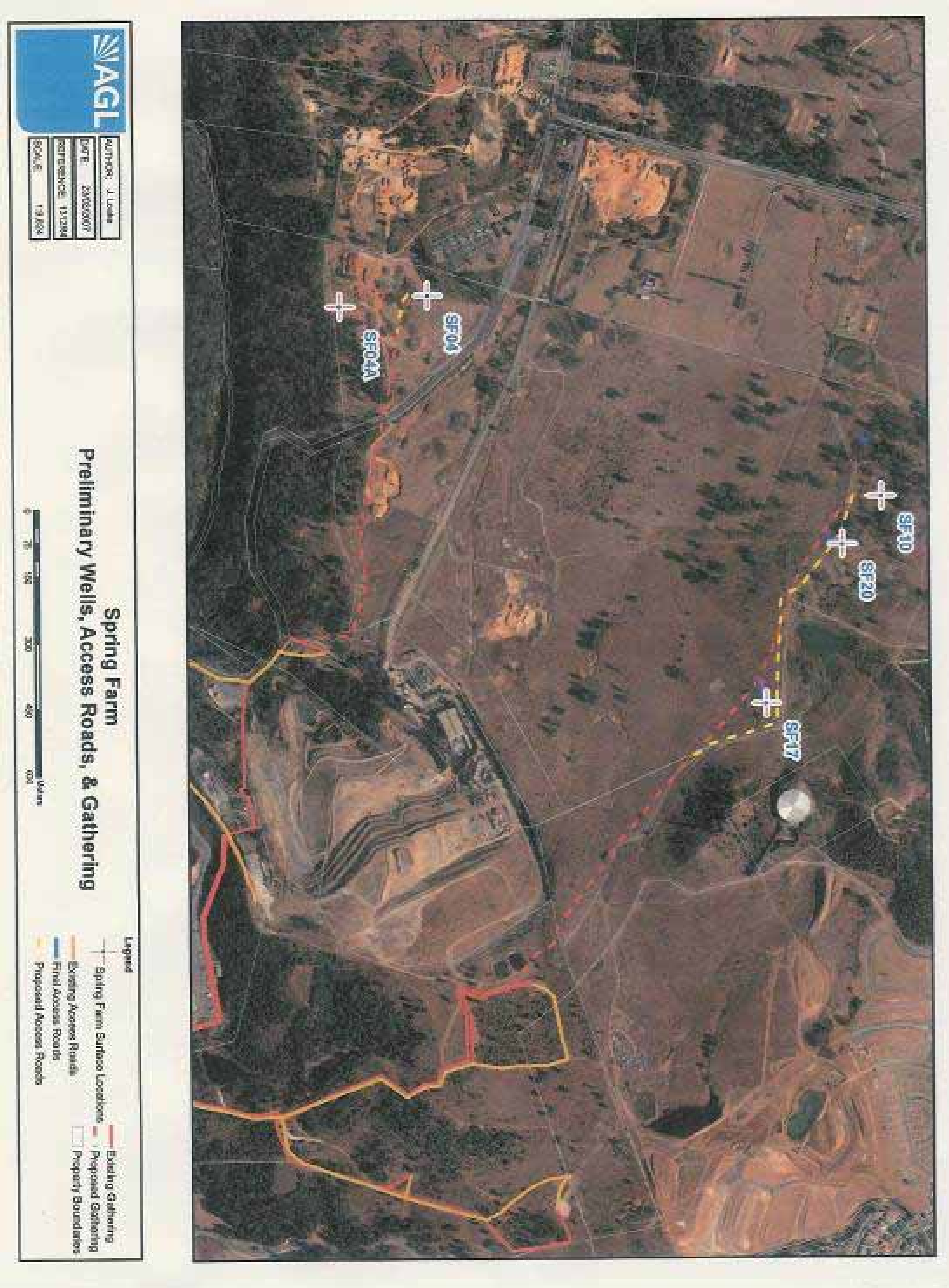
This *Aboriginal Cultural Heritage Survey and Assessment* has been prepared by Dominic Steele of *Dominic Steele Consulting Archaeology* (DSCA) with valuable assistance provided by the following individuals and organisations.

Mrs Glenda Chalker	*Cubbitch Barta Native Title Claimants Aboriginal Corporation*
Mrs Donna Whillock	*Tharawal Local Aboriginal Land Council*
Mr Tom Lawler	*AGL Gas Production (Camden) Pty Limited*
Ms Caroline Wilby	*Dominic Steele Consulting Archaeology*

Figure 1: General Location of the Study Area at Menangle, Camden, NSW.

Figure 2: Menangle Park (MP24 & MP34/33): Proposed Gas Well Locations, Access Route Options, and Gas Gathering Line Alignments.

Figure 3: Spring Farm (SF04 & SF04A): Proposed Gas Wells Locations, Access Route Options, and Gathering Line Alignments.



2.0 Environmental Background

2.1 Introduction

Ongoing archaeological research in the Camden region demonstrates the pre-Contact environment influenced not only the availability of resources to Aboriginal people in the past, but strongly determines what types of archaeological sites are likely to be located (and/or survive) when land is inspected to assess potential Aboriginal archaeological sensitivity in contemporary development circumstances.

- The distribution and availability of resources (such as drinking water, plant and animal foods, raw materials of stone used for artefact manufacture, and wood and vegetable fibres used for other tool production and maintenance needs) are all influenced by the nature of soils, the composition of vegetation cover, and other climactic characteristics including temperature and rainfall.
- The location of different site-types (such as open campsites, scarred trees, axe grinding grooves and engravings etc) are also influenced by the above factors, along with a range of other associated features which are specific to different land-systems and bedrock geologies.
- The nature and extent to which a given parcel of land has been subject to impacts as a consequence of post-Contact land use practices will define what types of Aboriginal archaeological evidence is likely to survive.

Assessing the environmental context of a study region is therefore an important procedure necessary for understanding potential past Aboriginal land use practices and/or predicting archaeological site distribution patterns. The information presented below is considered pertinent to the assessment of archaeological potential, site visibility, and likely levels of disturbance within the context of the current study.

2.2 Resources Available to People in the Past

Prior to the impacts European settlement had on the pre-Contact Aboriginal population and their traditional land use practices in the Camden region, Aboriginal material culture appeared to have included a wide range of items related to subsistence, cultural and social activities, and materials utilised for the creation of shelter.

Items documented in the region (see for example Atkinson 1998) to have been created and used by Aboriginal people include bark huts, spears, spear-throwers, shields, waddy/clubs, boomerangs, digging sticks, containers, animal skin cloaks, stone heat retainers, ground-edge axe/hatchet heads and flaked stone tools.

Prior to timber felling, vegetation clearance, agriculture and development in the local landscape, it is likely that a variety of edible or otherwise useful plants would have been present within the vicinity of the current study area inclusive of the flowers, nectar, fruits and leaf-bases of many plants and shrubs which are edible when collected at certain times of the year and/or when they are suitably processed. Fibres for string bags and fishing lines are likely to have been procured from the inner bark of various shrubs and trees including Kurrajong and Grass Tree. The latter was also likely to have been employed for gum extraction and adhesive, and the fabrication of spear shafts from the dried stem. Likewise, Tea Tree bark is recorded to have been used to make containers, while the bark of other trees is also recorded to have been employed in the construction of semi-permanent shelters and/or dwellings.

The range of food types exploited by Aboriginal people in the local region was also diverse and included resources sought from riverine, swamp, forest and undulating upland and plain environments. Kangaroos and wallabies, along with a range of smaller mammals (such as possums), would have been exploited by Aboriginal people in the region where and when these food resources were available in the past. Fish, reptiles, and birds are also likely to have contributed to the diet. Our understanding of these activities is however limited.

Finally, archaeological evidence indicates that Aboriginal people exploited in the past a wide range of stone raw materials including quartz, quartzite, mudstone and chert for the production of flaked stone artefacts. Additional raw materials of stone such as silcrete and metamorphic materials (for the production of ground stone implements such as axe heads, adzes and chisel blades) were also sourced from a variety of localities (such as Plumpton Ridge and the Nepean River) that in the former case are likely to have been transported/traded over considerable distances.

2.3 Geology, Topography, Vegetation and Soils

The surface geology of the study area (above the underlying Illawarra Coal Measures) comprises predominantly of shale units, inclusive of claystone, laminites, and sandstones of the Wianamatta Group. Otherwise, the local landscape comprises Quaternary alluvial deposits of silt, sand and clay (particularly along the margins of the Nepean River).

Soil landscapes in the Camden area reflect the underlying geology which is predominantly shale (Hazelton and Tille 1990). Local soils include those of the erosional Luddenham group that are present on the undulating to rolling hills and ridges that occur throughout the Wianamatta Shales and are often associated with occasional outcrops of Minchinbury Sandstone. These are generally shallow earthy clays on hill slopes, and moderately deep red and yellow podzolic soils on upper and lower slopes.

Prior to European settlement and occupation, two main vegetation communities would have dominated the Wianamatta Shales and podzolic soils of the study region. These would have consisted of *Grey Box Woodland* and *Grey Box-Ironbark Woodland* as outlined below (see Bannerman & Hazelton 1990 and Benson 1981 etc).

The Camden region has a long history of agricultural, urban residential and industrial land use. The majority of the original timber and associated under-storey vegetation on the properties that are the subject of this report has now been cleared. Ground cover in each of the locations inspected during the current field surveys was found to consist in the main of low pasture grasses that occur across various cleared agricultural paddocks.

The hydrology of the local landscape is dominated by the presence of the meandering alignment of the Nepean River. A number of other watercourses are also present within the local landscape including tributaries of Navigation, Menangle and Foot Onslow Creeks that are likely to have represented semi-permanent drinking-water points prior to European impacts that have now resulted in their filling and/or alteration of natural flows from damming and other agricultural/residential construction works.

3.0 Archaeological Context

3.1 Local Archaeological Context

3.1.1 Background Research

Background research into archaeological investigations previously completed in the local region was undertaken prior to the commencement of the current survey and assessment program. This included the completion of the following tasks:

- A review of previous studies completed for the local Camden/Menangle landscape to develop an understanding of the documented and potential Aboriginal cultural heritage sensitivity of the proposed activity areas at Menangle Park and Spring Farm illustrated in **Figures 2** and **3**.
- A review of information held on the DEC *Aboriginal Heritage Information Management System* (AHIMS) *Sites Register* for the two properties.

The combined results of this background review indicated that:

- A number of Aboriginal archaeological sites (largely comprising low-density distributions of flaked stone artefacts) and/or isolated finds had been located during previous studies within the vicinity of the proposed activity areas as assessed and reported in this report.
- No previously documented Aboriginal archaeological sites/objects however would be affected by the proposed works at Menangle Park and Spring Farm as illustrated in the locations identified in **Figures 2** and **3**.
- The majority of past Aboriginal heritage investigations in the local landscape had involved surface surveys only. Few controlled sub-surface archaeological excavations had been completed to date in the broader Camden/Menangle area that could be used to refine existing Aboriginal land-use/site predictive models available for the place.
- This outcome was considered to be pertinent to the assessment of the potential Aboriginal archaeological sensitivity of the proposed Menangle Park and Spring Farm activity areas, and would be highlighted as part of the current study.

3.1.2 Previous Archaeological Research

The principal findings of previous archaeological studies undertaken in the local region (and knowledge gaps) are outlined below. This review provides the basis for a site prediction model and assessment of potential archaeological sensitivity for the current proposal Menangle Park and Spring Farm locations that are presented in the following sections of this report. This summary considers:

- Previous Aboriginal cultural heritage investigations undertaken adjacent to the Nepean River in the local landscape.
- Previous Aboriginal cultural heritage investigations undertaken in hill slope and other landscape contexts adjoining the Nepean River within the Camden/Menangle area.
- The results of previous controlled archaeological excavations undertaken within the local Camden/Menangle landscape.

Archaeological Investigations of the Nepean River Banks and Alluvial Terraces

The majority of studies of the alluvial terraces and associated areas adjacent to the floodplain of the Nepean River in the Camden/Menangle area have been completed within sand and soil extraction contexts, and all have involved surface survey only. No controlled subsurface archaeological excavations have been completed at this time in these landforms in the local area.

Few Aboriginal archaeological sites have been identified by these studies and it is likely that this outcome is the result of a number of inter-related processes. These include:

- Poor ground visibility conditions encountered during the surveys.
- The possibility that pre-existing Aboriginal sites may have been removed and/or buried by alluvium as a result of repeated flooding episodes.
- The destruction of Aboriginal archaeological remains has occurred from past/ongoing sand extraction activities.

To illustrate this point, Byrne (1987) reported as part of research conducted within several locations on the alluvial terraces situated on the western side of the Nepean (within the context of the *Camden Park Conservation Plan*) that:

> *'…sand and soil extraction in this area of the Elizabeth Macarthur Agricultural Institute had removed the land surface to a depth of 3 metres and to a distance from the river of between 100-300 metres. He failed to locate archaeological material in this denuded landform. The Cubbitch Barta Native Title Claimants Corporation conducted a survey of the Elizabeth Macarthur Agricultural Institute property in 2000. No sites were found on alluvial terraces associated with the Nepean River corridor, however several small artefact scatters were located within the floodplain which extends from the river along Navigation Creek (as quoted in Dibden 2004b:10)'.*

Other studies have however reported the location of Aboriginal archaeological sites and/or the identification of areas of potential Aboriginal heritage sensitivity in these landforms despite ongoing land use impacts.

In summary: Our current understanding of how Aboriginal people may have used the banks, flats and terraces of the Nepean River, and how archaeological evidence may occur and/or survive in these landforms is still limited and requires further consideration.

Archaeological Investigations of the Hill Slopes adjoining the Nepean River Corridor

Past archaeological investigations in the hills and slopes which adjoin the Nepean River corridor in the local Camden/Menangle landscape include those by Byrne (1987), Corkill & Edgar (1991), Corkill (1994 and 1995), Dibden (2000, 2001a, 2002d-e, 2003, and 2004a-d), Kinhill (1988), Steele (2005a-c) and McDonald (1990). The principal results of these studies are summarised below.

- McDonald (1990) identified two low-density open camp sites (Menangle Park 1 & 2) during a survey of 300 ha of low hill-slopes incised by intermittent creeks at Menangle Park. The sites were located on a ridgeline and beside a minor watercourse respectively. A third site (Menangle Park 3) was located nearby on the same ridgeline by Corkill and Edgar (1991) during subsurface testing, and both Menangle Park 2 and 3 were subsequently reported to be highly disturbed and to comprise sparse numbers of unmodified silcrete flakes.
- A survey of an area to the south of Mt Gilead (Corkill 1994) identified 3 open artefact scatters, three isolated finds and two areas of PAD. An additional survey of a hilltop and hill-slopes at the headwaters of Menangle Creek to the south of Mt Gilead (Corkill 1995) failed to identify any sites, but one area of PAD was reported.
- A survey of the then proposed Camden Valley development at Cawdor (Kinhill 1988) and Ray Beddoe Gas Treatment Plant (Dibden 2000) failed to locate any sites and the areas were assessed to possess low archaeological sensitivity.
- Investigations of ephemeral creek lines in the local landscape (see for example Dibden 2001a, 2002d-e) located a small number of low-density (and often disturbed) artefact scatters and isolated finds. Each of these sites were considered to represent 'one-off' camping events where limited tool maintenance activities occurred. The artefact scatters were generally located on elevated landforms in close proximity to water sources, whilst the isolated finds were located across a range of landforms as a background distribution.
- Additional surveys of the Elizabeth Macarthur Agricultural Institute and Razorback properties (see for example Steele 2005b-c) revealed similar results to the studies summarised above with low-density scatters and isolated finds being the most common type of archaeological evidence recorded with a few notable exceptions.

In summary: The results of previous archaeological surveys undertaken in hill-slope contexts in the local landscape have revealed a low-density background scatter of stone artefacts to occur in most landform contexts. Sites located adjacent to ephemeral watercourse are typically small and contain low artefact numbers. However, there is likely to be variations in site size, with larger sites occurring near permanent water sources where suitable flat topography occurs.

Previous Archaeological Excavations in the Menangle Area River/Creek Contexts

The closest controlled archaeological excavations completed to date near the proposed activity locations assessed in this report consist of those at Menangle Park (Menangle Park 2 and 3) reported by Corkill & Edgar (1991) and Mt Taurus (MT3 and MT6) reported by Dibden (2004b). The outcomes of these investigations are summarised below.

- Excavation of Menangle Park 2 investigated a sloping landform located approximately 30m from a minor creekline (2nd order). Six artefacts were recovered from a total excavation area of 5.25m sq. Investigation of Menangle Park 3 sampled a flattish crest located between 80m and 100m from the Nepean River and a 2nd order creek. Seven artefacts were recovered from a total excavation area of 2.3m sq. In combination, items of silcrete dominate the limited assemblages revealed at these sites, although small numbers of quartzite and chert/indurated mudstone were also identified (Corkill & Edgar 1991).
- Sites MT3 and MT6 are located on an alluvial grassed flat located within the drainage depression of the 3rd order Foot Onslow Creek. The distance of the excavations ranged from between 30m and 60m of the watercourse. A total of 25 artefacts were recovered from a 10m sq area with an average density of 2.5 artefacts per sq m. Silcrete followed by quartz were found to be dominant raw materials in the collection (Dibden 2004b).

In summary: The predominance of silcrete and the relatively small artefact numbers recovered from the above sites is broadly typical of the results reported for other investigations in the local landscape. It would appear that creek slopes and flats situated in valley bottom contexts, and away from reliable water near to 3rd order watercourses in the local Menangle area are likely to predominantly contain sparse artefact distributions.

3.1.3 An Aboriginal Land use Model for the Projects

McDonald (JMCHM 1996) refers to the similarity between an Aboriginal occupation model proposed for the Camden area by Haglund (1989) and trends evident elsewhere on the Cumberland Plain where archaeological research has been more extensive and focused. A predictive model for Aboriginal site distribution on the northern Cumberland Plain developed by JMCHM (1999:19-21) may be applicable to the current study area but remains to be rigorously tested at this time. Namely:

I) The size (density and complexity) of archaeological features will vary according to permanence of water (ascending stream order), landscape unit and proximity to stone resources in the following way:

- In the headwaters of upper tributaries (first order creeks) archaeological evidence will be sparse and will comprise little more than background scatters.
- In the middle reaches of minor tributaries (second order creeks) archaeological evidence for sparse but focused activity (eg. one-off camp locations, single episode knapping floors) will be expected.
- In the lower reaches of tributary creeks (third order creeks) archaeological evidence for more frequent occupation will be expected. This will include repeated occupation

by small groups, knapping floors (perhaps used and re-used), and evidence of more concentrated activities.

- On major creek-lines (fourth order) and rivers (such as the Nepean) archaeological evidence for more permanent or repeated occupation will be evident. Sites will be complex and may even be stratified.
- Creek junctions may provide foci for site activity; the size of the confluence (in terms of stream ranking nodes) could be expected to influence the size of the site.
- Ridge-top locations between drainage lines will usually contain limited archaeological evidence although isolated knapping floors or other forms of one-off occupation may be in evidence in such a location.

II) Naturally outcropping silcrete (and other raw materials suitable for artefact manufacture) will have been exploited by Aboriginal people in the past and evidence for extraction activities (de-cortication, testing and limited knapping) would be found in such locations. It is possible that silcrete may occur naturally on the southern Cumberland Plain, but all of the known sources occur further to the north (Corkill 1999), the nearest known being at Luddenham. It is likely that small quartz pebbles that occur in the sandstones and conglomerates which underlie much of the local region will have been used by Aboriginal people. Sources of other raw materials such as tuff, indurated mudstone and chert in the region remain unknown at present.

III) Sites in close proximity to an identified stone source would cover a range of size and cortex characteristics. As one moves away from the resource, the general size of the artefacts in the assemblage should decrease, as should the percentage of cortex.

IV) Most sites on the Cumberland Plain have been dated to the late Holocene and it has been argued (Kohen 1986) that most date to the last 1,000 to 1,500 years. There is increasing evidence (eg. Attenbrow 1987, McDonald & Rich 1993) that dates obtained from shelter sites around the Sydney region are comparable to those available for stone tool assemblages from the Plain. It is reasonable to assume that occupation of this area commenced by c14,000 years ago (Kohen 1986), and continued until the arrival of white settlers. Most sites however will date to the last 3,000 years. It is unlikely that very early dates (such as posited by Nanson et al 1987) would be expected within the region. Recent testing of the Cranebrook Terrace revealed no artefacts below 2m, and bio-turbation was proposed as the mechanism for these occurring at such depth.

- On the margins of the shale plain, in the interface between the shale and sandstone geologies, a further element can be added to this model.

V) Where sandstone features occur (either overhangs or platform), these may have provided a focus for a number of activities, either camping, art production (for the former) or the production/sharpening of axes (for the latter). Sandstone platforms may also have been used for the production of art (i.e. engravings) although these are very rare on the margins of the Plain.

3.2 Site Prediction

3.2.1 Background

Predictive models of site location attempt to identify areas of relative archaeological sensitivity (high, moderate and low etc) as a tool that can be used for the planning and management of Aboriginal sites in development circumstances. These models are generally based upon a consideration of the following types of information:

- The land systems/landscape units contained within a study area.
- The proximity of water resources.
- The results of previous archaeological survey and assessment projects.
- The distribution of recorded sites and known site densities.
- An understanding of traditional Aboriginal land use patterns.
- The levels of disturbance associated with past land use practices.

Broad predictive models however have their limitations as outlined below:

- It is often possible to identify areas of high archaeological sensitivity.
- However, it is not always possible to identify areas of low archaeological sensitivity with the same certainty.
- This latter outcome is compounded in areas where limited ground surface visibility occurs and the detection of open artefact scatters for example (representing the predominant site type in the local region) is as a result problematic.
- The regional archaeological studies of the Cumberland Plain reviewed above have generally proposed that the coastal lowland ecotone should be regarded as archaeologically sensitive, with areas which have been heavily developed and extensively disturbed representing the only areas currently identifiable as possessing low archaeological sensitivity.

3.2.2 Site Prediction for the Current Proposal

On the basis of the background archaeological information reviewed above, the types of sites which may be expected to occur/survive within the proposed activity locations illustrated in **Figures 2** and **3** are outlined below and are hierarchically ranked from most likely to least.

- Open Artefact Scatters and Isolated Finds: These site types are the most frequently recorded in the local landscape and are likely to occur on dry and relatively flat landforms along or adjacent to both major and minor watercourses and wetlands. However, repeatedly or continuously occupied sites where people undertook a variety of subsistence and site maintenance activities (such as stone knapping, artefact

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manufacture and repair etc) are more likely to be located on elevated ground situated at principal creek confluences and/or on the margins of rich wetland resource zones.

Surface scatters of flaked stone artefacts (or less commonly durable food remains such as animal and fish bone or shell in favourable preservation circumstances) may be the result of mobile hunting activities (eg. transitory movement through the landscape), whilst single or low density occurrences might relate to tool loss, tool maintenance activities or abandonment. These types of sites are often buried in alluvial or colluvial deposits and only become visible when subsurface sediments are exposed by erosion or disturbance. Available evidence suggests such site types can vary considerably in size, contents and significance.

Isolated artefacts may represent a single discard event and/or the only visible evidence of a more extensive artefact scatter which remains buried and/or obscured by poor surface visibility conditions. Numerous isolated finds have been reported within the local region.

- Potential Archaeological Deposits (PAD): PAD sites are locations that are assessed as having a high likelihood to contain (buried) subsurface Aboriginal archaeological features or deposits (artefacts etc). Areas of PAD are frequently associated with actively aggrading landforms, and may occur in association with surface exposures of finds or alternatively may exhibit no surface materials at all. Potential Aboriginal archaeological deposits are generally identified on the basis of their context within (or associated with) landscape features that are likely to have represented favourable campsite locations in the past (such as flat, dry and relatively elevated land overlooking a watercourse etc).

  In this regard, a research project undertaken in the northern Cumberland Plain in 1993 to 1995 (JMCHM 1997) indicated that approximately 1/3rd of the 61 sites investigated through excavation had no surface manifestations of artefacts, and that where items were present on the surface, the ratio of surface to recovered subsurface finds was approximately 1:25. It was further highlighted that none of the sites could be adequately characterised by their surface finds alone.

- Scarred Trees: These sites are the result of bark or wood removal to make shields, shelter, canoes containers or carving designs into the exposed wood. These sites have rarely survived early timber clearance, bush fires and timber cutting. The definite ascription of scarring on a tree to an Aboriginal origin is not always possible. Europeans often removed bark for roofing material and stock watering troughs. Other scars may be the result of surveyor and miner blazes, lightning strikes or cockatoo pecking. Unless the tree is at least 100 years old the scarring is unlikely to have an Aboriginal origin. These sites are relatively rare in the local region.

4.0 Site Inspection and Recording Methods

4.1 Definition of Survey & Analysis Units

The following survey and analysis units have been defined to assist in the assessment of potential Aboriginal cultural heritage sensitivity for the current project.

- Survey Unit I: Spring Farm (SF04 and SF04A)
- Survey Unit II: Menangle Park (MP24 and MP34/33)

4.2 Field Survey and Recording Methods

The site investigations reported here involved a standard archaeological field survey, recording and assessment of the proposed well site locations, their associated gathering line systems, and preferred access alignments at Spring Farm and Menangle Park. The survey and recording methods employed were as follows:

- Any items of Aboriginal cultural heritage that may be located during the field survey were to be recorded by GPS and plotted onto pertinent 1:25,000 topographical maps. Maps of differing scale were also used to facilitate the location of pertinent field observations. Photographic records, sketch plans and diary descriptions were also been compiled as part of the field records.
- Reporting was concerned in the main with topography (whether sites, features or areas of potential archaeological sensitivity were located on slopes or flats etc), context, vegetation, ground exposures, the nature of ground visibility, and the presence and extent of disturbance.

The distinction between site categories (open campsites vs isolated finds etc) was defined according to the following criteria:

- Isolated Finds consist of single artefacts that are located more than 50m apart.
- Sites comprise open artefact scatters that consist of two or more artefacts situated within 50m of each other.

The following attributes of each stone artefact that may be located during these investigations were to be recorded:

- Artefact Type: This category records the presence of items such as flakes, flaked pieces and cores etc.
- Raw Material: Raw materials may include silcrete and indurated mudstone etc.
- Dimensions: Maximum length, width and thickness of finds are to be recorded.
- Other: Comments include the presence of cortex and retouch etc.

4.3 Assessment of Archaeological Potential

Frequently used criteria inclusive of landform, aspect, topography and subsurface integrity were employed in this study to define areas of *Potential Archaeological Deposit* (PAD).

Recognition, ascription and recording of scarred trees as being potentially of *definite*, *probable*, or *possible* Aboriginal origin is based upon the assessment criteria summarised by Navin Officer (1997).

5.0 Survey Results and Conclusions

5.1 Field Observations and Results

5.1.1 Survey Unit I (Spring Farm)

The field inspection in this portion of the study area commenced towards the eastern end of the proposed access route and gathering line corridor that will link up with well sites SF04 and SF04A illustrated in **Figure 3**. An indicative view of this location is provided by **Figure 4**. The works proposed will largely follow an existing graded track (extending from Glenlee Road) leading to the Jacks Gully Waste Management Facility. The preferred alignment of the gathering line will deviate to the left of the vegetation illustrated in the background of this photograph. As a result of the creation of this access track and its ongoing use by heavy vehicles, the location was found to display extremely high levels of disturbance and retain minimal archaeological potential.

The land situated further to the east of the fringing vegetation was likewise found to extensively disturbed from past excavation and grading works (possibly associated in part to the creation of the electivity transmission lines present in this locality) and was also assessed to retain limited to no Aboriginal archaeological sensitivity (see **Figure 5**).

An open campsite previously identified to occur in this general locality approximately a decade ago appears to have been destroyed by works in this area (Glenda Chalker pers comm). No evidence for this site was identified during the site inspection.

To the west of the Glenlee Road crossing, the proposed access and gathering line alignment to the well sites will again largely follow an existing vehicle track as illustrated in **Figure 6**. The proposed well SF04A is to be located in a cleared and heavily grassed area fringed by immature timber as indicated in **Figure 7**. The location was found to be distinctly furrowed in places suggesting the sub-surface profiles are likely to have been disturbed as a result of past vegetation clearance and timber felling/de-stumping.

The proposed well SF04 is to be sited adjacent to the Nepean Electricity Substation as illustrated in **Figure 8**. This location was observed to have been heavily disturbed from past excavation and grading works that had served to extensively truncate the sub-surface soil profiles. Surrounded by extensive stockpiles of up-cast deposits, this location was determined as a result to retain no archaeological potential.

5.1.2 Survey Unit II (Menangle Park)

Access to the proposed well MP24 and associated route of the gathering line from Menangle Road will follow an existing track leading in to the Menangle Sand and Soil Facility that runs parallel with the rail easement. An indicative view of the cleared and grassed paddock within which future works are proposed to be undertaken is provided by **Figure 9**. Past vegetation clearance and possible ploughing of this parcel of land is likely to have reduced the potential for intact Aboriginal archaeological deposits to survive in this locality.

Indicative views of the proposed MP34/33 well site are provided by **Figures 10** and **11**. The locality is gently undulating, has been largely cleared of its original native vegetation, and contains numerous excavated channels and agricultural furrows in places. A previously recorded open campsite (HLA 2004) occurs approximately 150m to the south-west of the proposed MP34/33 well and will remain unaffected by future works.

5.2 Evaluation

5.2.1 Archaeological Visibility, Survey Coverage and Disturbance

The failure to detect any evidence for past Aboriginal visitation and/or use at the activity locations proposed for future gas production works documented in this report may be the direct result of the generally poor nature of archaeological visibility presently evident in Survey Units I and II (as illustrated in **Figures 4** to **11**). These conditions therefore inhibited the detection of any potential surface manifestations of Aboriginal archaeological features and deposits that may have been present at these sites.

- However, each of the proposed Menangle Park and Spring Farm work locations were found to display moderate to extremely high levels of disturbance as a result of past land use practices (particularly at Spring Farm) including previous timber felling and vegetation clearance, ongoing pasture improvement and possible soil tilling, and in places clear evidence for recent excavation/grading works.
- Each of these Menangle Park and Spring Farm locations therefore appeared to retain limited Aboriginal archaeological potential and the likelihood for substantial and intact Aboriginal archaeological deposits to survive at each site was considered to be relatively unlikely.

The background Aboriginal archaeological research, site inspection, analysis and assessment of the proposed works reported here further indicated that:

- The majority of the proposed activity areas (well sites, gathering systems and access etc) would be located in disturbed landscapes that are sited varying distances from the main channel of the Nepean River and its associated tributaries.
- The Aboriginal archaeological site predictive information presented in **Section 3.0** suggests that areas away from the Nepean River, and along the margins of lesser watercourses that occur in the study area, may nevertheless have been subject to frequent Aboriginal visitation and use in the past as people moved between favourable resource zones.
- However, these data also indicated that these visits may likely have been short term/transient in nature that may in turn not have resulted in the creation of substantial archaeological deposits as people moved to and from more favourable camping locations across the broader Camden/Menangle landscape.

- In this regard, it was predicted that each of the locations at Menangle Park and Spring Farm to be affected by the proposed works were unlikely to contain *substantial* and *intact* Aboriginal archaeological remains.
- It was finally concluded that the *potential* Aboriginal archaeological resource that may be impacted upon by each of the proposed projects detailed in previous sections of this report were likely to consist of isolated and/or low density distributions of flaked stone artefacts that would be present in largely disturbed recovery contexts. This conclusion is reviewed below.

Figure 4: Indicative View Looking East Along the Proposed SF04 and SF04A Gathering Line and Access Route. Note Exposed Vehicle Track in Foreground.

Figure 5: Indicative View Looking East Along the Proposed SF04 and SF04A Gathering Line and Access Route. Note Extensive Disturbance.

Figure 6: Indicative View Looking West Along the Proposed SF04 and SF04A Gathering Line and Access Route. Note Exposed Vehicle Track in Foreground.

Figure 7: Indicative View of the Proposed SF04A Well Site. Note Cleared and Grassed Topography.

Figure 8: Indicative View of the Proposed SF04 Well Site. Note Levels of Past Disturbance from Excavation and Grading Works.

Figure 9: Indicative View of the Proposed MP24 Well Site. Note Cleared and Grassed Paddock.

Figure 10: Indicative View of the Proposed MP34/33 Well Site. Note Cleared and Undulating Topography.

Figure 11: Indicative View of the Proposed MP34/33 Well Site. Note Cleared and Undulating Topography.

6.0 Heritage Impact Assessment

6.1 Impact of the Spring Farm & Menangle Park Proposals

The background Aboriginal archaeological research, site inspection, analysis and assessment undertaken for the current study for Menangle Park and Spring Farm proposals coded as MP24 and MP34/33 and SP4 and SP4A respectively indicate that:

- No *previously* documented Aboriginal archaeological sites or objects will be impacted upon by the proposed works in the locations that are illustrated in **Figures 2** and **Figures 3,** or detailed in greater details in **Figures 4** to **11**.
- One *previously* documented Aboriginal archaeological site (as reported by HLA 2004) occurs within the proximity of the proposed MP34/33 well as indicated in **Figure 2** and **Figures 10** and **11.**
- This Aboriginal archaeological site will however remain unaffected by the works as previously discussed. It occurs at a distance of at-least 150m to the south-west of the proposed activity footprints.
- Given the highly disturbed nature of the proposed activity areas at Menangle Park and Spring Farm illustrated in **Figures 4** to **11**, no Aboriginal cultural heritage constraints have been identified to the works proceeding as intended at each of these localities.
- It is expected that any as yet undetected Aboriginal archaeological remains that may be exposed by the proposed site works to be implemented in the locations illustrated in **Figures 4** to **11** will consist of isolated items of flaked stone and/or low-density distributions of artefacts that may be identified in highly disturbed contexts.

6.2 Mitigation Actions and Options

A number of Aboriginal cultural heritage management and mitigation actions are suggested that should be implemented prior to, and during, future development phases for the Menangle and Spring Farm proposals as illustrated in **Figures 2** to **11**. These will serve to avoid/reduce impacts to the potential Aboriginal archaeological resource and include the following:

General Options/Actions

- Briefing the Development Proponent's site managers and contractors about the nature of the Aboriginal archaeological sites previously recorded within the vicinity of the Menangle Park and Spring Farm activity areas, and the statutory obligations of all parties with regard to the protection and reporting of Aboriginal cultural heritage sites and objects that may be exposed during future construction phases.
- Briefing the Development Proponent's site managers and contractors about the requirement to strictly adhere to the defined and designated impact zones proposed

throughout the course of the future projects at both properties (as illustrated in **Figures 2** and **3**) to ensure all disturbances to the existing conditions of the subject areas are kept to a minimum.

- Briefing the Development Proponent's site managers and contractors about potential Aboriginal cultural heritage issues (and protocols) for the projects prior to the commencement of each construction phase(s) in the two areas illustrated in **Figures 2** and **3** at Menangle Park and Spring Farm.
- The establishment of appropriate temporary fencing (as needed) prior to the commencement of each construction phase at Menangle Park and Spring Farm (as illustrated in **Figures 2** to **11**) to clearly demarcate the location of intended works relative to future construction schedules.

<u>Should Future Works Expose Aboriginal Finds at Menangle Park & Spring Farm</u>

- In the unexpected circumstance that any previously undetected Aboriginal sites or objects be unearthed during future development works at the site locations illustrated in **Figures 2** to **11,** these activities would temporarily cease within the immediate vicinity of the find locality and would be duly relocated to other areas (allowing for an appropriate buffer zone of at least 50m).
- The Director's-General of the *Department of Environment and Conservation* and the *Department of Planning* would consequently be contacted to advise on the appropriate course(s) of action(s) in consultation with the *Tharawal Local Aboriginal Land Council* and the *Cubbitch Barta Native Title Claimants Aboriginal Corporation* for how best the evaluation, recording, salvage and/or relocation requirements of the item(s) would proceed prior to the recommencement of site works at the find(s) location(s) as deemed necessary by all stakeholder groups.
- The implementation of appropriate management actions (that could include the collection, relocation of items and/or re-design of site works etc) would be undertaken according to standard Aboriginal cultural heritage procedures and protocols as endorsed in the NPWS publication *Aboriginal Cultural Heritage Standards and Guidelines Kit* (1997).

6.3 Evaluation

On the basis of the above considerations, it is concluded that the proposed works illustrated in **Figures 2** to **11** and described in **Section 1.2** of this report are unlikely to have an adverse impact upon the Aboriginal cultural heritage values of the localities concerned and should proceed as proposed, contingent upon the implementation of the actions and advice that are recommended in **Section 7.0.**

7.0 Management Recommendations

7.1 Basis for Recommendations

The following recommendations are based upon the legal requirements and automatic statutory protection provided to Aboriginal 'objects' and 'places' under the terms of the *National Parks and Wildlife Act of 1974*, where it is;

> *an offence to knowingly damage, deface or destroy Aboriginal sites or relics without the prior consent of the Director General of the National Parks and Wildlife Service,*

in conjunction with;

the results of the recently completed (February 2007) Aboriginal archaeological and heritage investigations of the proposed Menangle Park and Spring Farm locations as outlined in **Section 1.2** of this report and illustrated in **Figures 2** to **11** in this document

and;

the views expressed by the *Tharawal Local Aboriginal Land Council* and the *Cubbitch Barta Native Title Claimants Aboriginal Corporation* as outlined within their respective correspondences that will be shortly forwarded to the Development Proponent and appended to this report (**Appendices 1** and **2**).

7.2 Recommendations

<u>It is recommended that:</u>

I The liaison that has been established between the Development Proponents and the *Tharawal Local Aboriginal Land Council* (TLALC) and the *Cubbitch Barta Native Title Claimants Aboriginal Corporation* (CBNTCAC) during the project should be maintained in the future within the context of implementing the Aboriginal cultural heritage requirements documented in this report.

II There are no 'clear or obvious' Aboriginal Archaeological or cultural heritage constraints to the proposed works at SP04, SP04A, MP24 and MP34/33 (as illustrated in **Figures 2** to **11**) from proceeding as intended at this time, and no further archaeological input would appear to be required prior to the commencement of construction works in these locations should Development Consent be approved.

III Prior to the commencement of future works at Menangle Park (MP24 & MP 34/33), and Spring Farm (SP04 and SP04A) as illustrated in **Figures 2** to **11**), defined impact zones in each locality should be clearly designated and adhered to throughout the course of the projects to ensure all disturbances to the existing condition of the sites are kept to a minimum.

IV Should any Aboriginal objects be unearthed during future works in the locations illustrated in **Figures 2** to **11**, activities should temporarily cease within the immediate vicinity of the find locality, be relocated to other areas (allowing for a curtilage of at least 50m), and the DEC be contacted to advise on the appropriate course of action to allow the TLALC and the CBNTCAC to record and collect the identified item(s).

X A copy of this report should be forwarded to:

The Chairperson
Tharawal Local Aboriginal Land Council
PO Box 440
Picton, NSW, 2571

XI A copy of this report should be forwarded to:

The Chairperson
Cubbitch Barta Native Title Claimants Aboriginal Corporation
55 Nightingale Road
Pheasants Nest, NSW, 2574

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Appendix 1

Tharawal Local Aboriginal Land Council Report

THARAWAL
LOCAL ABORIGINAL LAND COUNCIL

Hey Aaron,
On the 2nd and 16th of February 2007, I attended an on foot survey of the Menangle Park and Spring Farm properties. We attended the artefact scatter area that had previously been recorded between sf04 and gl6. However none of these artefacts were relocated as there were earthworks in progress at the time. I have no other problems with the work outlined in this area of Spring farm. Any future work will however need further consultation. I would like to take this opportunity to thank you for your invitation to attend this survey,

Yours in Indigenous Unity,

Donna Whillock
Tharawal Local Aboriginal Land Council
Cultural And Heritage Representative.

P.O. BOX 20, BUXTON NSW 2571
220 WEST PARADE COURIDJAH NSW 2571
TELEPHONE: (02) 4681 0059 • (02) 4681 0799 • FAX: (02) 4683 1375
tharawal@ideal.net.au

Appendix 2

Cubbitch Barta Native Title Claimants Aboriginal Corporation Report

Cubbitch Barta Native Title Claimants
Aboriginal Corporation,
55 Nightingale Road,
PHEASANTS NEST. N.S.W. 2574.
2nd May, 2007.

Dominic Steele Consulting Archaeology,
33 England Avenue,
MARRICKVILLE. N.S.W. 2204.

Dear Dominic,

RE; STAGE 2 MENANGLE
AND SPRING FARM.

I would like to take this opportunity of commenting on the Aboriginal Cultural Heritage Assessment in regards to the above project.

The field work was carried out on the 2nd & 16th February, 2007, during which there were no new Abriginal sites recorded. An artefact scatter that was recorded, probably some ten years ago by myself and Mary Dallas, has been destroyed by earthworks that have recently taken place along the proposed gathering line from the proposed SF04 to GL6 and none of the artefacts were relocated during the survey.

The recommendations that are made within the draft report are fully agreed to.

Yours faithfully,

G. Chalker.

Glenda Chalker
Hon Chairperson
Phone/Fax 46841129
0427218425

Appendix B: Cubbitch Barta Native Title Claimants Response

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Cubbitch Barta Native Title Claimants
Aboriginal Corporation,
55 Nightingale Road,
PHEASANTS NEST. N.S.W. 2574.
6th September, 2007.

Mr. A. Clifton,
AGL,
P.O. Box 67,
MENANGLE. N.S.W. 2568.

Dear Aaron,

SPRING FARM AND
MENANGLE PARK

I have read the draft document about the above proposed project. I took part in the field survey for the project along with Donna Whillock from Tharawal Land Council. The survey took part over a very long period of time, and it has taken some while for me to sort out the report and the consequences it will have. I guess the best way to make my comments, such as HLA have done in regards to the impacts of the wells and gathering lines.

1. SF 10 gas well, gathering line and access road. All impacts to sites S7, S5 & S 6 should be avoided , if that means moving either the gas well, gathering line and access road, then that is what will need to be done. It was recommended in the field that this site be avoided at all costs, because of the high density of artefacts in this location. I do not believe that the report actually reflects the concentration.
2. SF 20 gas well, gathering line and access road. The proposed gas well does not impact on any sites, but the gathering line will if it is kept on the same route as currently proposed. The position of the access road, should be moved.
3. SF17 gas well, gathering line and access road. The report indicates that there will be no impact to the sites S9, S10, what about S8. These three sites as recorded are in actual fact the same site. The gathering line and access road will impact them. The report also says that there is likely intact sub surface deposits off the track. I believe that this not only applies to the area where the artefacts are located, but also to the whole of that high spur line, where SF17 is located. This site was also discussed in the field, and it was suggested at the time other possible locations in order to avoid this highly sensitive area.
4. Gathering and water pipeline to SF17 gathering system. This area should be fenced off, and possibly the line moved slightly
5. Jacks Gully Road to SF17 . The two artefacts located along this road are in a highly disturbed area, which also contains road base etc. I would agree to relocating them, off the track and away from any impact.
6. SF04 & SF04 gas wells and gathering line. There are no constraints to either of these.

7. MP02 gas well and gathering line. M6 and M7 are two single artefacts than can possibly be moved from the track to avoid impact, however M8 which is possibly site #52-2-2277 which is where the proposed gas well would be located, should be avoided, and possibly moved to another location. During the field survey, I indicated to the archaeologist, that this area be identified as a pad, because of its location in the landscape. It is a terraced area less than twenty metres from the creek, and the artefacts that are exposed, are on the very edge of the track and the terraced area.
8. MP03 and gathering line. Site M5 can be avoided, if there is adequate precautionary measures in place, so that there is no accidental secondary damage. There are no constraints for MP03.
9. MP04 and gathering line to MP05. There were artefacts previously recorded both by Heritage Concepts, and also by Julie Dibden (Sydney Gas), however during the field survey there was only one isolated artefact relocated. If the gathering line is to follow this route, then the opportunity to collect any artefacts and relocated should be available, and the works to remain strictly within the track area.
10. Access Road MP04 to Glenlee Road. The two sites along this route consist of a scarred tree, and an artefact scatter. The tree could be avoided, however on the proposed route of the access track, it would impact the site. I would hope that the access track can be moved, and that the site be avoided and measures be taken, such as fencing, to avoid any accidental or secondary damage.
11. MP06. There are no constraints.
12. MP96 to MP05, gas wells and gathering line. This site should not be impacted, however measures should be taken, such as fencing, to avoid any accidental or secondary damage.
13. MP11, MP19, gas wells and gathering line, and access road. These four sites are within what should be within a Riparian Corridor, that is within 50 metres of a creek line, and should be avoided at all costs. They sit in the landscape on the break of the slope between the hills and the creek line. The only alternative is to move up slope from the sites.
14. Access Rod MP33. The exact location of this site needs to be accurately identified in the landscape, so that any or no impact can be determined, prior to any works taking place.

The sites are our link from our past to the present and to the future, so that our grandchildren, can still learn and understand from them. If we continue just to destroy them they will not have that opportunity. So those of us today, have an obligation to look after our sites, just as we all do today to look after our environment, so that it can be enjoyed by future generations.

Hoping that these comments can assist with the process

Yours faithfully,

G. Chalker

Glenda Chalker
Hon. Chairperson
Phone/Fax 02 46 841129 0427218425

7. MP02 gas well and gathering line. M6 and M7 are two single artefacts than can possibly be moved from the track to avoid impact, however M8 which is possibly site #52-2-2277 which is where the proposed gas well would be located, should be avoided, and possibly moved to another location. During the field survey, I indicated to the archaeologist, that this area be identified as a pad, because of its location in the landscape. It is a terraced area less than twenty metres from the creek, and the artefacts that are exposed, are on the very edge of the track and the terraced area.

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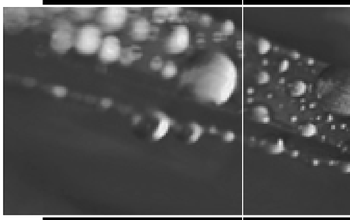
Hoping that these comments can assist with the process

Yours faithfully,

G. Chalker

Glenda Chalker
Hon. Chairperson
Phone/Fax 02 46 841129 0427218425



This report was prepared by HLA-Envirosciences Pty Limited (HLA ENSR),
a subsidiary of ENSR Corporation, an AECOM company.
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