



EIS 1381 Vol 2

AB019999

Environmental impact statement for a proposed extraction
industry and landfill at Marsden Park, NSW



GANIAN PTY LTD

ENVIRONMENTAL IMPACT STATEMENT FOR A PROPOSED EXTRACTIVE INDUSTRY AND LANDFILL AT MARSDEN PARK, NSW

VOLUME 2

APPENDICES



Prepared by:

ENVIRO-MANAGERS PTY LTD

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May 1998

GANIAN PTY LTD



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May 1998

VOLUME 2

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**APPENDIX 1
CORRESPONDENCE**

New South Wales Government

Department of Urban Affairs and Planning

.....

Ms Valerie Smith
Director
Enviro-Managers Pty Ltd
P O Box 270
ARTARMON NSW 2064

Contact: Miranda Yue
Our Reference: P97/00243 Pt 1
Your Reference:

18 AUG 1997

Dear Ms Smith,

Proposed Development of an Abandoned Quarry for a Waste Disposal and Recycling Depot at Marsden Park, Blacktown City

Thank you for your letter of 30 June 1997 seeking consultation with the Director-General for the preparation of an environmental impact statement (EIS) for the above development.

Under clause 52 of the Environmental Planning and Assessment Regulation 1994 (the Regulation), the Director-General requires that the key issues outlined below be specifically addressed in the EIS.

Key Issues

- the objectives and the relevant provisions of the Sydney Regional Environmental Plan No. 19 - Rouse Hill Development Area, in particular the provisions in relation to "Living Area" and how would the proposal affect the future urban development in the "Living Area" as identified in the map;
- the objectives and the relevant provisions of the Sydney Regional Environmental Plan No. 20 - Hawkesbury Nepean River;
- the objectives and the relevant provisions of the Draft Sydney Regional Environmental Plan No. 20 - Hawkesbury Nepean River 1996;
- the objectives and any relevant provisions of Sydney Regional Environmental Plan No. 9 - Extractive Industry (No.2);
- the impact on the traffic volume and traffic flow on the nearby roads, particularly Richmond Road;
- details of the disposal of water currently collected in the void, including the method of disposal and the impacts on the receiving environment; and
- impacts on flora, fauna and any threatened species, population or ecological communities, including any remnant Cumberland Plain Woodland which has been listed by the Scientific Committee as a threatened ecological community, and an assessment of the need for a Species Impact Statement according to section 5A of the Environmental Planning and Assessment Act 1979.

Governor Macquarie Tower
1 Farrer Place, Sydney 2000
Box 3927 GPO, Sydney 2001

Telephone: (02) 9391 2000
Facsimile: (02) 9391 2111

The EIS should also include the results of consultation with relevant public authorities and organisations, including the Metropolitan and Regional Management Branch of the Department, Department of Mineral Resources, Blacktown City Council and the Hawkesbury Nepean Catchment Management Trust.

Attached please find two sets of EIS Guidelines: *Landfilling, Extractive Industries - Quarries* and an attachment: *Advice on the Preparation of an EIS for a Waste Recycling Facility*. These documents contain the type of information most likely to be relevant to your proposal. Not all matters raised therein may be appropriate for consideration in the EIS, equally, they are not exhaustive.

Schedule 2 of the Environmental Planning and Assessment Regulation 1994 outlines the general requirements for the form and contents of an EIS. A copy of Schedule 2 is at Appendix 1 of the attached EIS Guidelines.

Should you have any further enquiries please do not hesitate to contact Miranda Yue on phone (02) 9391-2201.

Yours sincerely,



for
David Mutton
Acting Manager
Major Assessments and Hazards Branch
As Delegate for the Director-General

Department of Urban Affairs and Planning

ATTACHMENT

**ADVICE ON THE PREPARATION OF AN ENVIRONMENTAL IMPACT
STATEMENT (EIS) FOR A WASTE RECYCLING FACILITY.**

The reason for requiring an environmental impact statement for a waste recycling facility is due to their potential to create public or environmental nuisance due to noise, dust, odours and wastes which affect air and water quality.

The purpose of this paper is to outline various issues relevant to the preparation and consideration of an EIS for a materials recycling facility. It is intended to assist the preparation of the EIS. It is the applicant's responsibility to identify and address, as fully as possible, the matters relevant to the specific development proposal in complying with the statutory requirements for EIS preparation.

The matters nominated in this paper are not intended as a comprehensive identification of all issues which may arise in respect of such work. Some of the issues nominated may not be relevant to a specific proposal. On the other hand, there may be other issues, not included, that are appropriate for consideration in the EIS.

Information provided should be clear, succinct and objective and where appropriate be supported by maps, plans, diagrams or other descriptive detail. The purpose of the EIS is to enable members of the public, the consent authority (usually the council) and the Department of Urban Affairs and Planning to properly understand the environmental consequences of the proposed development.

1. Description of the proposal.

The description of the proposal should provide general background information on the location and extent of the works, existing and proposed, an indication of adjacent developments, and details of the site, land tenure, zonings and relevant forward planning proposals and any other land use constraints.

The extent to which the supply of raw materials and access to markets for the finished product has determined the location of the plant in preference to alternative sites should be stated.

This section should provide specific information on the nature, intent and form of the development. It should, as far as possible, include such details as the processes involved, wastes created and landscaping. A description should also be provided of associated operations such as the transport of materials and the use of the end product if such use is likely to have environmental implications.

Particular details that may be relevant include:

- . Characteristics and economic significance of the product.
- . Plans of operation.
- . Any proposals for future expansion, including staging and timing.
- . Capacity of plant now and in the future.

- . Sources and quantities of raw materials.
- . Type of processes, machinery and equipment to be used.
- . Expected life of the operation of the plant.
- . Number of persons to be employed.
- . Hours of operation.
- . Means of storage, location, quantity and details of necessary stockpiling.
- . Types and quantities of products for recycling and details of any storage required.
- . Access arrangements - truck routes, truck numbers, parking, etc.
- . Site drainage and erosion controls.
- . Water supply requirements.

2. Description of the Environment.

This should provide details of the environment in the vicinity of the development site and also of aspects of the environment likely to be affected by any facet of the proposal. In this regard, physical, natural, social, cultural and economic aspects of the environment should be described to the extent necessary for assessment of the environmental impact of the proposed development.

3. Analysis of Environmental Impact.

Potential environmental impacts usually associated with these types of operations are listed below. Where relevant to the specific proposal, these should be addressed in the EIS, taking into account the adequacy of safeguards proposed to minimise them.

- . Likely noise disturbance caused by the operations, including transport operations, on nearby residences, particularly at night.
- . Other impacts of trucking movements, including access across railways and on to highways.
- . Potential for air pollution, including odours, organic vapours and particulate matter.
- . Water management: including water requirements and the separating of clean and contaminated runoff before discharge; water treatment; quality and quantity of effluent for disposal.
- . Treatment and disposal of waste material.
- . Effects on the visual environment.

In addition, any potential for fire hazard or risks to public safety and any proposals to monitor and reduce environmental impacts should be included.

4. Contact with relevant Government Authorities.

In preparing the EIS, it is suggested that authorities, such as those listed below, should be consulted and their comments taken into account in the EIS.

- . The Environment Protection Authority in regard to air, water and noise impacts and relevant pollution control legislation requirements;
- . The Heritage Office if the proposal is likely to affect any place or building having heritage significance for the State;

- . the National Parks and Wildlife Service if Aboriginal places or relics are likely to be affected;
- . New South Wales Agriculture should be contacted if prime agricultural land may be affected by the proposal.
- . NSW Fisheries if areas of significant fish habitat will be affected.
- . Department of Land and Water Conservation if the proposal may have implications for soil erosion, or will disturb acid sulphate soils, or on water bodies subject to the legislative responsibilities of this agency.

It is the responsibility of the person preparing the EIS to determine those Departments relevant to the proposed development.



Blacktown City Council

In Reply
Please Quote: 174751
97-36427C
Ms. Portelli:DS

12 August 1997

Enviro-Managers Pty Ltd
P.O. Box 270
ARTARMON 2064

Attention: Valerie Smith

Dear Ms Smith,

Re: Various Lots, Hollingsworth Road, Fulton Road, Richmond Road,
Marsden Park

I refer to your recent letter dated 7 July 1997 regarding the proposed use of an abandoned quarry for a waste disposal and recycling depot, specifically any matters which should be considered in the preparation of the Environmental Impact Statement.

As previously advised at a Developer Advisory Panel meeting with Team West on the 17 June 1997 it is considered that a number of important factors need to be addressed. These include:

- The Threatened Species Conservation Act (TSC Act) 1995 - On Friday 13 June 1997, notice was published in the Government Gazette that Cumberland Woodland Vegetation has been included as a threatened ecological community under the TSC Act. It is noted that the subject properties may contain vegetation of a type which is consistent with the Cumberland Woodland community.

The implications of this are that Council must now require that you engage a suitably qualified environmental consultant to assess the impact of the development proposal upon any threatened species, populations or ecological communities or their habitats which may occur on the subject land. Such assessment is to comply with the requirements for an 8 point test as set out in the TSC Act.

AD053843.LET/PH

- Compliance with DUAP's EIS guidelines September 1996 for land filling which sets out key issues of:
 - waste management
 - surface and ground water quality issues
 - traffic
 - air quality issues
 - the visual impact
- With regard to traffic matters it is suggested that you consult with Lee Pickard and Graham Richards of the Blacktown Regional RTA office.
- A Drainage Strategy/Water Management Plan should be included in any EIS to ensure only clean runoff leaves the site.
- The required EIS is to document in full any extraction, crushing, and recycling activities proposed in association with the landfill operation. Any EIS should be prepared in 2 parts, that is, the extraction operation in one part and any land fill/recycling operations in a separate part.
- Any development must have regard for Council's site contamination policy (copy of which was provided at the June 17th meeting).
- Consultation with Mr Les Johnson of the Environment Protection Authority at the Penrith Office is also recommended.
- Liaison with Malcolm Hughes at the Hawkesbury Nepean Catchment Management Trust (HNCMT) is suggested as the subject site falls within this catchment.
- The site adjoins rural residences and a caravan park. The impact of any development on the residents must be carefully examined and details of the measures to ameliorate any impact must be addressed.
- It is also usual procedure to write to DUAP for an outline of their requirements for the preparation of an EIS.

Any EIS should document staging of the development over the life of the landfill to enable Council to have regard for appropriate timeframes.

I trust this information is of assistance. Please do not hesitate to contact Ms J. Portelli on 9839 6000 between 9.00am and 12.00noon should you wish to discuss the matter further.

Yours faithfully,

TERRY McCORMACK
GENERAL MANAGER

Per:

A handwritten signature in black ink, appearing to be 'Terry McCormack', written over a light blue horizontal line.

Metropolitan Area
Old Wallgrove Road Wallgrove
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NETWORK/OPERATIONS/C/MET/GBH/EGW

ENVIRO-MANAGER PTY LTD
P.O. BOX 270
ARTARMON NSW 2064

ATTENTION: VALERIE SMITH

4th August 1997

Dear Valerie

PROPOSED DEVELOPMENT OF AN ABANDONED QUARRY AT MARSDEN PARK FOR A WASTE DISPOSAL AND RECYCLING DEPOT

I refer to your letter dated 30th June 1997 regarding the proposed waste disposal and recycling depot on land which is affected by two easements for the Sydney West-Sydney North Nos 1 & 2 transmission line.

From the submitted plan the transmission line are located in the proposed buffer zone, which is understood would not be developed, however the access to the site is proposed from Hollinsworth road which would create some input from TransGrid regarding the location and the levels of the access road on the easement area for the Sydney West - Sydney North (feeder 20) 330kv transmission line.

We await a copy of the EIS and the detailed plans for our appraisal.

In regards to our transmission lines it is advised that transmission line easements are acquired by Electricity Transmission Authority (trading as TransGrid) to provide adequate working space along the route of the line for construction and maintenance work and also to ensure that no work or other activity is undertaken under or near the transmission line or the structures which could either by accident or otherwise create an unsafe situation either for persons or for the security of the transmission line.

Having regard to the above no objection will be raised in principle to the proposed development subject to the following conditions:

1. Details of the proposed ground levels on the easement area are to be submitted for examination when available to ensure that adequate clearances are maintained. It should be noted that formal approval will not be given to the development if such clearances are not maintained.

2. Access to the transmission line structures shall be available at all times to TransGrid plant and personnel. In this regard a continuous and unobstructed access way shall be retained along the easement. Notwithstanding where vehicle access is not available along the easement for geographic reasons (i.e. valleys, cliffs, escarpments, rivers, water courses etc.) suitable alternative vehicle access (4.5 metres wide) shall be provided. Access gates should be installed in an agreed location.
3. Excavation work or other alterations to existing ground levels shall not be carried out within the easement area without the prior written approval of TransGrid. Approval will not normally be granted for such work within 16 metres of any supporting structure.
4. Utility services, shall not be installed within the easement area without the prior written approval of TransGrid. Approval will only be given to underground services. All services proposed to be installed within 30 metres of a transmission line structure are required to be non-metallic.
5. Site offices, buildings or other substantial structures or parts thereof shall not be erected within the easement area.
6. Minor structures, plant or equipment, fences or barbeques shall not be erected or installed within the easement area without the prior written approval of TransGrid.
7. Obstructions of any type shall not be placed in the easement area within 15 metres of any part of a transmission line structure.
8. Vehicles, plant or equipment having a height exceeding 4.3 metres when fully extended shall not be brought onto or used within the easement area without prior TransGrid approval.
9. The parking of vehicles within the easement area shall be limited to types whose height when fully extended does not exceed 4.3 metres. Where vehicular access or parking is within 16 metres of a transmission line structure, adequate precautions shall be taken to protect the structure from accidental damage.
10. Trees and shrubs may be planted within the easement area provided that they are species whose mature height is less than 4 metres and do not interfere with access to any transmission line structure.
11. Garbage, refuse or fallen timber shall not be placed within the easement area.
12. Flammable material shall not be stored within the easement area.
13. Explosives shall not be used within the easement area without the prior written approval of TransGrid.
14. Flammable liquid carriers, caravans and other camping vehicles shall not be parked within the easement area.

Further to all the above in regards to minor structures such as metallic and non-metallic fences the following list of fencing restrictions is provided for your information.

- A. Brick, masonry walls or other substantial structures or parts thereof shall not be erected within the easement area.
- B. All other types of fencing erected within the easement area is subject to a height limitation of 2.5 metres.
- C. The erection of all fencing is not permitted within 15 metres of any part of the transmission line structure and is not permitted in a location which could create an unsafe work area for TransGrid staff.
- D. Metallic fencing within 4 metres of the overhead conductors or crossing the easement should be electrically isolated from the remainder of the fence and all other fences not on the easement.
- E. Regarding unobstructed access refer to Item '2'.
- F. The erection of all fencing is not permitted within 4 metres of the vertical projection of the overhead conductor or within 15 metres of any part of the transmission line structure and is not permitted in a location which could create an unsafe work area for TransGrid staff.
- E. Dogs and livestock shall not be kept within the easement area if they are likely to create a dangerous situation for TransGrid staff and thus restrict access.
- G. Access gates should be fitted with padlocks, these will be supplied and installed by TransGrid staff upon notification.

It should be noted that all proposed activities within an easement area require written approval from TransGrid. For such approval, detailed plans drawn to scale and fully dimensioned, showing property boundaries and other relevant information should be forwarded to TransGrid.

For any further assistance please do not hesitate to contact the Engineering Officer Easements on Telephone Number (02) 9620 0777 or mobile No. 0411 153142.

Yours faithfully


G HOBBS FOR
MANAGER/CENTRAL

Ms V. Smith
Director
Enviro-Managers P/L
PO Box 270
ARTARMON 2064



Western Sector
Public Health Unit

A joint unit of
Western Sydney and
Wentworth Area
Health Services

13 New Street
North Parramatta
NSW 2151
Telephone (02) 9640 3603
Facsimile (02) 9640 3608

Dear Ms Smith

I refer to your request for comments on the requirements for an Environmental Impact Statement on the proposed development of the abandoned Monier quarry site at Marsden Park.

Matters which should be considered in this statement include measures by which the proponent intends to mitigate odour, noise and dust nuisance, control vermin / pests, landfill gas, windblown debris / litter, leachate, stormwater discharge, scavenging and unwanted waste types, protect existing groundwater and watercourses, and manage waste receipt, unauthorised access, fire, waste disposal from staff amenities and wet weather contingencies.

The Environmental Impact Statement should also provide details of the proponent's plans to monitor compliance with the relevant authorities with regard to the above aspects of the development.

Yours faithfully

Ron Bouwman
Senior Environmental Health Officer



The Director
Enviro-Managers Pty Ltd
PO Box 270
ARTARMON NSW 2064

NSW DEPARTMENT OF MINERAL RESOURCES
Minerals and Energy House, 29-57 Christie Street
(P.O. Box 536), St Leonards, NSW 2065, Australia
Phone (02) 9901 8888 · Fax (02) 9901 8777
DX 3324 St Leonards

Our Ref: L97/0336

Attention: Ms V Smith

Dear Madam,

**PROPOSED WASTE DISPOSAL AND RECYCLING DEPOT AT
ABANDONED MARSDEN PARK BRECCIA QUARRY**

I refer to your letter of 30th June, 1997 seeking this Department's requirements for an environmental impact statement (EIS) to be prepared for the abovementioned proposal.

The subject site, although now abandoned, was identified in the Sydney Regional Environmental Plan No 9 - Extractive Industry as being a hard rock deposit of regional significance. This site has not been included in SREP9(2). However, there may still be extractable material available even though the site was abandoned. The possible sterilisation of any remaining resource will need to be justified in the EIS.

It is noted from your preliminary diagram that the proposed waste site will be approximately 30% larger than the abandoned quarry, and material excess to the proponent's needs may be sold. Should the quantity of the saleable material be in the order of thousands of tonnes then the EIS will have to be written from the point of view of an extractive and landfill operation.

Hard rock (breccia) is not a prescribed mineral under the Mining Act, 1992. Therefore, the Department of Mineral Resources has no statutory authority over the extraction of this commodity, apart from its role under the Mines Inspection Act, 1901 (as amended) with respect to the safe operation of mines and quarries. However, this Department is the principal government authority responsible for assessing the State's resources of construction materials and for advising State and local government on their planning and management.

The operator must observe all relevant requirements of the Mines Inspection Act, 1901 (as amended). Advice on these requirements should be sought from Mr Peter Diamantes, Regional Inspector of Mines - telephone (02) 9901 8455 or Mobile 018 295 657.

With regard to the requirements of the Department of Mineral Resources for geological and resource information which should

be incorporated in environmental impact statements, the following are considered essential:

1. The amount of material available for extraction and the method or methods used to determine this amount (e.g. drilling, trenching, geophysical methods). Plans and cross-sections summarising this data, at a standard scale, showing location of drillholes etc. and the area proposed for extraction, should be included in the EIS. Relevant supporting documentation such as drill logs should be appended.
2. Characteristics of the material to be produced. For hard rock aggregate proposals information such as grainsize and mineralogy, nature and extent of weathering or alteration, and amount and type of deleterious minerals, if any, should be indicated. Details of tests carried out to determine the characteristics of the material should be appended.
3. An assessment of the quality of the material based on the testing, and of the suitability of the material for the anticipated range of applications should be given.
4. Anticipated annual production, staging (if any), and life of the operation.
5. Alternative sources to the proposal and their availability.
6. Transport routes.
7. Disposal of waste products and the location and size of stockpiles.
8. Assessment of noise, vibration, dust and visual impacts, and proposed measures to minimise these impacts.
9. Proposed rehabilitation procedures during, and after completion of, extraction operations, and proposed final use of site.
10. Justification for the proposal in terms of local and, if appropriate, regional context.

If you have any queries on this matter please contact Mr Alan Ferguson of the Geological Survey on (02) 9901 8367.

Yours faithfully,



S.R. Lishmund
for Director-General

22/7/97



28 July 1997

The Director
Enviro-Managers Pty Ltd
P.O. Box 270
ARTARMON NSW 2064

ATTENTION: VALERIE SMITH

Dear Madam

PROPOSED DEVELOPMENT OF AN ABANDONED QUARRY AT MARSDEN PARK FOR A WASTE DISPOSAL AND RECYCLING DEPOT

In reply to your letter dated 30 June 1997 Integral Energy offers the following comments regarding the above site at Marsden Park.

Integral Energy has an out of service 11,000 volt overhead line traversing the property from Richmond Road to the former Quarry. This line was used previously to supply power to the former quarry for its normal operations. One bay of overhead line has been removed to provide isolation. There are no substations on the property as these were removed when operations ceased. This line could be used in the future to supply any new load at the site. If this line had to be removed or relocated it would be at the developers expense.

Additionally Transgrid own and operate two 330,000 volt transmission lines across this property to the south and the west. Attached is a diagram illustrating Integral Energy assets at the site.

Yours faithfully

John Phillips
Regional Planner - Hills
NETWORK PLANNING

Attach

Integral Energy Networks

A business unit of Integral Energy Australia

Your contact: Mr John Phillips ☐ **Direct: 9853-6571** In Reply Quote: 91/45594.JP.JH

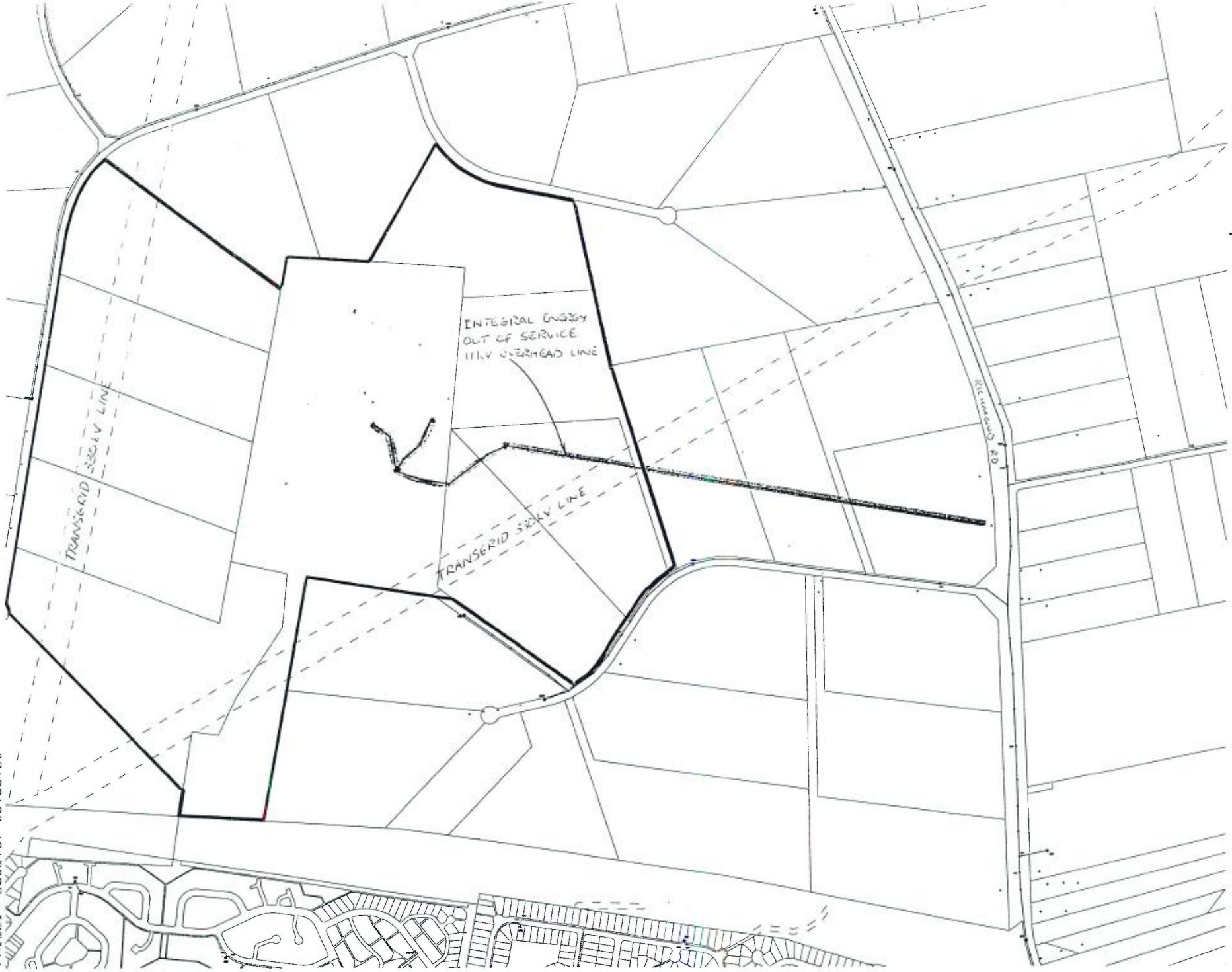
Huntingwood Drive, Huntingwood NSW 2148

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integral@integral.com.au

PHILLI--28JULY97-09.38.20



25 July, 1997



Sydney and South Coast

NSW Agriculture

299 George Street Windsor 2756
(Locked Bag 11)

Valerie Smith
Enviro-Managers Pty Ltd
PO Box 270
ARTARMON NSW 2064

Telephone: (045) 770 600
Facsimile: (045) 770 650

Dear Ms Smith

**Proposed Development Of An Abandoned Quarry At Marsden Park For A
Waste Disposal And Recycling Depot**

I refer to your letter of 30 June 1997 which sought NSW Agriculture's comments on the requirements for an EIS for the above development proposal.

Matters of direct concern to NSW Agriculture include:

- the proximity of the operation to agricultural land uses;
- the potential impact of the operation on agricultural land uses by way of noise, dust and/or other nuisance generation;
- the potential impact on water resources used for agriculture, both ground and surface waters; and,
- the nature and extent of management responses to any environmental contamination that may arise out of the activity.

Thank you for this opportunity to raise these matters with you and I look forward to reviewing your EIS at the appropriate time.

Yours sincerely

Tom Grosskopf
Agricultural Environment Officer
WINDSOR



Environment
Protection
Authority
New South Wales

PO Box 1135 Chatswood NSW 2057
Tel .02. 9795 5000 Fax .02. 9325 5678

Ms V Smith
Director
Enviro-Managers Pty Ltd
P.O. Box 270
ARTARMON NSW 2064

Our Reference: CH96

Your Reference:

20 AUG 1997

Contact: Stephen Durrington

Dear Ms Smith

**Re: Proposed Development of Abandoned Quarry at Marsden Park
For A Waste Disposal and Recycling Depot.**

I refer to your letter of 30 June 1997 seeking comments from the Environment Protection Authority (EPA) regarding the requirements for an Environmental Impact Statement (EIS) for the above proposed development.

The EPA is pleased to have the opportunity to provide you with the attached comments listing those matters that the EPA believes should be addressed in the EIS.

1.0 Surface and Ground Water Management

To allow the operators of waste depots to comply with the Clean Waters Act, the water management system should be designed and constructed to prevent the discharge of any polluted water from the site.

The EIS will need to develop the necessary controls for the management of stormwater during rain events.

Details of groundwater monitoring must be provided and an assessment of any feasible future impacts.

Sediment and erosion controls should include, but not necessarily be limited to the following:

- objective for a closed water management system with adequate capacity of sediment retention dams;
- measures to ensure that all disturbed areas drain to sediment dams within the closed water management system;

- diversion of uncontaminated surface water from rehabilitated or undisturbed areas around the disturbed work area;
- vegetation covering of overburden and stockpile areas;
- locating stockpiles within the catchment of sediment retention dams;
- rehabilitation of exposed areas, particularly those disturbed areas which are currently not within the catchment of the ponds.

2.0 Noise Control

The EIS needs to identify any proposed noise controls to ensure emissions at the boundary and any nearby residence comply with the noise limits contained in the EPA's "Environmental Noise Control Manual" (ENCM) and with any conditions which may be attached to the licence for the premises. Existing acoustic environment must be fully described including monitoring results.

Off-site road traffic noise impact will need to be assessed.

3.0 Air Pollution

The EIS must assess the emission of dust from the proposed activities and predict the emission of air pollutants from the premises. Existing ambient dust deposition and ambient concentrations must be provided.

Disposing of wastes by open burning is prohibited under the Clean Air (Control of Burning) Regulation 1995.

Work areas, access roads and ramps must be kept sufficiently damp to prevent the generation of any windblown dust.

All practical measures must be taken to minimise the creation of any dust nuisance, which might arise during the execution of the works. Appropriate equipment and facilities, such as water spray carts, must be provided for the application of water to disturbed areas.

4.0 Site Plan

The EIS should include a site plan, which clearly depicts the location, design and layout of all the proposed work and environmental controls.

The plan should show land form, geology, soil types, surface water, vegetation cover, land use, location of access tracks, Heritage or other particular conservation features should also be represented in the plan.

5.0 Integrated Soil and water Management Plan

A soil and water management plan should be included in the EIS. The soil and water management plan should also include an erosion and sediment control component

designed to prevent environmental degradation from erosion, water pollution and waterlogging.

6.0 Site Rehabilitation Plan

A rehabilitation plan should be included in the EIS to define the future land use and aesthetic appearance of the site once landfilling operations have ceased. Site rehabilitation measures should be fully described.

7. Government Waste Policy

As you may be aware, the NSW Government has released a waste reform package. This package clearly identifies the Government's objectives in relation to waste management.

Regulatory instruments associated with this package include the State Environment Planning Policy No 48 (officially gazetted on 29 December, 1995) and the Waste Minimisation and Management Act, 1995 and Regulation.

8. Environmental Guidelines: Solid Waste Landfills (EPA)

This Guideline (copy enclosed) outlines a comprehensive set of environmental goals that must be addressed in the preparation of a Landfill Environmental Management Plan (LEMP).

The EPA has selected a performance based approach for these guidelines to promote and achieve the best environmental outcomes. Under the performance based approach, the emphasis is on achieving the most environmentally beneficial outcomes for the effective treatment and disposal of waste.

The environmental goals specified in the guidelines can be met by either adopting one or more of the "benchmark techniques" listed in the guidelines, or by presenting an alternative approach for the EPA's consideration.

9. EPA's Statutory Requirements.

The EPA's statutory approval would be required prior to the construction of any surface water controls. The EPA's approval is also required for the installation of plant and equipment to control air or noise emissions, as the premises would be scheduled under both the Clean Air and Noise Control Acts.

To operate the facility, licences will be required under the Pollution Control Act, 1970 and the Waste Minimisation and Management Act, 1995.

The EPA welcomes the opportunity to provide comments on the scope and content required for the EIS for the proposed development.

The EPA trusts that the information contained in this submission is of use to you and the issues raised will be addressed within the EIS. Please contact Stephen Durrington on 047 213 700 should you wish to discuss any of the above matters.

The EPA looks forward to reviewing the EIS upon completion.

Yours sincerely

A handwritten signature in black ink, appearing to read 'L. Johnston', written in a cursive style.

LES JOHNSTON
Acting Head Western Operations Unit
For Director-General.



CATCHMENT MANAGEMENT TRUST

18th July 1997

Valerie Smith, Director
Enviro-Managers Pty Ltd
PO Box 270
ARTARMON 2064

Contact: Tony Towers
Our Ref: LM/BL/EIS
mars-pk-fil
Your Ref:

Dear Ms Smith,

Proposed Waste Disposal And Recycling Depot - Hollingsworth Road, Marsden Park

Thank you for your letter seeking our requirements for the EIS on the above proposal. The Trust's general requirement is that the EIS address the impact upon the Hawkesbury River and, in this location, particularly Bells Creek and their catchments.

Specifically, the EIS should indicate the way in which the following criteria will be achieved:

1. Satisfying the Trust's policy on water quality and quantity:

- ♦ *Any water flow or changes in flow from the area should not alter the downstream natural hydrology (frequency or peaks) for all events up to the one in two year storm event (30 minute event), and should not alter the downstream peak levels for events up to the 1 in 100 year event.*
- ♦ *Surface runoff should not compromise the: ANZECC Guidelines standard for healthy rivers - aquatic ecosystems, water supply for livestock; and NHMRC Guidelines for recreational water quality - visual amenity and secondary contact recreation.*
- ♦ *Groundwater should be protected from the impacts of any contaminated surface waters and/or leachate.*

The EIS should assess and make recommendations for mitigation measures where relevant for: the quality and quantity of existing surface flows; control of landfill runoff and leachate; the management of waste waters, oils and grease; and any potential infiltration into the ground water and effects on water bores.

2. The Trust supports the preparation of a Landfill Environmental Management Plan. The Trust is particularly concerned with the management of erosion and sediment control, surface water control including load and leachate, odour, the stability of stored material, effective monitoring techniques and rehabilitation programs. This Plan should be prepared in accordance with ISO 14000. It should specifically identify who is responsible for implementation of each action and the timeframe; document reporting mechanisms including the management routine for after hours activation of alarms; and an incident management system. We consider that management should exclude the general public from the site, particularly as the opportunity exists for the public to bring onto the site hazardous materials.
3. Establish in terms of ESD principles: the need for, and appropriateness of, using such a site for landfill and the cumulative effect of this proposal in the light of adjacent uses.

4. Construction of a final landform that will be geomorphologically stable in the long term.
5. Maintenance of the landscape buffers and flora and fauna habitats. Any significant effect on threatened species, populations or communities is to be assessed in terms of the Threatened Species Conservation Act. The Trust is particularly concerned for the future of any remnant Cumberland Plain Woodland. The EIS should indicate the principles for a site specific vegetation management plan which would aim to revegetate the entire area and control weeds and other pests.
6. Assurance of air quality - dust, gas and odour.
7. Provision for monitoring and environmental impact prediction verification.
8. The consistency of the proposal with the:
 - ♦ *Environmental Guidelines: Solid Waste Landfills*, NSW E.P.A. 1996; and
 - ♦ *EIS Practice Guideline: Landfilling*, NSW DUAP 1996

The EIS should also address the provisions of Sydney Regional Environmental Plan No 20 Hawkesbury-Nepean River and the draft amendments to the Plan, in particular the consistency of the proposal with the Plan's aims, objectives and criteria.

The Trust, in providing this advice does not at this stage have a particular position on the proposal. The Trust's position will be determined following an examination of the EIS.

Should you wish to discuss any matter raised in this letter, please contact the Trust's staff.

Yours sincerely,



Malcolm Hughes

Director, Planning & Assessment Program

cc.

Erich Weller	Chairperson
Michael Druce	Catchment Co-ordinator
<u>South Creek Catchment Management Committee</u>	



The Manager
Enviro-Managers Pty Ltd
PO Box 270
ARTARMON NSW 2064

Contact: John Ross
Phone: (02) 9895 7441

Attention: Valerie Smith, Director

Our Ref: 022675B
[CPL150.DOC]
Your Ref:

8 7 97

Dear Sir/Madam,

Re: EIS Requirements, Waste and Recycling Depot, Marsden Park.

Thank you for your letter of 30 June 1997 requesting information/comment to assist in the preparation of the above EIS.

Water Resources Matters

Enclosed for your information, retention, and use as appropriate, are the following documents:

- a) "Amendments to the NSW Rivers and Foreshores Improvement Act";
- b) "The 7-Step Method of controlling Bank Erosion and Sediment Build-up";
- c) "A Guide to Stream Channel Management";
- d) "The Importance of the Riparian Zone in Water Resource Management - A Literature Review";
- e) "NSW State Rivers and Estuaries Policy";
- f) "Minimum Standards for Works in Rivers and Lakes"; and
- g) "General Requirements for Environmental Impact Statements". (This is essentially a checklist of water resources matters to be addressed in the assessment of environmental impacts).

Soil Conservation and Land Management

Erosion and sediment control is an important environmental consideration prior to and during any development. It is essential to minimise onsite erosion and to prevent the offsite sedimentation of adjacent properties, streams and waterbodies.

In this context, the following guidelines should be used in the study where appropriate.

- The proposal should be staged to minimise the area exposed to erosion damage at any one time.
- Permanent drainage and sediment control works should be installed as a first step, or as soon as practicable during land development. These works should then be immediately vegetated/stabilised.
- Topsoil should be stripped from each area to be disturbed and stockpiled for later spreading to aid revegetation.
- Temporary erosion and sediment control measures should be incorporated during all stages of development.
- Stormwater runoff from disturbed areas should be filtered through sediment-trapping structures. Where practicable runoff from undisturbed areas should be controlled separately.
- Disturbed areas should be progressively stabilised and revegetated so that no areas remain untreated for more than 7 days after earthworks are completed.
- All erosion and sediment control measures should be maintained in a functional condition. Maintenance procedures should be set up to ensure that accumulated sediment is removed from filter fences, traps and basins before 60% of the available capacity is lost.
- Temporary sediment control measures should be removed and these sites rehabilitated once they are no longer required.

Floodplain Management

All development proposals, as appropriate, should consider the State Government's Flood Policy as outlined in the Floodplain Development Manual (1986). The primary objective of the State Government's Flood Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers, and to reduce the private and public losses resulting from flooding.

Consideration should be given, where appropriate, to the impacts of flooding on a proposed development and the impact of that proposed development on flooding for the full range of flood events. Provision should also be made for flood free access to the site, for the full range of flood events, for public safety.

Other Ecological Matters for Consideration

- What will be the impact of the proposal, if any, on surface water flows and hydrology of the area, particularly in relation to any wetland?
- What will be the controls on surface water quality?
- What will be the impact of the proposal, if any, on groundwater quality and quantity?

- What will be the impact of the proposal on vegetation, both onsite and adjacent? Will there be a buffer zone between the proposal and any other significant vegetation or waterbodies such as wetlands?
- What are the planned erosion and sediment controls for the proposal? These should take the form of an Erosion and Sedimentation Control Plan which can be reviewed by the Department.
- Is the proposal likely to impact on sensitive soils (e.g. acid sulphate soils)?
- Is there likely to be any impact on the habitat of endangered species?
- If water supply is intended to be obtained from surface or groundwater, a licence under the Water Act (1912) may need to be obtained from the Department.

I trust the above comments and enclosed information will be helpful.

Yours sincerely,



John A Ross,
Environmental Review Co-ordinator,
for Catchment Planning Manager,
Sydney-South Coast Region



**NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE**

Valerie Smith
Director
Enviro-managers Pty Ltd
PO Box 270
ARTARMON NSW 2064

Your ref:
Our ref: SZT/ME/96/112

Dear Ms Smith

Proposed Marsden Park Landfill and Recycling Depot.

Thank you for your letter dated 30th June 1997 in which you consulted with the National Parks and Wildlife Service on the above proposal.

The Service has a statutory responsibility for the protection and care of native flora, native fauna and Aboriginal sites, and for the management of Service estate. Accordingly the Service has an interest in ensuring that potential impacts to these attributes are appropriately assessed.

To assist you in this regard, it is recommended that the matters referred to in the attached guidelines be addressed in your assessment where appropriate. The attached guidelines also provide information on any approvals that may be relevant under the National Parks and Wildlife Act and a summary of the Service's databases which may be of assistance to you in your assessment.

If you have any questions concerning this matter, please contact Ms Meagan Ewins, Environmental Planning Officer, on (02) 9585 6921.

Yours sincerely,

M. L. Ewins

ME
Ms Lou Ewins
Manager, Environmental Planning Unit
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GENERAL GUIDELINES FOR IMPACT ASSESSMENT

The National Parks and Wildlife Service (NPWS) has an interest in the potential impacts of the proposal on the following:

- areas of native vegetation,
- areas of potential value as habitat for native fauna,
- sites and places of Aboriginal heritage, and
- land dedicated under the National Parks and Wildlife Act (NPW Act).

If these attributes are anticipated to be present in your study area and / or likely to be impacted, it is recommended that assessments by a suitably qualified person be undertaken to determine the extent of impact. Details of the qualifications and experience of the person undertaking the work should be provided. In addition, a detailed description of survey methodology including survey design, sampling methods, weather conditions, time and duration of surveys and location of survey sites and transect lines should also be provided.

The matters recommended to be addressed in the assessment are as follows:

- description of the proposal and the way in which the environment will be modified;
- map(s) placing the proposal in a regional and local setting;
- applicability of Local Environmental Plans, Regional Environmental Plans and State Planning Policies (including SEPP 44 and SEPP 46) to the proposal should be discussed;
- information on the current and past land uses of the site and that of the surrounding area;
- detailed description and mapping of all vegetation communities in the study area;
- identification of any vegetation communities or plant species which are of local, regional or state conservation significance (including threatened communities, plant species or populations listed under the Threatened Species Conservation Act, 1995). The criteria for establishing significance should be documented;
- description of known or expected fauna assemblages within the study area;
- identification of fauna habitat likely to be of local, regional or state significance (including habitat of threatened fauna species or

populations listed under the Threatened Species Conservation Act, 1995);

- identification of whether there are any sites or places of cultural significance to the Aboriginal community;
- mapping of the location of all Aboriginal sites (including archaeological sites and potential sites) within the study area and an assessment of the significance of these sites;
- identification of habitat corridors and linkages between areas of remnant native vegetation which may assist faunal movement through the area;
- prediction of the likely impact of the proposal on the above attributes (quantification of the extent of impact where practical);
- assessment of measures available to minimise the impact of the proposal on these attributes and monitoring program if appropriate, and
- prediction of the likely impact of the proposal on land dedicated under the NP&W Act.

Threatened Species legislation

You are also advised that the Threatened Species Conservation Act, 1995 (TSC Act) came into effect on the 1 January 1996. The TSC Act effectively replaces the legislative scheme introduced by the Endangered Fauna (Interim Protection) Act, 1991 and amends the way threatened species are considered under the Environmental Planning and Assessment Act, 1979 and the National Parks and Wildlife Act, 1974.

It is recommended that consideration be given to the provisions of the TSC Act when undertaking the assessment of a proposal. Information on the provisions of the TSC Act may be obtained from the Department of Urban Affairs and Planning Circular No. A13 (12 December 1995). The Service has also produced an Information Pack on the TSC Act.

Aboriginal heritage and community consultation

With regard to Aboriginal heritage, it is recommended that an assessment of whether there are any places of cultural significance to the Aboriginal community be conducted. This should involve consultation with community representatives and if necessary documentary research to establish whether there are any places of traditional or historic significance to the Aboriginal community.

It is further recommended that assessment be conducted of the archaeological potential of the study area if the proposal involves disturbance to substantially unmodified ground surfaces. One means to assess archaeological potential is to obtain a site search from the Service.

In providing this information, the Service will provide advice as to the archaeological potential of the site and whether further surveying is recommended.

If the site does have archaeological potential then it is recommended that a survey be undertaken in consultation with the Local Aboriginal Land Council.

Should Aboriginal archaeological sites be present in the study area, you should consider the requirements of the NP&W Act with regard to Aboriginal relics. Under s90 of the Act it is an offence to knowingly damage or destroy relics without the prior permission of the Director-General of the NPWS.

Databases

The NPWS has two GIS databases which may provide information of use to you if you proceed to undertake further assessment. These are:

- Atlas listing of fauna and flora records in NSW;
- Aboriginal Sites register.

The material from these databases is available upon written application and the receipt of the appropriate fee. If you are interested in obtaining access to the Atlas database, please contact the Data Licensing Officer, GIS Division, on (02) 9585-6684. Records from the Aboriginal Sites register may be obtained upon written application to the Registrar, Cultural Heritage Conservation Division, on (02) 9585-6471.

APPENDIX 2
WATER MANAGEMENT

Prepared by:
DOUGLAS PARTNERS PTY LTD



Douglas Partners

Geotechnics • Environment • Groundwater

**REPORT
ON
HYDROGEOLOGICAL ASSESSMENT
AND WATER MANAGEMENT PLAN**

**PROPOSED QUARRY AND
WASTE DISPOSAL FACILITY
MARSDEN PARK**

***Prepared for
ENVIRO-MANAGERS PTY LTD***

**MARCH 1998
PROJECT 24681A**

Douglas Partners Pty Ltd
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**HYDROGEOLOGICAL ASSESSMENT
AND WATER MANAGEMENT PLAN
FOR PROPOSED QUARRY AND WASTE DISPOSAL FACILITY,
MARSDEN PARK**

1. INTRODUCTION

1.1 Background

This report details the results of the development of a water management plan and baseline surface and groundwater assessment by Douglas Partners Pty Ltd (DP) between October 1997 and March 1998 pertaining to the proposed quarrying and Class 2 non-putrescible landfilling of the disused quarry at Marsden Park, Sydney NSW. The study was conducted at the request of Ms Valerie Smith of Enviro-Managers Pty Ltd for inclusion in an EIS for the project prepared on behalf of the proponent, Ganiem Pty Ltd. The site is accessed from the west of Richmond Road, Marsden Park, Sydney, approximately 200m north of the Hollinsworth Road intersection (Drawing 1, Appendix A).

The site comprises a former quarry which operated between 1964 and about 1990. The volcanic breccia was principally quarried for road construction materials. The void left by the quarry is currently filled with water and the surrounding areas covered by hummocky stockpiles of river gravels previously imported and crushed on site. Four large dams lie to the east, southeast, and southwest of the quarry (Drawing 1, Appendix A) and the site is surrounded by regenerating eucalypt forest stands.

The site is located on a relative topographic high which drains radially into ephemeral streams. The landform is gently sloping with an average topographic gradient of 2% to 3%. Localised surface drainage has been directed into the quarry by the previous site owner. No major creeks or rivers flow adjacent to the site.

Landuse peripheral to the site is rural. The proposed quarry and landfill site is zoned 1(a) General Rural, and is 1 km from the nearest zoned residential land to the south at Bidwill.

1.2 Scope Of Work

It is understood the current water management assessment undertaken by DP is to be included as an appendix in the EIS for the proposed quarry/landfill project. The current water management assessment comprises two parts:-

1. Hydrogeological Investigation - assessment of baseline surface and groundwater conditions; and
2. Development of a Water Management Plan.

The hydrogeological investigation was used to establish the existing baseline surface and groundwater conditions prior to site operations. Six piezometers were installed in the current investigation, augmenting the previous two, water levels monitored, and surface and groundwater samples were analysed to assess water quality. The Water Management Plan (WMP) addresses management of various water issues with regards to existing conditions and proposed site operations.

1.3 Previous Investigations

There has been little previous environmental or hydrogeological assessment undertaken on the site. Two groundwater samples were collected from pre-existing boreholes (WB-1 and WB-2) as part of a preliminary assessment into the baseline groundwater quality during September 1997 (DP Issued Report No. 24681). The results indicated generally poor water quality with highly saline conditions present. The salinity was attributed to the ions, predominantly sodium and chloride, possibly derived from a connate source within the underlying shale bedrock.

The preliminary report concluded that the baseline water quality in the bores is unlikely to suffer derogation of utility or be severely impacted by the proposed quarrying and landfilling activities.

2. SITE DESCRIPTION

2.1 Location

The proposed quarry and waste disposal facility is located on the western side of Richmond Road, Marsden Park. The site is approximately rectangular in shape and occupies a total area of 141.65 ha described as Part Portions 26, 27, 28, 29, 32, 33, 34, 35, 36 and 47 of Deposited Plan 262886. The abandoned quarry site is located on Lot 47 and comprises 39 ha. The site is located in a rural setting generally surrounded by rural properties.

2.2 Topography

The subject area within the site comprises a flooded quarry in volcanic breccia. The quarry ceased operations around 1990. The southern portion of the quarry is lined with river gravels imported from the Hawkesbury River. A number of dams exist across the site developed as water retention basins utilised in conjunction with previous quarrying activities. Site plans (Drawings 1 and 2) depicting the local topography and the general surface conditions at the site are included in Appendix A.

The surrounding topography is gently undulating with an average gradient of 2-3 % and drains away from the site towards Bells Creek to the northeast and South Creek to the northwest. The proposed quarry extension and waste disposal site is located upon a slight ridge and the land falls radially from the site. The elevated central site area represents the neck of a volcanic intrusion.

2.3 Vegetation and Landuse

Vegetation across the site comprises large stands of eucalypt trees generally extending from the quarry to the outer limits of the site. Previous site uses include a quarry that involved the extraction of volcanic materials and importation of river gravels for crushing purposes. Quarrying materials were predominantly utilised for road base purposes. It is understood some areas of the site have previously been used for night soil disposal.

Current surrounding land use activities are predominantly pastoral and grazing. A pig farm is located adjacent to the northwestern corner of the site whilst a caravan park bounds a small area of the southern site boundary.

3. GEOLOGY

3.1 Geology

The Penrith 1:100 000 Series Geological Sheet indicates that the site is underlain by a volcanic neck (diatreme) comprising ash, tuff and breccia. The surrounding country rock comprises lower Bringelly Shales, which are, in turn, underlain by Ashfield Shale. These beds form part of the Wianamatta Group of Middle Triassic age.

The Bringelly Shales comprise a series of claystones, siltstones, laminites and lithic sandstone units with occasional minor sequences of carbonaceous material. The rocks are generally dark in colour, but may be lighter where natural leaching of iron and other minerals has occurred. Nodular ironstone bands are common within a couple of metres of the surface and may form an impermeable hardpan in places.

DP fieldwork and other bores drilled across the site confirmed the geological mapping predominantly comprising medium to high strength volcanic breccia located across the central site area. Interbedded shales, siltstones and sandstones were encountered in bores positioned around the perimeter of the previous quarry. The rock was observed to be of low strength in the near surface (approximately 5.0 m - 10.0 m) with increasing strength at depth and typically grading from highly weathered through to fresh rock.

3.2 Soils

Reference to the Penrith 1:100 000 Soil Landscape Sheet indicates the site lies on the boundary of two soil types; residual soils related to the Wianamatta Group shales and fluvial soils of the Hawkesbury/Nepean River System.

The residual soils generally occur on areas of gently undulating relief, usually with slopes of <5%. The soils are characteristically shallow to deep, red and brown podzolic soils, generally of high plasticity, low wet strength and high reactivity. On steeper slopes, such residual soils may become a soil erosion hazard with the potential for local mass movement. Slopes in the subject site are generally of low angle with gentle relief - average gradient is between 2% to 3%.

The second soils type is fluvial in nature related to the Tertiary terraces of the Hawkesbury/Nepean River System. These soils generally comprise soft to firm, mottled, orange clays and clayey sands. Iron nodules are common and silcrete boulders may occur in the clay and sand matrix up to 200 mm in size. The soils characteristically have a high wind erosion hazard if vegetation is cleared and the soils exposed. Gully, sheet and rill erosion on dissected areas may occur. Water logging is also characteristically associated with impermeable soils.

DP fieldwork confirmed the presence of residual clay soils and some sandy clay soils across the entire site.

3.3 Filling

A site inspection and anecdotal information has revealed that river gravels from the Hawkesbury/Nepean River System were previously imported onto site for the purposes of crushing to form rock aggregate. The river gravels generally form the north-eastern wall of the quarry void and extend several hundred meters to the south of the former quarry. The thickness of the deposits is believed to be approximately 1m but field observations indicate these may be up to 10 m thick in the immediate vicinity of the quarry.

4. FIELDWORK METHODOLOGY

4.1 Groundwater Monitoring

4.1.1 Bore Drilling

Six groundwater bores, WB3, WB4, WB5, WB6, WB7 and WB8 were drilled to a depth of 20.0 m utilising a truck mounted Scout rotary drilling rig. The method of drilling involved deployment of a 125 mm solid flight auger or blade to nominal refusal followed by the use of a 96 mm Poly-Crystalline Diamond bit (PCD rotary drilling piece). Water supplied by pumping from the local dam was utilised to wash rock and sediment returns back out of the hole.

The approximate locations of the six groundwater bores were determined following a site inspection and discussions with Enviro-Managers Pty Ltd and Ganim Pty Ltd. The exact

locations were determined by surveying and are shown on Drawing 1, Appendix A. Detailed drill logs are included in the Test Bore Report Sheets in Appendix B.

The bores were located in an approximate radius around the perimeter of the quarry to provide information on the groundwater flow direction, potential flow paths and local hydrogeochemistry.

4.1.2 Piezometer Installation Details

Piezometers were installed in each of the six bores. The piezometers comprised a 3 m screened length of machine slotted Class 18 UPVC pipe at the base of the bore (20 m total depth). Riser pipes were connected via screw threads such that no solvents or glues were required. All pipes were acid washed following manufacture and rinsed in Decon 90 and distilled water on site prior to installation in the case of contamination during transportation.

A gravel screen was placed to 0.5 m above the screened section of the pipes. The purpose of the screen was to enable water to infiltrate into the piezometer whilst restricting the amount of suspended soil or sediment that can enter the bore column. A 0.5 metre layer of bentonite clay was placed immediately above the gravel screen to act as an impermeable barrier, hence stopping the infiltration of water from above the screened section.

The remaining portions of the bores were back-filled with soil or drill returns and bentonite pellets. A concrete plinth was installed around the piezometer to prevent surface water infiltration and to secure the piezometer in place. A protective steel casing was installed over the PVC pipe and a lockable cap was fitted. Details of the piezometer installations are shown in the Piezometer Construction Report Sheets in Appendix C.

Table 1 lists the design and survey details of each of the groundwater monitoring bores located at the Marsden Park Quarry. Bores 1 and 2 (herein known as WB1 & WB2) were previously drilled by Amaral Consultants (Queensland).

TABLE 1 - BORE HOLE DETAILS : MARSDEN PARK

Bore Number	Drilling Method	Depth of Bore (m)	Screen Length (m)	Remains Intact	Easting	Northing	RL m, AHD
WB1*	Unknown	Unknown	Unknown	✓	284121.06	1267925.89	42.484
WB2*	Unknown	Unknown	Unknown	✓	283886.72	1268077.63	46.785
WB3	SFA, Blade & PCD	20 m	3.0	✓	284321.61	1268107.66	38.130
WB4	Blade & PCD	20 m	3.0	✓	284481.75	1268102.97	38.830
WB5	Blade & PCD	20 m	3.0	✓	284223.32	1267689.41	43.220
WB6	Blade & PCD	20 m	3.0	✓	283911.46	1267446.84	44.800
WB7	Blade & PCD	20 m	3.0	✓	283703.68	1267588.91	44.130
WB8	Blade & PCD	20 m	3.0	✓	283817.00	1268194.29	45.200

* Bores B1 & B2 (WB1 & WB2) installed by Amaral Consulting (Queensland)

SFA denotes Solid Flight Auger

PCD denotes rotary drilling with a Poly-Crystalline Diamond bit

4.1.3 Slug Tests

The hydraulic conductivity of the hydrogeological units within the screened section of each bore was determined by undertaking small scale groundwater slug (head recovery) tests. The standing groundwater level was recorded after equilibrium following installation of the piezometers and immediately prior to dewatering. Piezometers were then dewatered via a tremie pipe utilising an air lift compressor. The water level in the well was measured immediately after the tremie pipe was removed and thereafter measured at discrete time intervals until 20 minutes had elapsed or 37% recovery had occurred.

In productive water wells dip meter measurements are often inadequate because of rapid water level recovery. Under these circumstances automatic measuring devices must be used to measure recovery. For the purpose of this exercise, however, where the hydraulic conductivity was presumed to be fairly low, dip meter measurements were found to be adequate for the required purpose. Field results of head recovery tests are presented in Section 5.1.3. Results and working sheets are presented in Appendix D.

4.1.4 Groundwater Sampling

Groundwater samples were collected from each bore 24 hours after well development (i.e. purging of the bore). Samples were collected using a Grundfos 50 mm SS submersible pump capable of pumping large volumes of groundwater or a disposal Teflon bailer.

Groundwater samples were placed on ice to maintain temperatures at less than 4°C for transportation to the laboratory. Preservation techniques generally complied with those outlined in Appendix E. All sampling data was recorded on DP Chain of Custody Field Sheets as presented in Appendix F. The field and sample handling procedures comprised the following quality control/quality assurance (QA/QC) protocols:-

- collection of prewashed sampling bottles from NATA registered laboratory, prior to travelling to the site;
- washing of sampling equipment in a 3% solution of phosphate free detergent (Decon90) then rinsing with distilled water prior to each sample being taken;
- transfer of the sample into prepared glass bottles;
- placement of the glass bottles into a 4°C cool, insulated and enclosed container for transport to the laboratory; and
- collection of one duplicate for QA/QC purposes.

The samples were transferred to Australian Environmental Laboratories (Sydney) for analysis. The laboratory is certified by the National Association of Testing Authorities (NATA) to conduct the necessary tests and is required to carry out in house QA/QC procedures.

A detailed account of sampling methods and procedures adopted for the groundwater sampling is presented in DP's Manual of Standard Operating Procedures; Monitoring Programme for Surface Water and Groundwater.

Groundwater samples obtained from the bores at the Marsden Park were analysed for the parameters listed in Table 2. Results of the laboratory analysis are presented in Section 5.

TABLE 2 - LIST OF DETERMINANDS ANALYSED AT MARSDEN PARK

Chemical Determinant	Required Analytical Detection Limit (µg/L)
Alkalinity	1000
Ammonia	50
Calcium	5000
Chloride	5000
Fluoride	500
Iron	300
Manganese	50
Magnesium	5000
Nitrate	100
pH	0.1 pH unit
Total phenolics*	50
Potassium	5000
Sodium	5000
Sulphate	5000
Total organic carbon (TOC) **	50
Bicarbonate	-
Carbonate	-
Total Dissolved Solids	-
Dissolved Oxygen	-
Faecal Coliforms per 100 mL	-
E. Coli per 100 mL	-

* Total phenolics or summation of 17 individual phenol containing compounds identified by USAEPA Method 8040 (USAEPA, 1992).

** For groundwater analyse filtrate from a 0.45 micron pore diameter filter; for surface water analyse TOC on an unfiltered water sample

4.2 Surface Water Monitoring

Surface water samples were collected from dams located on site and from areas of surface water drainage peripheral to the site (local streams) to determine local surface water quality.

Surface samples were collected using a 'grab' technique. This technique involves placing a sample bottle in a support frame on a metal extension and lowering it into the water until filling has occurred.

Three water storage samples were collected from dams on site including one sample from water presently occupying the former quarry (D-series). The second and third samples were collected from two other dams on site.

Four surface water samples were collected from pools located along local streams (C-series). Sample C12 was collected to the south of the site from an ephemeral tributary that flows in a westerly direction towards South Creek. South Creek is located approximately 5 kilometres to the west of the site and flows north towards the Hawkesbury River. Sample C13 was collected from a ephemeral stream that flows towards the east and joins Bells Creek. Bells Creek is located approximately 1.5 kilometres to the east of the site and has a northerly flow. Samples C14 & C15 were collected from two localities along Bells Creek.

The locations of the surface water samples collected at, or in the vicinity of, the Marsden Park site are shown on Drawing 2, Appendix A. Results of the chemical analyses of samples are presented in Section 5.

5. EXISTING HYDROGEOLOGY

5.1 Groundwater

The volcanic diatreme typically comprises a fine grained crystalline matrix with coarse grained clastic or volcanic rock fragments composed of broken, angular fragments. The composition of the volcanic breccia including the fine grained volcanic matrix restricts the permeability of the formation producing extremely low hydraulic conductivities. Groundwater flow will be predominantly controlled by the extent of fracturing throughout the rock formation.

The composition of the shales, siltstones and sandstones including the variation in grain size, shape and sorting restricts the intergranular permeability of the formation. In general, groundwater flow would be variable throughout the formation, principally governed by localised jointing, fracturing, bedding, and the relative thickness of the weathered zone.

Groundwater movement through the river gravels present across areas of the site will be significant, with high hydraulic conductivities common. However, the limited areal and vertical extent of the river gravels and the presence of the underlying volcanic breccia and sedimentary units is likely to produce a very low overall flow of groundwater across the site.

Groundwater in the shales is typically highly saline which renders it largely unsuitable for use either as a potable resource, livestock watering, or irrigation. Old (1942) reported total salt concentrations of up to 31750 mg/L in waters taken from bores within the Bringelly Shales with typical values of Total Dissolved Solids (TDS) in the Marsden Park area in the order of 20000 mg/L.

5.1.1 Drilling Returns

Drilling returns from the six bores indicated a principle lithology comprising low to medium strength, highly weathered to fresh, interbedded shales, siltstones and sandstones. The bedrock was generally overlain by 3.0 m - 7.0 m of residual clays and sandy clays that typically contained ironstone nodules.

Detailed drill logs are included in the Test Bore Report Sheets presented in Appendix B, together with soil, rock description and classification methodology. Piezometer construction details are included in Appendix C.

5.1.2 Groundwater Levels and Flow

Following piezometer installation, groundwater bores were allowed to equilibrate for a period of several weeks. Groundwater levels were then recorded using a stainless steel depth gauge prior to slug tests and purging of the bores on 30 October, 1997. The pre-sampling standing water levels (SWLs) are shown in Table 3.

TABLE 3 - GROUNDWATER SWLs - 30 OCTOBER 1997

Borehole No.	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
Ground Level RL m, AHD	42.48	46.79	38.13	38.83	43.22	44.80	44.13	45.20
Water Depth Below Ground Level	3.19	9.94	2.70	4.25	11.08	4.02	4.38	7.03
SWL RL m, AHD	39.29	36.85	35.43	34.58	32.14	40.78	39.75	38.17

Static Water Levels (SWLs) in the piezometers at Marsden Park indicate a radial drainage pattern away from the quarry. Inferred SWL Contours are plotted in Drawing 1, Appendix A. The quarry is located on a regional topographic high and surface drainage divide - likely a result of the volcanic diatreme at the centre of the quarry which produced a raised erosional feature. The groundwater drainage pattern approximately resembles the topographic contours and surface drainage.

Of note is the relatively low SWL in WB2 indicating a localised groundwater "sink" in the direction of the quarry. A localised topographic high lies immediately to the northwest of WB2 and most likely comprises a groundwater drainage divide proximal to WB2. The hydrogeology of the (unknown) rockmass surrounding the bore may have been affected by quarry operations, namely blasting, and possibly represents a strong hydraulic connection zone with the quarry via fractures.

Due to the site location on a topographic divide, the regional groundwater flow is likely to be in the same direction as the surface drainage - i.e. to the northwest and north towards the tributaries of South Creek, and to the northeast towards Bell's Creek.

5.1.3 Hydraulic Conductivity

The hydraulic conductivities of the formation in which the screened sections of the bores are installed was carried out using the Hvorslev method (1951) which utilises the head recovery technique described in Section 4.1.3.

The results of the recovery tests are presented in Table 4. Detailed documentation of the recovery data is provided in Appendix D.

TABLE 4 - HYDRAULIC CONDUCTIVITY RESULTS

Bore Number	Hydraulic Conductivity (m/sec)	Materials Encountered
WB1+	9.27×10^{-6} m/sec	assumed 1m river gravel at surface, shale at depth
WB2+	4.26×10^{-7} m/sec	shale
WB3	2.94×10^{-8} m/sec	clays overlying medium strength shale, siltstone & sandstone
WB4	7.11×10^{-8} m/sec	clays overlying medium strength shale, siltstone & sandstone
WB5	1.42×10^{-9} m/sec	clays overlying medium strength shale, siltstone & sandstone
WB6	4.96×10^{-8} m/sec	clays overlying medium strength shale, siltstone & sandstone
WB7	3.88×10^{-8} m/sec	clays overlying medium strength shale, siltstone & sandstone
WB8	7.11×10^{-9} m/sec	clays overlying medium strength shale, siltstone & sandstone

+ Drilled previously by Amaral Consultants

The hydraulic conductivity values obtained from the recovery tests are typical of shales, generally ranging from 10^{-8} to 10^{-9} m/sec. The results are consistent with the reported local geology and stratigraphy intersected whilst drilling.

Results indicate the shale materials across the site are generally of low hydraulic conductivity. Despite the low values obtained, all of the materials tested exceed EPA Benchmark hydraulic conductivity criteria for leachate barriers of 1×10^{-9} m/sec. Therefore, the insitu rock material is marginally unsuitable for use as a natural leachate barrier and suggests a natural clay (or synthetic) liner will be required to impede the flow of leachate.

5.1.4 Groundwater Quality

Groundwater samples were collected from Bores WB3 - WB8 and analysed for a range of indicator determinands in line with the NSW EPA Environmental Guidelines : Solid Waste Landfills. The results of the analyses are summarised in Table 5. Detailed laboratory reports and laboratory QA/QC are given in Appendix G.

TABLE 5 - GROUNDWATER LABORATORY RESULTS AT MARSDEN PARK

Chemical Determinant	WB3 (mg/L)	WB4 (mg/L)	WB5 (mg/L)	WB6 (mg/L)	TC1 ¹ (mg/L)	WB7 (mg/L)	WB8 (mg/L)
Calcium	320	510	210	85	83	160	230
Iron	0.06	<0.06	<0.06	<0.06	0.08	<0.06	0.26
Magnesium	900	850	550	370	360	370	570
Manganese	<0.2	0.3	0.66	0.24	0.2	1.2	2.6
Potassium	35	37	36	11	20	31	39
Sodium	7500	6500	4700	4000	4300	3700	5100
Ammonia (as N)	2.1	2.3	2.8	1.5	0.3	1.0	2.0
Alkalinity (as CaCO ₃)	870	810	550	430	380	1100	870
Bicarbonate	870	810	550	430	380	1100	870
Carbonate	<1	<1	<1	<1	<1	<1	<1
Fluoride	0.3	0.4	0.4	0.4	0.4	0.3	0.4
Total Dissolved Solids	18000	16000	11000	9500	8400	7800	12000
Total Organic Carbon	20	12	9.5	9.4	10	18	20
Total Phenolics	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
pH	6.8	6.4	7.8	7.4	7.4	7.3	7.4
Chloride	13000	11000	7100	7100	6400	5000	9000
Nitrate (as N)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sulphate	2100	1400	840	620	460	560	920
Dissolved Oxygen	9.5	8.9	9.4	11	8.1	15	12
Faecal Coliforms ²	0	0	530	78	14	54	110
E. Coli ²	0	0	460	78	14	54	110

Notes:

- 1 Sample TC1 is a field duplicate of Bore WB6, in accordance with DP's QA/QC Procedures
- 2 Sample is recorded as number per 100 mL

Analyses of groundwater samples from Marsden Park indicate the existing (1997) groundwater is highly saline and of poor quality. The groundwater is typified by high Total Dissolved Solids (TDS), in the range 7800 mg/L to 18000 mg/L, comprised predominantly of sodium, chloride, and sulphate. The analyses also show low levels of ammonia and faecal coliforms, important in establishing the groundwater pre-conditions prior to the proposed quarry/landfill operations.

The groundwater is not regarded as a resource and the poor quality and high salinity preclude its use as a potable water supply, as livestock water, and for irrigation. The groundwater chemistry is summarised below:-

pH and Bicarbonate

The pH of groundwater samples collected from the monitoring bores generally indicates neutral conditions prevail across the site with a range of pH 6.4 to 7.8. The neutral nature of the groundwater is reflective of moderate to high bicarbonate (HCO_3^-) concentrations. The carbonate system typically acts as a natural buffering system in groundwater. Carbonic acid (H_2CO_3) is the dominant dissolved carbonate species present below pH 6 and would be expected to comprise approximately 96 % of carbonate in groundwater at pH 4.6. Alternately, at pH 7 bicarbonate (HCO_3^-) essentially accounts for the total dissolved carbonate species in groundwater, whilst at higher pH values (> 10.38) the carbonate ion becomes the dominant carbonate species. This phenomena accounts for the absence of carbonate in all groundwater samples analysed.

Ammonia and Nitrate

Ammonia levels were detected at ranges between 1.1 and 2.8 mg/L. The most common sources of ammonia entering groundwater come from domestic sewerage or industrial effluents (ANZECC, 1992). However, denitrification of nitrates may also be a source given the surrounding agricultural landuse and probable application of fertilisers. Extremely low levels or the absence of nitrates further suggests that denitrification processes may be occurring. The allowable concentration of ammonia in groundwater based on the guidelines for the protection of aquatic ecosystems (ANZECC, 1992) is a function of temperature and pH. Concentrations range between 1.5 - 2.2 mg/L for temperatures between 15 - 20°C and pH 7 - pH 7.5. These guidelines generally indicate ammonia concentrations are within anticipated background levels.

Cations/Anions and Salinity

The major anion and cation distribution is presented on the Piper Trilinear Diagram shown in Figure 1. The piper trilinear shows the groundwater plotting on the right hand side of the trilinear plots for each bore suggesting a dominance of sodium and chloride. The groundwater can be characterised as $\text{Cl}^- - \text{SO}_4^{2-} - \text{Na}^+$ type facies.

Groundwater salinities were detected at very high to extremely high levels across the entire site as evidenced in the high levels of total dissolved solids. The high TDS values are typical of the local natural groundwater and are dominated by the ions sodium and chloride. These two ions are most likely derived from connate seawater or from dissolution of salts released from the underlying shale rock.

Total Organic Carbon

Total organic carbon represents the organic content within the groundwater that may be available for biological or chemical processes. Chemical analysis indicates that moderate levels of TOC are present within the monitoring bores surrounding the site.

Faecal Coliforms

Based on the former site history which suggested that areas of the site may have been utilised for night soil disposal, faecal coliform numbers were analysed. The laboratory results indicate varying numbers of faecal coliforms across the site. No faecal coliforms were detected in bores WB3 & WB4 located to the northeast of the site. Numbers ranged between 14 and 530 per 100 mL in other bores around the site. Total faecal coliform numbers are predominantly comprised of the pathogen E.coli.

Faecal pollution in groundwater is inferred from the presence of coliforms and human sewage by the presence of E.coli. These micro-organisms may enter the groundwater system from leaking sewer pipes, septic tank percolation, areas of intensive animal husbandry or polluted rivers. Faecal coliform presence indicates one of the above sources is contributing to the presence of faecal pollution in local groundwater. The Australian Guideline Value for Microbiological Water Quality sets a safe drinking water standard of <1 total coliform/100 mL for drinking water.

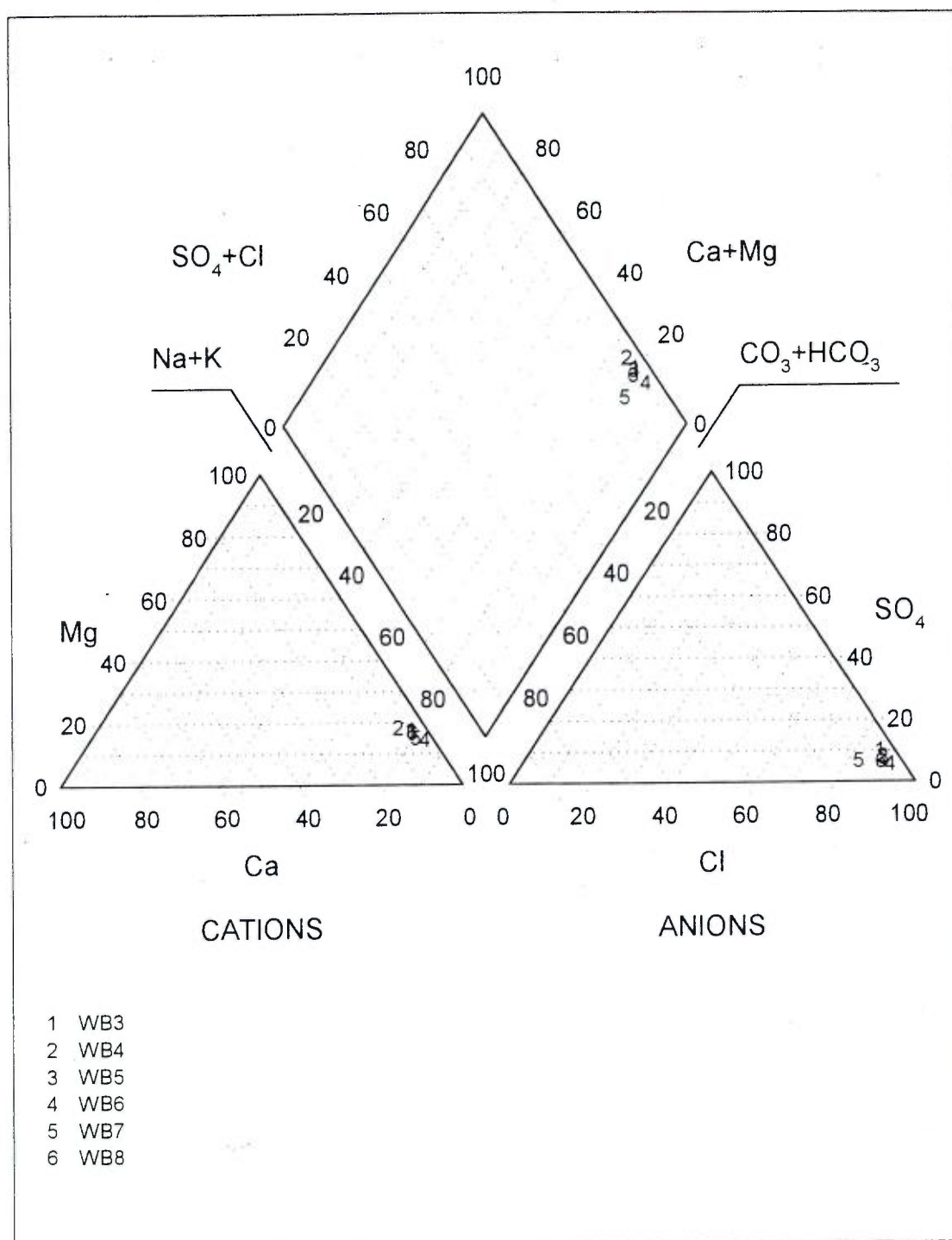


Figure 1 - Piper Diagram Showing Ionic Concentration Percentages in Groundwater Bores from Marsden Park

No previous monitoring has been conducted on Bores WB3-WB8. However, previous laboratory results obtained from bores WB1 and WB2 indicate very similar groundwater quality characterised by high salinity groundwater dominated by the ions sodium and chloride. Ammonia and nitrate levels were generally low while the pH was again neutral resulting in high bicarbonate concentrations. Analysis was not undertaken for faecal coliform in WB1 and WB2.

5.2 Surface Water

Surface water storage at the site is comprised of four large dams, including the water filled void left by the quarry, shown in Drawing 1, Appendix A. Surface drainage from the site is generally radial due to the high localised topographic relief, although the land is relatively flat with an average gradient of 2% to 3%. Drainage from the site is via minor ephemeral streams which meander predominantly to the northwest, north, and to the northeast of the site shown in Drawing 2, Appendix A. The drainages on site were dry at the time of the investigation and it was necessary to sample creeks off site.

Three surface samples were collected from dams on site and four samples were collected from local water courses - surface sample locations are shown in Drawing 2, Appendix A. The samples were analysed for a range of indicator determinands in line with the NSW EPA Environmental Guidelines : Solid Waste Landfills. The results of the analyses are listed in Table 6; D - series samples denote Dam samples, and C - series samples denote Creek samples. Detailed laboratory reports and laboratory QA/QC are included in Appendix G.

TABLE 6 - SURFACE WATER LABORATORY RESULTS AT MARSDEN PARK

Chemical Determinant	D9 (mg/L)	D10 (mg/L)	D11 (mg/L)	C12 (mg/L)	C13 (mg/L)	C14 (mg/L)	C15 (mg/L)
Calcium	5.6	6.1	9.7	26	27	11	48
Iron	1.0	0.41	0.2	0.2	1.7	0.6	0.28
Magnesium	8.7	22	27	37	11	12	20
Manganese	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Potassium	10	<2	3.2	8.1	7.0	2.8	5.8
Sodium	59	240	220	250	62	83	250
Ammonia (as N)	4.4	0.2	0.1	0.1	0.1	0.1	0.3
Alkalinity (as CaCO ₃)	130	340	350	52	120	75	150
Bicarbonate	130	130	250	42	120	75	150
Carbonate	<1	210	100	10	<1	<1	<1
Fluoride	0.5	0.1	0.1	0.4	0.5	0.4	0.8
Total Dissolved Solids	220	620	620	950	280	290	1100
Total Organic Carbon	16	19	16	9.8	18	9.8	17
Total Phenolics	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
pH	7.6	9.4	9.3	9.2	7.2	7.3	7.3
Chloride	69	210	120	600	80	100	480
Nitrate (as N)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulphate	4.5	3.7	31	73	45	25	75
Dissolved Oxygen	9.5	18	14	16	6.4	13	7.5
Faecal Coliforms ¹	71	0	19	0	92	82	13
E.Coli ¹	71	0	19	0	92	55	13

Notes:

- 1 Sample is recorded as number per 100 mL
 D Series denote Dam samples
 C Series denote Creek samples

5.2.1 Dam Water Quality

Dam waters were sampled and analysed from the locations shown in Drawing 2, Appendix A. The dam waters are typically of poor quality due to the presence of faecal coliforms with TDS ranging from 220 mg/L to 620 mg/L. pHs are neutral to slightly alkaline and there are no major pollutants. The chemistry of the dam waters does not demonstrate any direct hydraulic connection between the dams and groundwater.

Analyses of the dam samples indicate these waters, and waters stored in the dams in the future, may be suitable for use for dust suppression and irrigation of revegetated areas. However, it is proposed to retain and leave undisturbed the existing Southern Dam due to the dam's ecological sensitivity. It is proposed to drain and use the existing Western Dam as a leachate collection dam. These two intended uses for the respective dams preclude their use as sedimentation ponds for storing dust suppression waters. This will necessitate the construction of two new dams, of similar dimensions to the dams they are respectively replacing, in the proposed locations shown in Drawing 1, Appendix A.

Analysis of waters from the quarry dam, sample No. D11, indicate this water may be suitable for discharge into the surrounding drainages, the water quality not exceeding limits in the Clean Waters Regulations (1972) for discharge into water courses. The relevant government regulatory body permit(s) will necessarily have to be obtained prior to draining and pumping from the dam but preliminary water quality analysis indicates the dam water will not derogatively impact on creek water quality at the site. Alternatively, the quarry dam waters may be used to replenish the existing dams on site or provide initial storage in the proposed new dams on site.

The dam waters contain low to moderate faecal coliforms concentrations which preclude the use of the water for drinking purposes. The source of the faecal coliforms is likely to be stock and wildlife which water from the dams.

5.2.2 Creek Water Quality

Creek waters were sampled peripheral to the site in locations where surface water was available - locations are shown in Drawing 2, Appendix A. Two tributaries of South Creek to the northwest and north of the site and two locations on Bells Creek to the east were sampled.

Generally the creek waters are of poor quality due to the presence of faecal coliforms possibly sourced from the rural land use and animal husbandry industries in the area.

There are no other major pollutants and the waters are of neutral pH to slightly alkaline. TDS concentrations range from 280 mg/L to 1100 mg/L. The low TDS concentrations, the ephemeral nature (discontinuous flow) of the creeks, and the low hydraulic conductivity in the shale bedrock suggest there is no baseflow from groundwaters contributing to

streamflow in the immediate vicinity of the quarry. The latter is especially so between storm events.

5.3 QA/QC Results

Quality assurance/quality control (QA/QC) procedures comprised an integral part of this hydrogeological investigation, and included both field and laboratory QA/QC procedures.

5.3.1 Field QC Results

The field QC comprised duplicate sampling, and approximately 10% additional samples were obtained during the course of sampling. Of a total of 12 samples obtained, one of these was a duplicate sample (TC1 of WB6). Sample TC1 were analysed for the range of determinands outlined in Table 2. The comparative results of analysis are included in Table 5. The results indicate an acceptable consistency between the sample WB6 and the duplicate TC1, with the exception of potassium (58%), ammonia (133%) and faecal coliform (139%). A relative percentage difference of $\pm 30\%$ is generally considered acceptable. RPDs are not applicable at very low concentrations, i.e. at concentrations 5 times the PQL and this may have contributed to the discrepancy observed in the potassium and ammonia analysis. Faecal coliform QA/QC analysis is considered acceptable if duplicate numbers are within one order of magnitude.

5.3.2 Laboratory QA/QC Results

The analytical laboratory is certified by the National Association of Testing Authorities (NATA) and is required to conduct in-house QA/QC procedures. These are normally included in every analytical run and include the following:-

Reagent blank

This sample is prepared and analysed at the beginning of every analytical run, following calibration of the analytical apparatus. The laboratory results for reagent blanks for water analyses indicated concentrations of all analytes to be below laboratory detection limits. These results are included in the laboratory report in Appendix G.

Spike/Recovery

This sample is prepared by adding a known amount of analyte prior to analysis, and then treated exactly the same as all other samples. The recovery result indicates the proportion of the known concentration of the analyte which is detected during analysis. The spike/recovery results for most analytes were within the range 71 - 111 %. A range of 75-125 % is generally considered acceptable. These results are included in the laboratory report in Appendix G.

Duplicates

These are additional portions of a sample which are analysed in exactly the same manner as all other samples. Duplicate (repeat) samples are analysed during each analytical run. The duplicate sample results indicate that the relative percentage difference (RPD) between samples and repeat samples is generally below 10 %. An order of magnitude is considered acceptable for QA/QC purposes when analysing for microbiological parameters.

5.4 Summary of Existing Hydrogeological Baseline Conditions

Based on the hydrogeological investigation undertaken at Marsden Park during October 1997, review of previous groundwater quality monitoring conducted on site, and visual observations made during the present investigation, the following summary may be made:-

- the hydrogeological characteristics of the site are dominated by relatively low hydraulic conductivities in the underlying interbedded shale and sandstone lithology. The nature of the groundwater flow is severely restricted by the composition of the bedrock material, particularly the fine grain size of the rock, thus groundwater is likely to flow along fracturing or jointing within the rock mass;
- the measured hydraulic conductivities for the rock materials were measured between 9.27×10^{-6} to 1.42×10^{-9} m/sec. This exceeds the guideline value of 1×10^{-9} m/sec for natural leachate barriers defined by the New South Wales Environmental Protection Authority (Environmental Guidelines : Solid Waste Landfills). The permeability of the rock mass would therefore be unsuitable for direct landfill disposal. Residual soils would be required for the placement of a landfill liner that would meet the requirements of the NSW EPA;

- groundwater analysis indicated highly saline groundwater with poor overall groundwater quality unsuitable for domestic purposes. Low levels of ammonia and the presence of faecal coliform suggest there may be local sources of organic contamination, possibly related to surrounding agricultural, animal husbandry, or anthropogenic activities (i.e. pig farming to the northwest of the site, grazing, and the nearby caravan park). The site was previously used for night soil disposal;
- the influence of the volcanic neck on groundwater chemistry is difficult to determine, but may contribute to the presence of trace metals and sulphides;
- surface water is generally of poor overall quality containing faecal coliforms and low levels of ammonia in most samples. Low ionic concentrations in surface samples indicate saline groundwater is not contributing to baseflow in most streams or dams with the exception in the vicinity of sample C15;
- review of the hydrogeological and hydrogeochemical data indicates there should be little environmental impact on local groundwater or surface water, provided sufficient water management strategies are developed and implemented; and
- it is recommended that a groundwater and surface water monitoring programme be implemented to accumulate water quality data and determine variations in baseline groundwater chemistry prior to commencing quarrying or landfilling activities.

6. SURFACE WATER MANAGEMENT PLAN

6.1 Introduction

The objectives of surface water management on site are:-

- to provide sufficient water to meet quarry / landfill operational requirements;
- to utilise the poorest quality water suitable for each particular use; and
- to prevent impacts and derogation of water quality in surface drainages and groundwater as a result of site operations.

The surface water management plan is designed to keep site run-off and potential leachate waters isolated from each other. Surface drainage water and water pumped from the void prior to and during operations will be diverted around the proposed quarry/landfill operations. Stormwater runoff within the site will be fully controlled and no uncontrolled discharges will occur to adjoining properties or watercourses.

It is proposed to preserve and leave undisturbed the existing Southern Dam due to the ecological sensitivity of the dam. It is proposed to utilise the existing Western Dam as a leachate collection dam. To provide sufficient water for the quarry and landfill operations, two new dams will be required to be constructed. The proposed two dams are herein known as the Southwestern and Northeastern Dams - the locations are shown in Drawing 1, Appendix A. The existing Eastern Dam will be retained and utilised for water storage and as a sedimentation pond during site operations.

The site is located on a regional topographic high and is considered to constitute a very low flood hazard.

6.1.1 Drainage of Quarry Dam

It is proposed to pump out and dispose of waters currently filling the quarry. The estimated approximate volume of these waters is 214500 m³ (214.5 megalitres). This estimate is based on an average water depth of 6.5m and a calculated surface area of 33000 m².

Sampling and water quality analysis indicates the quarry dam waters will be suitable for discharge to the surrounding natural water courses. Analytes tested do not exceed the limits listed in the Clean Waters Regulations (1972) for discharge into water courses. Sampling and analyses from creeks peripheral to the site indicate the quarry dam waters will not detrimentally impact water quality in the creeks.

Appropriate permits from the relevant government bodies (EPA and DLWC) will necessarily have to be obtained prior to disposal of the quarry dam waters.

6.2 Water Demands

Clean potable water is required for staff consumption and to service amenities. Water of lesser quality will be required for dust control and for irrigation of revegetated areas.

The service mains of Blacktown City Council is the principal source of potable water supply - a reticulated water supply exists near Bidwell which will be extended to the site. The mains water will also serve to augment the supply for dust control if necessary. Total potable water demand will depend on the number of employees and is estimated at approximately 100 litres per person per day.

Water for dust control will be provided by the existing and proposed dams on site - the backup water supply will be the reticulated mains water. Unsealed access roads and active quarry/landfill areas will require dust control during dry weather. Using a water application rate of 1.5 times the average evaporation rate for Richmond, 1.54 metres per year, the maximum water demand for unsealed roads dust suppression is estimated to be approximately 11000 m³ per year (11 megalitres per year). The latter assumes an estimated maximum length of unsealed access / haul roads of 0.8 km and 6m width. The haul road to the quarry site will be sealed but roads in and around the quarry will be unsealed.

The crushing and screening plant will require non-potable water for dust control. Quarry production will be approximately 300000 tonnes per annum. Water requirements for dust suppression during the crushing process will be in the order of 2% of production by weight. This equates to approximately 6000 m³ (6 megalitres) of water required for dust control during the crushing and screening process.

Revegetated areas will require watering during vegetation establishment stages. It is assumed native plant species suitable for the local climate will be used. Assuming an average area of 1 hectare of revegetation per year, at an application rate of 400 mm per year, the anticipated water demand for revegetation irrigation is approximately 4000 m³ per year (4 megalitres per year).

It is estimated the total volume of non-potable water demand for the Marsden Park proposed quarry/landfill operations will be approximately 21000 m³ per year (21 megalitres per year). Current storage capacity of the existing and proposed dams adjacent to the

quarry is estimated to be approximately 42000 m³ (42 megalitres). The three dams to be utilised are the existing Eastern Dam, and two new dams shown in Drawing 1 as the proposed Northeastern and Southwestern Dams.

6.3 Surface Drainage

Existing surface drainage is in a predominantly natural radial drainage pattern dictated by the relative topographic high at the site of the quarry. Ephemeral drainages fall radially from the site with the main drainage to the east of the quarry intersected by and draining into the existing dams constructed for the previous quarry operation (Drawing 1, Appendix A). Due to it's ecological value, the existing Southern Dam will be retained, left undisturbed, and not utilised by the proposed quarry/landfill operations. The existing Eastern Dam will be retained for the proposed quarry/landfill operation and will continue to be used as a detention and storage dam. Additionally, two dams are proposed to be constructed in the southwest and northeast areas of the site. Surface drainage will be directed to these dams, shown in Drawing 1, Appendix A as the Proposed Northeastern and Southwestern Dams.

The previous landowner has directed surface waters via channels and drains into the quarry to facilitate filling the quarry void. This practice will be terminated and runoff directed away from the quarry. Surface runoff will be prevented from flowing into the proposed quarry/landfill by the construction of bunds 1.0m wide by 0.5m high along the perimeter of the void - the location of the proposed bunds are shown in Drawing 1, Appendix A. Runoff from unsealed access roads will be directed away from the quarry by the construction of table drains (i.e. road shoulder drainage runoffs) every 100m. The table drains will reduce erosion and mitigate sediment migration from the road surface.

All drainage on the northern, southern, and eastern sides of the quarry and operations site will be directed to the ephemeral stream (with linked dam chain and proposed Northeastern Dam) which flows to the northeast along the eastern boundary of the site. All drainage on the western side of the quarry/landfill operations will be directed towards the proposed Southwestern Dam.

Open earth trapezoidal drains (i.e. flat floor), approximately 200 mm deep, 1600 mm wide at the top, and 800 mm wide at the base, with side batters of 1 vertical to 2 horizontal, will link major points of surface water accumulation. The open earth drains will be constructed

as needed depending on the dynamics of the landform during removal of overburden and alluvial gravels for use as cover material in the landfill. Provisional locations of the earth drains are shown in Drawing 1, Appendix A. A section of earth drain construction is shown in Drawing 3, Appendix A.

6.4 Water Quality Objectives

The main creeks to the northwest and to the east of the site, South Creek and Bells Creek respectively, are classified waterways under the Clean Waters Act and are subject to specific water quality criteria for industrial discharges. There is discontinuous flow from the ephemeral streams on site to tributaries of the main creeks. The EPA will develop licence conditions under the Pollution Control Act for site discharges other than uncontaminated stormwater should this become necessary during normal site operations.

The water quality guidelines and standards set in the Clean Waters Regulations (1972) and the Australian and New Zealand Environment and Conservation Council (ANZECC, 1992) are considered the most applicable to the quarry / landfill operation.

6.5 Pollution Control

The surface water management plan addresses waters of variable quality produced during site operations, including:-

- clean water runoff from undisturbed vegetated areas;
- turbid water runoff from disturbed areas;
- water polluted from site operations;
- stormwater runoff from within the quarry/landfill; and
- leachate from the (non-putrescible) landfill.

On the northern, eastern, and southern side of the quarry clean (storm) water runoff will be diverted, where possible, via table drains and open earth drains around disturbed areas and into the ephemeral drainage with the linked existing and proposed dams at the eastern

boundary of the site. Runoff on the western side of the site will be diverted to the proposed dam in the southwest of the site. This will serve to maximise the site water storage reserves. The area around the bunded perimeter of the quarry will be graded away from the excavation to prevent ingress of surface water flowing into the void. If necessary, the water will be acceptable for discharge to the local water courses providing the water does not intersect waste material or become contaminated en-route.

Prior to construction, the Environmental Protection Authority, the Department of Land and Water Conservation, and Blacktown City Council will need to approve plans and specifications for all clean water drainage works.

6.5.1 Design Criteria

Appropriate design criteria will be used to design and construct drainage structures.

The Department of Land and Water Conservation recommends that a (design) storm with a one in ten year Average Recurrence Interval (ARI), six hour duration (Intensity, $I_{10/6}$), be used for the design of sediment ponds.

Other surface drainage structures will also be designed using a (design) storm of one in ten year ARI. The design discharges for the drainage structures will be based on the recommendations in Australian Rainfall and Runoff (Bureau of Meteorology, 1987) utilising a storm duration equivalent to the time of concentration.

Drains will be installed with a minimum grade of 1% - the same grade will be assumed for sizing drains. Open earth drains will need to be approximately 200 mm deep with side batters of 1 vertical to 2 horizontal. The drains are nominally sized to be 1600 mm wide at surface and 800 mm wide at the base. The drain design is shown in Drawing 3, Appendix A. The size of the drains will vary over the length dependent on the actual catchment area draining to that interval of the drain.

6.5.2 Catchment Areas and Discharges

For the purpose of determining if the proposed and existing dams are of sufficient capacity to be used as sediment detention ponds, the discharge from each catchment is calculated. The two catchments are labelled in Drawing 1, the divide based on topographic contours

and a site inspection. The formula for calculating discharge (Q_{10}) from each catchment at Marsden Park is from Australian Rainfall and Runoff utilising data from the Bureau of Meteorology and is as follows:-

$$Q_{10} = 0.00278 \times C \times I \times A$$

where:

- Q_{10} = peak flow rate (m^3 / sec) of a 1 in 10 Average Recurrence Interval (ARI) storm,
- C_{10} = 0.4 (coefficient of runoff for a 1 in 10 year ARI storm for Established Pasture with heavy soil),
- $I_{10/6}$ = 14.90 mm/hr (rainfall intensity for a 1 in 10 year ARI storm of 6 hours duration),
- A = catchment area (hectares).

The discharge volumes for the design storm for Catchments 1 & 2 are listed below in Table 7.

TABLE 7 - DESIGN DISCHARGE VOLUMES - CATCHMENTS 1 AND 2

	Catchment Area 1	Catchment Area 2
Catchment Area (ha)	4.00	12.50
Design Discharge (m^3/sec)	0.07	0.20

6.5.3 Sedimentation Dams

It is proposed to use one of the existing dams (Eastern) on site and construct two additional dams (Northeastern and Southwestern) for use as sedimentation dams to which all surface drainage will be directed. The following analysis confirms that the proposed and existing dams are of sufficient capacity to conform with the Department of Land and Water Conservation guidelines published in "Urban Erosion and Sediment Control" (1992).

The following assumptions have been made in analysis of the dam capacities:-

- areas are approximate and exclude proposed buildings; and

- the catchments and dam locations are as shown in Drawing 1, Appendix A.

Table 8 lists the details of the sedimentation dams.

TABLE 8 - SEDIMENTATION DAMS

	Southwestern Dam - Catchment Area 1	Combined Northeastern (NE) and Eastern (E) Dams - Catchment Area 2
Catchment Area (ha)	4.00	12.50
Design Discharge (m ³ /sec)	0.07	0.20
Storage Volume (m ³)	10395	(NE)29700 + (E)2520
Surface Area (m ²)	6930	(NE)14850 + (E)2520
Approx. Total Depth (m)	1.5	(NE)2.0 & (E)1.0
Surface Dimensions (m)	105 x 66	(NE)90 x 165 & (E)84 x 30
Detention Time (hrs)	41.25	44.75
Runoff Volume (m ³) (Design 6 hour storm)	1512	4320

The sedimentation dams will discharge via a drainage pipe to a channel which will direct the treated waters into the natural drainages. A small reed-filled dam in the northeast of the site at the headwaters of the ephemeral drainage will be enlarged to form the Northeastern Dam.

The existing and proposed dams are of more than adequate capacity for use as sedimentation ponds. It should be noted the existing dam water levels were at approximately half capacity at the time of the investigation (November 1997). Total capacity of the dams is more than 7 times the (design) runoff volumes expected during a 1 in 10 ARI storm of 6 hour duration.

6.5.4 Disturbed Areas Runoff

Runoff from disturbed areas of the site will be directed by table drains and open earth trapezoidal drains (i.e. flat floor) to the sediment dam in the respective catchments. Disturbed areas comprise areas excavated for cover material for the landfill or unsealed road construction.

Runoff from capped non-active cells in the landfill will be intercepted by sumps which will subsequently be pumped to the surface to join the sedimentation dam drainage system.

6.5.5 Contaminated Water Management

Contaminated water will include the storm runoff from the active quarry and landfill area. This water will be intercepted by a sump and subsequently pumped to the surface leachate collection dam. It is proposed to utilise the existing dam in the west of the site as a leachate collection dam, with a capacity of 27720 m³ - the proposed location is shown in Drawing 1, Appendix A. The leachate collection dam is detailed in Section 6 of this report.

The contaminated water collection sump will be located at the base of the landfill and progressively relocated to higher levels as construction and filling of cells proceeds upwards. The leachate dam waters will include leachate, contaminated water from the landfill, and surface generated contaminated water. Leachate dam waters will be disposed of by evaporation, irrigation, dust control (water quality pending), and recycling over the active landfill.

6.5.6 Truck Washing Station

Water used in the truck wheel washing facilities will be directed to the leachate dam. Wash down facilities will comprise a sealed area, either bitumen or concrete, which drains to a collection sump. The sump will be screened with coarse mesh to collect large waste debris and litter which will subsequently be placed in a bin at the wash down facility for later disposal at the landfill.

Each quarry/landfill truck leaving the site will be required to wash down the wheels and chassis using a high pressure low volume water hose. Waters from the wash down station sump will be piped into the leachate dam.

7. LEACHATE MANAGEMENT PLAN

7.1 Projected Leachate Quality

It is proposed that the landfill will be classified as Class 2, Non-putrescible. Based on the anticipated non-putrescible waste composition at the site it is anticipated that leachate will be of low organic strength, with a low to moderate constituent composition of complex volatiles and leached metals. The disposal of industrial or chemical wastes in significant volumes is unlikely and therefore the leachates are similarly not expected to contain high levels of synthetic or chlorinated chemicals.

The leachate quality will vary depending on a number of factors including actual waste types and quality, refuse moisture, compaction and density, and the rate of waste decomposition. Key leachate quality parameters to be monitored are detailed in Section 8.3 of this report.

Controls on waste input, water infiltration and leachate recirculation will also affect the ultimate quality of leachates generated at the site. Although it is proposed to recirculate the leachate over and through the landfill, the predicted leachate quality or throughput volumes should not pose problems either in terms of overloading the attenuative capacity of the wastes to treat the leachate or producing volumes of leachate which cannot easily be collected, stored and recirculated without undue impact.

Waste emplacement densities at Marsden Park Landfill are expected to range from 0.6 tonnes/m³ to 0.85 tonnes/m³ and with an initial refuse moisture content of 30% dry weight. It is likely that an absorptive capacity of 0.16 to 0.27 m³/dry tonne of refuse can be achieved before any substantial leachate is generated. On this basis leachate recirculation should prove to be a satisfactory means of reducing leachate volumes and also of treating the quality of leachate by utilising the attenuative capacity of the landfill.

Moisture retention characteristics of the waste column and leachate strength and volumes will ultimately depend on the success of:-

- controls on waste intakes;
- control of water input to the waste cell; and

- controls over leachate discharge including treatment (possibly oxygen entrainment prior to injection) and monitoring of quality to ensure that the leachate is suitable for spray irrigation or injection.

7.2 Projected Leachate Volumes and Storage

Conservative estimates of total leachate generation of the Marsden Park landfill are in the order of 22000 m³ per annum. This estimate is based on the proposed final landfill footprint of approximately 130000 m², an anticipated maximum filling rate of 360000 tonnes per annum, average annual rainfall of 815.5 mm, a design infiltration rate of 20% (expected to be higher than actual), and no liquid waste input. Effective rainfall would drop to approximately 80 mm per annum following final capping. Leachate volumes would reduce correspondingly.

The dam proposed for leachate collection and storage during landfill operations is the existing dam in the western area of the site which has a total capacity of 27720 m³. The dam is located to the west of the existing quarry void shown in Drawing 1, Appendix A. A section of the dam is shown in Drawing 3, Appendix A. The dam is approximately 105 m long, 66 m wide, and is estimated (from anecdotal evidence) to be 4 m deep. The sides of the dam are raised embankments approximately 2 m high, suitable to prevent the ingress of surface waters. The capacity will be adequate for the landfill operation at peak production and takes account of the extraction of leachate dam waters for irrigation of revegetated areas and recycling through the landfill as well as losses due to evaporation. The dam is located in the west of the site adjacent to the limit of the quarry/landfill operations to facilitate proximity to the proposed landfill leachate sump and to reduce pumping distances.

The design capacity of the dam also provides for rainfall directly into the dam and potential overflow. Rainfall directly into the dam is calculated using a design storm of 1 in 50 year ARI of 24 hour duration. The EPA recommends in "Environmental Guidelines : Solid Waste Landfills", 1996, that a 1 in 25 year ARI be used, however this data was not available. The use of an ARI of 1 in 50 represents a more conservative worst case scenario. The design storm volume is 1464 m³. This equates to approximately 5.3% of the leachate dam capacity. Capacity of the existing dam in the west of the site proposed to be used as the leachate dam is more than adequate to accommodate the estimated annual leachate production and rainfall into the dam.

7.3 Leachate Collection and Treatment

7.3.1 Leachate Barrier System

7.3.1.1 General Considerations

Hydraulic conductivity tests undertaken at Marsden Park indicate the bedrock is not suitable as a landfill leachate barrier without the installation and construction of a landfill liner. The liner must have a maximum permeability coefficient of 1×10^{-9} m/s in accordance with NSW EPA Guidelines.

Landfill liner installation will subscribe to an environmental management philosophy which is broadly in line with the goals and objectives of the *Environmental Guidelines : Solid Waste Landfills* (EPA, 1996).

The proposed conceptual layout and configuration of the proposed refuse cells and the selection and placement of suitable materials to form the basal liner are reviewed in the following sections.

7.3.1.2 Liner Composition

Economic factors and materials availability will dictate the selection of liner forming materials. Similarly, site specific characteristics, the nature of the wastes being landfilled and the likely degree of impact, if the site were not to be lined, are also key issues in liner selection.

Four basic types of basal landfill liners are generally available, viz:-

- earthen or natural liners (comprising mainly clays and silt);
- bentonite amended soils (BES);
- composite liners (earthen and synthetic), and
- geosynthetic (usually formed from high density polyethylene - HDPE).

Much has been written regarding the advantages and disadvantages of the above systems and there is a vast body of information, most of it inconclusive, regarding the suitability of each system. Certainly one important argument for the installation of earthen layers is that

they have a proven durability over long periods of (geological) time whilst modern synthetic materials are largely unproven over periods in excess of 30 years. The 30 years time frame represents a very short period when compared against the potential biochemical activity and related pollution potential which can occur within landfill sites. Nevertheless, membrane liners, either singly or in concert with natural materials can provide an excellent barrier against the movement and migration of leachate into the adjacent groundwater and substrate.

Selection of materials at the Marsden Park Landfill will be dictated by the waste cell configuration, availability of suitable local materials, and projected waste intakes and waste categories. Suitable local materials for use as a basal landfill liner at Marsden Park will almost certainly comprise the residual clay soils to be stripped as overburden as the quarrying operation progresses to the south. The use of HDPE liners may also be incorporated into the liner design to conserve suitable clay reserves. Geotechnical tests, including compaction and permeability tests, may be necessary to determine if on site clays are suitable for use as a landfill liner.

7.3.1.3 NSW Benchmark Leachate Barrier Systems

The NSW EPA has established 'Benchmark' techniques and criteria for the installation of leachate barrier and collection systems in certain categories of landfills. EPA's benchmark criteria '1 and 2' were established in the publication *Environmental Guidelines - Solid Waste Landfills* (1996) and this recommends a liner which, depending on the hydrogeological characteristics of the natural substrate, may require to be either:-

- a composite liner including a synthetic layer of high density polyethylene (HDPE); or
- a layer of compacted clay with corresponding leachate drainage and collection systems.

Apart from the benchmark design criteria EPA also indicate that under certain circumstances natural barrier systems may be utilised when hydrogeological investigations have indicated that such a barrier is suitable. Based on the nature and location of the site, and the findings of the groundwater study natural bedrock liner options for the landfill would not appear to be adequate for conformance with EPA guidelines particularly given the hydrogeological nature of the site. The availability of suitably natural materials,

however, may provide a ready source for barrier construction. The liner must have a maximum permeability coefficient of 1×10^{-9} m/s in accordance with NSW EPA Guidelines.

EPA indicate the relevant environmental goals associated with the barrier and collections system are as follows:-

- preventing pollution of water by leachate;
- detecting water pollution;
- remediating water pollution;
- preventing landfill gas emission;
- assuring quality of design, construction and operation; and
- remediating landfill after closure; and preventing degradation of local amenity.

EPA also indicate that following settlement (presumably of the waste and consolidation of the clay liner beneath the waste) the upper surface of the liner must exhibit a transverse gradient of 3% and a longitudinal gradient of 1%. In addition the required transverse gradient of the collection system is specified as 3%¹ and the minimum longitudinal gradient specified by the NSW EPA is 1% which of course conforms with the barrier gradient into which the leachate collection system is installed.

The Guideline suggests leachate discharge (during non-storm events) in the following ways:-

- spraying or land application over completed areas of the landfill, or injection back into the landfill in accordance with the landfill license conditions; or
- treatment to an acceptable quality (not defined) and discharge (as effluent) in accordance with the conditions of the site license under the Waste Minimisation and Management Act (1995)

7.3.2 Leachate Collection System

In regard to the leachate collection system the environmental goals cited by the EPA are the same as for the barrier. EPA indicate that all leachate in excess of field capacity of the

¹The transverse gradient of 3% is actually the post settlement gradient of the barrier, but as the barrier will form the immediate subgrade of the leachate collection system the gradient is assumed to be the same.

waste (refuse) should be collected in a leachate collection system and prevented from escaping from the landfill into groundwater, surface water or subsoil.

A schematic plan of the proposed leachate drainage and collection system in the Marsden Park Landfill is shown in Drawing 4, Appendix A. The leachate drainage and collection system will form an integral component of the leachate barrier system. This will then be conveyed to a system of collection pipes which will gravity feed towards the northern end of the site as landfilling progresses to the south. Leachate collection drains should have a fall of at least 1% but not greater than 3% to avoid internal scouring from rapid flow.

The perforated collector pipe network will form a herringbone arrangement with feeder pipes (probably 150 to 200 mm Ø) directed in a raking or chevron pattern towards the main drain (probably 300-500 mm Ø). Perforated collector pipes will be placed in a filter liner that must have a permeability coefficient of $> 1 \times 10^{-3}$ m/s and a grain size of > 20 mm. The filter drains are to be covered in a robust geotextile for protection (Drawing 5, Appendix A). The lateral leachate collection pipes will be spaced at intervals of not more than 50m with a minimum diameter of 150 mm. It is envisaged that a single main drain will traverse the landfill base in a broadly north-south direction, picking up leachate from the lateral feeder drains as it progresses towards the collection sump which will be constructed to cater for the leachate collection from the entire landfill.

The concept design of the proposed sump and riser arrangement are shown in Drawing 6, Appendix A. The sump will comprise a concrete plinth and box arrangement keyed into leachate filter drains as detailed above. The sump is to be connected to a concrete tank (leachate chamber) large enough to store leachate and contaminated surface runoff from a 1 in 25 year storm event. The leachate riser is to be constructed of concrete 'caisson type' rings 1.50 m in diameter and shall be built up progressively along with the final filling of the initial landfill cell. A pump and headworks is to be installed for recirculation of leachate. A low level cut out sensor is to be installed in the pump to allow automatic pumping to occur. Drawings 7 and 8, Appendix A, show a concept design for the completed sump and collection system. Leachate waters not immediately used for recycling (reinjection back into the landfill) or irrigation will be piped and stored in the leachate dam.

The maximum volume of leachate that would require to be handled depends on a large number of variables including:-

- the incident rainfall;
- the size of the operating waste cell;
- the system of management which is adopted to prevent infiltration during operations;
- the effectiveness of clean-water diversions;
- the degree and effectiveness of cover during operations; and
- the effectiveness of the intermediate cover and final capping layers.

As landfill cell construction progresses to the south, successive leachate collection drainage systems and sumps will be installed at the base of each cell. It is envisaged approximately four separate landfill cells will ultimately be required and the sumps for each will be linked into a common extraction system.

7.3.3 Leachate Recirculation

Leachate collected in the sump may be pumped back over the landfill either in the form of spray irrigation or by direct injection. Excess leachate will be pumped to the leachate dam. Irrigants will be pumped from the collection sump to the upper parts of the operating waste disposal cell and sprayed over the completed parts of the adjacent cell.

The landfill provides a microbiological substrate to assist in the degradation of organic contaminants and for the adsorption and absorption of inorganic solutes. Leachate recirculation is most effective where the waste column exhibits a refuse moisture deficit.

During periods of heavy rainfall alternative leachate disposal measures may include the direct injection of leachate into the waste cell via a series of 2-3 tube wells (300 mm diameter and 1.5 m deep) thus avoiding the potential for rapid runoff of leachate with rainwater. All rainwater flowing within the cell will be collected as leachate and disposed of accordingly. The collection sump has been designed with sufficient capacity to capture and store contaminated rainwater (flow over the surface of the cell) and leachate during any anticipated rainfall event. The sump will be fitted with a trigger mechanism and when activated will commence leachate disposal via the system described above.

In terms of future leachate treatment options at the Marsden Park Landfill, it is expected that leachate recirculation combined with evaporation from the leachate dam and irrigation of revegetated areas should provide adequate treatment. These measures should preclude the need for disposal of excess leachate off-site.

A number of injection well points, possibly linked by an infiltration gallery (comprising coarse aggregate) may be constructed progressively with development of sections of the landfill. Successive cells can be fitted with similar systems, each of which will be connected to the main (initial) leachate collection sump.

8. WATER MONITORING PROGRAMME

8.1 Baseline Monitoring

Baseline monitoring of surface and groundwater has been undertaken in the current investigation to establish the respective water qualities prior to site operations. At least one more round of baseline monitoring will be undertaken before the site begins production.

Priority will be given to establishing the baseline water quality of the quarry dam before application for permits to dispose of dam waters. This may require additional sampling sites and depths as well as a modified range of determinands for analysis.

8.2 Groundwater Monitoring

The primary environmental goal in groundwater monitoring and assessment is to detect the early development of groundwater pollution resulting from quarrying / landfilling activities. The design, number and location of groundwater monitoring wells will adequately determine if groundwater contamination is occurring.

The groundwater monitoring programme will be undertaken on a quarterly basis to provide information on possible groundwater contamination that may result from quarry / landfill activities - this will be prescribed in the final licence requirements.

Eight permanent bores have been established which will adequately determine the presence of groundwater contaminants. Groundwater samples will be analysed for the list of determinands detailed in Table 9 in line with the NSW EPA 'Benchmark 5'.

**TABLE 9 - INDICATOR PARAMETERS FOR GROUNDWATER and SURFACE WATER
MONITORING PROGRAMME**

Chemical Determinand	Analytical Detection Limit (µg/L)
Field Analysis	
Electrical Conductivity	1 mS/m
pH	0.1 pH unit
Dissolved Oxygen	1000
Redox Potential	1 Eh
Temperature	0.1
Laboratory Analysis (EPA)	
Alkalinity	1000
Ammonia	50
Arsenic	50
Cadmium	2
Chromium	10
Copper	5
Mercury	0.1
Nickel	150
Zinc	50
Lead	50
Calcium	5000
Chloride	5000
Fluoride	500
Iron	500
Manganese	50
Magnesium	5000
Nitrate	100
Nitrite	100
Total Kjeldhal Nitrogen	100
Total phenolics	50
Potassium	5000
Sodium	5000
Sulphate	5000
Total organic carbon (TOC)	50
Bicarbonate	-
Carbonate	-
Total Dissolved Solids	-
Faecal Coliforms per 100 mL	-
E. Coli per 100 mL	-

In summary, groundwater monitoring will comprise:-



- quarterly monitoring of a minimum of 8 monitoring bores conducted by a suitably qualified and approved person;
- sample analysis for the list of determinands in Table 9 to determine the possible migration of leachate into downgradient groundwater;
- reporting of the analytical results on a quarterly basis; and
- initiation of a Water Action Plan in the event of significant exceedances of Environmental Trigger Levels.

8.3 Leachate Monitoring

Periodic leachate monitoring is not specified, however, initial characteristic testing for aromatics, volatiles, halocarbons, and base, neutral and acid digestible organic contaminants are recommended in the *Environmental Guideline - Solid Waste Landfills* (1996). Quarterly and batch testing of representative samples for all contaminants identified in the groundwater monitoring programme may also be required under certain circumstances, and whilst these circumstances are not defined in the Guideline it is almost certain that the site license conditions will specify periodicity and parameters for leachate testing.

Leachate will also be regularly sampled from the collection sump and analysed for the prescribed set of parameters detailed in Table 10.

TABLE 10 - INDICATOR PARAMETERS FOR LEACHATE MONITORING PROGRAMME

Chemical Determinand	Analytical Detection Limit (µg/L)
Field Analysis	
Electrical Conductivity	1 mS/m
pH	0.1 pH unit
Redox Potential	1 Eh
Temperature	0.1 c
Laboratory Analysis	
Absorbable organic halogens	10
Alkalinity	1000
Ammonia	50
Calcium	5000
Chloride	5000
Fluoride	500
Iron	500
Manganese	50
Magnesium	5000
Nitrate	100
Total phenolics	50
Potassium	5000
Sodium	5000
Sulphate	5000
Total organic carbon	50
Additional Laboratory Analysis	
Biological oxygen demand	ND

The leachate monitoring programme will be conducted to assess the quality of leachate being used for irrigation and recirculated into the landfill.

8.4 Surface Water Monitoring

The surface water monitoring programme will be conducted at the four locations shown in Drawing 2, Appendix A. These locations are those used in the current investigation to establish baseline conditions. Monitoring will ensure that surface water in natural water courses peripheral to the site is not degraded through site operations and leachate contamination. The monitoring points have been selected at localities upstream and downstream of the quarry/landfill potentially at risk from surface contamination. The sites will be:-

- two sites along South Street in tributaries of South Creek;
- two sites along Bells Creek, one near South Street and the other at the Richmond Road crossing.

Surface water monitoring will be conducted quarterly in association with leachate and groundwater monitoring. Surface water samples obtained from the selected locations will be analysed for the list of determinands detailed in Table 9. Any deviation from the baseline levels will result in the occupier implementing a 'Water Contamination Remediation Action Plan' to further delineate the source and extent of contamination.

9. POTENTIAL ENVIRONMENTAL IMPACTS

9.1 Surface Hydrology and Water Quality

The proposed quarry/landfill operation and subsequent rehabilitation on closure will result in the following potential sources of contamination for surface water:-

- active quarry areas;
- clay extraction areas;
- active landfill areas;
- disturbed areas; and
- leachate generation from the landfill.

Waters from the activities listed above will vary in quality from slightly turbid to significant levels of suspended and dissolved solids concentrations. There is potential for leachate generation which will chemically reflect the waste stream of the proposed Class 2 non-putrescible landfill.

Without the proposed surface water drainage and storage controls, there is potential for waters from the above areas to be discharged from the site. Clean runoff may also be polluted by entering the above areas if proposed diversion and separation practises are not implemented. Such contamination could increase the volume of contaminated runoff which will require collection and treatment prior to discharge from the site.

With the implementation of the Water Management Plan, comprising the pollution control practises, drainage controls and storage, leachate management system, and water monitoring programme detailed in Sections 6, 7 and 8, the possibility of such pollution should largely be eliminated. The mitigation measures and proposed drainage / dam systems will also restrict off site discharges from storm events.

The proposed controlled discharge from the site is unlikely to have a significant impact on water quality in Bells Creek to the east and South Creek to the northwest of the site. A mitigating factor during storm events are the rural dams situated along the ephemeral drainages some distance from the quarry/landfill operations area. These are not included in site controls or calculations and therefore present an in-place contingency for sediment and pollution control.

It is anticipated that leachate recirculation, evaporation from the leachate dam, and irrigation of revegetated areas will provide adequate treatment of leachate. Should the practises proposed prove insufficient for the leachate volumes produced, provision may be made for the disposal of excess leachate to the sewerage system after application for permits from the appropriate regulatory bodies.

9.2 Groundwater

With the implementation and construction of the leachate management infrastructure proposed in Section 7, there should be minimal interaction and flow between landfill cells and groundwater beneath the site. The stipulated lining of cells, and collection and storage of leachate at the site is designed to preserve groundwater quality. Similarly, construction and lining of dams to guarantee their integrity will minimise mixing of stored surface waters and groundwater.

Landfill cell construction with HDPE (Geofabric) liners and compacted clay liners (to EPA required hydraulic conductivity of 1×10^{-9} m/sec) will encapsulate the waste and prevent migration of leachate from the cell into the surrounding formation.

The low permeability of the shales and the low regional groundwater gradient is also likely to negate the possible migration of leachate.

Should the leachate volumes generated be higher than anticipated, provision may be made to treat higher volumes at surface on site. Alternatively, disposal off-site to the sewerage system may be necessary subsequent to receiving regulatory body approval.

If the proposed water monitoring programme identifies leachate migration into the surrounding aquifer, measures should be taken to identify and rectify the source. This may include capping of some sections of the landfill, redesign, and reconstruction of parts of the leachate collection and storage system.

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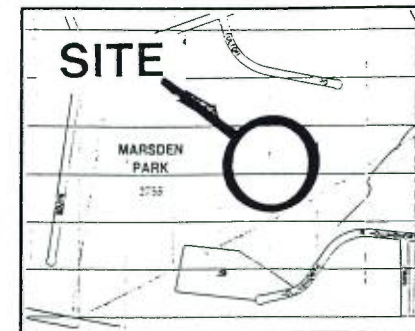
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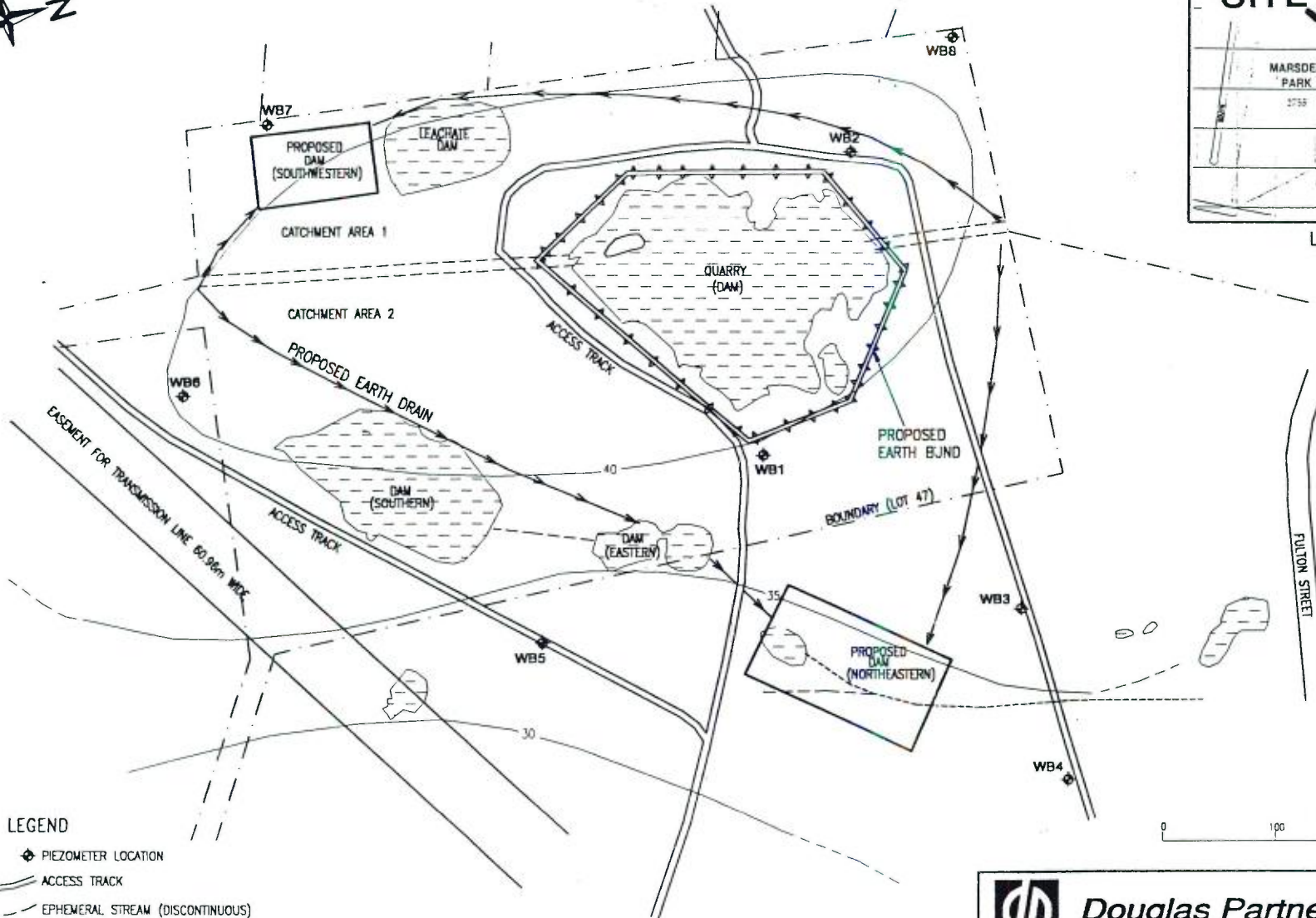
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APPENDIX A
Site Drawings



LOCALITY PLAN



LEGEND

- PIEZOMETER LOCATION
- ACCESS TRACK
- EPHEMERAL STREAM (DISCONTINUOUS)
- STATIC WATER LEVEL CONTOUR (INFERRED) ,m, AHD
- CATCHMENT DIVIDE (APPROXIMATE)
- PROPOSED OPEN EARTH DRAIN--WITH FLOW DIRECTION
- PROPOSED EARTH BUNDS

0 100 200 300m
SCALE
1:4000



Douglas Partners
Geotechnics, Environmental, Groundwater

Sydney, Newcastle, Brisbane,
Melbourne, Perth, Wyang,
Singleton, Carrabelltown,
Townsville, Cairns, Wollangong

TITLE: Location of Water Management Infrastructure
Static Water Level Contours
Proposed Quarry/Landfill
Richmond Road
MARSDEN PARK



CLIENT: Enviro Managers Pty Ltd

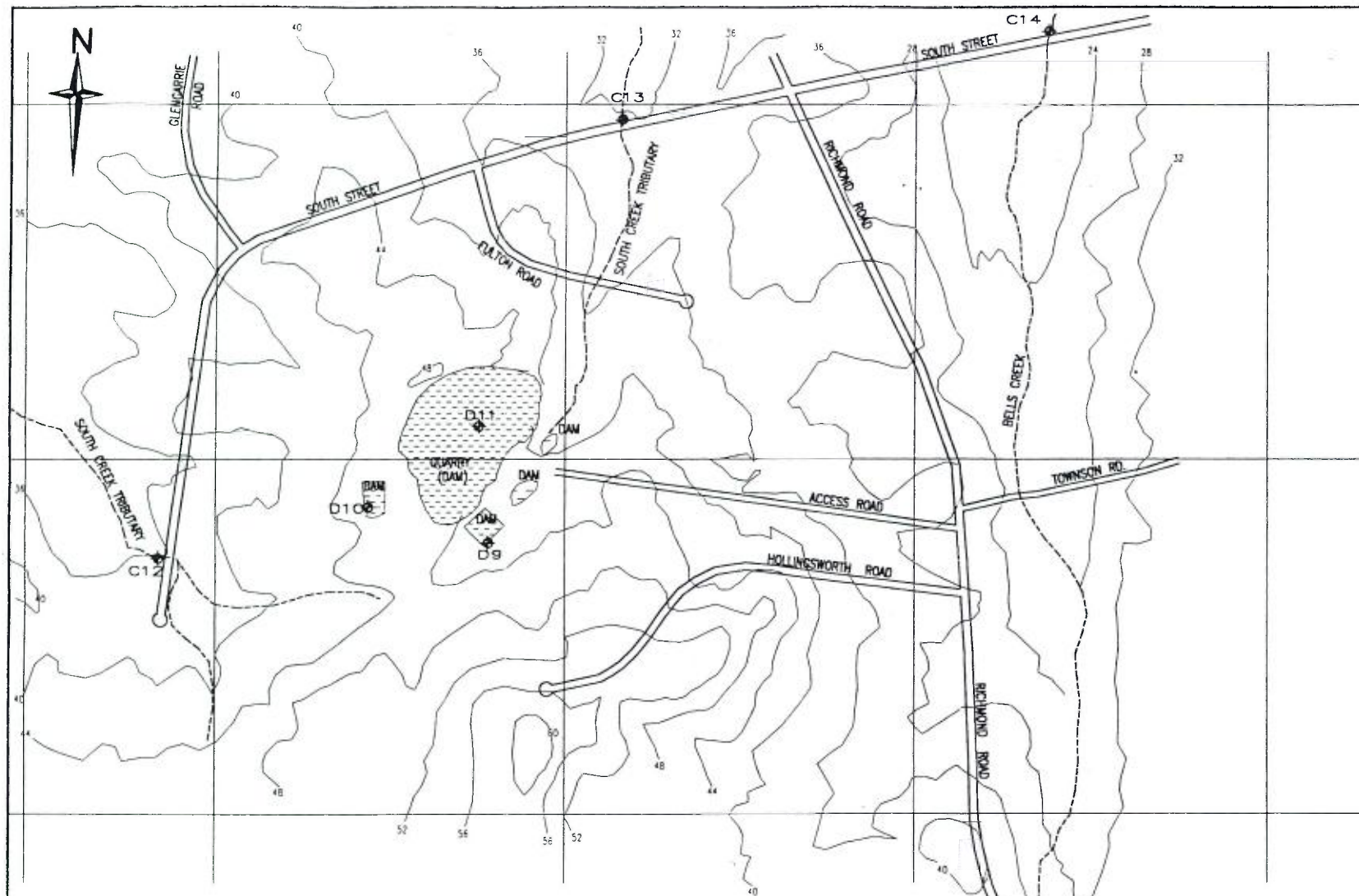
DESIGNED BY: [Signature]

PROJECT NO: 24684

OFFICE: SYDNEY

DATE: 20.1.1998

DRAWING NO: 1



LEGEND

◆ SURFACE SAMPLE LOCATION

--- CREEK

— TOPOGRAPHIC CONTOUR

0 50 100m 1:1250



Douglas Partners
Geotechnics, Environmental, Groundwater

Sydney, Newcastle, Brisbane,
Melbourne, Perth, Wyang,
Singleton, Campbelltown,
Tombville, Coims, Wollongong



TITLE: Surface Sample Locations
Topographic Contours
Proposed Quarry/Landfill
Richmond Road
MARSDEN PARK

CLIENT: Enviro Managers Pty Ltd

DRAWN BY: PSCH | SCALE: As shown

PROJECT No. 24681A

OFFICE: SYDNEY

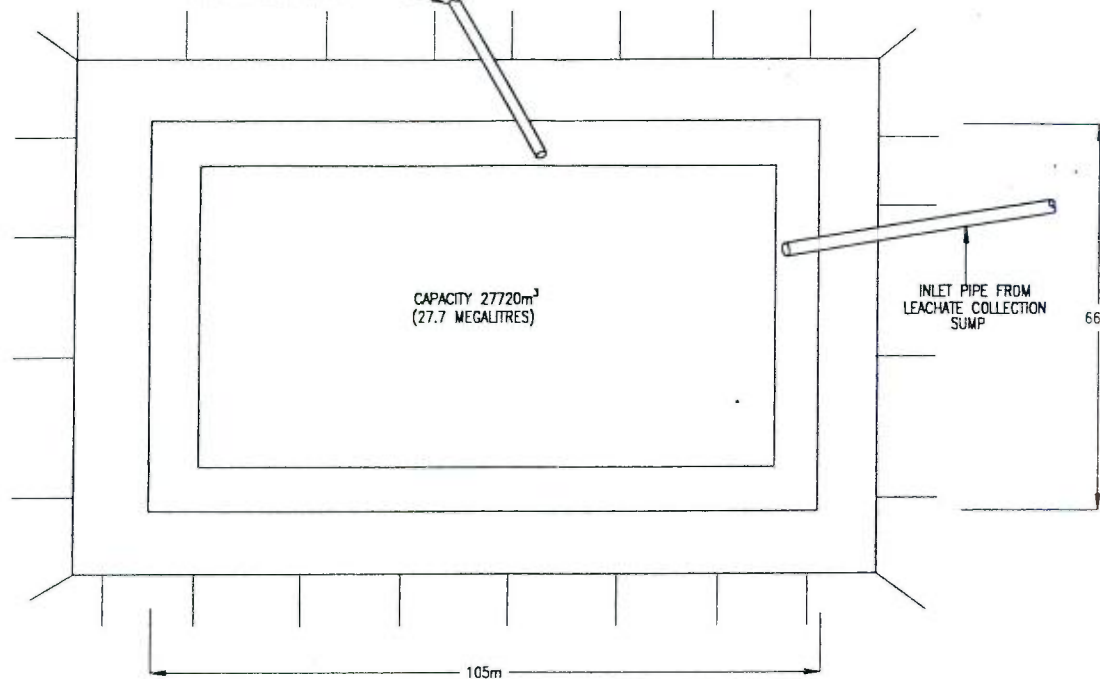
APPROVED BY:

TCC

DATE: 20.3.1998

DRAWING No: 2

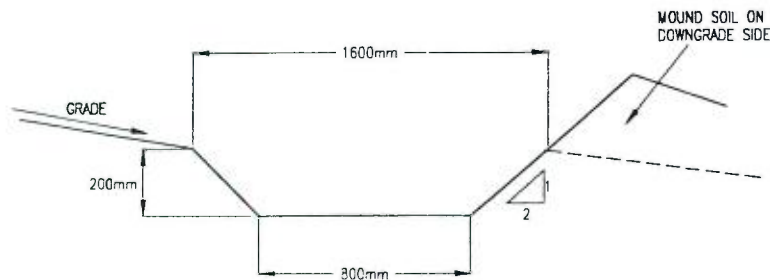
200mm DIAMETER PIPE INLET
FROM WHEEL WASHING



PLAN
LEACHATE DAM

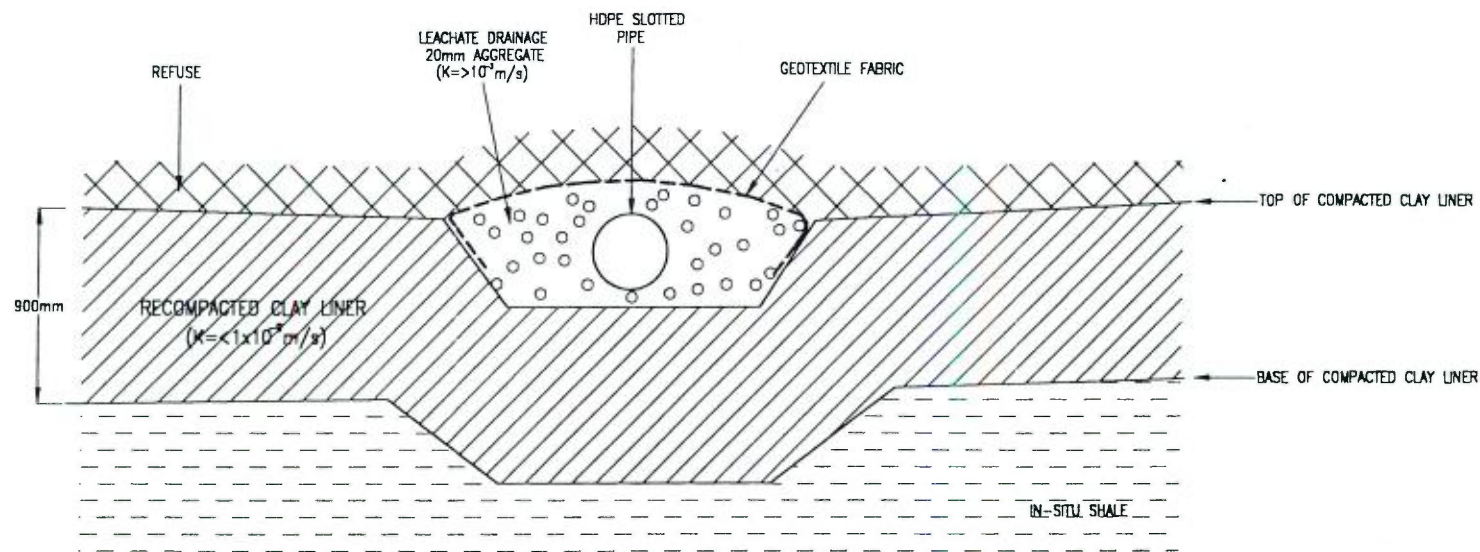


SECTION
LEACHATE DAM



DETAIL
OPEN EARTH DRAINS

 Douglas Partners Geotechnics, Environmental, Groundwater		Sydney, Newcastle, Brisbane, Melbourne, Perth, Wyang, Singleton, Campbelltown, Townsville, Cairns, Wollongong	
TITLE: Open Earth Drains and Leachate Dam Water Management Plan Richmond Road MARSDEN PARK			
CLIENT: Enviro Managers Pty Ltd		PROJECT No: 24681A	
DRAWN BY: PSCH	SCALE: N.T.S.	OFFICE: SYDNEY	DATE: 20/1/2008
APPROVED BY: 		DRAWING No: 1	



Douglas Partners
Geotechnics, Environment, Groundwater

Sydney, Newcastle, Brisbane,
Melbourne, Perth, Wyang,
Singleton, Campbelltown,
Townsille, Cairns, Wollongong

TITLE:

Proposed Leachate Collection Drain
Marsden Park Landfill
Richmond Road
MARSDEN PARK



CLIENT: Enviro Managers Pty Ltd

DRAWN BY: PSCH SCALE: N.T.S.

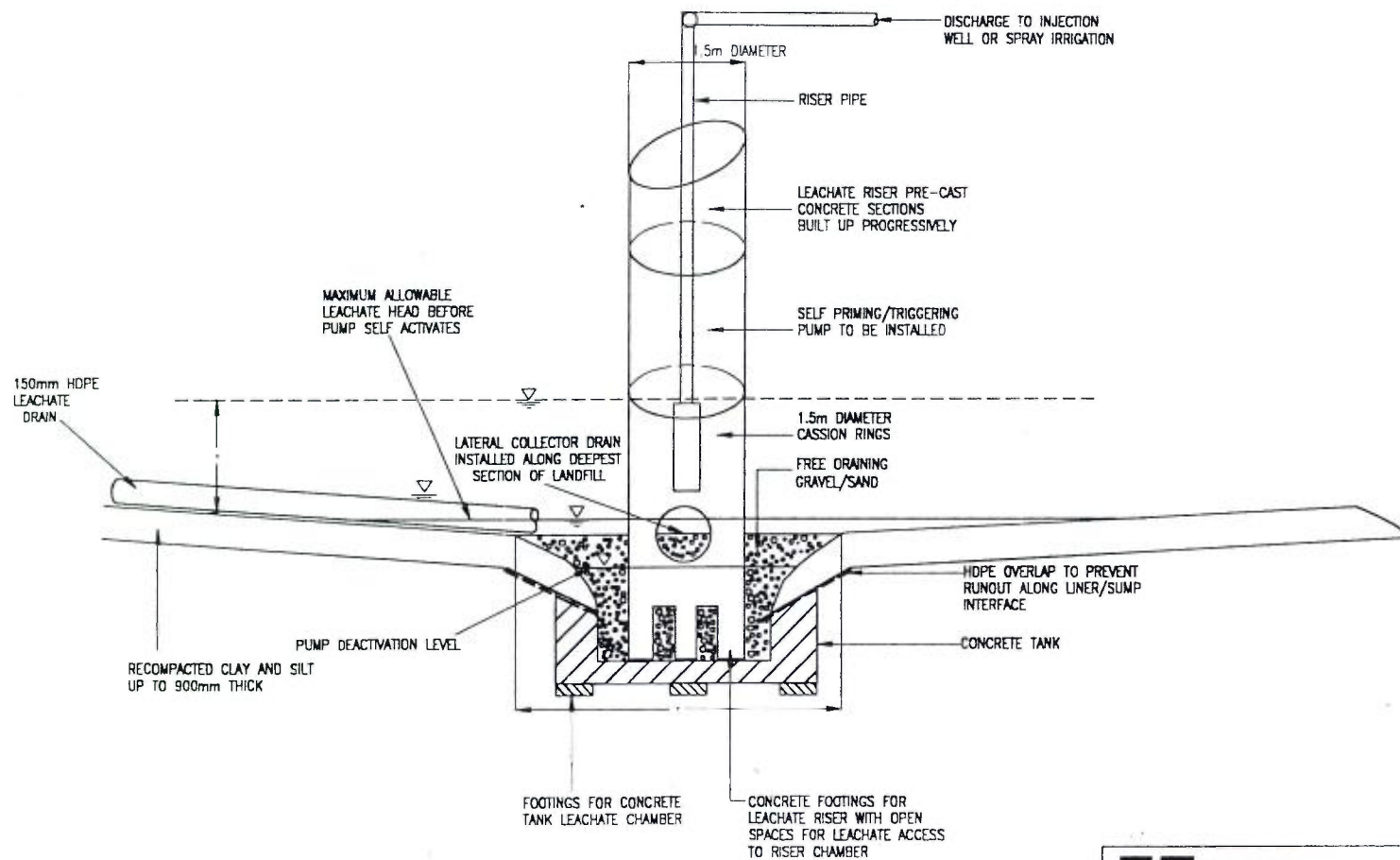
PROJECT No: 24681A

OFFICE: SYDNEY

REVISED BY: TCC

DATE: 20.3.1998

DRAWING No: 5



Douglas Partners
Geotechnics, Environment, Groundwater

Sydney, Newcastle, Brisbane,
Melbourne, Perth, Wyang,
Singleton, Campbelltown,
Tombville, Cairns, Wollongong

TITLE:

**Schematic Detail of Leachate Collection
Marsden Park Landfill
Richmond Road
MARSDEN PARK**



CLIENT: Enviro Managers Pty Ltd

DRAWN BY: PSCH SCALE: As shown

PROJECT No: 24681A

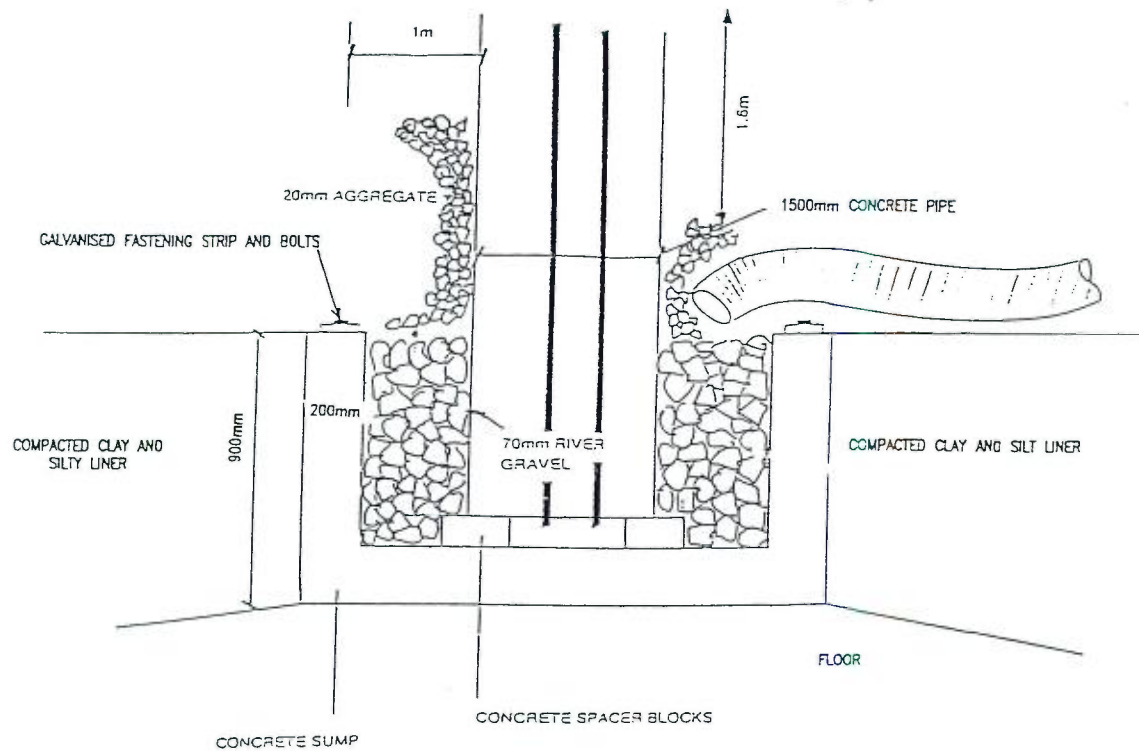
OFFICE: SYDNEY

APPROVED BY:

TCC

DATE: 20.3.1998

DRAWING No: 6



DP Douglas Partners
Geotechnics, Environment, Groundwater

Sydney, Newcastle, Brisbane,
Melbourne, Perth, Wyang,
Singleton, Campbelltown,
Townsville, Cairns, Wollongong

TITLE:
Cross Section of Proposed Leachate Sump
Marsden Park Landfill
Richmond Road
MARSDEN PARK

CLIENT: Enviro Managers Pty Ltd

DRAWN BY: PSCH SCALE: As shown

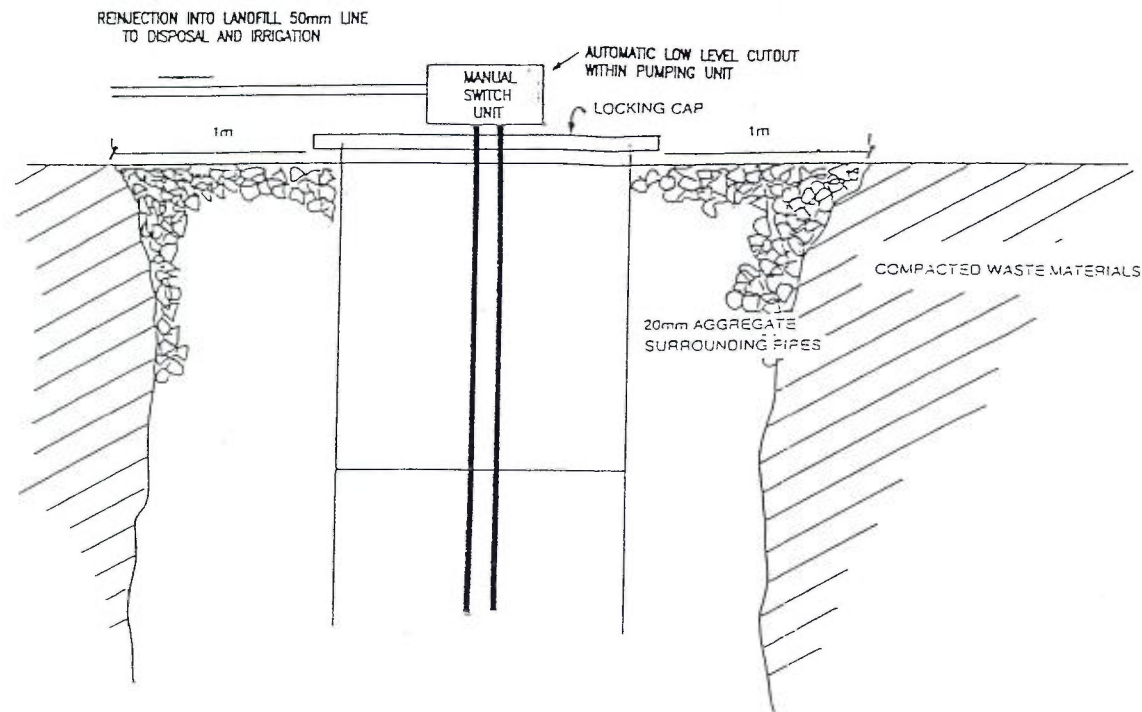
PROJECT No: 24681A

OFFICE: SYDNEY

APPROVED BY:

20

No:



Douglas Partners
Geotechnics, Environment, Groundwater

Sydney, Newcastle, Brisbane,
Melbourne, Perth, Wyang,
Singleton, Campbelltown,
Towansville, Cairns, Wollongong

TITLE:

Section Elevation of Proposed Leachate Sump
Marsden Park Landfill
Richmond Road
MARSDEN PARK

CLIENT: Enviro Managers Pty Ltd

DRAWN BY: PSCH | SCALE: As shown

PROJECT No: 2468/A

OFFICE: SYDNEY

APPROVED BY:

TCC

DATE: 20.3.1998

DRAWING No: 8

APPENDIX B
Test Bore Report Sheets

AN ENGINEERING CLASSIFICATION OF SEDIMENTARY ROCKS IN THE SYDNEY AREA

This classification system provides a standardised terminology for the engineering description of the sandstone and shales in the Sydney area, but the terms and definitions may be used elsewhere when applicable.

Under this system rocks are classified by Rock Type, Degree of Weathering, Strength, Stratification Spacing, and Degree of Fracturing. These terms do not cover the full range of engineering properties. Descriptions of rock may also need to refer to other properties (e.g. durability, abrasiveness, etc.) where these are relevant.

ROCK TYPE DEFINITIONS

Rock Type	Definition
Conglomerate:	More than 50% of the rock consists of gravel sized (greater than 2 mm) fragments.
Sandstone:	More than 50% of the rock consists of sand sized (.06 to 2 mm) grains.
Siltstone:	More than 50% of the rock consists of silt sized (less than .06 mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of clay or sericitic material and the rock is not laminated.
Shale:	More than 50% of the rock consists of silt or clay sized particles and the rock is laminated.

Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, e.g. clayey sandstone, sandy shale.

DEGREE OF WEATHERING

Term	Symbol	Definition
Extremely Weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly Weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable.
Moderately Weathered	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly Weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	Fr	Rock substance unaffected by weathering.

STRATIFICATION SPACING

Term	Separation of Stratification Planes
Thinly laminated	<6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	>2 m

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics (Reference).

Strength Term	Is(50) MPa	Field Guide	Approx. qu MPa*
Extremely Low:	0.03	Easily remoulded by hand to a material with soil properties.	0.7
Very Low:	0.1	May be crumbled in the hand, Sandstone is "sugary" and friable.	2.4
Low:	0.3	A piece of core 150 mm long x 50 mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	7
Medium:	1	A piece of core 150 mm long x 50 mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.	24
High:	3	A piece of core 150 mm long x 50 mm dia. core cannot be broken by unaided hands, can be slightly scratched or scored with knife.	70
Very High:	10	A piece of core 150 mm long x 50 mm dia. may be broken readily with hand held hammer. Cannot be scratched with pen knife.	240
Extremely High:		A piece of core 150 mm long x 50 mm dia. is difficult to break with hand held hammer. Rings when struck with a hammer.	

* The approximate unconfined compressive strength (qu) shown in the table is based on an assumed ratio to the point load index of 24:1. This ratio may vary widely.

DEGREE OF FRACTURING

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude known artificial fractures such as drilling breaks.

Term	Description
Fragmented:	The core is comprised primarily of fragments of length less than 20 mm, and mostly of width less than the core diameter.
Highly Fractured:	Core lengths are generally less than 20 mm - 40 mm with occasional fragments.
Fractured:	Core lengths are mainly 30 mm - 100 mm with occasional shorter and longer sections.
Slightly Fractured:	Core lengths are generally 300 mm - 1000 mm with occasional longer sections and occasional sections of 100 mm - 300 mm
Unbroken:	The core does not contain any fracture.

REFERENCE

International Society of Rock Mechanics, Commission on Standardisation of Laboratory and Field Tests, Suggested Methods for Determining the Uniaxial Compressive Strength of Rock Materials and the Point Load Strength Index. Committee on Laboratory Tests Document No. 1. Final Draft October 1972

Prepared by the Sydney Group of the Australian Geomechanics Society, January, 1975.



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NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the S.A.A. Site Investigation Code. In general, descriptions cover the following properties — strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descend into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (e.g. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow

sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (e.g. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test F3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7 blows

as 4, 6, 7
 N = 13

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm

as 15, 30/40 mm

The results of the tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples

in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test F4.1.

In the tests, a 35 mm diameter rod with a cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records.

The information provided on the charts comprises:—

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower (A) scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main (B) scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6) N \text{ (blows per 300 mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

$$q_c = (12 \text{ to } 18) c_u$$

- Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on

soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two, relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test F 3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Bore Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Ground Water

Where ground water levels are measured in boreholes there are several potential problems

- In low permeability soils, ground water although present, may enter the hole slowly, or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.

- Water table levels will vary from time to time with seasons or recent prior weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (e.g. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (e.g. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency.
- changes in policy or interpretation of policy by statutory authorities.
- the actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is

recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

GRAPHIC SYMBOLS FOR SOIL & ROCK

SOIL

	BITUMINOUS CONCRETE
	CONCRETE
	TOPSOIL
	FILLING
	PEAT
	CLAY
	SILTY CLAY
	SANDY CLAY
	GRAVELLY CLAY
	SHALY CLAY
	SILT
	CLAYEY SILT
	SANDY SILT
	SAND
	CLAYEY SAND
	SILTY SAND
	GRAVEL
	SANDY GRAVEL
	COBBLES/BOULDERS
	TALUS

SEDIMENTARY ROCK

	BOULDER CONGLOMERATE
	CONGLOMERATE
	CONGLOMERATIC SANDSTONE
	SANDSTONE FINE GRAINED
	SANDSTONE COARSE GRAINED
	SILTSTONE
	LAMINITE
	MUDSTONE, CLAYSTONE, SHALE
	COAL
	LIMESTONE

METAMORPHIC ROCK

	SLATE, PHYLLITE, SCHIST
	GNEISS
	QUARTZITE

IGNEOUS ROCK

	GRANITE
	DOLERITE, BASALT
	TUFF
	PORPHYRY

SEAMS



SEAM
> 10 mm



SEAM
< 10 mm



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 13 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB3
SHEET 1 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Test Results	Core Recovery %
0.10	SANDY CLAY - brown, sandy clay. Minor humic material and rootlets				
	CLAY - brown/red clay. 10% 5mm rounded ironstone pebbles				
1.5	CLAY - red/brown clay. 5% 5mm rounded ironstone pebbles				
2.0	CLAY - orange clay, damp				
2.25	CLAY - grey/orange mottled clay, damp. 5% relict rock fragments. Possibly extremely weathered shale				
4.0	CLAY - grey/dark grey mottled clay. Possibly extremely weathered shale				
5					
6					
7					
8					
9					
10					

RIG: B40

DRILLER: McDERMOTTS LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: AUGER 125mm-2.5m, BLADE 96mm-11.5m, PCD 96mm-20m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER BELOW 2.5m. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A Auger sample	M Moisture content (%)
B Bulk sample	pp Pocket Penetration (kPa)
D Disturbed sample	Ux x mm dia tube
HV Hand Vane	Wp Plastic limit (%)

CHECKED:

Initials: TCC

Date: 12.3.98



Douglas Partners
Geotechnics • Environment • Groundwater

TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 13 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB3
SHEET 2 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Results	Headspace PID (ppm)
10	CLAY - grey/dark grey mottled clay. Possibly extremely weathered shale				
11 11.0	SHALE - low strength, moderately weathered light grey shale				
12					
12.80	SHALE - medium strength, fresh, grey shale				
13					
14					
15					
16					
17					
17.20	INTERBEDDED SHALE AND SANDSTONE - medium strength, fresh, light grey/grey interbedded shale and sandstone. Approximately 5% intermittent high strength, fine grained sandstone bands. Drill returns 10% sandy. Approximately 5% black carbonaceous laminae				
18					
18.80	SANDSTONE - medium strength, fresh light grey sandstone. Fine grained				
19					
19.70	SANDSTONE - low strength, fresh, light grey sandstone. Fine grained				
20 20.0					

RIG: B40

TEST BORE DISCONTINUED AT 20.0 METRES

DRILLER: McDERMOTTS LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: AUGER 125mm-2.5m, BLADE 96mm-11.5m, PCD 96mm-20m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER BELOW 2.5m. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A auger sample
B bulk sample
C core drilling
pp Pocket Penetration (kPa)
PL point load strength I_s (50)MPa
S standard penetration test
Ux x mm dia. tube
V shear vane (kPa)

CHECKED:

Initials: TCC

Date: 12.3.98



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 14 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB4
SHEET 1 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Results	Headspace PID (ppm)
0.10	SANDY CLAY - brown sandy clay with rootlets				
1.2	CLAY - reddish brown clay. Approximately 10% 5mm ironstone pebbles				
2.4	CLAY - tan brown/red mottled clay. Approximately 5% 5mm ironstone pebbles				
3.0	CLAY - red/grey mottled clay, with a trace of sand. Possibly extremely weathered shale				
5.0	CLAY - light brown clay. 5% chips of extremely weathered light brown shale				
7.2	SANDY CLAY - light brown/grey mottled clay. 10% extremely weathered shale fragments. Possibly extremely weathered interbedded shale and sandstone				
9.5	INTERBEDDED SHALE AND SANDSTONE - low strength, highly weathered, light grey interbedded shale and sandstone. Drill cuttings approximately 30% fine grained sand. Drill chips display interbedded rock types. Shale thinly laminated				
	SHAPE - low strength, moderately weathered, dark grey shale. 10% black carbonaceous laminae				

RIG: B40

DRILLER: McDERMOTT'S LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, BLADE 96mm-5.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A auger sample	PL point load strength f_s (50MPa)
B bulk sample	S standard penetration test
C core drilling	U x mm dia tube
pp Pocket Penetration (kPa)	V shear vane (kPa)

CHECKED:

Initials: *tec*

Date: 12.3.98



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 14 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB4
SHEET 2 OF 2

LOCATION: RICHMOND ROAD, HANSDEN HILL					
Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Results	Headspace PID (ppm)
10	SHALE - low strength, moderately weathered, dark grey shale. 10% black carbonaceous laminae				
11					
12					
13	SHALE - medium strength, fresh grey shale. Thinly laminated. Traces of black carbonaceous laminae. Some zones (5%) of fine grained sandy drill returns - possibly indicate interbedded sandstone in shale formation				
13.3					
14					
15					
16					
17					
18					
19					
20-20.0	TEST BORE DISCONTINUED AT 20.0 METRES				

RIG: B40

DRILLER: McDERMOTTS LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, BLADE 96mm-5.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A auger sample
B bulk sample
C core drilling
pp Pocket Penetration (kPa)

PL point load strength I_s (50)MPa
S standard penetration test
Ux x mm dia. tube
V shear vane (kPa)

CHECKED:

Initials: Tcc

Date: 12.3.98



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 14 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB5
SHEET 1 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Results	Headspace PID (ppm)
0.10	SANDY CLAY - loose brown sandy clay with rootlets				
1.0	SANDY CLAY - reddish dark brown sandy clay. 10% 5mm ironstone pebbles. Approximately 20% fine grained sand				
1.8	SANDY CLAY - red/brown mottled sandy clay. 5% 5mm ironstone pebbles. Approximately 10% fine grained sand				
2.0	CLAY - tan brown/red mottled clay. <1% 5mm ironstone pebbles. Possibly extremely weathered shale				
3.5	CLAY - brown/orange/grey mottled clay				
6.0	CLAY - brown clay. 5% relict shale fragments. Extremely weathered shale				
7.2	SHALE - very low strength, highly weathered dark grey shale. Approximately 15% black carbonaceous laminae				
9.0	SHALE - low strength, moderately weathered grey shale				

RIG: B40

DRILLER: McDERMOTTS LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, BLADE 96mm-5.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A auger sample
B bulk sample
C core drilling
pp Pocket Penetration (kPa)
PL point load strength I_s (50MPa)
S standard penetration test
Ux x mm dia. tube
V shear vane (kPa)

CHECKED:

Initials: TCC

Date: 12.3.98



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 14 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB5
SHEET 2 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Results	Headspace PID (ppm)
10	SHALE - low strength, moderately weathered grey shale				
11					
11.5	INTERBEDDED SHALE AND SANDSTONE - medium strength, slightly weathered light grey interbedded shale and sandstone. Drilling returns comprise approximately 20% fine grained sandstone chips and 80% shale fragments				
12					
13					
14					
14.5	SHALE - low strength, fresh grey shale. Thinly laminated				
15					
16					
17					
18					
19					
20-20.0	TEST BORE DISCONTINUED AT 20.0 METRES				

RIG: B40

DRILLER: McDERMOTTS LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, BLADE 96mm-5.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A auger sample
B bulk sample
C core drilling
pp Pocket Penetration (kPa)
PL point load strength I_s (50)MPa
S standard penetration test
Ux x mm dia. tube
V shear vane (kPa)

CHECKED:

Initials: Tee

Date: 12.3.98



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 15 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB8
SHEET 1 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Test Results	Core Recovery %
0.10	SANDY CLAY - brown sandy clay with rootlets				
0.90	CLAY - brown/grey mottled clay. Approximately 5% 5mm ironstone pebbles				
	CLAY - tan brown/red mottled clay. 5% shale fragments. <1% 5mm ironstone pebbles				
2.20	CLAY - brown clay, with some (approximately 5%) extremely weathered shale fragments. <1% 5mm ironstone pebbles				
6.8	SHALE - very low strength, moderately weathered grey shale				
8.0	INTERBEDDED SHALE AND SANDSTONE - low strength, moderately weathered, light grey interbedded shale and sandstone. Shale thinly laminated. Approximately 30% of rock chips are fine grained sandstone				
9.2	SHALE - low strength, fresh, grey shale				

RIG: B40

DRILLER: McDERMOTT'S LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A Auger sample	M Moisture content (%)
B Bulk sample	pp Pocket Penetration (kPa)
D Disturbed sample	Ux x mm dia. tube
HV Hand Vane	Wp Plastic limit (%)

CHECKED:

Initials: TCC

Date: 12.3.98



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 15 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB6
SHEET 2 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Results	Headspace PID (ppm)
10	SHALE - low strength, fresh, grey shale				
11					
12					
13					
14					
15					
15.5	SHALE - medium strength, fresh, dark grey shale. Approximately 5% black carbonaceous laminae (fossiliferous shale)				
16					
16.2	INTERBEDDED SHALE AND SANDSTONE - medium strength, fresh, light grey interbedded shale and sandstone. Approximatley 1% black carbonaceous laminae				
17					
18					
18.3	SHALE - medium strength, fresh, dark grey shale. Approximately 5% black carbonaceous laminae (fossiliferous shale)				
19					
20-20.0	TEST BORE DISCONTINUED AT 20.0 METRES				

RIG: B40

DRILLER: McDERMOTTS LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A auger sample
B bulk sample
C core drilling
pp Pocket Penetration (kPa)
PL point load strength I_s (50)MPa
S standard penetration test
Ux x mm dia. tube
V shear vane (kPa)

CHECKED:

Initials: Tcc

Date: 12.3.98



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 15 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB7
SHEET 1 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Test Results	Core Recovery %
0.10	SANDY CLAY - brown sandy clay with rootlets				
0.9	CLAY - red/tan brown mottled clay. Approximately 5% 5mm ironstone pebbles				
2.5	CLAY - tan/red mottled clay. Approximately 5% 5mm ironstone pebbles				
3.3	SHALE - very low strength, highly weathered, red/tan mottled shale				
3.9	SANDSTONE - low strength, moderately weathered, brown sandstone. Fine grained				
4.0	SANDSTONE - medium strength, fresh, grey sandstone. Fine grained. Approximately 5% carbonaceous laminae - fossiliferous sandstone. (minor interbedded shale layers)				
5.0					
6.0					
7.0					
8.0					
9.0					
10.0					

RIG: B40

DRILLER: McDERMOTT'S LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, BLADE 96mm-8.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A Auger sample	M Moisture content (%)
B Bulk sample	pp Pocket Penetration (kPa)
D Disturbed sample	Ux x mm dia. tube
HV Hand Vane	WP Plastic limit (%)

CHECKED:

Initials: *TCC*

Date: 12.3.98



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 15 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB7
SHEET 2 OF 2

Description of Strata		Sampling & In Situ Testing			
		Type	Depth (m)	Results	Headspace PID (ppm)
10	SANDSTONE - medium strength, fresh, grey sandstone. Fine grained. Approximately 5% carbonaceous laminae - fossiliferous sandstone. (possibly minor interbedded shale layers)				
11					
12					
12.8	SHALE - low strength, fresh, dark grey laminated shale. Thinly laminated. <1% carbonaceous laminae. (Minor sandstone interbeds from 13m to 14m and from 15m to 17m)				
13					
14					
15					
16					
17					
18					
19					
20-20.0	TEST BORE DISCONTINUED AT 20.0 METRES				

RIG: B40

DRILLER: McDERMOTT'S LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, BLADE 96mm-8.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A auger sample	PL point load strength I_p (50MPa)
B bulk sample	S standard penetration test
C core drilling	Ux x mm dia. tube
PP Pocket Penetration (kPa)	V shear vane (kPa)

CHECKED:

Initials: Tce

Date: 12.3.98



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CLIENT: ENVIRO-MANAGERS PTY LTD
 PROJECT: GROUNDWATER MONITORING
 LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 15 OCT 97
 PROJECT No.: 24681A
 SURFACE LEVEL:

BORE No. WB8
 SHEET 1 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Test Results	Core Recovery %
0 0.10	SANDY CLAY - brown sandy clay with rootlets				
1	SANDY CLAY - tan brown/grey mottled sandy clay. Approximately 5% extremely weathered shale and sandstone fragments. Possibly extremely weathered interbedded shale and sandstone. Drill cuttings 30% fine grained sandstone				
2					
3					
3.5	SANDY CLAY - light brown sandy clay. Approximately 5% extremely weathered shale fragment, thinly laminated. Possibly extremely weathered interbedded shale and sandstone				
4					
5					
6					
6.5	SHALE - low strength, highly weathered, greyish brown shale. Approximately 10% black carbonaceous laminae				
7					
8					
8.4	INTERBEDDED SHALE AND SANDSTONE - medium strength, slightly weathered, brownish grey interbedded shale and sandstone. Approximately 1% black carbonaceous 2mm platy fragments				
9					
10					

RIG: B40

DRILLER: McDERMOTT'S LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER
 CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A Auger sample	M Moisture content (%)
B Bulk sample	pp Pocket Penetration (kPa)
D Disturbed sample	Ux x mm dia. tube
HV Hand Vane	Wp Plastic limit (%)

CHECKED:

Initials: Tcc

Date: 12.3.98



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TEST BORE REPORT

CLIENT: ENVIRO-MANAGERS PTY LTD
PROJECT: GROUNDWATER MONITORING
LOCATION: RICHMOND ROAD, MARSDEN PARK

DATE: 15 OCT 97
PROJECT No.: 24681A
SURFACE LEVEL:

BORE No. WB8
SHEET 2 OF 2

Depth m	Description of Strata	Sampling & In Situ Testing			
		Type	Depth (m)	Results	Headspace PID (ppm)
10	INTERBEDDED SHALE AND SANDSTONE - medium strength, slightly weathered, brownish grey interbedded shale and sandstone. Approximatley 1% black carbonaceous 2mm platy fragments				
11					
12					
13	SANDSTONE - medium strength, fresh, light grey sandstone. Approximately 1% carbonaceous 2mm laths				
13.0					
14					
15					
15.35	INTERBEDDED SHALE AND SANDSTONE - medium strength, fresh, grey interbedded shale and sandstone. Approximately 5% carbonaceous laminae (60% shale - thinly laminated, dark grey) (40% sandstone - fine grained)				
16					
16.85					
17					
18	SHALE - medium strength, fresh, dark grey shale. Approximately 5% carbonaceous laminae. Thinly laminated				
18.10					
19					
20					
20.0	TEST BORE DISCONTINUED AT 20.0 METRES				

RIG: B40

DRILLER: McDERMOTTS LOGGED: CALLAN

CASING: NONE

TYPE OF BORING: BLADE 125mm-2.5m, PCD 96mm-20.0m

GROUND WATER OBSERVATIONS: NO FREE GROUNDWATER OBSERVED

REMARKS: DRILLING WITH WATER FROM SURFACE. GRAPHIC LOGS OF PIEZOMETER
CONSTRUCTION DETAILS ARE INCLUDED IN APPENDIX B

SAMPLING & IN SITU TESTING LEGEND

A auger sample	PL point load strength I_s (50MPa)
B bulk sample	S standard penetration test
C core drilling	Ux x mm dia tube
pp Pocket Penetration (kPa)	V shear vane (kPa)

CHECKED:

Initials: Tcc

Date: 12.3.98



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APPENDIX C
Piezometer Construction Report Sheets



Project : GROUNDWATER MONITORING
Client : ENVIRO-MANAGERS PTY. LTD.
Location : RICHMOND ROAD, MARSDEN PARK

Date : 13 Oct 1997
Project No. : 24681A
Bore No. : WB 3

	YES	NO
LOCKABLE STEEL STAND PIPE	Y	
FLUSH GATIC COVER		N
LOCKABLE BUTTERFLY PLUG		N
CONCRETE WELL HEAD	Y	
BACKFILLED WITH	DRILL CUTTINGS	
BENTONITE PLUG	Y	
GRAVEL SIZE	2-5 mm	
FILTER SOCK		N
MACHINE SLOTTED	Y	
HAND SLOTTED		N
BOTTOM CAP	Y	

Please complete this table if information not recorded on bore log

DRILLING METHODS
FROM TO

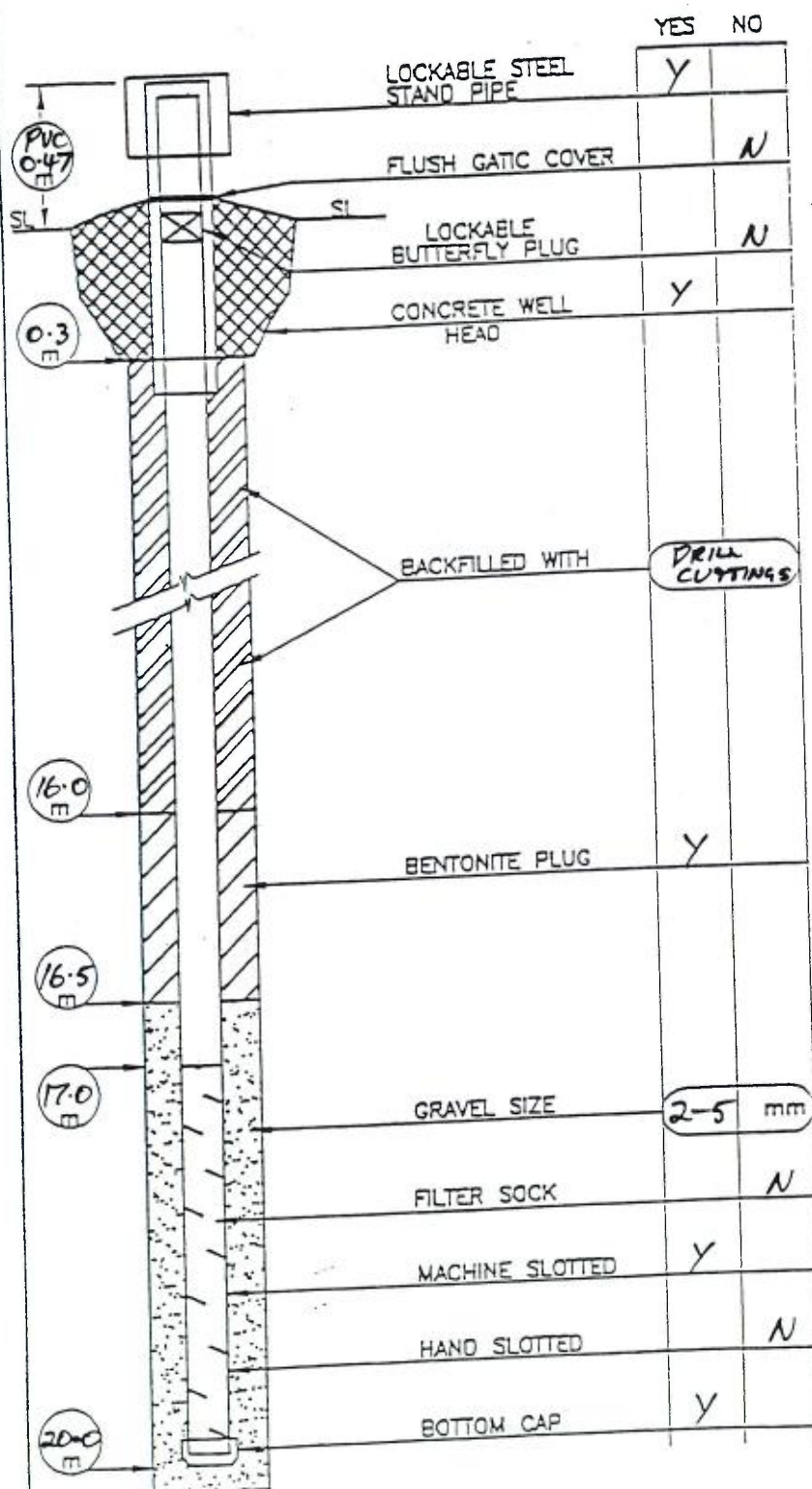
HAND AUGER
SQUID FLIGHT
HOLLOW FLIGHT
CASING (HW STEEL) +0.47 - 0.53m
ROTARY
MUD
CORING
UPVC CASING +0.49 - 20.0m
(50mm DIAMETER, CLASS 18).

WAS ANY GROUNDWATER NOTED: NO - BORE DRILLED WITH WATER.
AT WHAT DEPTH: 2.70m BELOW SURFACE LEVEL. DATE: 30.10.97
DEPTH TO GROUNDWATER



Project : GROUNDWATER MONITORING
Client : ENVIRO-MANAGERS PTY. LTD.
Location : RICHMOND ROAD, MARSDEN PARK

Date : 14.10.97
Project No. : 24681A
Bore No. : WB4 -



Please complete this table
if information not recorded
on bore log

DRILLING METHODS
FROM | TO

HAND AUGER
SOLID FLIGHT
HOLLOW FLIGHT
CASING (HW STEEL) + 0.45 - 0.55m
ROTARY
MUD
CORING
UPVC CASING + 0.47 - 200mm
(50mm DIAMETER,
CLASS 18).

WAS ANY GROUNDWATER NOTED: NO - BORE DRILLED WITH WATER
 AT WHAT DEPTH: 4.25m
 DEPTH TO GROUNDWATER: 4.25m BELOW SURFACE LEVEL DATE: 30.10.97



Project : **GROUNDWATER MONITORING**
Client : **ENVIRO-MANAGERS PTY. LTD.**
Location : **RICHMOND ROAD, MARSDEN PARK**

Date : **14.10.97**
Project No. : **24681A**
Bore No. : **WB5**

	YES	NO
LOCKABLE STEEL STAND PIPE	Y	
FLUSH GATIC COVER		N
LOCKABLE BUTTERFLY PLUG		N
CONCRETE WELL HEAD	Y	
BACKFILLED WITH	DRILL CUTTINGS	
BENTONITE PLUG	Y	
GRAVEL SIZE	2-5 mm	
FILTER SOCK		N
MACHINE SLOTTED	Y	
HAND SLOTTED		N
BOTTOM CAP	Y	

Please complete this table if information not recorded on bore log

DRILLING METHODS
FROM TO

HAND AUGER
SOLID FLIGHT
HOLLOW FLIGHT
CASING (HW STEEL) +0.36 - 0.64m
ROTARY
MUD
CORING
UPVC CASING +0.38 - 20.0m
(50mm DIAMETER, CLASS 18).

WAS ANY GROUNDWATER NOTED:
AT WHAT DEPTH
DEPTH TO GROUNDWATER

No - BORE DRILLED WITH WATER.
11.08m BELOW SURFACE LEVEL DATE: 30.10.97



Project : GROUNDWATER MONITORING
Client : ENVIRO-MANAGERS PTY. LTD.
Location : RICHMOND ROAD, MARSDEN PARK

Date : 15.10.97
Project No. : 24681A
Bore No. : WB6

	YES	NO
LOCKABLE STEEL STAND PIPE	Y	
FLUSH GATIC COVER		N
LOCKABLE BUTTERFLY PLUG		N
CONCRETE WELL HEAD	Y	
BACKFILLED WITH	DRILL CUTTINGS	
BENTONITE PLUG	Y	
GRAVEL SIZE	2-5 mm	
FILTER SOCK		N
MACHINE SLOTTED	Y	
HAND SLOTTED		N
BOTTOM CAP	Y	

Please complete this table if information not recorded on bore log

DRILLING METHODS
FROM TO

HAND AUGER
SOLID FLIGHT
HOLLOW FLIGHT
CASING (HW STEEL) +0.48 -0.52m
ROTARY
MUD
CORING
UPVC CASING +0.50 -20.0m
(50mm DIAMETER, CLASS 18).

WAS ANY GROUNDWATER NOTED: NO - BORE DRILLED WITH WATER.
AT WHAT DEPTH
DEPTH TO GROUNDWATER 4.02m BELOW SURFACE LEVEL DATE: 30.10.97



Project : GROUNDWATER MONITORING
Client : ENVIRO-MANAGERS PTY. LTD.
Location : RICHMOND ROAD, MARSDEN PARK

Date : 15.10.97
Project No. : 24681A
Bore No. : WB7

	YES	NO
LOCKABLE STEEL STAND PIPE	Y	
FLUSH GATIC COVER		N
LOCKABLE BUTTERFLY PLUG		N
CONCRETE WELL HEAD	Y	
BACKFILLED WITH	DRILL CUTTINGS	
BENTONITE PLUG	Y	
GRAVEL SIZE	2-5 mm	
FILTER SOCK		N
MACHINE SLOTTED	Y	
HAND SLOTTED		N
BOTTOM CAP	Y	

Please complete this table if information not recorded on bore log

DRILLING METHODS
FROM TO

HAND AUGER
SOLID FLIGHT
HOLLOW FLIGHT
CASING (HW STEEL) +0.43-0.52m
ROTARY
MUD
CORING
UPVC CASING +0.45-20.0m
(50mm DIAMETER, CLASS 18).

WAS ANY GROUNDWATER NOTED: NO - BORE PRIMED WITH WATER
AT WHAT DEPTH
DEPTH TO GROUNDWATER: 4.38 m BELOW SURFACE LEVEL DATE: 30.10.97



Project : **GROUNDWATER MONITORING**
Client : **ENVIRO-MANAGERS PTY. LTD.**
Location : **RICHMOND ROAD, MARSDEN PARK**

Date : **15.10.97**
Project No. : **24681A**
Bore No. : **WB8**

	YES	NO
LOCKABLE STEEL STAND PIPE	Y	
FLUSH GATIC COVER		N
LOCKABLE BUTTERFLY PLUG		N
CONCRETE WELL HEAD	Y	
BACKFILLED WITH	DRILL CUTTINGS	
BENTONITE PLUG	Y	
GRAVEL SIZE	2-5 mm	
FILTER SOCK		N
MACHINE SLOTTED	Y	
HAND SLOTTED		N
BOTTOM CAP	Y	

Please complete this table if information not recorded on bore log

DRILLING METHODS
FROM TO

HAND AUGER
SOLID FLIGHT
HOLLOW FLIGHT
CASING (HW STEEL) +0.45 -0.55m
ROTARY
MUD
CORING
UPVC CASING +0.47 -20.0m
(50mm DIAMETER, CLASS 18).

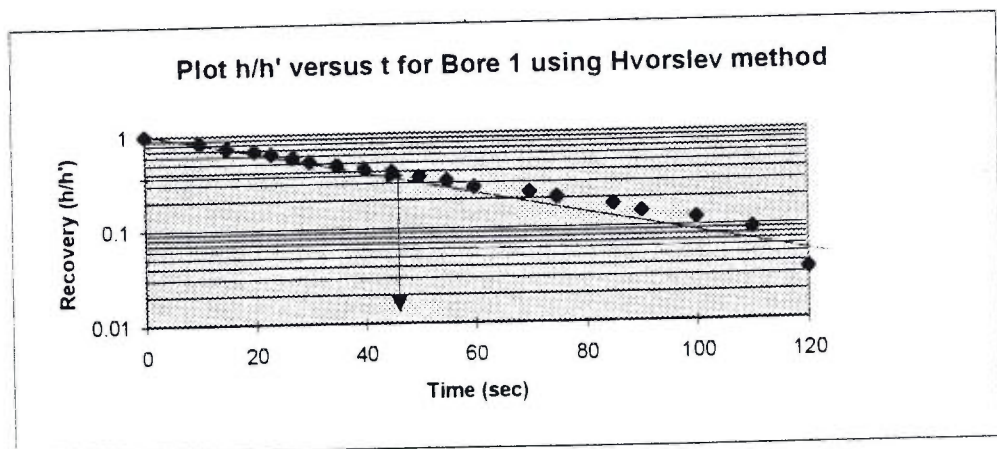
WAS ANY GROUNDWATER NOTED: **NO - BORE DRILLED WITH WATER.**
AT WHAT DEPTH: **7.03m**
DEPTH TO GROUNDWATER: **7.03m** BELOW SURFACE LEVEL
DATE: **30.10.97**

APPENDIX D
Head Recovery (Slug) Test Details

Hydrogeological Investigation - Marsden Park (Project No. 24681A)							
Head Recovery Test Results							
Bore Number	r (m)	R (m)	Le (m)	To (sec)	$r^2 \ln(Le/R)$ m ²	2LeTo (msec)	K (m/sec)
BH1	0.025	0.05	3	46	0.002559	276	9.27E-06
BH2	0.025	0.05	3	1000	0.002559	6000	4.26E-07
WB3	0.025	0.05	3	14500	0.002559	87000	2.94E-08
WB4	0.025	0.05	3	6000	0.002559	36000	7.11E-08
WB5	0.025	0.05	3	300000	0.002559	1800000	1.42E-09
WB6	0.025	0.05	3	8600	0.002559	51600	4.96E-08
WB7	0.025	0.05	3	11000	0.002559	66000	3.88E-08
WB8	0.025	0.05	3	60000	0.002559	360000	7.11E-09
Bores BH1 & BH2 have an assumed screen length of 3.0 m							

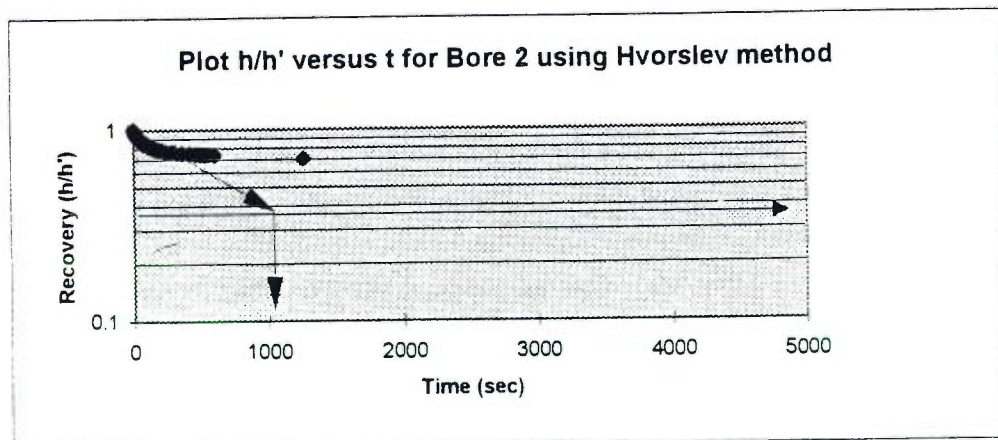
Bore BH1 Recovery

Time (sec)	Depth to water (top of piezo)	Change in water level (m)	Ratio (h/h')
Static	3.7		
0	5.46	1.76	1
10	5.19	1.49	0.85
15	5	1.3	0.74
20	4.9	1.2	0.68
23	4.8	1.1	0.63
27	4.71	1.01	0.57
30	4.6	0.9	0.51
35	4.52	0.82	0.47
40	4.45	0.75	0.43
45	4.39	0.69	0.39
50	4.31	0.61	0.35
55	4.25	0.55	0.31
60	4.17	0.47	0.27
70	4.11	0.41	0.23
75	4.06	0.36	0.20
85	4	0.3	0.17
90	3.95	0.25	0.14
100	3.91	0.21	0.12
110	3.86	0.16	0.09
120	3.76	0.06	0.03



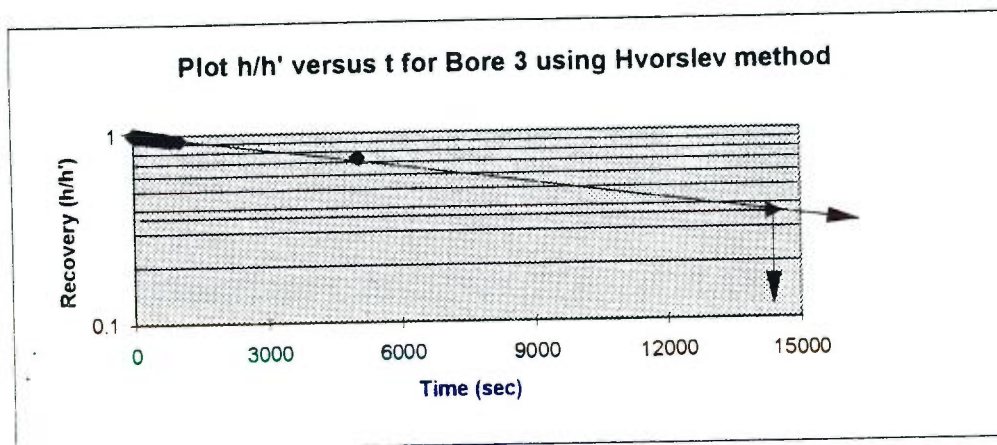
Bore BH2 Recovery

Time (sec)	Depth to water (top of piezo)	Change in water level (m)	Ratio (h/h')
Static	10.46		
0	14.1	3.64	1
5	14.01	3.55	0.98
10	13.96	3.5	0.96
15	13.91	3.45	0.95
20	13.86	3.4	0.93
25	13.81	3.35	0.92
35	13.78	3.32	0.91
40	13.73	3.27	0.90
45	13.69	3.23	0.89
50	13.65	3.19	0.88
60	13.61	3.15	0.87
65	13.58	3.12	0.86
75	13.53	3.07	0.84
105	13.47	3.01	0.83
120	13.4	2.94	0.81
150	13.37	2.91	0.80
165	13.35	2.89	0.79
175	13.3	2.84	0.78
190	13.32	2.86	0.79
210	13.3	2.84	0.78
240	13.25	2.79	0.77
280	13.24	2.78	0.76
300	13.23	2.77	0.76
360	13.2	2.74	0.75
420	13.19	2.73	0.75
465	13.17	2.71	0.74
510	13.15	2.69	0.74
540	13.15	2.69	0.74
600	13.13	2.67	0.73
1260	13.02	2.56	0.70



Bore WB3 Recovery

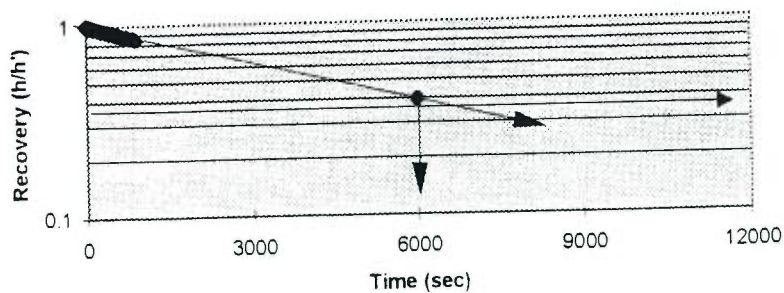
Time (sec)	Depth to water (top of piezo)	Change in water level (m)	Ratio (h/h')
Static	3.19		
0	8.21	5.02	1
60	8.2	5.01	1.00
90	8.19	5	1.00
120	8.19	5	1.00
140	8.18	4.99	0.99
150	8.17	4.98	0.99
170	8.16	4.97	0.99
180	8.16	4.97	0.99
190	8.15	4.96	0.99
210	8.14	4.95	0.99
220	8.13	4.94	0.98
230	8.12	4.93	0.98
240	8.12	4.93	0.98
250	8.11	4.92	0.98
260	8.11	4.92	0.98
270	8.1	4.91	0.98
280	8.1	4.91	0.98
290	8.09	4.9	0.98
300	8.07	4.88	0.97
320	8.07	4.88	0.97
360	8.06	4.87	0.97
380	8.06	4.87	0.97
400	8.05	4.86	0.97
420	8.04	4.85	0.97
440	8.03	4.84	0.96
460	8.02	4.83	0.96
480	8.01	4.82	0.96
500	8.01	4.82	0.96
520	8	4.81	0.96
540	7.99	4.8	0.96
570	7.98	4.79	0.95
600	7.97	4.78	0.95
630	7.96	4.77	0.95
660	7.94	4.75	0.95
690	7.93	4.74	0.94
720	7.92	4.73	0.94
750	7.91	4.72	0.94
870	7.87	4.68	0.93
1020	7.84	4.65	0.93
5040	6.86	3.67	0.73



Bore WB4 Recovery

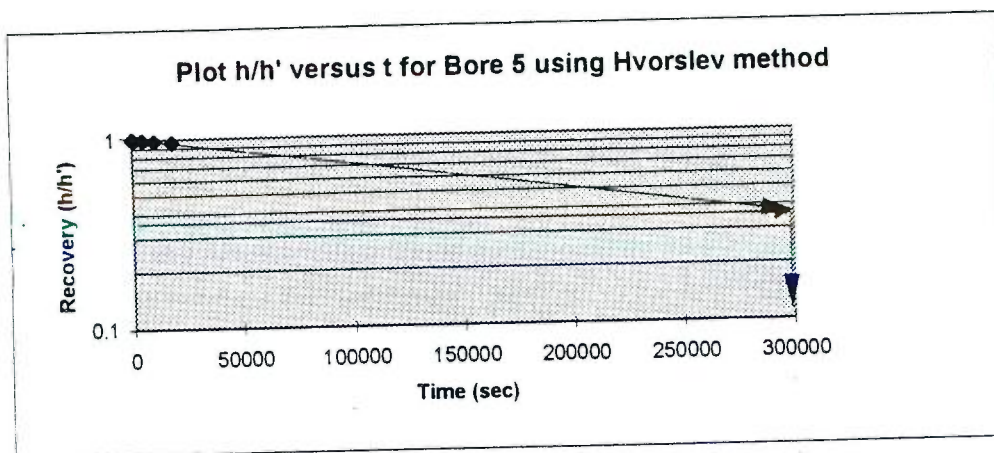
Time (sec)	Depth to water (top of piezo)	Change in water level (m)	Ratio (h/h')
Static	4.72		
0	11.43	6.71	1
40	11.42	6.7	1.00
50	11.39	6.67	0.99
60	11.37	6.65	0.99
65	11.35	6.63	0.99
70	11.34	6.62	0.99
80	11.33	6.61	0.99
90	11.32	6.6	0.98
100	11.3	6.58	0.98
105	11.29	6.57	0.98
115	11.27	6.55	0.98
120	11.26	6.54	0.97
140	11.24	6.52	0.97
160	11.22	6.5	0.97
180	11.19	6.47	0.96
200	11.16	6.44	0.96
220	11.14	6.42	0.96
240	11.12	6.4	0.95
260	11.1	6.38	0.95
280	11.07	6.35	0.95
300	11.05	6.33	0.94
330	11.02	6.3	0.94
360	10.99	6.27	0.93
390	10.95	6.23	0.93
420	10.92	6.2	0.92
450	10.9	6.18	0.92
480	10.88	6.16	0.92
510	10.83	6.11	0.91
540	10.8	6.08	0.91
570	10.76	6.04	0.90
600	10.74	6.02	0.90
660	10.67	5.95	0.89
750	10.6	5.88	0.88
840	10.51	5.79	0.86
900	10.44	5.72	0.85
6000	7.39	2.67	0.40

Plot h/h' versus t for Bore 4 using Hvorslev method



Bore WB5 Recovery

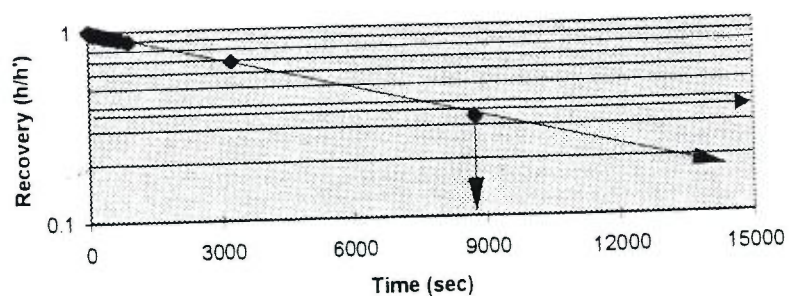
Time (sec)	Depth to water (top of piezo)	Change in water level (m)	Ratio (h/h')
Static	11.46		
0	18.55	7.09	1
10	18.55	7.09	1.00
200	18.54	7.08	1.00
270	18.53	7.07	1.00
390	18.52	7.06	1.00
510	18.51	7.05	0.99
720	18.5	7.04	0.99
4560	18.47	7.01	0.99
10080	18.4	6.94	0.98
18180	18.3	6.84	0.96



Bore WB6 Recovery

Time (sec)	Depth to water (top of piezo)	Change in water level (m)	Ratio (h/h')
Static	4.52		
0	10.72	6.2	1
10	10.69	6.17	1.00
20	10.68	6.16	0.99
30	10.65	6.13	0.99
40	10.64	6.12	0.99
50	10.63	6.11	0.99
60	10.61	6.09	0.98
80	10.6	6.08	0.98
90	10.59	6.07	0.98
100	10.58	6.06	0.98
110	10.57	6.05	0.98
120	10.56	6.04	0.97
140	10.55	6.03	0.97
160	10.54	6.02	0.97
180	10.53	6.01	0.97
210	10.51	5.99	0.97
240	10.48	5.96	0.96
280	10.44	5.92	0.95
330	10.41	5.89	0.95
360	10.32	5.8	0.94
390	10.35	5.83	0.94
420	10.33	5.81	0.94
480	10.3	5.78	0.93
540	10.24	5.72	0.92
630	10.2	5.68	0.92
720	10.15	5.63	0.91
900	10	5.48	0.88
3240	8.75	4.23	0.68
8760	6.58	2.06	0.33

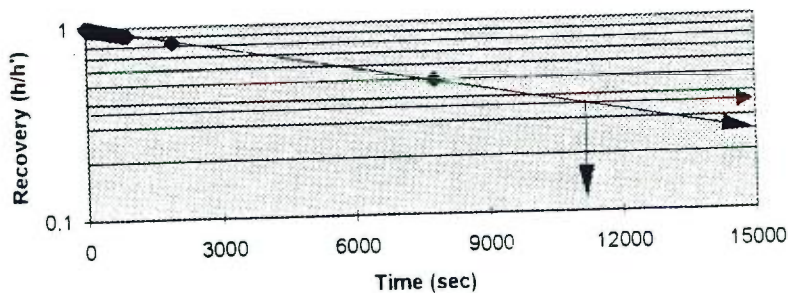
Plot h/h' versus t for Bore 6 using Hvorslev method



Bore WB7 Recovery

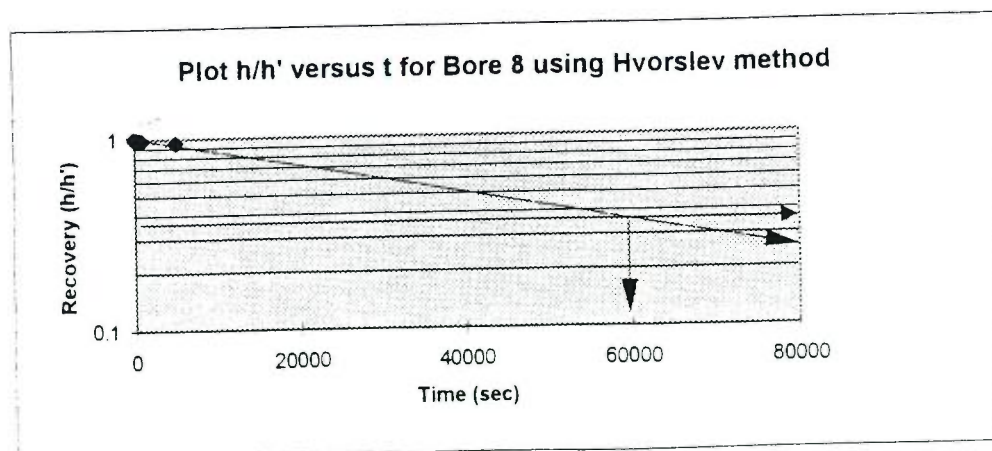
Time (sec)	Depth to water (top of piezo)	Change in water level (m)	Ratio (h/h')
Static	4.83		
0	11.45	6.62	1
30	11.44	6.61	1.00
40	11.43	6.6	1.00
50	11.41	6.58	0.99
60	11.4	6.57	0.99
70	11.39	6.56	0.99
80	11.38	6.55	0.99
90	11.37	6.54	0.99
100	11.36	6.53	0.99
110	11.35	6.52	0.98
120	11.34	6.51	0.98
140	11.33	6.5	0.98
160	11.32	6.49	0.98
180	11.3	6.47	0.98
200	11.29	6.46	0.98
220	11.28	6.45	0.97
240	11.26	6.43	0.97
270	11.24	6.41	0.97
300	11.21	6.38	0.96
360	11.19	6.36	0.96
390	11.16	6.33	0.96
420	11.13	6.3	0.95
480	11.11	6.28	0.95
540	11.07	6.24	0.94
570	11.05	6.22	0.94
600	11.02	6.19	0.94
660	11	6.17	0.93
720	10.97	6.14	0.93
780	10.92	6.09	0.92
840	10.88	6.05	0.91
900	10.84	6.01	0.91
1920	10.33	5.5	0.83
7800	8.13	3.3	0.50

Plot h/h' versus t for Bore 7 using Hvorslev method



Bore WB8 Recovery

Time (sec)	Depth to water (top of piezo)	Change in water level (m)	Ratio (h/h')
Static	2.26		
0	12.78	10.52	1
10	12.98	10.72	1.02
20	12.77	10.51	1.00
30	12.77	10.51	1.00
40	12.76	10.5	1.00
50	12.76	10.5	1.00
60	12.76	10.5	1.00
70	12.76	10.5	1.00
80	12.76	10.5	1.00
90	12.76	10.5	1.00
100	12.75	10.49	1.00
110	12.75	10.49	1.00
120	12.75	10.49	1.00
140	12.75	10.49	1.00
160	12.74	10.48	1.00
180	12.74	10.48	1.00
210	12.73	10.47	1.00
240	12.73	10.47	1.00
260	12.72	10.46	0.99
280	12.71	10.45	0.99
300	12.71	10.45	0.99
330	12.7	10.44	0.99
360	12.7	10.44	0.99
390	12.69	10.43	0.99
420	12.69	10.43	0.99
450	12.68	10.42	0.99
480	12.68	10.42	0.99
510	12.68	10.42	0.99
600	12.67	10.41	0.99
680	12.67	10.41	0.99
750	12.66	10.4	0.99
810	12.65	10.39	0.99
900	12.64	10.38	0.99
4980	12.28	10.02	0.95



APPENDIX E
Sample Preservation Techniques

Trade Waste Samples

Parameter	Container	Minimum Sample Size (ml)	Preservation	Maximum Holding Times
Acidity	P,G	100	4°C	14 days
Alkalinity	P,G	200	4°C	14 days
BOD	P,G	500	4°C	48 hours
Bromide	P,G	50	4°C	28 days
BTEX/VAC's	PT40T	2 x 40	4°C, pH<2 (HCl)	14 days
Carbamates	G(S)T	100	4°C	7 days
Carbon, Total Organic (TOC)	G	50	Analyse Immediately or pH<2 (HCl, 4°C)	28 days
Chlorine, Residual	P,G	500	Analyse Immediately	ASAP
Chloride	P	50	NR	>28 days
COD	P,G	100	Analyse Immediately or pH<2 (H ₂ SO ₄), 4°C	28 days
Chlorophyll	P,G	500	Dark, 4°C	28 days
Chromium VI	P(A), G(A)	200	4°C	24 hours
Colour	P,G	100	4°C	48 hours
Conductivity	P,G	50	4°C	28 days
Cyanide (total/free)	P,G	100	pH>12 (NaOH), 4°C	14 days
Explosives	G(S)T	100	4°C	7 days
Fluoride	P	100	NR	28 days
Hardness	P,G	100	pH<2 (HNO ₃)	6 months
Metals - Total (acid digestible)	P(A), G(A)	-	Analyse Immediately or pH<2 (HNO ₃)	6 months
- Dissolved	P(A), G(A)	-	Filter through 0.45µm filter then pH<2 (HNO ₃)	6 months
Nitrogen: Ammonia/TKN	P,G	500	Analyse Immediately or pH<2 (H ₂ SO ₄), 4°C	28 days
Nitrate	P,G	100	Analyse Immediately, 4°C	48 hours
Nitrite	P,G	100	Analyse Immediately, 4°C	48 hours
Oil & Grease	G(S)T	500	pH<2 (H ₂ SO ₄), 4°C	28 days
OC's/PCB's*	G(S)T	500	4°C, pH 5-8	7 days
OP's*	G(S)T	500	4°C, pH 5-8	7 days
Phthalates*	G(S)T	500	4°C	7 days
PAH's*	G(S)T	500	4°C	7 days
pH	P,G	50	Analyse Immediately, 4°C	ASAP
Phenolics	P,G	500	pH<2 (H ₂ SO ₄), 4°C	28 days
Phenoxy Acids*	G(S)T	500	4°C	7 days
Phosphate (Total P)	G(A)	100	pH<2 (H ₂ SO ₄), 4°C	28 days
Phosphate (ortho)	P,G	100	Analyse Immediately, 4°C	48 hours
SVOC's*	G(S)T	500	4°C	7 days
Solids (total & suspended)	P,G	500	4°C	7 days
Sulphate	P,G	100	4°C	28 days
Sulphide	P,G	100	4°C ♦	28 days
Surfactants	P,G	500	4°C	48 hours
TPH	G(S)T	250	4°C, pH<2 (H ₂ SO ₄)	14 days
Turbidity	P,G	50	Analyse Immediately, (dark)	48 hours
VHC's/VAC's	PT40T	2 x 40	4°C	14 days
VOC's	PT40T	2 x 40	4°C	14 days

- ♦ Add 4 drops 2N zinc acetate per 100ml sample and NaOH to pH>9
- * Extracted within Maximum Holding Times and analysed within 40 days
- G = Glass Jar
- G(A) = Glass, acid washed
- G(S) = Glass, solvent washed
- NR = Not Required

- G(S)T = Glass, solvent washed, with Teflon lined lid
- P = Plastic (Polyethylene or equivalent)
- P(A) = Plastic, acid washed
- PT40T = 40ml Vial suitable for Purge & Trap

Reference: APHA 18th Ed, and AmdeI SPM-01

APPENDIX F
Chain of Custody Documentation - Field

Client: PENRITH WASTE SERVICE
Project: GROUNDWATER SAMPLING Project No: 24681A
Location: MARSDEN PARK

Field									DP Lab	Despatch
Sample ID	Depth (m)	Duplicate Sample	Depth (m)	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: <u>TCC</u> Date: <u>31 OCT 97</u>	☐ AEL ☐ Date:
						By	Date	Time	Storage Location*	
WB 3				W	G	TCC	31 OCT 97	10.00 am	FRIDGE	
WB 3				↓				↓		
WB 3				↓						
WB 4				W				10.45 am		
WB 4				↓				↓		
WB 4				↓						
WB 5				W				11.30 am		
WB 5				↓				↓		
WB 5				↓						
WB 6		TCI		W				12.15 pm		
WB 6		TCI		↓				↓		
WB 6		TCI		↓						
WB 7				W				1.00 pm		
WB 7				↓				↓		
WB 7				↓						
WB 8				W				2.00 pm		
WB 8				↓				↓		
WB 8				↓						

*Default storage: Glass containers in fridge, plastic containers shelved.

APPENDIX G
Laboratory Results and Chain of Custody Documentation

14 November 1997

Douglas Partners

96 Hermitage Rd
West Ryde NSW 2114

Your Reference: MARSDEN PARK 24681A
Australian Environmental Laboratories Report No.: 7222

Attention: TOM CALLAN

Dear Sir,

We received 14 water samples on the 5th of November 1997. The samples were analysed in accordance with your instructions and the results are contained in this report.

Results are reported on an as received basis for waters.

Yours faithfully
AUSTRALIAN ENVIRONMENTAL LABORATORIES



Tania Notaras
Laboratory Manager



David Springer
Inorganic Chemist



DOUGLAS PARTNERS
Project: MARSDEN PARK (24681A)

OUR REFERENCE	7222-1	7222-1.rpt	7222-2	7222-3	7222-4	7222-5	7222-6	7222-7	7222-8	7222-9	7222-10
YOUR REFERENCE	BH3	BH3	BH4	BH5	BH6	BH7	BH8	D9	D10	D11	C12
SAMPLE TYPE	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
UNITS (unless otherwise stated)	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Dissolved Calcium, Ca	320	-	510	210	85	160	230	5.6	6.1	9.7	26
Dissolved Iron, Fe	0.06	-	<0.06	<0.06	<0.06	<0.06	0.26	1.0	0.41	0.20	0.20
Dissolved Magnesium, Mg	900	-	850	550	370	370	570	8.7	22	27	37
Dissolved Manganese, Mn	<0.2	-	0.30	0.66	0.24	1.2	2.6	<0.5	<0.5	<0.5	<0.5
Dissolved Potassium, K	35	-	37	36	11	31	39	10	<2	3.2	8.1
Dissolved Sodium, Na	7500	-	6500	4700	4000	3700	5100	59	240	220	250
Ammonia, as N	2.1	-	2.3	2.8	1.5	1.0	2.0	4.4	0.2	0.1	0.1
Tot Alkalinity, as CaCO3	870	920	810	550	430	1100	870	130	340	350	52
Bicarbonate HCO3, as CaCO3	870	920	810	550	430	1100	870	130	130	250	42
Carbonate, CO3, as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	210	100	10
Fluoride, F	0.3	0.3	0.4	0.4	0.4	0.3	0.4	0.5	0.1	0.1	0.4
Total Dissolved Solids by Calculation	18000	18000	16000	11000	9500	7800	12000	220	620	620	950
Total Organic Carbon	20	-	12	9.5	9.4	18	20	16	19	16	9.8
Total Phenolics (as Phenol)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
pH (pH Units)	6.8	6.8	6.4	7.8	7.4	7.3	7.4	7.6	9.4	9.3	9.2
Chloride, Cl	13000	12000	11000	7100	7100	5000	9000	69	210	120	600
Nitrate, as N	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulphate, SO4	2100	-	1400	840	620	560	920	4.5	3.7	31	73
Dissolved Oxygen*	9.5	9.5	8.9	9.4	11	15	12	9.5	18	14	16
Faecal Coliforms per 100mL #	0	-	0	530	78	54	110	71	0	19	0
E. Coli per 100mL #	0	-	0	460	78	54	110	71	0	19	0

Method Codes : SEM-001, SEI-036, SEI-012, SEI-038/SEI-048, SEI-017, TOC Analysed by AEL Melbourne, Report No: 20795,
SEI-065, SEI-001, SEI-010, #ANALYSED BY EML REPORT NO:97/S108606, *ANALYSED OUTSIDE THE RECCOMENDED
HOLDING TIME.

DOUGLAS PARTNERS
Project: MARSDEN PARK (24681A)

OUR REFERENCE	7222-11	7222-12	7222-13	7222-14	.BLANK	.SPK
YOUR REFERENCE	C13	C14	C15	TC1		
SAMPLE TYPE	WATER	WATER	WATER	WATER	WATER	WATER
UNITS (unless otherwise stated)	mg/L	mg/L	mg/L	mg/L	mg/L	%Recovery
Dissolved Calcium, Ca	27	11	48	83	<0.01	71
Dissolved Iron, Fe	1.7	0.6	0.28	0.08	<0.06	100
Dissolved Magnesium, Mg	11	12	20	360	<0.03	101
Dissolved Manganese, Mn	<0.5	<0.5	<0.5	0.20	<0.02	105
Dissolved Potassium, K	7.0	2.8	5.8	20	<0.03	103
Dissolved Sodium, Na	62	83	250	4300	<0.002	95
Ammonia, as N	0.1	0.1	0.3	0.3	<0.03	98 (7222-3)
Tot Alkalinity, as CaCO ₃	120	75	150	380	<1	-
Bicarbonate HCO ₃ , as CaCO ₃	120	75	150	380	<1	-
Carbonate, CO ₃ , as CaCO ₃	<1	<1	<1	<1	<1	-
Fluoride, F	0.5	0.4	0.8	0.4	<0.1	104
Total Dissolved Solids by Calculation	280	290	1100	8400	<5	-
Total Organic Carbon	18	9.8	17	10	-	-
Total Phenolics (as Phenol)	<0.05	<0.05	<0.05	<0.05	<0.05	82 (7222-11)
pH (pH Units)	7.2	7.3	7.3	7.4	-	-
Chloride, Cl	80	100	480	6400	<2	-
Nitrate, as N	<0.1	<0.1	<0.1	<0.1	<0.1	111 (7222-2)
Sulphate, SO ₄	45	25	75	460	<0.4	-
Dissolved Oxygen*	6.4	13	7.5	8.1	<0.5	-
Faecal Coliforms per 100mL #	92	82	13	14	-	-
E. Coli per 100mL #	92	55	13	14	-	-

Method Codes : SEM-001, SEI-036, SEI-012, SEI-038/SEI-048, SEI-017, TOC Analysed by AEL Melbourne,
 Report No: 20795, SEI-065, SEI-001, SEI-010, #ANALYSED BY EML REPORT NO:97/S108606, *ANALYSED
 OUTSIDE THE RECCOMENDED HOLDING TIME.

CHAIN OF CUSTODY DESPATCH SHEET

Project Name: MAREPEN PARK
Project No: 24681A
DP Contact Person: TOM CALLAN
Prior Storage: asky / fridge / shelved (circle)

To: AEL
12 EXCEL ST

Sample ID	Sample Type S-soil W-water	Lab ID	Analytes				
			<u>AS ATTACHED.</u>				
BH3		1					
BH4		2					
BH5		3					
BH6		4					
BH7		5					
BH8		6					
D9		7					
D10		8					
D11		9					
C12		10					
C13		11					
C14		12					
C15		13					
TC1		14					
PQL (S)	mg/kg						
PQL (W)	mg/L						

PQL = practical quantitation limit, *As per Laboratory Method Detection Limit

Date relinquished: 4.11.97
Total number of samples in container: 14 (EACH SAMPLE - 3 x 1 LITRE BOTTLES)
Results required by: NORMAL (11.11.97)

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax

Signature: [Signature]
Date: 11.9.97 Lab Ref: 7222

Chemical or Property	Required Detection Level (RDL) in µg/L
<u>FAVORABLE CONFORMS (INCLUDING E.C.O.) NORMAL</u>	
Alkalinity	1,000
Ammonia	50
Calcium	5,000
Chloride	5,000
Fluoride	500
Iron	300
Magnesium	5,000
Manganese	50
Nitrate	100
pH	0.1 pH unit
Total phenolics*	50
Potassium	5,000
Sodium	5,000
Sulphate	5,000
Total organic carbon (TOC)**	50
TDS (TOTAL DISSOLVED SOLIDS)	NORMAL
DISSOLVED OXYGEN	NORMAL

Send results to:

Douglas Partners Pty Ltd
96 Hermitage Road
West Ryde NSW 2114
Australia

Phone (02) 809 0666
Fax (02) 809 4095

APPENDIX 3
AIR QUALITY ASSESSMENT

Prepared by:
HOLMES AIR SCIENCES

AIR QUALITY IMPACT ASSESSMENT

**PROPOSED LANDFILL OPERATION
RICHMOND ROAD, MARSDEN PARK**

24 April, 1998

Prepared
for
Enviro-Managers Pty Ltd

by

Holmes Air Sciences

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April, 1998 _____ Holmes Air Sciences

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1. INTRODUCTION

This report has been prepared by Holmes Air Sciences for Enviro-Managers Pty Ltd, for inclusion in the Environmental Impact Statement for the operation of a non-putrescible landfill operation in a former quarry. The purpose of the report is to assess the impacts on air quality due to the proposed operations at the site at Marsden Park. The assessment will focus on dust impacts due to renewed quarrying activities as well as the potential for odour impacts due to the landfill operations.

The report contains the results of a dispersion modelling study using computer-based dispersion models known as DUSTGLC, to predict dust concentration and deposition levels, and AUSPLUME Version 4.0 for Windows, to predict odour impacts.

2. LOCAL SETTING AND PROJECT DESCRIPTION

The proposed site for the quarrying/landfill operations is shown in **Figure 1**. It consists of a former quarry (1964 - 1990) which supplied material used mainly in road construction. Since 1990 it has been left largely unrehabilitated and the former pit has been filled with water. Regenerating forest stands surround the site which act to isolate it from the nearest residences. A caravan park on the southern boundary and the strip of land for the proposed Castlereagh Freeway separate the quarry site from the nearest zoned residential land to the south at Bidwill.

During the life of this project there will be essentially two separate operations taking place. Ganian Pty Ltd proposes to establish a solid waste (non-putrescible) landfill depot at the abandoned quarry site. The existing pit will be expanded and deepened producing quarry product and also cover material for the landfill as required.

Water in the pit will be pumped out and the pit maintained in a dry condition. Quarrying will begin at the northern end, extracted down to a depth of about 35 m in a series of stepped 10 m benches. The material will be made up of clay/shale and breccia, and that not suitable for roadbase and/or brickmaking will be stockpiled and used as cover material, the remainder hauled to the crushing plant to the southeast. When the final floor is reached the 10 m benches will be quarried back to the original cut creating a face ready to receive landfill. Quarrying will then continue to the south in further series of 10 m benches.

As a method of excavation priority will be given to ripping as opposed to blasting. It is anticipated that the top two benches can be ripped but by the time production rates peak it is expected that blasting will be required at a rate of about one blast per week.

Landfill will then be placed against the northern wall and move southwards as the quarry progresses. A distance of 100 m will be maintained between the quarry and landfill operations. Existing stockpiles from the previous quarrying activities will be used as cover material for the landfill, supplemented by newly excavated material that is not sold on. All quarried material (mainly clay/shale) will be crushed and screened on-site at the plant located near the existing weighbridge structure on the access road. The proportion of the material that is sold will be trucked off-site from the plant via the sealed access road.

The full extent of the quarry and landfill areas are shown in **Figure 2**. The boundary will remain within the existing tree cover surrounding the site, and there will be no disturbance to the tree cover or to the dam in the southeast corner.

The maximum excavation rate is expected to reach 300,000 t/y, the majority of this sold as product while the remainder is used as cover material. It is expected that the rate of landfill will peak at 30,000 t per month (360,000 t/y) brought to the site in 25 t on-road trucks.

At least part of the solid waste to be used for landfill will consist of organic material. These will include cardboard, wood and paper products. Whenever biodegradable material is deposited in a landfill site, landfill gas will be produced due to microbial activity. The processes involved during biodegradation is still not fully understood. The majority of the landfill gas will consist of carbon dioxide and methane but there are also other trace gases produced. These include organic sulphides and volatile fatty acids which give the gas its characteristic odour.

3. AIR QUALITY ISSUES

3.1 Dust

This section discusses air quality goals noted in New South Wales (NSW) by the EPA. These goals are used to assess air quality impacts, but they are not formal standards in NSW; that is, they are not legally binding standards. These relate to the air emissions considered in this report, namely dust from quarry operations. The health issues on which the goals are based are also discussed.

The NSW Environmental Protection Authority (EPA) notes air quality goals for particulate matter determined by the United States Environment Protection Agency (US EPA) and the National Health and Medical Research Council (NHMRC), and these are listed in **Table 1**.

It should be noted that the National Environment Protection Council (NEPC) is currently determining a new set of air quality goals for adoption at a national level, which are part of the draft National Environment Protection Measures (NEPM). These are included in **Table 1** and are more stringent than the current goals. In its recent publication "Action for Air" (EPA, 1998) the NSW EPA has adopted the NEPM standards for particulate matter as interim goals.

Table 1 - Air quality standards/goals noted by the NSW EPA		
POLLUTANT	STANDARD	AGENCY
Total suspended particulate matter (TSP)	90 µg/m ³ (annual mean)	NHMRC
Particulate matter < 10 µm (PM ₁₀)	50 µg/m ³ (annual mean) 30 µg/m ³ (annual mean) 150 µg/m ³ (24-hour maximum) 50 µg/m ³ (24-hour maximum)	US EPA NSW EPA Interim US EPA Draft NEPM and NSW EPA Interim

Air quality impacts from dust emissions occur in a number of ways. Firstly there is the potential for dust deposition to soil surfaces such as washing, motor vehicles, the outsides of buildings, swimming pools and to lead to a build up of sediment in rainwater tanks which collect water from roofs. These are referred to as effects on amenity. These effects would occur in the absence of the quarry and it is the extent to which the effects are worsened that determines the acceptability or otherwise of dust emissions from a quarry. Air borne dust also has the potential to cause health effects.

3.1.1 Concentration

The effects of dust on amenity and health can be assessed by comparing dust deposition rates and dust concentrations with recognised air quality criteria established as a result of research both in New South Wales and overseas. To cover the full range of possible adverse impacts it is necessary to make reference to criteria for both long-term (annual averages) and short-term (24-hour) periods and for dust within a range of particle sizes.

In the following discussion reference will be made to three classes of dust, $PM_{2.5}$, PM_{10} and Total Suspended Particulate matter (TSP). $PM_{2.5}$ refers to dust in the fine particle size range 0 to 2.5 μm . This dust can be inhaled into the deepest areas of the lung. PM_{10} dust relates to particles less than 10 μm aerodynamic size and TSP relates to all suspended particles (which are usually in the size range 0 to 50 μm , larger particles settling out too rapidly to be considered a significant air quality issue). TSP concentration measurements therefore include PM_{10} particles and PM_{10} particles included $PM_{2.5}$ particles. Particles in the $PM_{2.5}$ and PM_{10} size range have recently become the focus of considerable scientific attention because of the strong correlation between excess mortality and fine particle concentration that has been noted in the Six Cities Study undertaken by **Dockery et al. (1993)** in the United States. The correlation is weaker with TSP concentrations, presumably because a substantial fraction of TSP particles are too large to enter the sensitive areas of the respiratory system.

PM_{10} particle concentrations are of interest because these particles can reach the lower parts of the respiratory system by inhalation and can have health impacts as well as nuisance impacts. $PM_{2.5}$ particles are those that show the strongest association with health effects and it is possible that in the future the air quality goals for the protection of human health will be expressed in terms of the concentrations $PM_{2.5}$ rather than PM_{10} or TSP concentrations. The US EPA has recently reformulated its air quality standards for particulate matter to include concentration limits for $PM_{2.5}$.

In Australia, the NEPC has proposed a 24-hour PM_{10} goal of 50 $\mu g/m^3$, which is part of the draft NEPM recently released for public comment. The NSW EPA has historically noted the US EPA 24-hour standard of 150 $\mu g/m^3$ and an annual average standard of 50 $\mu g/m^3$ for PM_{10} . It will now adopt the draft NEPM 24-hour standard of 50 $\mu g/m^3$ as an interim goal and refer to a new annual average of 30 $\mu g/m^3$ as a long-term reporting goal.

The NSW EPA also continues to note the NHMRC's 90 $\mu g/m^3$ annual average goal for total suspended particulate matter (TSP). This level is recommended as the maximum permissible level in urban environments.

$PM_{2.5}$ particles in the atmosphere are generally the result of combustion processes in motor vehicles, bushfires and industrial processes. Some $PM_{2.5}$ particles are generated by evaporation of sea-spray and from vegetation. Most quarrying dust is composed of coarser particles with a tendency to cause nuisance effects rather than pose a threat to human health. Work undertaken on behalf of the **SPCC (1983)** shows that close to dust sources on open cut mines the mass fraction of the $PM_{2.5}$ and PM_{10} in the TSP fraction of dust is approximately 6 per cent and 40 to 50 per cent respectively, this will be similar for quarries.

3.1.2 Deposition

The EPA consider that residential areas begin to experience dust related nuisance impacts when annual average dust (insoluble solids) deposition levels exceed 4 $g/m^2/month$, and that dust impacts would be at unacceptable levels when they reached 10 $g/m^2/month$ (**SPCC 1983**). In the early 1990s the EPA (**Dean et al., 1990**) refined these criteria. They are now expressed in terms of an acceptable increase in dust deposition over the existing background. **Table 2** shows the maximum acceptable increase in dust deposition over the existing dust levels.

For example, in residential areas with annual average deposition levels of between 0 and 2 g/m²/month, an increase of up to 2 g/m²/month would be permitted before it is considered that a significant degradation of air quality had occurred.

The criteria for dust fallout levels in **Table 2** are set to protect against nuisance impacts and they are not relevant for interpreting the significance of dust in quarry working areas, where the distinction between what is deposited dust and dumped soil or overburden is unclear. In other words there are no limits to the quantity of dust deposition that is acceptable within the working areas of the quarry.

Table 2 - EPA criteria for dust fallout		
Existing dust fallout level (g/m ² /month)	Maximum acceptable increase over existing fallout levels (g/m ² /month)	
	Residential	Other
2	2	2
3	1	2
4	0	1

3.2 Odour

3.2.1 Preamble

This section discusses air quality goals relating to odour. It should be noted that there is still considerable debate in the scientific community about appropriate odour goals as determined by dispersion modelling.

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

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

There are variations in the literature in the terminology for odour thresholds. The NSW EPA has used the definition of the **detection** threshold as the lowest concentration which will elicit a response, but where the panellist is essentially guessing correctly. This corresponds to the first end point in the forced-choice olfactometry method. The odour **recognition** threshold is the minimum concentration at which the panellist is certain they can detect the odour. This is also referred to as the certainty threshold and is the second endpoint in forced-choice olfactometry and similar to the first end point in yes/no olfactometry.

There is a general move in Europe and Australia to adopting the certainty threshold as the odour standard and referencing this to a standard concentration of butanol (40 ppb). The ratio of recognition to detection threshold (or certainty to guessing threshold) varies but as a general rule is of the order of three.

As with all sensory methods of identification there is variability between individuals. Consequently the results of odour measurements depend on the way in which the panel is selected and the way in which the panel responses are interpreted. The process by which these imprecise measurements are translated into regulatory goals is still being refined.

3.2.2 Air quality goals

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

The New South Wales Environment Protection Authority (NSW EPA) have in recent times attempted to refine odour goals and the way in which they should be applied with dispersion models to assess the likelihood of nuisance impact arising from the emission of odour. However as discussed above these procedures are still being developed and odour goals are likely to be revised in the future.

There are two factors that need to be considered:

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

The term "level of exposure" has been used to reflect the fact that odour impacts are determined by several factors the most important of which are the frequency of the exposure, the intensity of the odour, the duration of the odour episodes and the offensiveness of the odour (the so-called FIDO factor). In determining the offensiveness of an odour it needs to be recognised that for most odours the context in which an odour is perceived is also relevant. Some odours, for example the smell of sewage, hydrogen sulphide, butyric acid, landfill gas etc, are likely to be judged offensive regardless of the context in which they occur. Other odours such as the smell of jet fuel may be acceptable at an airport, but not in a house, diesel exhaust may be acceptable near a busy road, but not in a restaurant etc.

In summary, whether or not an individual considers an odour to be a nuisance will depend on the FIDO factors as discussed above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

It is common practice to use dispersion model to determine compliance with odour goals. This introduces a complication because Gaussian dispersion models are only able to directly predict concentrations over an averaging period of 3-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a 3-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source. To determine more rigorously the ratio between the one-second peak concentrations and three-minute and longer period average concentrations (referred to as the peak-to-mean ratio) that might be predicted by a Gaussian dispersion model, the NSW EPA commissioned a study by **Katestone Scientific Pty Ltd (1995)**. This study recommended peak-

to-mean ratios for a range of circumstances. For emissions from elevated stacks, the peak-to-mean ratio is of the order of eight. For area sources and line sources, it ranges from 1.4 to 2.8. The ratio is also dependent on atmospheric stability and the distance from the source. A summary table of these ratios is presented in **Appendix A**. In the case of the proposed landfill site at Marsden Park the emissions will be from area sources, and the peak-to-mean ratio will therefore vary from 1.4 to 1.7 under stable conditions. (More discussion on emission rates is given in **Section 0**).

The EPA has recently prepared some draft guidelines for composting facilities which include some recommendations for odour criteria. Although this assessment is not for a composting facility this information is the most recent available and the recommendations will be used here. They are based on the nose response times incorporating the peak-to-mean ratios discussed above.

In summary, for an urban area, the odour goal is 2 odour certainty units, to be complied with for 99% of the time, using nose response time emission rates, that is factoring emission rates used in the modelling so that they incorporate peak-to-mean ratios. For rural/industrial areas the odour goal is 7 odour certainty units. It should be noted that the terms "urban" and "rural" in this context do not necessarily refer to Council zoning but to the density of nearby residences. As explained below, the difference between odour goals for urban and rural areas is based on considerations of risk rather than differences in odour acceptability between the areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk than in a sparsely populated area that some individuals within the population will find the odour unacceptable.

Although the Marsden Park site has been zoned Rural 1(a) by Council, the density of residences particularly at the adjacent caravan park (approximately 400 people), suggests that the relevant odour goal for the site will lie somewhere between the 2 ou and 7 ou level. (The EPA classification of rural and urban is not specific in relation to population density). The site has therefore been assessed with respect to both goals and is predicted to achieve total compliance with the rural goal of 7 ou.

4. DISPERSION METEOROLOGY AND EXISTING AIR QUALITY

This section describes the dispersion meteorology, general climate and air quality in the study area. As well as information on prevailing wind patterns, historical data on temperature, humidity and rainfall are presented to give a more complete picture of the local climate.

4.1 Temperature, humidity and rainfall

Table 3 presents the temperature, humidity and rainfall data for Richmond, northwest of the site (**Bureau of Meteorology, 1997**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean and median monthly rainfall and the average number of raindays per month.

From temperature data recorded for over 55 years, the annual average maximum and minimum temperatures experienced are 23.7°C and 11.0°C. The maximum monthly average temperature is recorded, on average, in January at 29.6°C. July is the coldest month on average, with an average minimum temperature of 3.6°C.

Table 3 - Temperature, humidity and rainfall data for Richmond AMO/MO (Station number 067033 Latitude 33 Deg 36 Min S Longitude 150 Deg 47 Min E Elevation 19 m)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Temperatures (C) and Relative Humidity (%) (47 years of record)													
Dry-bulb	22.1	21.4	20.2	16.6	12.3	9.2	8.0	10.4	14.1	17.7	19.6	21.4	16.1
3 pm Mean Temperatures (C) and Mean Relative Humidity (%) (45 years of record)													
Dry-bulb	28.0	27.3	25.9	23.1	19.4	16.8	16.5	18.0	20.6	23.0	25.3	27.3	22.6
Daily Maximum Temperature (C) (55 Years of record)													
Mean	29.6	28.6	27.0	23.9	20.3	17.6	17.2	18.8	21.6	24.5	26.8	28.7	23.7
Daily Minimum Temperature (C) (57 Years of record)													
Mean	17.4	17.4	15.5	11.8	7.9	5.1	3.6	5.0	7.5	11.0	13.7	15.9	11.0
Rainfall (mm) (59 Years of record)													
Mean	93.9	104.1	92.1	70.3	58.8	56.4	35.9	45.8	40.2	64.1	75.0	71.6	808
Raindays (Number) (51 Years of record)													
Mean	11	11	11	9	9	8	6	8	8	10	10	10	110

Source : Bureau of Meteorology (1997)

The annual average humidity reading from 47 years of data collected at 9 am is 74%. The month with the highest 9 am humidity on average is June, with an average reading of 83%. The annual average humidity at 3 pm from 45 years of data is much lower at 47%. The months with the highest 3 pm humidity on average are May and June with 53%.

Rainfall data collected over 59 years show that February is the wettest month on average, with a mean rainfall reading of 104 mm. The average number of raindays for February is 11. July is the driest month with an average rainfall of 36 mm. The average annual rainfall is 808 mm and the average number of raindays is 110.

4.2 Wind data for Richmond

The closest meteorological monitoring station with data which can be considered as representative of the meteorological conditions at the quarry site is at Richmond, to the northwest. **Figure 3** presents seasonal and annual wind rose diagrams compiled from this data. Wind direction is quite variable throughout the year, although they are slightly more frequent from the northeast and southwest. The stronger winds are from the southwest and generally in winter and spring which is a common pattern for Sydney. Southeasterlies predominate in the summer months which is also typical in Sydney.

4.3 Existing air quality

An air quality monitoring network was established at the end of 1994 for a quarrying operation (Schofields) about 2 km east of the Marsden Park site. It was set up to measure existing air quality in the vicinity the Schofields quarry site. This site and also the location of the five dust gauges are shown in **Figure 1**. **Table 4** summarises this data, also showing annual averages.

Gauge D2 shows readings of 5.1 g/m²/month in 1995 and 9.9 g/m²/month in 1996. In 1995 this seems to be due to one abnormally high reading, possibly due to foreign matter such as bird droppings or insects in the dust gauge, but also its position in relation to the existing quarry operations. 1996 shows consistently high readings for D2, likely to be due to the adjacent quarry. Gauge D3 also shows a higher reading of 4.2 g/m²/month in 1996 due to one abnormally high reading in January of that year, again likely to be due by its close proximity to the Schofields quarry.

Deposition rates for the remaining gauges (D1, D4 and D5) are between 2 and 3 g/m²/month (or less) which is within the EPA goal of 4 g/m²/month. These gauges are further from the existing quarry operations at Schofield and are likely to be more representative of the background conditions. Increases of between 1 and 2 g/m²/month due to the Marsden Park quarry/landfill operations would therefore be acceptable given existing deposition levels.

Table 4 - Dust deposition data collected for the quarrying/landfill site at Schofields (g/m²/month)

Date	D1	D2	D3	D4	D5
Jan-95	3.1	3.0	1.0	1.2	1.8
Feb-95	1.5	1.6	0.9	0.9	0.5
Mar-95	1.3	7.9	0.9	1.1	0.9
Apr-95	2.4	1.1	0.7	0.8	1.3
May-95	2.5	1.1	1.1	0.8	0.2
Jun-95	1.9	20.9	7.7	1.7	1.0
Jul-95	0.5	3.0	0.9	0.8	0.9
Aug-95	N/A	N/A	N/A	N/A	N/A
Sep-95	3.7	N/A	1.7	3.0	4.6
Oct-95	2.1	3.5	1.5	1.6	5.5
Nov-95	1.3	6.7	2.7	1.5	3.1
Dec-95	1.4	1.9	1.5	0.7	3.3
Average	2.0	5.1	1.9	1.3	2.1
Jan-96	0.6	9.9	12.8	2.9	7.7
Feb-96	1.9	11.2	N/A	1.4	4.9
Mar-96	0.9	15.1	7.7	0.2	4.0
Apr-96	1.1	5.9	0.5	3.0	1.0
May-96	0.9	16.3	0.6	0.5	0.8
Jun-96	3.2	N/A	3.8	0.8	0.7
Jul-96	2.1	N/A	2.7	1.2	1.0
Aug-96	2.0	0.7	1.3	0.9	2.5
Average	1.6	9.9	4.2	1.4	2.8

5. ESTIMATED EMISSIONS

There will be different emissions from each section of the proposed project. Dust emissions will occur from the quarrying operations while odour emissions will be the issue for the landfill component. Although these two operations will be kept separate they will be occurring simultaneously and are both considered in this assessment. **Sections 5.1 and 5.2** outline how the relevant emission rates were calculated.

5.1 Dust

Estimated emission totals are presented in **Table 5**, and details of the calculations are presented in **Appendix B**. The emissions are likely to be reduced by as much as 30% due to the sheltering effect of the surrounding trees. The values calculated in **Appendix B**, as well as the reduced emissions due to the trees, are both listed in **Table 5**.

Table 5 - Estimated dust emissions for quarry operations in a year of maximum production		
Activity	TSP emission rate (kg/y)	
	Calculated in Appendix A	Reduced due to windbreak effects
Quarry Activities		
Drilling	518	363
Blasting	2,048	1,434
Loading blasted material to dump trucks	8,400	5,880
Transporting material to plant	7,200	5,040
Transporting material to stockpiles	1,600	1,120
Dumping overburden to stockpile	360	252
Dumping material to plant feed-bin	3,240	2,268
Crushing (primary and secondary)	7,560	5,292
Crushing (tertiary)	25,110	17,577
Screening	86,400	60,480
Loading product material to trucks	7,560	5,292
Wind erosion from exposed area including stockpiles	8,760	6,132
TOTAL	158,756	111,130
<i>Ratio of dust created to product</i>	<i>0.59 kg/t</i>	<i>0.41 kg/t</i>
Landfill Activities		
Hauling landfill to pit	29,952	20,966

Dust emissions have been estimated by analysing the proposed quarry operations. It is not anticipated that the level of activity or the mode of operation will change substantially over the life span of the quarry once the maximum production rate of 300,000 t/y has been reached.

The operations which apply in each case have been combined with emission factors developed, both locally and by the US EPA, to estimate the amount of dust produced by each activity. The fraction of fine, inhalable and coarse particles for each activity has also been taken into account and these are included in the calculation table in **Appendix B**.

5.2 Odour

Emission rates from area sources are probably the most difficult to measure for a variety of reasons. Firstly the source is often heterogeneous. For example in the case of a landfill sites, there will be different odour emission rates from different area sources. Secondly, unlike stack emissions, area emission rates are dependent upon atmospheric conditions including wind speed, degree of turbulence, temperature, etc. This clearly adds another level of complexity to odour assessments.

As the Marsden Park landfill site is currently not operational it is not possible to make measurements of odour emissions which are site specific. Furthermore, landfill gas production is a very complex process and emission rates will change over time. For example, a report by **Maunsell (1994)** shows that maximum emission rates may not occur until up to 4 years after the filling and capping of the landfill site. This report also presents a landfill gas model shown in **Figure 4**. This model has been used to determine emission rates at various times throughout the life span of the Marsden Park site, and will be explained in the following paragraphs.

Measurements made for a non-putrescible landfill site after six months (CEE, 1994) have indicated levels of approximately 0.5 ou/m²/min (certainty units). Odours from the site will reach their maximum after a number of years (perhaps 4 years), when it is estimated that emissions may increase by a factor of 14. That is, to model for a worst-case scenario it is necessary to take into account the potential increase in odour over time to approximately 7 ou/m²/min (or 0.117 ou/m²/s). These worst-case emissions however, will not occur over the whole area. As the landfill progresses, emissions from the previously capped cells will rise to a peak and then fall again over the lifetime of the project.

This variation in emission rates may occur in a similar fashion to that suggested by the Maunsell (1994) model in Figure 4. Assuming that the peak for Marsden Park will be approximately 0.117 ou/m²/s, this landfill gas model was used to estimate the emissions at 5, 8, 11 and 14 years. The landfill site was then divided into five sections of equal area and an emission rate assigned to each area. Assuming that the landfill progresses from north to south, Section 5 (the most southerly area) will be capped last. Approximately 1-2 years after this section is capped, the odour from Section 5 is assumed to have reached its peak of 0.117 ou/m²/s (based on Figure 4). Meanwhile, Sections 1 - 4 will have reached their peak and emissions will have reduced significantly.

As discussed in Section 3.2.2, peak-to-mean ratios must also be considered in order to estimate "nose response" emission rates over the area. In the case of the Marsden Park site this needs to be done for two scenarios to take into account residences within 1 km of the site and those further away. Table 6 shows estimated odour emissions for both scenarios using the information in Appendix A. Emissions have been calculated for stable conditions since this is when off-site impacts are most likely to occur.

Table 6 - Estimated emission rates over the proposed site						
		Specific emission rate (ou.m ³ /s/m ²)			Total Emission Rate (ou.m ³ /s)	
	P/M factor	"Actual"	"Nose response"	Area (m ²)	"Actual"	"Nose response"
Near field*						
Section 1	1.7	0.027	0.046	18,000	486	828
Section 2	1.7	0.035	0.060	18,000	630	1,080
Section 3	1.7	0.044	0.075	18,000	792	1,350
Section 4	1.7	0.059	0.100	18,000	1,062	1,800
Section 5	1.7	0.117	0.199	18,000	2,106	3,582
Far field*						
Section 1	1.4	0.027	0.038	18,000	486	684
Section 2	1.4	0.035	0.049	18,000	630	882
Section 3	1.4	0.044	0.062	18,000	792	1,116
Section 4	1.4	0.059	0.083	18,000	1,062	1,494
Section 5	1.4	0.117	0.164	18,000	2,106	2,952

* Near field applies to distances less than 1 km from the site, and far field refers to distances further than 1 km from the site.

Details of how these emission rates are used in the modelling are provided in an example of a model output file shown in **Appendix B**.

6. ASSESSMENT OF IMPACTS

DUSTGLC has been used to model dust concentrations and deposition levels while AUSPLUME Version 4.0 has been used to estimate odour impacts. DUSTGLC has been widely used for dust assessments in the Hunter Valley and a full technical description is presented in the Environmental Impact Statement for the Lemington Northern Open Cut Extension (**Dames & Moore, 1984**). The model uses work by **Slinn (1982)** to estimate dust deposition rates and is based on the sector average model outlined by **Turner (1970)**. AUSPLUME is an advanced Gaussian dispersion model developed on behalf of the Victorian EPA (**VEPA, 1986**). It is based on the US EPA's Industrial Source Complex (ISC) model and has been improved to include the recommendations of the American Meteorological Society's expert panel on dispersion modelling which are outlined in a paper by **Hanna et al (1977)**. It is widely used throughout Australia and is regarded as a "state-of-the-art" model.

The predictions have been made over a grid 4 km by 4 km with 100 m spacing. Results are presented in **Figures 5 to 10** and discussed in **Sections 6.1 and 6.2** with reference to individual goals.

6.1 Dust

6.1.1 Concentration

Figure 5 shows the predicted dust concentrations due to proposed quarrying operations. It can be seen that these activities are not expected to adversely effect the surrounding area, including the individual residences to the north and east, and the southern residential area, Bidwill. Increases in dust concentrations at the nearest residences, on South Avenue, are not predicted to exceed the NHMRC's air quality goal of $90 \mu\text{g}/\text{m}^3$ (annual average) for TSP. Assuming that PM_{10} particles constitute approximately 50% of TSP particles, the increase in PM_{10} concentrations due to the proposed operations are estimated to be less than $5 \mu\text{g}/\text{m}^3$ ($10 \mu\text{g}/\text{m}^3$ TSP) (annual average) at South Avenue, and even further reduced at the Bidwill to the south.

Residents at the caravan park are also not expected to be adversely impacted upon, with predicted increases in TSP concentrations of approximately $20 \mu\text{g}/\text{m}^3$ ($10 \mu\text{g}/\text{m}^3 \text{PM}_{10}$). Annual average background concentrations would need to be of the order of $70 \mu\text{g}/\text{m}^3$ before the NHMRC $90 \mu\text{g}/\text{m}^3$ would be exceeded, which is unlikely to be the case in this area. The EPA's interim annual goal of $30 \mu\text{g}/\text{m}^3$ for PM_{10} is also unlikely to be exceeded at any of the nearby residences.

Predicted increases may in fact be lower than these conservative estimates if the sheltering effect of the surrounding trees is greater than anticipated or if more trees are planted around the site boundaries. These trees are to remain during all stages of the development and are likely to assist in reducing the spread of dust from the quarry site.

6.1.2 Deposition

Figure 6 shows the predicted dust deposition rates around the proposed site. In **Section 4.3** it was shown that annual average dust deposition rates of approximately $2 - 3 \text{ g}/\text{m}^2/\text{month}$ currently exist in the area, allowing an increase of $1 - 2 \text{ g}/\text{m}^2/\text{month}$ from the landfill site and associated quarrying activities.

Dust deposition levels are not predicted to increase by more than 1 g/m²/month (annual average) outside the buffer zone marked in **Figure 6**. Deposition levels of 0.5 g/m²/month or less are predicted for all residences including those at the caravan park. This is not expected to raise the existing levels above the goal of 4 g/m²/month. The quarry activities are therefore not predicted to cause an exceedance of the EPA goal.

6.2 Odour

The results of the odour modelling for both near and far field scenarios are shown in **Figures 7 and 8**. It can be seen that both the 2 ou and 7 ou contours extend beyond the of the buffer zone, however, as will be discussed below, this does not define the impact area. This is defined by the frequency of compliance with these levels. The majority of the residences marked are also predicted to experience exceedances of the 2 ou level at one time or another. This does not necessarily mean that the frequency based goal is exceeded.

As discussed in **Section 3.2**, frequency of exposure is a significant factor when estimating odour impacts. In other words, impacts are considered acceptable if there are less than 88 occasions per year (1% of the time) on which either 2 ou or 7 ou is exceeded.

Figures 9 and 10 show the predicted percentage compliance with the 2 ou and 7 ou levels, respectively. It can be seen in **Figure 9** that levels at all residents, except for those in the northern section of the adjacent caravan park, are predicted to comply with the frequency based goal of 2 ou. It is also shown, however, that the levels are not expected to be excessive at the caravan park as they achieve a 98.6% compliance with the 2 ou goal. It is predicted that full compliance with the 7 ou rural goal is achieved.

An inspection of a similar operation at Mulgoa, south of Penrith, indicated that odour is detectable in the pit where landfill is being dumped, but that at locations further removed there was no detectable odour. The site visit was made at sunrise after a calm clear night following a warm day, a time when odours are likely to be detectable. The model predictions discussed in this report are conservative and it is likely that although the caravan park residents may experience odour levels of more than 2 ou on occasions, these are expected to be relatively isolated incidents.

7. CONCLUSIONS

The results of dispersion modelling indicate that the proposed quarry operations at the Marsden Park Landfill site are unlikely to adversely affect nearby residences with regard to dust. A dust monitoring network should be established prior to the quarry activities and monitored throughout the life of the quarry.

Worst-case odour predictions have indicated full compliance with the 7 ou rural goal and compliance with the 2 ou urban goal at nearby residences, except for the northern section of the caravan park. Although there are predicted to be some exceedances of the urban frequency based goal at the adjacent caravan park; these levels are not expected to be excessive and are predicted to occur for less than 1.5% of the time. This is unlikely to cause any significant nuisance impacts. Given that the waste is non-putrescible, the nature of the odour is unlikely to be as offensive as that from a putrescible waste landfill site, or from the nearby piggery north of the existing quarry.

The estimates of odour emissions from the site is conservative. The material delivered to the site will not be odorous and will not therefore cause any short-term impacts at the time of delivery. The only odours which are likely to occur are from landfill gas which is produced over time. As discussed earlier, odour generation from landfill sites is not constant and will reach a peak and

then diminish. This report has assessed the period of maximum gas generation which would last for possibly 2 years, and has found full compliance with the rural odour goal and substantial compliance with the urban odour goal. At other times in the life of the project the odour emissions will be less. While the area is zoned rural the population density at the caravan park places the development somewhere between rural and urban for impact assessment purposes. The predicted level of impact is therefore considered to be unlikely to cause a nuisance

8. REFERENCES

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APPENDIX A
PEAK-TO-MEAN RATIOS FOR
VARIOUS SOURCE TYPES

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

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

$i_{\max}$ is maximum centreline intensity of concentration

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

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

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

p is the averaging time power law exponent

h is stack height

Katestone Scientific (1995)

Highlighted sections refer to those numbers used in calculations for this assessment

APPENDIX B
ESTIMATED DUST EMISSIONS
AND ODOUR OUTPUT FILE

ESTIMATED DUST EMISSIONS FOR MAXIMUM PRODUCTION

Drilling (US EPA, 1985 - Table 8.24-4)

In a year of maximum production approximately 125,000 bcm of material will be blasted, assuming 1 blast approximately every 10 - 12 days each producing 4,000 bcm [Assuming a density of approximately 2.4 t/bcm, 125,000 bcm is approximately equal to 300,000 t]. A blast of this size will require 27 holes, therefore totalling approximately 864 holes per year (32 blasts per year). Each hole will generate approximately 0.6 kg of dust during drilling. Total dust due to overburden drilling over the year will therefore be 518 kg [864 holes x 0.6 kg/hole].

Blasting

The TSP emission factor equation for blasting overburden, where the area of the blast, $A \text{ m}^2$, is given by:

$$E_{TSP} = 0.008 \times A^{1.5} \text{ — kg/blast}$$

Approximately 4,000 bcm of rock will be blasted during each blast. For a 10 m bench this would equate to an area of approximately 400 m^2 . Using the above equation, the TSP emissions (E_{TSP}) will be 64 kg/blast. Assuming there are 32 blasts per year the total dust in one year from blasting will be 2,048 kg [64 kg/blast x 32 blasts].

Loading blasted material to trucks (US EPA, 1985 Table 8.19.1-1)

In the year of assessment approximately 300,000 t of material will be loaded to 30 t rear dump trucks. Each tonne of material loaded will generate approximately 0.028 kg of dust. Thus the total dust generated in a year will be 8,400 kg [300,000 t x 0.028 kg/t].

Transporting material to plant (NERDDC, 1988)

In the year of maximum production approximately 300,000 t of material will be excavated. Assuming 90% of this is salable, 270,000 t will be transported by 30 t rear dump trucks to the plant. Assuming a return travel distance of 0.4 km and dust generation rate of 4 kg/VKT and 50% control of dust by watering of the haul road the total dust generated will be 7,200 kg [(270,000 t / 30 t) x 0.4 km x 4 kg/km x (50/100)].

Transporting cover material to stockpiles (NERDDC, 1988)

The material not being sold but used as landfill cover will be the remaining 10%, approximately 30,000 t, to be transported by 30 t rear dump trucks to a stockpile in the northeast corner of the site. Assuming a return travel distance of 0.8 km and dust generation rate of 4 kg/VKT and 50% control of dust by watering of the haul road the total dust generated will be 1,600 kg [(30,000 t / 30 t) x 0.8 km x 4 kg/km x (50/100)].

Dumping overburden to stockpile (NERDDC, 1988)

Approximately 30,000 t of material will be dumped from 30 t rear dump trucks into the plant feed bin. Each tonne of material dumped will generate approximately 0.012 kg of dust. Therefore the total dust generated in the year will be 360 kg [30,000 t x 0.012 kg/t].

Dumping rock from trucks to plant feed-bin (NERDDC, 1988)

Approximately 270,000 t of material will be dumped from 30 t rear dump trucks into the plant feed bin. Each tonne of material dumped will generate approximately 0.012 kg of dust. Therefore the total dust generated in the year will be 3,240 kg [270,000 t x 0.012 kg/t].

Crushing (US EPA, 1985 Table 8.19.1-1)

In the year of assessment approximately 270,000 t of material will be crushed outside the pit using a primary jaw crusher, secondary cone crusher and tertiary impactor. Each tonne of material crushed in the primary and secondary crushing stage will generate approximately 0.014 kg of dust [0.140 kg/t reduced by 90 % when enclosed]. The total dust generated over the year by crushing will therefore be 7,560 kg [270,000 t x 0.014 kg/t x 2].

Tertiary crushing has a higher emission rate of 0.930 kg/t, which can be reduced by 90% to 0.093 kg/t through enclosure. The total dust generated over the year by an enclosed tertiary crushing operation will therefore be 25,110 kg [270,000 t x 0.093 kg/t].

Screening (US EPA, 1985 Table 8.19.1-1)

Approximately 270,000 t of material will pass through four screens in the processing plant in one year. Each tonne of material screened will generate approximately 0.08 kg of dust. The total dust generated by screening over the year will therefore be 86,400 kg [270,000 t x 0.08 kg/t x 4].

Loading product material to trucks (US EPA, 1985 - Table 8.19.1-1)

In the year of maximum production approximately 270,000 t of product material will be loaded to highway trucks by front-end loader. Each tonne of material loaded will generate approximately 0.028 kg of dust. Thus the total dust generated in Year 1 will be 7,560 kg [270,000 t x 0.028 kg/t].

Wind erosion from exposed area (SPCC/EPA, 1983)

The EPA emission factor for TSP emissions due to wind erosion is 0.4 kg/ha/h. Assuming that the disturbed area including stockpiles will be approximately 2.5 ha, the annual dust emissions are calculated to be 8,760 kg/y [2.5 ha x 0.4 kg/ha/h x 24 h/day x 365 day/year].

Transporting landfill to pit (NERDDC, 1988)

In the year of maximum production approximately 30,000 t of waste will be dumped in the pit per month. Assuming an average of 120 trips per day (approximately 37,440 trips for 6 day weeks), return travel distance of 0.4 km and dust generation rate of 4 kg/VKT and 50% control of dust by watering of the haul road the total dust generated will be 29,952 kg [37,440 x 0.4 km x 4 kg/km x (50/100)].

Emissions by particle size and source area for the Marsden Park Quarry/Landfill site

	Drilling	Blasting	Loading blasted material to dump trucks	Transport material to plant	Transport material to stockpile	Dumping to stockpile	Dumping to feed-bin	Crushing	Screening	Loading screened material to trucks	Wind erosion from exposed area	Hauling landfill to pit	Fine particle emission rate g/s	Inhalable particle emission rate g/s	Coarse particle emission rate g/s	Total emission rate g/s	Fine particles percentage	Inhalable particles percentage	Coarse particles percentage
Emission rate kg/y	363	1,434	5,880	5,040	1,120	252	2,268	22,869	60,480	5,292	6,132	20,966							
Number of sources	6	6	6	4	7	1	1	1	1	1	9	4							
FP %	9	5	4	6	6	4	4	9	9	4	0	6							
IP %	62	39	44	53	53	44	44	62	62	44	67	53							
CP %	29	56	53	41	41	53	53	29	29	53	33	41							
Source ID																			
1	1	1	1	0	0	0	0	0	0	0	0	0	0.002	0.018	0.021	0.041	0.04	0.44	0.52
2	1	1	1	0	0	0	0	0	0	0	0	0	0.002	0.018	0.021	0.041	0.04	0.44	0.52
3	1	1	1	0	0	0	0	0	0	0	0	0	0.002	0.018	0.021	0.041	0.04	0.44	0.52
4	1	1	1	0	0	0	0	0	0	0	0	0	0.002	0.018	0.021	0.041	0.04	0.44	0.52
5	1	1	1	0	0	0	0	0	0	0	0	0	0.002	0.018	0.021	0.041	0.04	0.44	0.52
6	1	1	1	0	0	0	0	0	0	0	0	0	0.002	0.018	0.021	0.041	0.04	0.44	0.52
7	0	0	0	1	1	0	0	0	0	0	0	1	0.013	0.112	0.087	0.211	0.06	0.53	0.41
8	0	0	0	1	1	0	0	0	0	0	0	1	0.013	0.112	0.087	0.211	0.06	0.53	0.41
9	0	0	0	1	1	0	0	0	0	0	0	1	0.013	0.112	0.087	0.211	0.06	0.53	0.41
10	0	0	0	1	0	0	0	0	0	0	0	1	0.012	0.109	0.085	0.206	0.06	0.53	0.41
11	0	0	0	0	1	0	0	0	0	0	0	0	0.000	0.003	0.002	0.005	0.06	0.53	0.41
12	0	0	0	0	1	0	0	0	0	0	0	0	0.000	0.003	0.002	0.005	0.06	0.53	0.41
13	0	0	0	0	1	0	0	0	0	0	0	0	0.000	0.003	0.002	0.005	0.06	0.53	0.41
14	0	0	0	0	1	0	0	0	0	0	0	0	0.000	0.003	0.002	0.005	0.06	0.53	0.41
15	0	0	0	0	0	1	0	0	0	0	1	0	0.000	0.018	0.011	0.030	0.01	0.61	0.38
16	0	0	0	0	0	0	1	1	1	1	0	0	0.247	1.744	0.894	2.885	0.09	0.60	0.31
17	0	0	0	0	0	0	0	0	0	0	1	0	0.000	0.014	0.007	0.022	0.00	0.67	0.33
18	0	0	0	0	0	0	0	0	0	0	1	0	0.000	0.014	0.007	0.022	0.00	0.67	0.33
19	0	0	0	0	0	0	0	0	0	0	1	0	0.000	0.014	0.007	0.022	0.00	0.67	0.33
20	0	0	0	0	0	0	0	0	0	0	1	0	0.000	0.014	0.007	0.022	0.00	0.67	0.33
21	0	0	0	0	0	0	0	0	0	0	1	0	0.000	0.014	0.007	0.022	0.00	0.67	0.33
22	0	0	0	0	0	0	0	0	0	0	1	0	0.000	0.014	0.007	0.022	0.00	0.67	0.33
23	0	0	0	0	0	0	0	0	0	0	1	0	0.000	0.014	0.007	0.022	0.00	0.67	0.33
24	0	0	0	0	0	0	0	0	0	0	1	0	0.000	0.014	0.007	0.022	0.00	0.67	0.33

Marsden Park Landfill - Maximum area covered (Near Field emission rates)

Concentration or deposition	Concentration
Emission rate units	OUV/second
Concentration units	Odour Units
Units conversion factor	1.00E+00
Background concentration	0.00E+00
Terrain effects	None
Smooth stability class changes?	No
Other stability class adjustments ("urban modes")	None
Ignore building wake effects?	No
Decay coefficient (unless overridden by met. file)	0.000
Anemometer height	10 m

DISPERSION CURVES

Horizontal dispersion curves for sources <100m high	Pasquill-Gifford
Vertical dispersion curves for sources <100m high	Pasquill-Gifford
Horizontal dispersion curves for sources >100m high	Briggs Rural
Vertical dispersion curves for sources >100m high	Briggs Rural
Enhance horizontal plume spreads for buoyancy?	Yes
Enhance vertical plume spreads for buoyancy?	Yes
Adjust horizontal P-G formulae for roughness height?	Yes
Adjust vertical P-G formulae for roughness height?	Yes
Roughness height	0.500m
Adjustment for wind directional shear	None

PLUME RISE OPTIONS

Gradual plume rise?	Yes
Stack-tip downwash included?	Yes
Building downwash algorithm:	Schulman-Scire method.
Entrainment coeff. for neutral & stable lapse rates	0.60, 0.60
Partial penetration of elevated inversions?	No
Disregard temp. gradients in the hourly met. file?	No

and in the absence of boundary-layer potential temperature gradients given by the hourly met. file, a value from the following table (in K/m) is used:

Wind Speed Category	Stability Class					
	A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.020	0.035
2	0.000	0.000	0.000	0.000	0.020	0.035
3	0.000	0.000	0.000	0.000	0.020	0.035
4	0.000	0.000	0.000	0.000	0.020	0.035
5	0.000	0.000	0.000	0.000	0.020	0.035
6	0.000	0.000	0.000	0.000	0.020	0.035

WIND SPEED CATEGORIES

Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Urban" values (unless overridden by met. file)

AVERAGING TIME: 3 minutes.

Marsden Park Landfill - Maximum area covered (Near Field emission rates)

SOURCE CHARACTERISTICS

AREA SOURCE: 1

X(m)	Y(m)	Ground Elevation	Height	Side length
298549	6267041	0m	2m	95m

(Constant) emission rate = $6.75E+02$ OUV/second
No gravitational settling or scavenging.

AREA SOURCE: 2

X(m)	Y(m)	Ground Elevation	Height	Side length
298634	6267040	0m	2m	95m

(Constant) emission rate = $6.75E+02$ OUV/second
No gravitational settling or scavenging.

AREA SOURCE: 3

X(m)	Y(m)	Ground Elevation	Height	Side length
298605	6267236	0m	2m	95m

(Constant) emission rate = $4.14E+02$ OUV/second
No gravitational settling or scavenging.

AREA SOURCE: 4

X(m)	Y(m)	Ground Elevation	Height	Side length
298686	6267231	0m	2m	95m

(Constant) emission rate = $4.14E+02$ OUV/second
No gravitational settling or scavenging.

AREA SOURCE: 5

X(m)	Y(m)	Ground Elevation	Height	Side length
298574	6267145	0m	2m	95m

(Constant) emission rate = $5.40E+02$ OUV/second
No gravitational settling or scavenging.

AREA SOURCE: 6

X(m)	Y(m)	Ground Elevation	Height	Side length
298661	6267142	0m	2m	95m

(Constant) emission rate = $5.40E+02$ OUV/second
No gravitational settling or scavenging.

AREA SOURCE: 7

X(m)	Y(m)	Ground Elevation	Height	Side length
298538	6266946	0m	2m	95m

(Constant) emission rate = $9.00E+02$ OUV/second
No gravitational settling or scavenging.

AREA SOURCE: 8

X(m)	Y(m)	Ground Elevation	Height	Side length
298617	6266944	0m	2m	95m

(Constant) emission rate = 9.00E+02 OUV/second
No gravitational settling or scavenging.

AREA SOURCE: 9

X(m)	Y(m)	Ground Elevation	Height	Side length
298520	6266848	0m	2m	95m

(Constant) emission rate = 1.79E+03 OUV/second
No gravitational settling or scavenging.

AREA SOURCE: 10

X(m)	Y(m)	Ground Elevation	Height	Side length
298606	6266850	0m	2m	95m

(Constant) emission rate = 1.79E+03 OUV/second
No gravitational settling or scavenging.

Marsden Park Landfill - Maximum area covered (Near Field emission rates)

RECEPTOR LOCATIONS

The Cartesian receptor grid has the following x-values (or eastings):

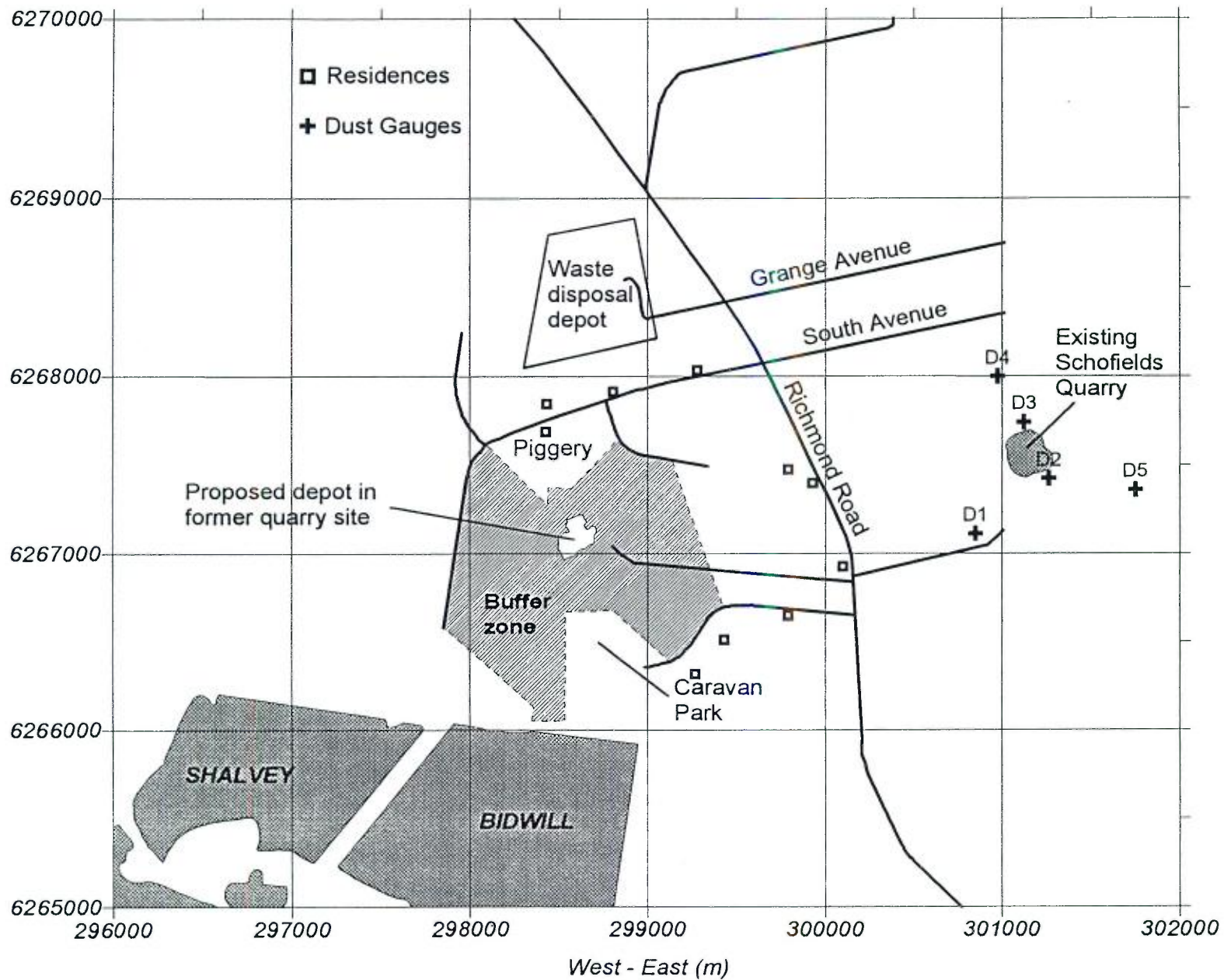
297000.m	297100.m	297200.m	297300.m	297400.m	297500.m	297600.m
297700.m	297800.m	297900.m	298000.m	298100.m	298200.m	298300.m
298400.m	298500.m	298600.m	298700.m	298800.m	298900.m	299000.m
299100.m	299200.m	299300.m	299400.m	299500.m	299600.m	299700.m
299800.m	299900.m	300000.m	300100.m	300200.m	300300.m	300400.m
300500.m	300600.m	300700.m	300800.m	300900.m	301000.m	

and these y-values (or northings):

6265000.m	6265100.m	6265200.m	6265300.m	6265400.m	6265500.m	6265600.m
6265700.m	6265800.m	6265900.m	6266000.m	6266100.m	6266200.m	6266300.m
6266400.m	6266500.m	6266600.m	6266700.m	6266800.m	6266900.m	6267000.m
6267100.m	6267200.m	6267300.m	6267400.m	6267500.m	6267600.m	6267700.m
6267800.m	6267900.m	6268000.m	6268100.m	6268200.m	6268300.m	6268400.m
6268500.m	6268600.m	6268700.m	6268800.m	6268900.m	6269000.m	

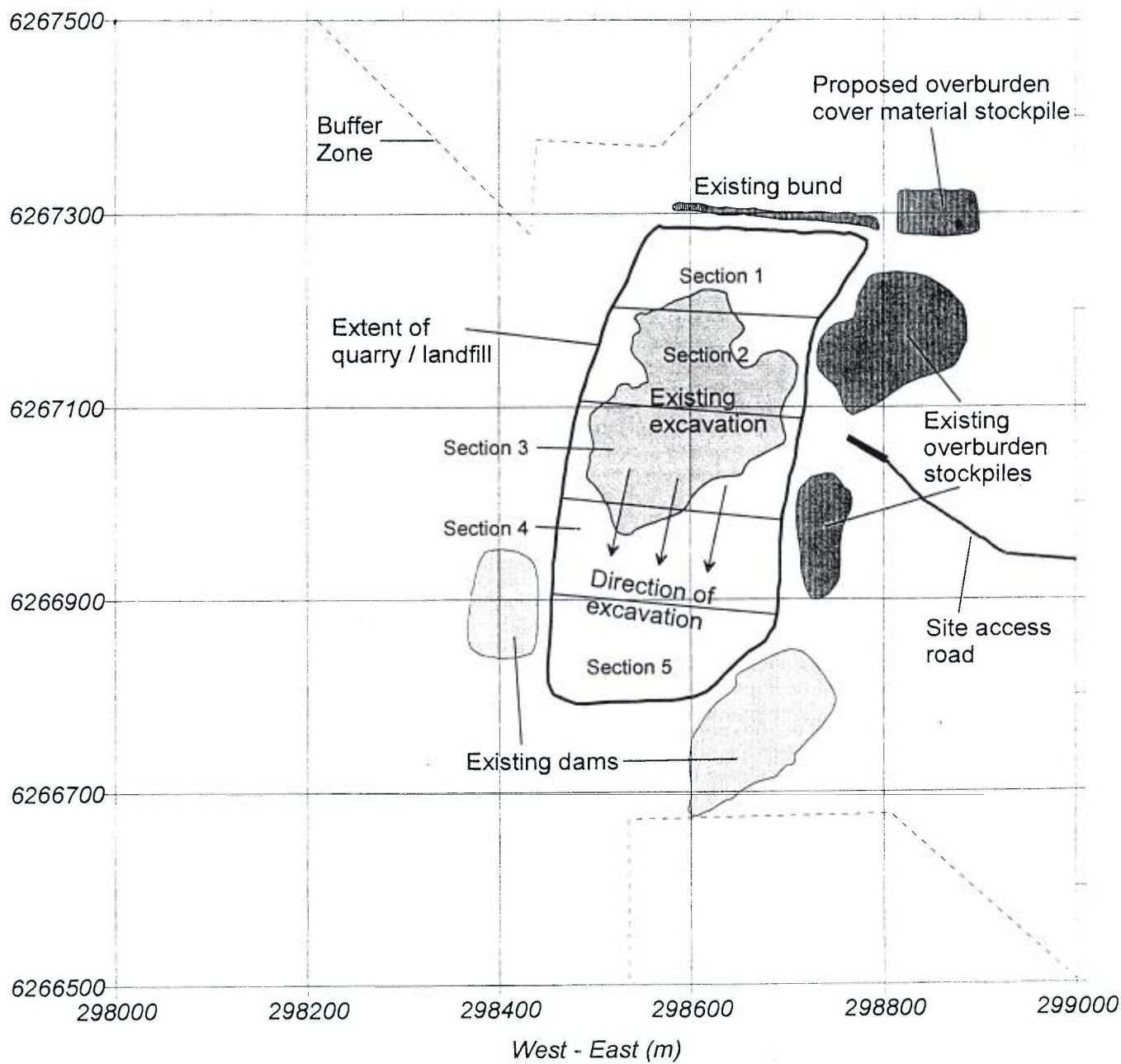
METEOROLOGICAL DATA : Richmond/Mascot meteorological data (1979, 80 & 81 d
a

FIGURES



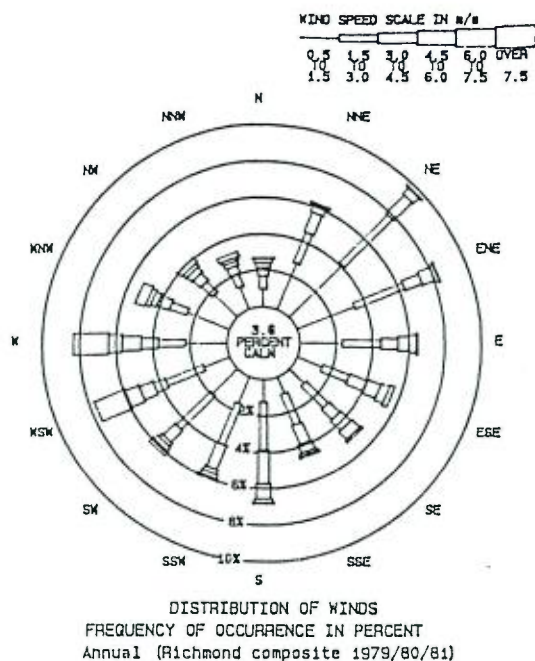
LOCALITY PLAN

FIGURE 1

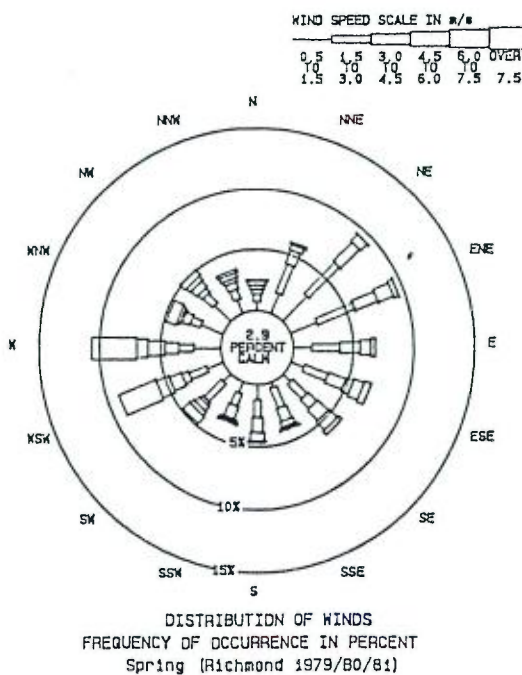
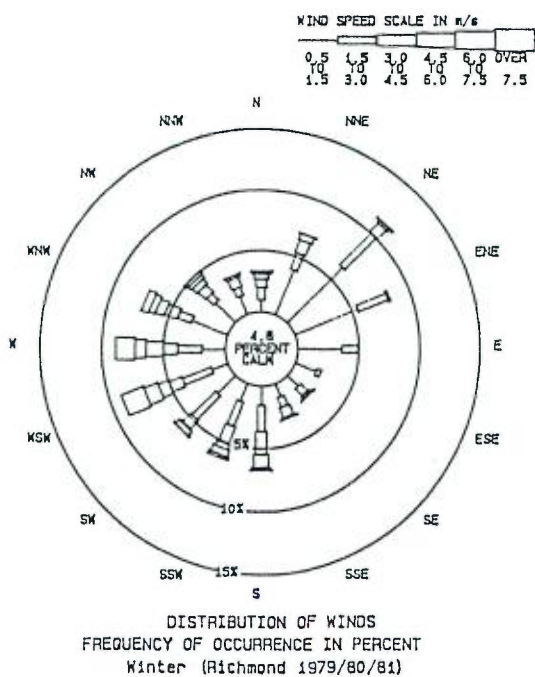
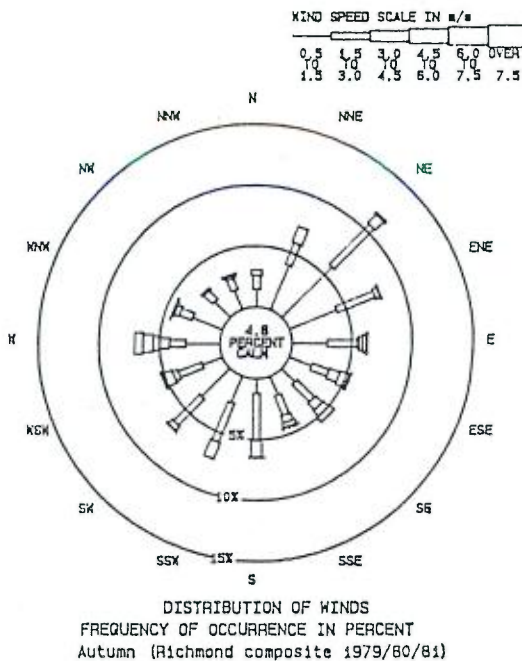
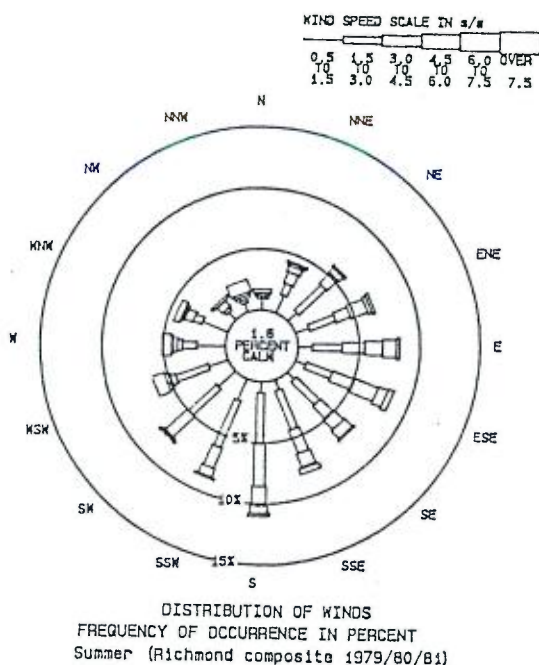


LAYOUT OF PROPOSED SITE

FIGURE 2

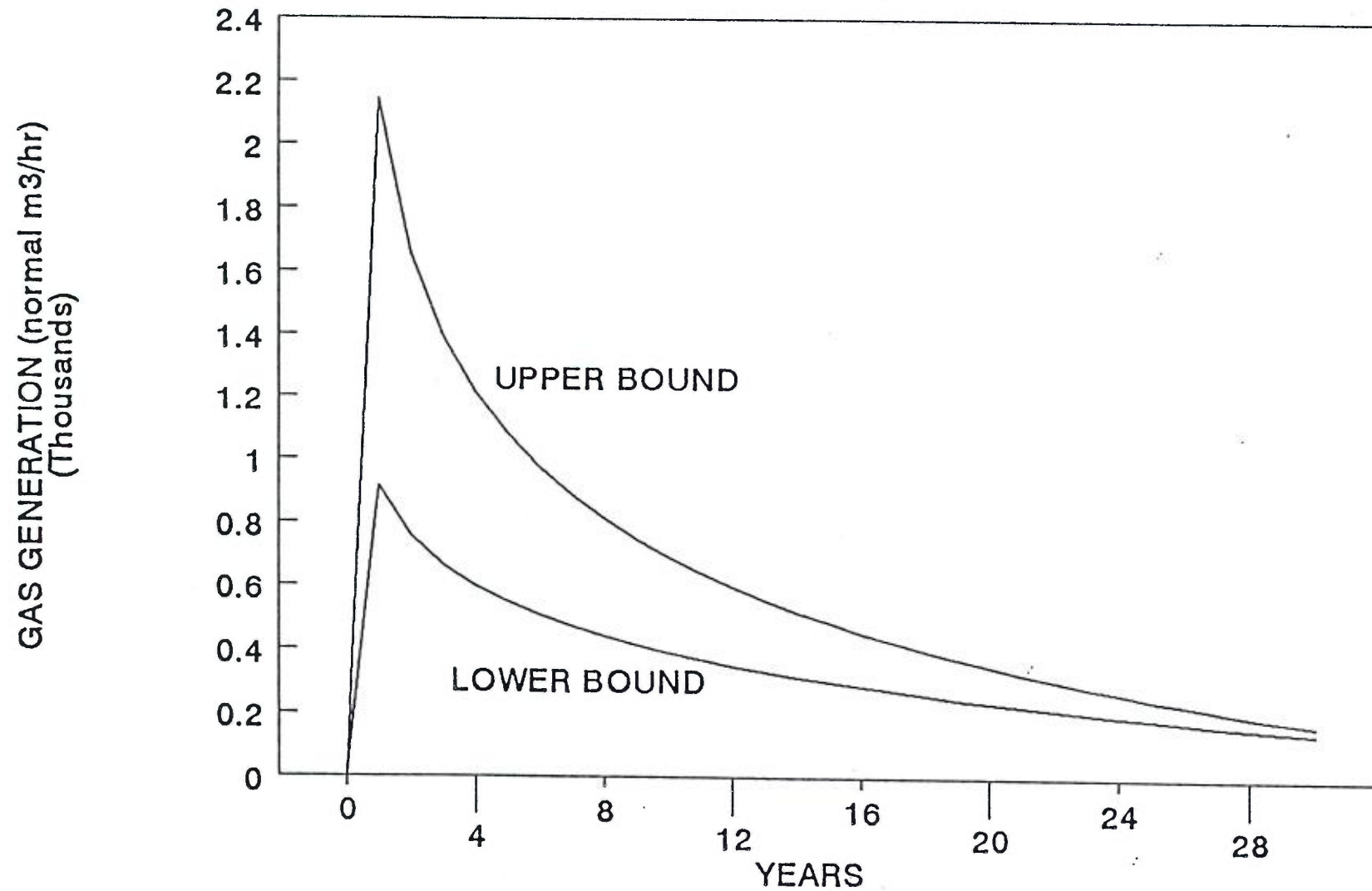


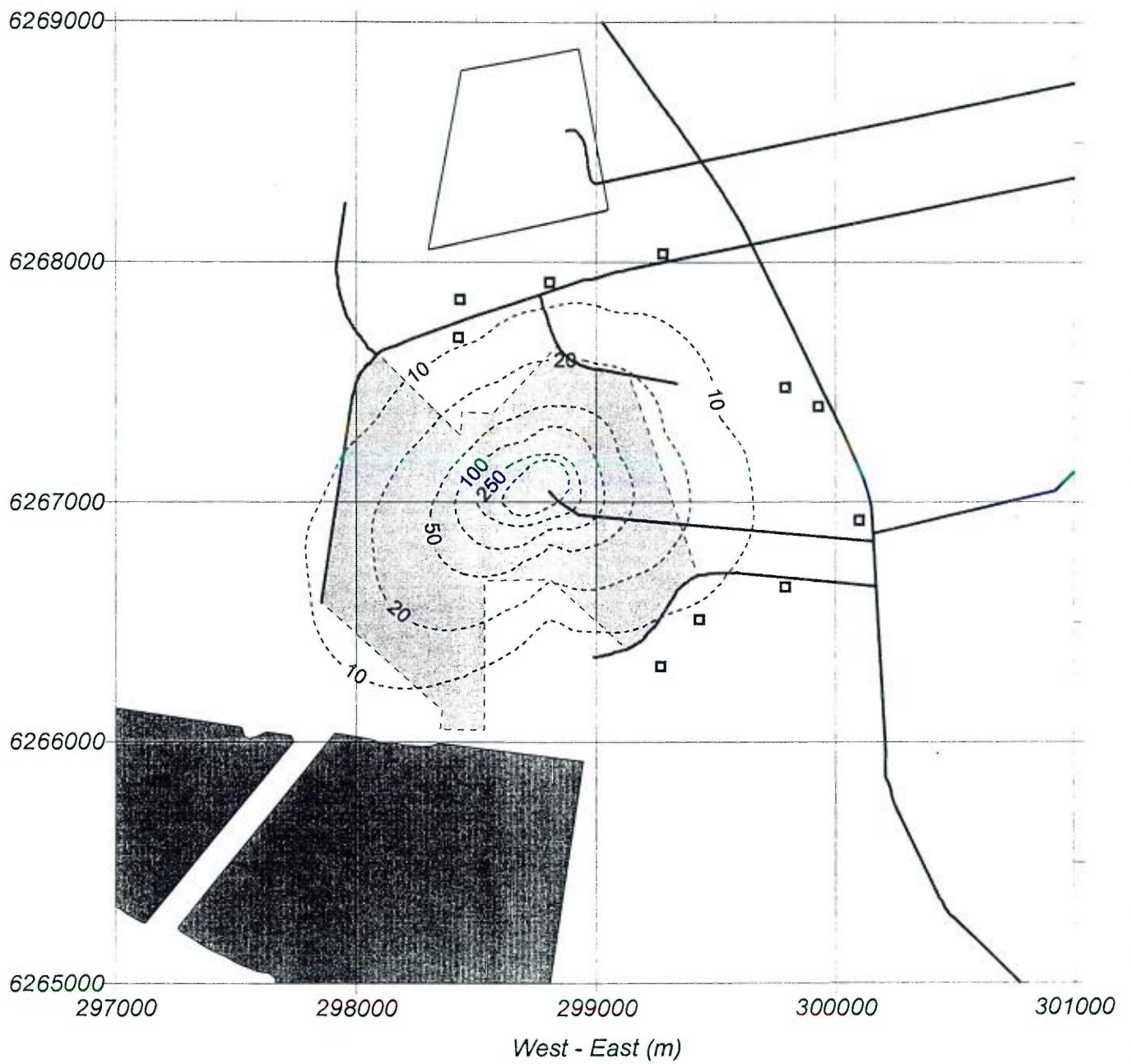
ANNUAL AND SEASONAL WINDROSES FOR RICHMOND (OVAL)



STANDARD GAS CURVES

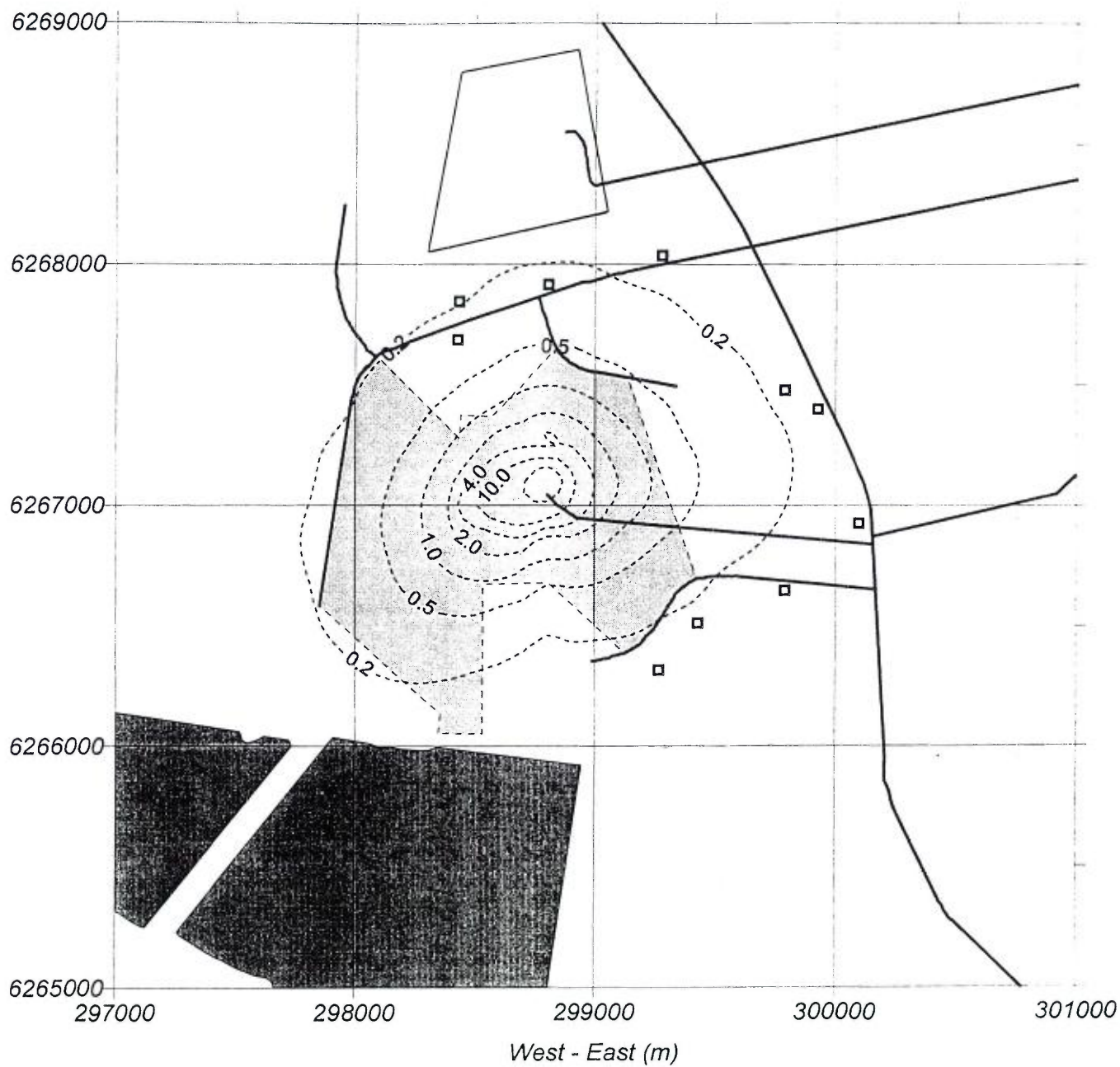
Waste input 1,000,000 m³





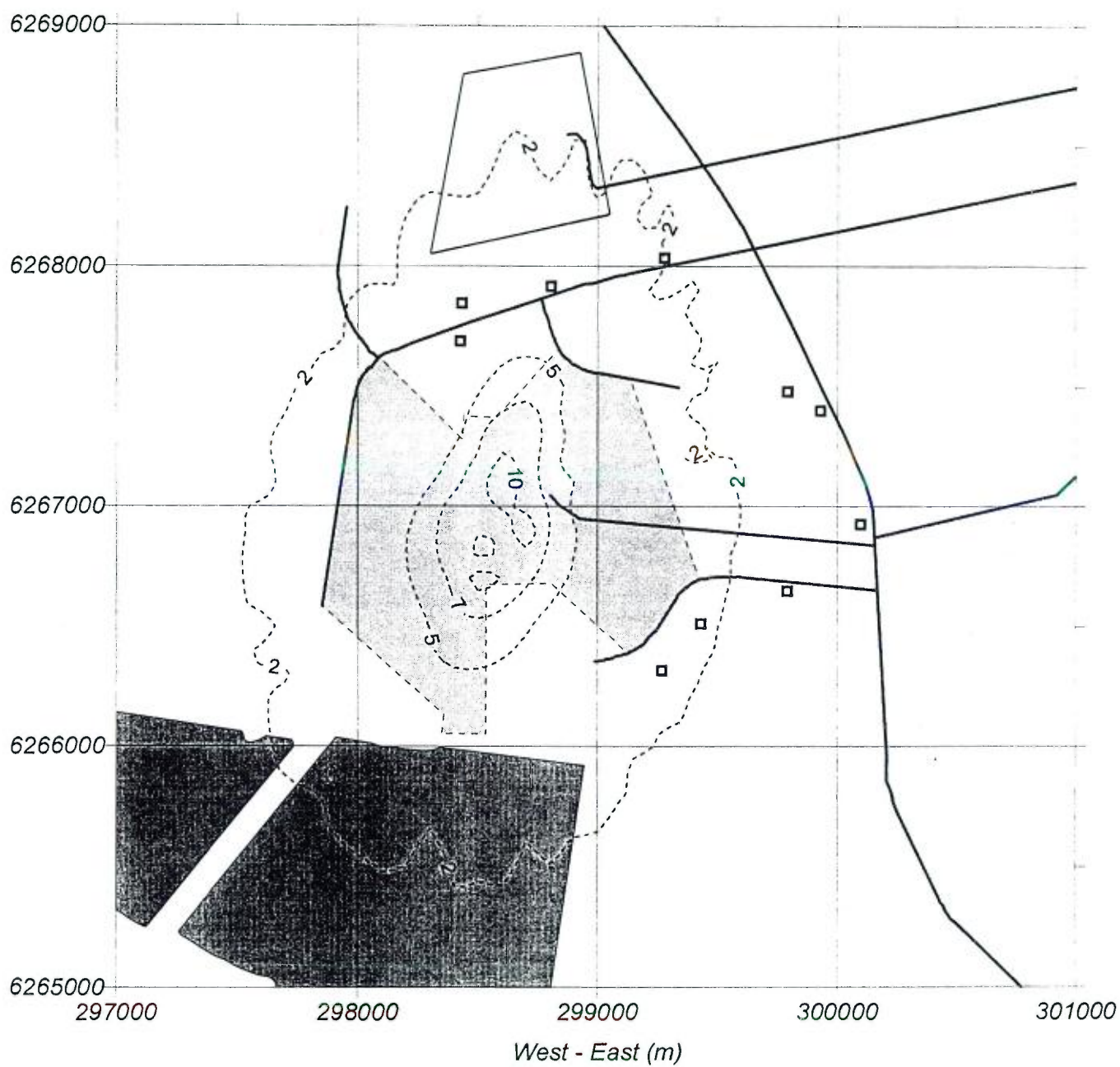
**PREDICTED ANNUAL AVERAGE TSP CONCENTRATION DUE TO
QUARRY OPERATIONS AT MARSDEN PARK - $\mu\text{g}/\text{m}^3$**

FIGURE 5



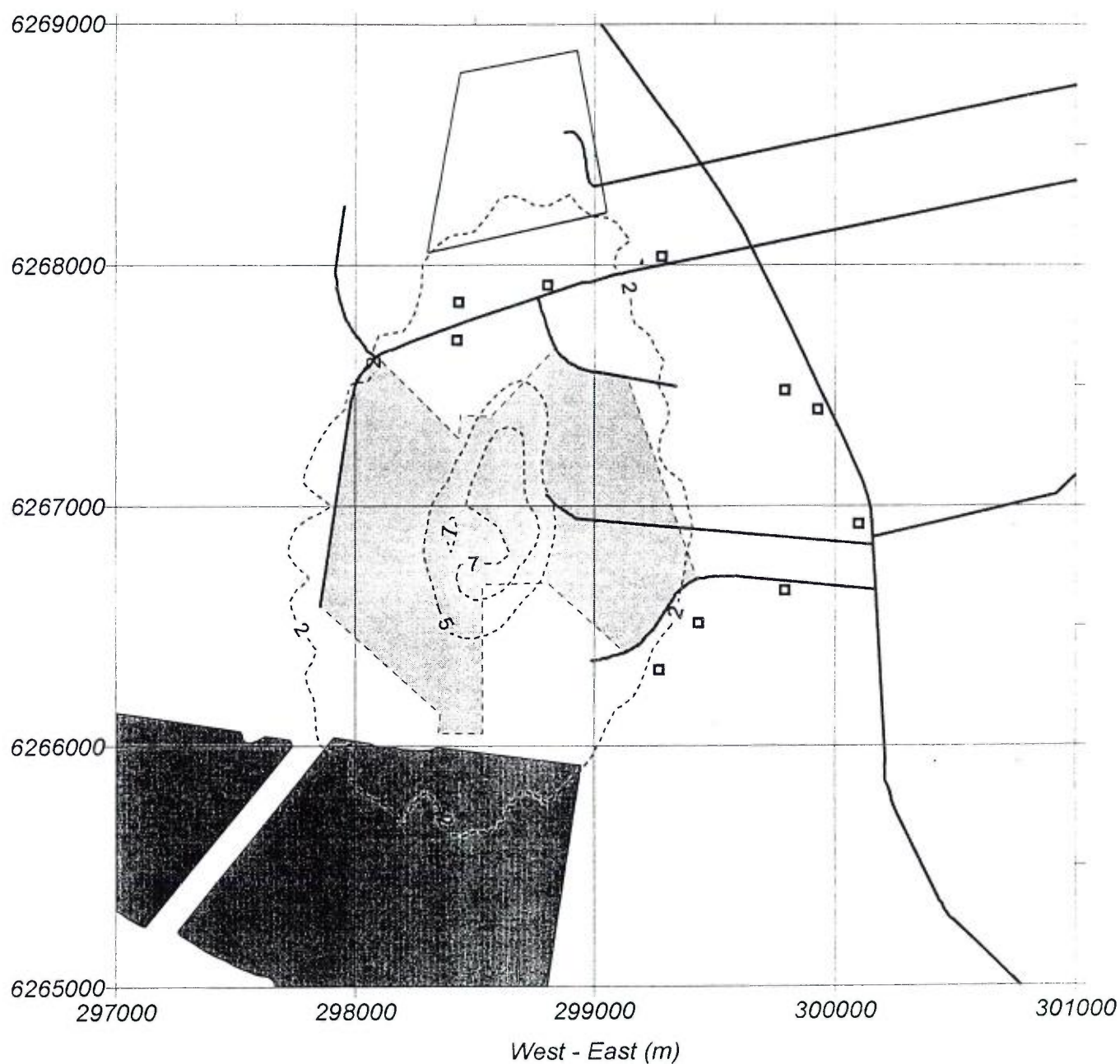
PREDICTED ANNUAL AVERAGE DUST DEPOSITION DUE TO
QUARRY OPERATIONS AT MARSDEN PARK - g/m²/month

FIGURE 6



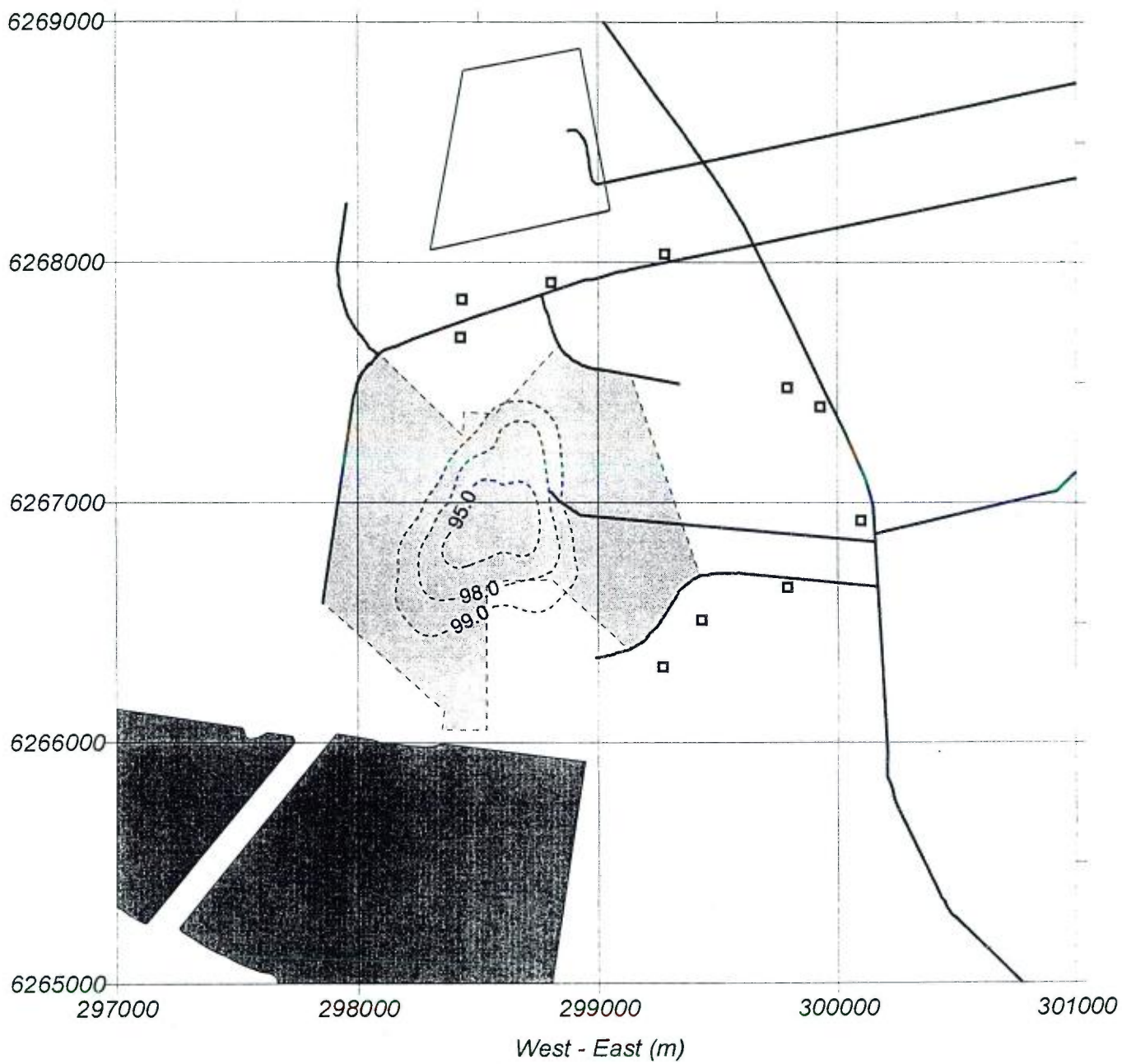
**PREDICTED MAXIMUM 3-MINUTE AVERAGE ODOUR (NEAR FIELD)
CONCENTRATIONS DUE TO LANDFILL OVER THE WHOLE SITE
AT MARSDEN PARK (odour units)**

FIGURE 7



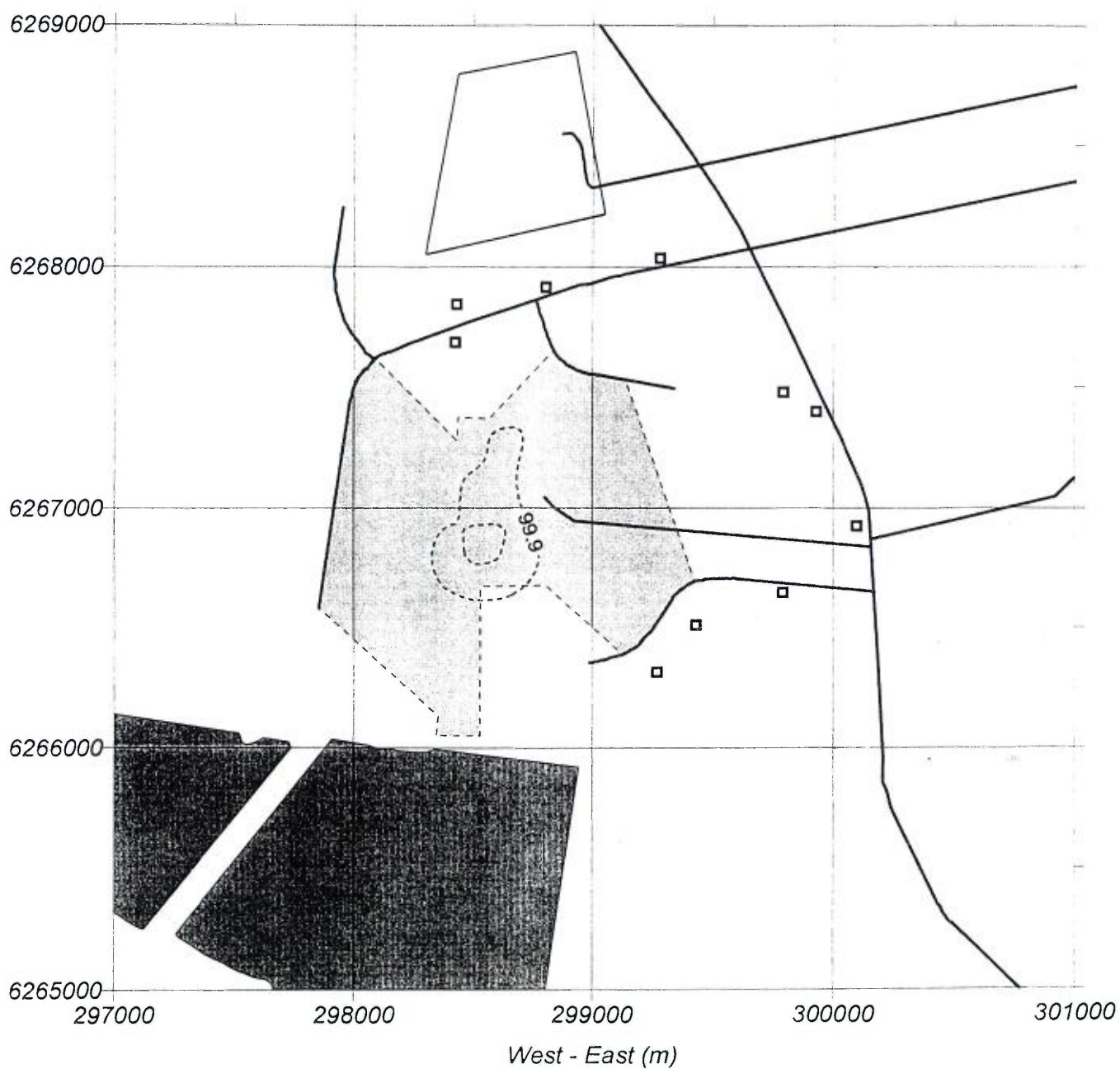
PREDICTED MAXIMUM 3-MINUTE AVERAGE ODOUR (FAR FIELD)
CONCENTRATIONS DUE TO LANDFILL OVER THE WHOLE SITE
AT MARSDEN PARK (odour units)

FIGURE 8



PERCENTAGE COMPLIANCE WITH THE 2 ODOUR UNIT URBAN GOAL
ASSUMING THE LANDFILL IS COMPLETE

FIGURE 9



PERCENTAGE COMPLIANCE WITH THE 7 ODOUR UNIT RURAL GOAL
ASSUMING THE LANDFILL IS COMPLETE

FIGURE 10

APPENDIX 4
FLORA AND FAUNA ASSESSMENT

Prepared by:
GUNNINAH ENVIRONMENTAL CONSULTANTS

PROPOSED QUARRY AND LANDFILL

RICHMOND ROAD,
MARSDEN PARK

FAUNA & FLORA ASSESSMENT REPORT

March 1998

Gunninah Environmental Consultants



**PROPOSED QUARRY AND LANDFILL
MARSDEN PARK**

FAUNA & FLORA ASSESSMENT REPORT

March 1998

1 INTRODUCTION

1.1 Background

Ganian Pty Ltd proposes to establish a non-putrescible landfill in a disused quarry off Richmond Road at Marsden Park, in western Sydney. The existing quarry is located on a property of approximately 142ha, much of which has been previously cleared for grazing and powerline easements. The study area is bounded by Hollinsworth road to the south, Fulton Street to the north, South Street to the west and Richmond Road to the east. A piggery abuts the study area to the north, with a caravan park occurring to the immediate south, beyond which is the residential area of Bidwill.

The proposed landfill will involve the disposal of between 5000 and 30000 tonnes per month for approximately 5 years. To increase the current capacity of the landfill, quarrying operations will be re-established prior to landfilling. Clay/shale and breccia will be extracted, increasing the depth and size of the existing quarry at this location. The proposed quarry will involve the extraction of 300,000 tonnes of material per annum. The project will also involve some stockpiling of materials, the construction of haul roads for both the quarry and landfill, and the establishment of a processing plant in the southeastern corner of the proposed disturbance area.

Whilst much of the study area has been subjected to clearing and grazing, some areas of relatively intact woodland also occur. Disturbance, such as long-term grazing, clearing, dumping of fill and overburden from the existing quarry, are common throughout the property. At the time of the field investigations the existing quarry was full of water, providing some resources for waterbirds and other species.

For the purpose of this report the 'subject site' is defined as the actual area that is likely to be directly affected by the proposed development, comprising the quarry itself, and the immediately surrounding area which is proposed for quarrying, haul roads and other infrastructure. The 'study area' comprises the whole property (bounded by South Street to the west, Fulton Road to the north, Richmond Road to the east and Hollinsworth Road to the south), as well as the subject site itself, and the 'general locality' comprises land in a 10km radius around the subject site.

1.2 Aims

This study was conducted to provide details of the flora and fauna and their habitats in the areas to be disturbed by the proposed activities.

The specific aims of this investigation are:

- to identify the flora species and vegetation communities present, or potentially present, in the study area, and their conservation significance;
- to identify species of native fauna which occur, or which may occur, in the study area, and their conservation significance;
- to identify fauna habitats present in the study area;
- to assess the significance of potential impacts of the proposed activities on native fauna and flora;
- to delineate impact amelioration measures which can be implemented to limit the effects of the proposal on native biota, and to enhance the local environment for native fauna and flora conservation, where possible; and

- to determine whether there will be "a significant effect on threatened species, populations or ecological communities, or their habitats", using Section 5A of the *Environmental Planning & Assessment Act 1979* (EP&A Act).

2 METHODS

An array of standard flora and fauna survey techniques were employed in the study area, as described in detail below and in Appendix 3. This assessment is based on information obtained during these field investigations. In addition, information from previous investigations in the immediate vicinity (Clements & Stephens 1989; Gunninah 1996; Mitchell McCotter 1996), in the general locality (NP&WS 1997), and from databases for the region (NP&WS Wildlife Atlas; AMBS Database; Birds Australia Atlas) has also been incorporated.

2.1 Flora

A botanical investigation was conducted on the 12th of November, 1997 to obtain detailed information on the floristics and structural characteristics of the vegetation communities present in the study area. All vascular plant species present were documented and height and projective foliage cover was estimated according to Specht (1970).

The community types recorded correspond to those already described in the region by Benson (1992) and have been described in accordance with the Western Sydney Urban Bushland Biodiversity Survey (UBBS - NP&WS 1997). Plant species nomenclature conforms to Harden (1990, 1991, 1992, 1993).

The vegetation communities recorded during the survey have been assessed with reference to the definition of Cumberland Plain Woodland provided by the New South Wales Scientific Community, established under the *NSW Threatened Species Conservation Act 1995* (TSC Act).

A database search (NP&WS Atlas of NSW Wildlife) was undertaken in order to ascertain the potential occurrence of Rare Or Threatened Australian Plant (ROTAP - Briggs & Leigh 1996) species and threatened plants (TSC Act) within a 10km radius of the site, and their potential presence on the subject site. The regional significance of species has been discussed by reference to Benson & McDougall (1991) and Benson *et al* (1996) and NP&WS (1997).

Due to the duration of the study and the time of year during which this study was undertaken, some short lived herbaceous and ephemeral species may not have been recorded due to the absence of vegetative material.

It should be noted that the boundaries between communities noted in this report are not distinct, as represented in the figures, with each vegetation type intergrading with others along its boundary, often sharing many common species.

2.2 Fauna

A detailed fauna investigation was conducted throughout the study area on the 12th, 19th and 20th of November, and on the 12th and 13th of December, 1997.

Specific survey techniques employed for these investigations included spotlighting surveys, microchiropteran bat surveys (using both direct and indirect capture techniques), avifauna surveys and intensive habitat searches for reptiles and amphibians and molluscs within potential habitats (Appendix 3; Figure 2). The structure of areas of habitat and their value for native fauna (in terms of habitats and resources) were also assessed during the field investigations.

Walked and driven spotlighting surveys were conducted over the study area using 100-watt hand-held spotlights. Calls of the Powerful and Masked Owls were played on one night in an attempt to elicit a territorial or inquisitive response. Microchiropteran bat surveys were

conducted using harp traps placed in potential flyways, and Anabat II echolocation recorders placed in areas of suitable habitat.

Particular attention was paid during field investigations to the possible presence of threatened fauna known from the region (based on the NP&WS Wildlife Atlas, AMBS Database and Birds Australia databases, and on previous investigations in the area), and to features or resources which could be of potential significance for native fauna.

3 VEGETATION

Vegetation communities throughout the study area have been described by reference to previous community descriptions and mapping in western Sydney (Benson 1992; NP&WS 1997).

Principal communities present in the study area (Figure 1) are:

- Grey Box woodland over the majority of the site;
- Grey Box/Ironbark Woodland along the South Street boundary;
- Shale-Gravel Transition Forest in the eastern portions of the site;
- Wetlands/artificial dams scattered throughout the site; and
- Disturbed/cleared areas (such as grazing land and powerline easements) interspersed with woodland.

In general, the vegetation exhibits varying degrees of disturbance, including long-term grazing, clearing, fire, construction of tracks and dams and erosion, with subsequent regeneration occurring in most places, particularly where grazing is restricted.

The topography of the study area is flat to gently sloping, with elevation decreasing to the southeast, towards Bells Creek. To the north, east and southeast of the quarry are several artificially constructed earth banks. Exposed soil has eroded and weed species have invaded where disturbance is greatest. Drainage lines are generally eroded and are commonly colonised by exotic species.

3.1 Vegetation Communities

Grey Box Woodland

Map Unit 10c - Benson 1992.

Occurrence

Grey Box Woodland occurs to the west, south and north of the quarry, with a small area to the east. This community is generally interspersed with pastoral land and, to the south-east, intergrades with the Castlereagh Woodland community, incorporating Shale/Gravel Transition Forest (Map Unit 9d) and Grey Box Woodland (Map Unit 10c - see below). To the west, the Grey Box Woodland intergrades with Grey Box - Ironbark Woodland (Map Unit 10d).

Structure

The upper storey stratum occurs to 18m in height, occasionally to 15m, with a projective foliage cover of between 20 and 30%. Trees are primarily semi-mature, with very few mature or juvenile specimens, especially in parts of the community located near the quarry. The understorey is medium to dense, and to 1.2m in height. The community exhibits little regeneration of upper canopy species, possibly as a result of previous disturbance, particularly grazing. Woody exotic species occur infrequently along broad drainage lines.

Floristics

The upper canopy is dominated by Grey Box *Eucalyptus moluccana* and Forest Red Gum *E. tereticornis*. Broad-leaved Ironbark *E. fibrosa* is often co-dominant. The abundance of Forest Red Gum varies across the study area, occurring as occasional small stands or individual specimens, or is completely absent within the Grey Box dominated community.

In more intact portions of the community, the upper understorey includes Parramatta Green Wattle *Acacia parramattensis*, Black She-Oak *Allocasuarina littoralis*, Cherry

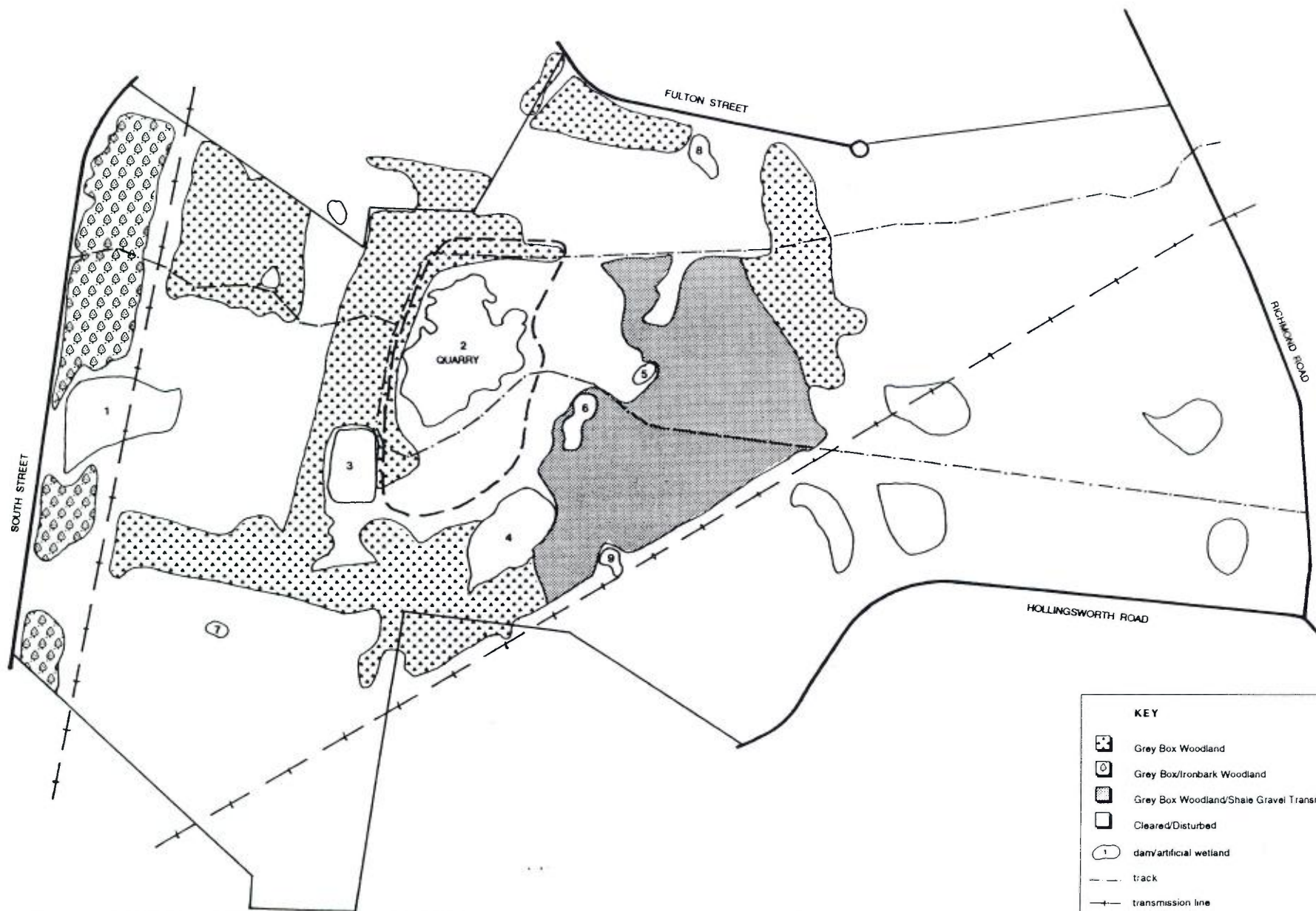


FIGURE 1 Vegetation Communities recorded in the Marsden Park study area.

KEY

-  Grey Box Woodland
-  Grey Box/Ironbark Woodland
-  Grey Box Woodland/Shale Gravel Transition Forest
-  Cleared/Disturbed
-  dam/artificial wetland
-  track
-  transmission line
-  approximate disturbance area

Ballart *Exocarpos cupressiformis* and *Acacia falcata*. This stratum is largely absent in more disturbed areas and limited to isolated specimens or small stands of the above species. Isolated individuals of White Feather Honeymyrtle *Melaleuca decora* and White Cedar *Melia azedarach* occur in damper sites (ie adjacent to drainage lines or where drainage may be impeded).

Blackthorn *Bursaria spinosa* dominates the understorey and occurs as occasional dense stands through the northern and western portions of the study area and in small isolated patches in other areas. *Grevillea juniperina*, Paperdaisy *Ozothamnus diosmifolius*, *Hibbertia diffusa*, *Dillwynia sieberi* and *Daviesia ulicifolia* occur sporadically throughout the area.

In more disturbed areas, native groundcover species are limited to hardier endemic species such as Kangaroo Grass *Themeda australis*, Half-berried Salt Bush *Atriplex semibaccata*, Tufted Hedgehog Grass *Echinopogon caespitosus* var *caespitosus*, Common Couch *Cynodon dactylon*, False Sarsaparilla *Hardenbergia violacea* and Kidney Weed *Dichondra repens*, among a variety of common exotic pasture species. In less disturbed areas Three-awn Speargrass *Aristida ramosa*, Wallaby Grasses *Danthonia linkii* var *linkii* and *Danthonia tenuior*, Eastern Nightshade *Solanum pungetium* and *Entolasia marginata* are common.

Numerous exotic species occur in this vegetation community including African Boxthorn *Lycium ferocissimum*, *Sporobolus indicus* var *capensis*, Paddy's Lucerne *Sida rhombifolia*, Rhodes Grass *Chloris gayana*, Purpletop *Verbena bonariensis*, Fireweed *Senecio madagascariensis*, Cobblers Pegs *Bidens pilosa*, Spear Thistle *Cirsium vulgare* and Fleabane *Conyza bonariensis*. African Olive *Olea europaea* ssp *africana*, Small Leaf Privet *Ligustrum sinense* and Blackberry *Rubus fruticosus* sp aggregate occur less commonly and are restricted to more disturbed areas.

Grey Box-Ironbark Woodland

Map Unit 10d - Benson 1992.

Occurrence

Grey Box-Ironbark Woodland is limited in distribution to the western portion of the site, adjacent to South Street, intergrading with Grey Box Woodland to the east.

Structure

The upperstorey strata occurs to 18m high, occasionally to 15m, with a projective foliage cover of between 20 and 30%. The upper understorey and understorey strata exhibit moderate diversity and appear structurally intact throughout much of the community. The understorey strata occurs to 1.2 m, and occasionally to 3m, in height.

Floristics

The upper canopy is dominated by juvenile and semi-mature specimens of Forest Red Gum, Narrow leaved Ironbark *Eucalyptus crebra* and Grey Box with occasional specimens of Broad-leaved Ironbark.

Commonly occurring upper understorey species include Parramatta Green Wattle, Black She-Oak *Allocasuarina littoralis*, Cherry Ballart and Sydney Green Wattle *Acacia decurrens*.

The understorey is dominated by Blackthorn *Bursaria spinosa*, which forms dense stands throughout the community. *Grevillea juniperina*, Paperdaisy, *Dillwynia sieberi* and *Daviesia ulicifolia* occur commonly throughout the area to 0.8 high.

Commonly occurring groundcover species include Kangaroo Grass, Love Creeper *Glycine tabacina*, *Einadia hastata*, Tufted Hedgehog Grass, Three-awn Speargrass, Wallaby Grass, Common Couch and False Sarsaparilla.

Weed infestation is largely concentrated along the powerline easement located to the east of this community. Along forest edges, numerous exotic species occur, including Paspalum *Paspalum dilatatum*, *Sporobolus indicus* var *capensis*, Paddy's Lucerne, Rhodes Grass, Veined *Verbena rigida*, Fireweed, Cobblers Pegs, Spear Thistle and Canadian Fleabane *Conyza canadensis* ssp *canadensis*.

Shale/Gravel Transition Forest

Map Unit 9d - Benson 1992.

Occurrence

Elements of Shale/Gravel Transition Forest are restricted in distribution to a broad, shallow drainage line in the southeast of the subject site.

Structure

The upper storey strata occurs to 18m in height, but occasionally to 15m, and exhibits a projective foliage cover of between 20 and 30%. The mid-canopy and shrub layers are patchily represented, with occasional dense stands interspersed with areas where these strata are almost absent. These latter areas are subject to some weed species infestation. The groundcover layer is sparse, mostly consisting of a mixture of hardy, grazing-resistant native species with common exotic species.

Floristics

The upper canopy is dominated by Broad-leaved Ironbark and Grey Box. In areas adjacent to the drainage line, Forest Red Gum, Thin-leaved Stringybark *Eucalyptus eugenioides* and Woollybutt *E longifolia* occur sporadically throughout the community.

The upper understorey includes White Feather Honeymyrtle and Ball Honeymyrtle *Melaleuca nodosa*, which form dense stands throughout more intact portions of the community, with occasional stands of Black She-Oak. In more disturbed areas, the upper understorey is largely absent, with a few isolated specimens of White Cedar occur along damper sites.

The understorey is dominated by Blackthorn, which occurs commonly in isolated patches, but sporadically in conjunction with Paperbark Teatree *Leptospermum trinervium* through the northern portion of the subject site. Ball Honeymyrtle and *Daviesia ulicifolia* occur occasionally throughout the area.

Commonly occurring groundcover species include Kangaroo Grass, Love Creeper, *Einadia hastata*, Tufted Hedgehog Grass, Three-awn Speargrass, Wallaby Grass *Danthonia tenuior*, *Entolasia marginata* and Common Couch.

Numerous exotic species occur in this community and include Rhodes Grass, Veined Verbena, Fireweed, Cobblers Pegs, Spear Thistle, African Olive *Olea europaea* ssp *africana* and Tall Fleabane *Conyza bonariensis*.

Wetland/ Artificial Dam

Map Unit 28c - Benson 1992.

Occurrence

Artificial wetlands occur sporadically throughout the survey area. The wetlands vary in size, condition and habitat value, depending on the extent of access by livestock and other disturbance. Several of the wetlands support riparian and aquatic vegetation, such as reeds, sedges and waterlilies. However, others are devoid of such vegetation, having been eroded by cattle.

Table 1 Locations and characteristics of the variety of wetlands and farm dams in the study area at Marsden Park.

Unit	Location	Characteristic Species	Surrounding Vegetation
Large wetlands with greater diversity of species:			
1	Western boundary (near South Street)	Terrestrial species: <i>Melaleuca decora</i>, <i>Lomandra longifolia</i>, <i>Centella asiatica</i>. Aquatic and semi-aquatic species: <i>Eleocharis cylindostachys</i>, <i>Eleocharis sphacelata</i>, <i>Typha orientalis</i>, <i>Juncus continuus*</i>, <i>Juncus acutus*</i>, <i>Juncus polyanthemus</i>, <i>Juncus usitatus</i>, <i>Triglochin procerum</i>, <i>Potamogeton tricarinatus</i>, <i>Nymphaea mexicana</i>, <i>Nymphoides geminata</i>, <i>Nymphoides indica</i>, <i>Villarsia exaltata</i>, <i>Eleocharis sphacelata</i>, <i>Typha orientalis</i>, <i>Cyperus eragrostis*</i>, <i>Cyperus polystachyos</i>, <i>Cyperus rotundus*</i>.	Highly disturbed. Cleared powerline easement
2	Main quarry	Terrestrial species: <i>Acacia binervia</i>, <i>Nicotiana glauca*</i>, <i>Acacia decurrens</i>, <i>Verbena bonariensis*</i>, <i>Verbena rigida*</i>, <i>Solanum pseudocapsicum*</i>, <i>Lomandra longifolia</i>, <i>Plantago lanceolata*</i>. Aquatic and semi-aquatic species: <i>Typha orientalis</i>, <i>Juncus acutus*</i>, <i>Juncus continuus*</i>, <i>Juncus polyanthemus</i>, <i>Juncus usitatus</i>, <i>Centella asiatica</i>.	Highly disturbed and modified terrain
3	Southwest of quarry	Terrestrial species: <i>Lomandra longifolia</i>, <i>Centella asiatica</i>. Aquatic and semi-aquatic species: <i>Eleocharis cylindostachys</i>, <i>Eleocharis sphacelata</i>, <i>Juncus acutus*</i>, <i>Juncus continuus*</i>, <i>Juncus polyanthemus</i>, <i>Juncus usitatus</i>, <i>Typha orientalis</i>.	Highly disturbed and modified terrain
4	South of quarry	Terrestrial species: <i>Casuarina glauca</i>, <i>Acacia parramattensis</i>, <i>Pittosporum undulatum</i>, <i>Melaleuca sieberi</i>, <i>Melaleuca decora</i>, <i>Melaleuca styphelioides</i>, <i>Lomandra longifolia</i>, <i>Persicaria decipiens</i>, <i>Centella asiatica</i>, <i>Rumex crispus</i>. Aquatic and semi-aquatic species: <i>Eleocharis cylindostachys</i>, <i>Eleocharis sphacelata</i>, <i>Juncus acutus*</i>, <i>Juncus continuus*</i>, <i>Juncus polyanthemus</i>, <i>Juncus usitatus</i>, <i>Cyperus eragrostis*</i>, <i>Cyperus polystachyos</i>, <i>Cyperus rotundus*</i>, <i>Ludwigia peploides</i> ssp. <i>montevidensis</i>, <i>Nymphoides geminata</i>, <i>Potamogeton tricarinatus</i>, <i>Triglochin procerum</i>.	Highly disturbed and modified terrain. Remnant regrowth along southern aspect of dam.

Table 1 contd

Locations and characteristics of the variety of wetlands and farm dams in the study area at Marsden Park.

Unit	Location	Characteristic Species	Surrounding Vegetation
Small wetlands with less diversity:			
5	East of quarry	Terrestrial species: <i>Melaleuca decora</i>, <i>Melaleuca nodosa</i>, <i>Melia azedarach</i>, <i>Melaleuca sieberi</i>, <i>Melaleuca styphelioides</i> <i>Acacia longissima</i>, <i>Lomandra longifolia</i> <i>Cheilanthes sieberi</i>, <i>Aneilema acuminatum</i>, <i>Commelina cyanea</i>. Aquatic and semi-aquatic species: <i>Juncus acutus</i>*, <i>Juncus continuus</i>*, <i>Juncus polyanthemos</i>, <i>Juncus usitatus</i>, <i>Typha orientalis</i>.	Moderately disturbed. Some regeneration of species.
6	Southeast of quarry	Terrestrial species: <i>Melaleuca sieberi</i>, <i>Melaleuca styphelioides</i>, <i>Pittosporum undulatum</i>, <i>Cheilanthes sieberi</i>, <i>Aneilema acuminatum</i>, <i>Persicaria decipiens</i>, <i>Rumex crispus</i>, <i>Commelina cyanea</i>, <i>Centella asiatica</i>. Aquatic and semi-aquatic species: <i>Typha orientalis</i>, <i>Ludwigia peploides</i> ssp <i>montevidensis</i>.	Moderately disturbed. Some regeneration of species.
7	Southwestern area	Terrestrial species: <i>Lomandra longifolia</i>, <i>Centella asiatica</i>. Aquatic and semi-aquatic species: <i>Juncus acutus</i>, <i>Juncus continuus</i>, <i>Juncus polyanthemos</i>, <i>Juncus usitatus</i>, <i>Cyperus polystachyos</i>.	Highly disturbed and modified terrain.
8	Adjacent to Fulton Street	Terrestrial species: <i>Lomandra longifolia</i>, <i>Centella asiatica</i>. Aquatic and semi-aquatic species: <i>Ludwigia peploides</i> ssp <i>montevidensis</i>, <i>Nymphoides geminata</i>, <i>Typha orientalis</i>, <i>Cyperus polystachyos</i>.	Highly disturbed and modified terrain.
9	Southern boundary line	Terrestrial species: <i>Lomandra longifolia</i>, <i>Centella asiatica</i>. Aquatic and semi-aquatic species: <i>Juncus acutus</i>, <i>Juncus continuus</i>, <i>Juncus polyanthemos</i>, <i>Juncus usitatus</i>, <i>Typha orientalis</i>, <i>Cyperus polystachyos</i>.	Highly disturbed and modified terrain

Disturbed Areas

Map Unit C - Benson 1992.

Occurrence

Disturbed areas occur throughout the survey area and surrounding the quarry, within powerline easements and along tracks and roads.

Structure

The upperstorey layers are absent, apart from isolated semi-mature or mature trees. The understorey is also largely absent, and where present consists substantially of weeds.

Floristics

The upper and understorey layers are generally absent, with occasional semi-mature and mature Forest Red Gum and Grey Box. Adjacent to the quarry, Coast Myall *Acacia binervia*, Parramatta Green Wattle, and exotic species, such as the African Olive *Olea europaea ssp africana* and African Boxthorn *Lycium ferocissimum*, occur sporadically to 4.5m high. Tree Tobacco *Nicotiana glauca* occurs in small open stands adjacent to the quarry.

Groundcover species are limited to hardier native species such as Kangaroo Grass, *Einadia hastata* and Common Couch, as well as common exotic species which include Paspalum, Paddy's Lucerne, Rhodes Grass, Veined Verbena, Fireweed, Cobblers Pegs, Spear Thistle and Canadian Fleabane.

3.2 Conservation Significance of the Vegetation Present

3.2.1 National and State Significance

Vegetation Communities

The NSW Scientific Committee has recently declared Cumberland Plain Woodland an Endangered Ecological Community, under Section 11 of the TSC Act (see Appendix 2), on the basis of "*the substantial reduction in the area occupied by the community, its fragmentation and the numerous threats to the integrity of the community*".

In its Final Determination, the Scientific Committee has provided details of the characteristics and definition of Cumberland Plain Woodland (Appendix 2). Included amongst these is an "*assemblage of plant species*", comprising 57 species of canopy, understorey and groundcover plants. The Scientific Committee notes that "*not all species listed occur in every single stand of the community*", but provide no information as to the minimum number of species which may legally or reasonably be considered to constitute Cumberland Plain Woodland. The NSW Scientific committee also provides a list of tree species which dominate the canopy of Cumberland Plain Woodland. These include "*one or more of the following*" - Grey Box, Forest Red Gum, Narrow-leaved Ironbark, Small-leaved Stringybark and Spotted Gum (Appendix 2).

Two of the communities present on the Marsden Park subject site are dominated by Grey Box, which is a characteristic overstorey species of Cumberland Plain Woodland, as defined by the Scientific Committee. In the Grey Box and Grey Box-Ironbark communities, 38 and 36 plant species (respectively) considered by the Scientific Committee to be characteristic of the Cumberland Plain flora were recorded (Appendix 1). This constitutes approximately 66% and 63% (respectively) of the total "*assemblage of plant species*" defined by the Scientific Committee. Consequently, these woodland stands could be considered to comprise Cumberland Plain Woodland, as defined by the Scientific Committee.

The reports and mapping of vegetation in western Sydney, upon which much of the NSW Scientific Committee's Final Determination is based, identify several main community groups (Benson & Howell 1990; Benson 1992). Included amongst these are Cumberland Plain Woodland (discussed above), which is a broad grouping of five or six vegetation communities, and Castlereagh Woodland, which includes five vegetation communities (Benson 1992). The vegetation mapping of Benson (1992) includes only Map Unit 10c (Grey Box Woodland) in the study area, although (as listed above) several other communities are also present.

The stands of Map Unit 10c (Grey Box Woodland) and Map Unit 10d (Grey Box-Ironbark Woodland) are component communities of Cumberland Plain Woodland, as defined by Benson (1992), whilst Map Unit 9d (Shale-Gravel Transition Forest) is a component of Castlereagh Woodland.

Plant Species

The NP&WS Atlas of NSW Wildlife has indicated the potential occurrence of eight Rare Or Threatened Australian Plant (ROTAP - Briggs & Leigh 1996) species in the general locality (*Allocasuarina glareicola*, *Dillwynia tenuifolia*, *Pultenaea parviflora*, *Acacia bynoeana*, *Acacia pubescens*, *Darwinia biflora*, *Micromyrtus minutiflora*, *Persoonia nutans* and *Pimelea spicata*).

However, no flora species of national (ROTAP) or state (TSC Act) conservation significance were recorded in the study area. The surveys of the subject site by the NP&WS for the UBBS (NP&WS 1997) also failed to locate any such species. Given that the high levels of past and current disturbance has substantially reduced the understorey and groundcover layers, none of these species are expected to occur.

3.2.2 Regional Significance

Vegetation Communities

The Grey Box woodlands of the Cumberland Plain are regarded as of regional conservation significance, having been severely reduced over the last 200 years, through extensive clearing for agriculture and urban development (Benson 1992). Mapping of these Grey Box Woodlands (Benson 1992) indicates that small isolated patches of this community are scattered throughout the Cumberland Plain, with some larger stands, such as parts of Shanes Park, the ADI St Marys site and the RAAF land at Orchard Hills. Although small in comparison to these other extensive remnants, the stands of woodland in the Marsden Park study area have been included in this mapping, and appear to constitute a significant remnant in relation to the regional distribution of this community.

Wetland communities (described by Benson as Wetland Complex Map Unit 28a; Freshwater Reed Swamps) and the Shale/Gravel Transitional Forest which both occur in the study area are also considered to be poorly conserved in the western Sydney region (NP&WS 1997). Several lagoons around Windsor, to the north of the site, including Bakers, Bushells and Pit Town Lagoons, have been identified as significant remnants of Map Unit 28a, with a large remnant of Shale/Gravel Transition Forest occurring at Windsor Downs Nature Reserve.

Plant Species

There are currently three assessments of the conservation significance of plant species in western Sydney. Benson & McDougall (1991) ascribe conservation ratings to plants considered regionally significant in Western Sydney. Benson *et al* (1996) assess the conservation significance of plant species within the Hawkesbury Nepean catchment, and cover a substantially greater area than Benson & McDougall (1991). The most recent assessment of the conservation of plant species in Western Sydney is included in the Urban Bushland Biodiversity Surveys by the NSW NP&WS (1997).

A number of the species considered to be regionally significant in western Sydney are not so in the Hawkesbury-Nepean catchment, reflecting the larger area and greater diversity of habitats in the latter area. In the UBBS (NP&WS 1997), several of the species considered to be of regional conservation significance by Benson & McDougall (1991) and Benson *et al* (1996) are considered "*relatively common to widespread*" in the western Sydney region. In addition, several species have not been mentioned in the UBBS, suggesting that these species may no longer be of conservation significance.

Of the species recorded during the survey in the Marsden Park study area (this report), 22 are considered to be of conservation significance in the Western Sydney region, according to the above publications (Benson & McDougall, 1991; Benson *et al* 1996; NP&WS 1997), due to their restricted distributions and inadequate conservation in the region.

In addition to the species recorded during this investigation, one species of "particular regional significance" (*Vittadinia pustulata*) was recorded in the study area during a previous investigation (NP&WS 1997).

Table 2 Flora species of regional conservation significance recorded in the study area.

Botanical Name	Benson & McDougall (1991)	Benson et al (1996)	NP&WS (1997)
<i>Acacia binervia</i>	✓		-
<i>Amyema gaudichaudii</i>	✓		V3
<i>Arthropodium minus</i>	✓		V2
<i>Atriplex semibaccata</i>	✓		V3
<i>Calotis dentex</i>	✓	✓	V2
<i>Clematis glycinoides</i>	✓		-
<i>Cyperus polystachyos</i>	✓		V3
<i>Danthonia linkii</i> var <i>linkii</i>	✓		V3
<i>Danthonia pilosa</i>	✓		V3
<i>Einadia polygonoides</i>	✓		V3
<i>Eleocharis cylindrostachys</i>	✓		V3
<i>Eucalyptus longifolia</i>	✓		-
<i>Glycine microphylla</i>	✓		V3
<i>Grevillea juniperina</i>	✓	✓	V1
<i>Juncus prismatocarpus</i>	✓		-
<i>Nymphoides geminata</i>	✓		V3
<i>Oplismenus aemulus</i>	✓		?
<i>Phyllanthus virgatus</i>	✓	✓	V3
<i>Potamogeton tricarlinatus</i>	✓		-
<i>Pultenaea microphylla</i>	✓	✓	V1
<i>Senecio hispidulus</i> var <i>dissectus</i>	✓		-
<i>Senecio hispidulus</i> var <i>hispidulus</i>	✓		V3

Key to NP&WS (1997) regionally vulnerable plant codings:

- V1-** All vulnerable species which are also ROTAP/TSC Act listings, regionally significant or rare (less than 5 records). These taxa are considered to be the most vulnerable.
- V2-** Vulnerable taxa which are uncommon (6-10 records). These taxa are likely to move into the V1 classification in the near future.
- V3-** Vulnerable taxa which are relatively common to widespread and are unlikely to become regionally extinct in the near future.

The majority of the regionally significant plants were recorded in the woodland communities, with a small number occurring in the wetlands around the study area. Only one species (*Acacia binervia*) was recorded in the vicinity of the old quarry. Given the largely cleared nature of the majority of the proposed disturbance area, and the lack of understorey and groundcover in the woodland which will be removed, impacts on these species are expected to be small, if any.

3.2.3 Local Significance

The Blacktown Local Government Area (LGA) has been subjected to extensive clearing for agriculture and residential and industrial development. However, the LGA does support several large bushland remnants, including Prospect Reservoir, Shanes Park (to the immediate west of the site) and parts of the ADI site (to the southwest), as well as natural vegetated corridors along creeklines (including Bells Creek), and several smaller isolated remnants (NP&WS 1997).

In the UBBS (NP&WS 1997), the NSW NP&WS have identified the study area and immediately adjacent lands (referred to as 'Shanes Park East') as "Bushland Remnant of Conservation Significance" (NP&WS 1997). This significance is based on the presence of significant vegetation communities and plant species on the site, and the potential for regeneration of native species. This area has also been identified as having "very good corridor potential" (NP&WS 1997) to link the Shanes Park site (to the west) with remnant vegetation along Bell's Creek and at Dean Park and Riverstone to the east.

3.3 Noxious Weeds

An array of introduced flora species were recorded in the study area, including Crofton Weed *Ageratina adenophora*, Pampas Grass *Cortaderia* spp, Patersons Curse *Echium* spp, Pellitory *Parietaria judaica*, Blackberry *Rubus fruticosus* spp aggregate and African Boxthorn *Lycium ferocissimum*. These species have been classified as noxious within Blacktown Local Government Area under the Noxious Weed Act 1993 (NW Act).

4 FAUNA

4.1 Fauna Habitats

By virtue of the long history, intensity and extent of clearing, agricultural activities and urban development, little of the previously existing natural habitat remains in Western Sydney in general. Much of the area surrounding the subject site has long been cleared of native vegetation, and provides only limited resources for most native fauna species.

Similarly, much of the study area has been subject to long term disturbance. However, despite the disturbed and degraded condition of much of the surrounding area, the study area does support some patches or stands of relatively intact woodland, and a range of potential habitats and resources for native fauna.

The three main fauna habitat types which occur in the study area include remnant and regrowth woodland, farm dams/wetlands and cleared pasture areas. Remnant stands of open woodland provide valuable fauna habitat, despite also being substantially disturbed and modified by agricultural activities. Farm dams, artificial wetlands and other features also provide valuable fauna habitat. Agricultural areas provide some resources for certain groups of fauna, including grasslands for bird species of open habitat preferences. All of these habitats have been disturbed to varying degrees through clearing, grazing, terrain modification, general access and weed-infestation.

4.1.1 Remnant Woodland

This habitat type includes remnant and regenerating Grey Box and Grey Box-Ironbark Woodland and Castlereagh Woodland communities, as described in Section 3. These patches of vegetation are considered of relatively high conservation value as fauna habitat, despite their disturbed condition, given the extent of clearing for agriculture and urban use in the surrounding landscape.

Woodland remnants on the subject site support an array of resources for native avifauna and mammals, and to a lesser extent herpetofauna. These communities provide nesting, perching and feeding resources for a range of native birds, and support a moderate number of small tree-hollows suitable for the nesting and roosting requirements of hollow-dependent fauna (for example, some small arboreal mammals, microchiropteran bats and bird species).

Tree-debris (including fallen branches and limbs, leaf litter and stockpiled logs) occurs throughout the study area, particularly in the more intact woodland to the west of the old quarry. These features provide potential shelter for reptiles, small mammals and snails.

Vegetation communities throughout the study area provide foraging resources for many species of native fauna. The shrub understorey (where present) provides foraging and shelter resources for small passerine birds and contributes to the foraging habitat of arboreal mammals. Mistletoe and winter-flowering eucalypts provide a potentially valuable foraging resource for nomadic species, such as the Painted and Regent Honeyeaters.

The value of these remnant patches of woodland as fauna habitat is, in most cases, dependent on the size of the remnant and the proximity of other remnants. Where remnant woodland is bisected by cleared pasture or powerline easements, such as in the study area, "edge effects" can substantially reduce the value of the woodland as habitat for native fauna. Less mobile species, such as arboreal mammals, often cannot traverse large cleared areas, and can be restricted to a small remnant patch. In addition, several

bird species are "*edge specialists*" (NP&WS 1997), such as the Grey Butcherbird, Magpie-lark and Noisy Miner, and can exclude species which require larger tracts of intact vegetation. Furthermore, weed species are more able to invade at the edges of remnant woodland, reducing the quality of habitat for native fauna.

Consequently, small, isolated patches of remnant woodland favour certain fauna species, and as a result, species diversity is generally reduced in such environments.

4.1.2 Farm Dams/Artificial Wetlands

Farm dams (artificial wetlands) often constitute a valuable source of habitat for aquatic and semi-aquatic vertebrate fauna, providing invertebrates and organic matter as food, as well as shelter, breeding and foraging sites amongst logs, vegetative debris and overhanging foliage. Reeds and rushes along the banks and shallow edges, and emergent vegetation, provide nesting and refuge habitat for a variety of waterbirds, reptiles and amphibians.

Farm dams and surrounding wetland vegetation, provide a concentrated source of insects which contribute to the foraging resources of a range of non-aquatic species, including insectivorous birds and microchiropteran bat species which may forage in the area. One microchiropteran bat species in particular, the Large-footed Myotis, forages exclusively over bodies of still water for small fish and aquatic invertebrates. This species was tentatively recorded during the investigations, and is likely to forage over the numerous farm dams scattered throughout the surrounding area.

As a result of unrestricted access by stock, several of the farm dams in the study area are severely disturbed and support little riparian or aquatic vegetation. As a result, these dams are of limited value for most species. Similarly, the old quarry supports very little emergent or aquatic vegetation, as a result of its artificial nature and reduced water quality (Plates 1 and 2). A small island in the centre of the quarry does provide a diurnal roost for a number of species, and mud flats at the edge in some areas provide foraging resources for several species (Plates 1 and 2).

Other dams have retained substantial aquatic vegetation, including waterlilies, and riparian vegetation, such as reeds and sedges. These areas (in particular dams # 1 and 4 - Figure 1) provide substantial foraging and shelter resources for many species, including amphibians, reptiles and birds.

The dam to the south of the old quarry (# 4 - Figure 1, Plate 4) provides an array of habitat features for native fauna, and appears to be a significant roosting site for waterbirds, including regionally significant species. Dead paperbarks in this wetland provide roosting sites for many species, particularly ibis and cormorants, and the large pile of sticks in the centre of this wetland provide roosting, and possibly nesting, habitat for Pelicans and Black-winged Stilts. A large number of birds were observed on this wetland, both during the day and evening, and it is considered to be the most significant wetland area in the study area.

4.1.3 Cleared Pasture/Grassland

This fauna habitat is characteristic of much of the study area and surrounding locality (eg Plate 3). Cleared pasture is generally of limited value for most native fauna species, given the scarcity of foraging and shelter resources. These communities typically support a lack of structural and floristic diversity, having been cleared of most trees and understorey and comprising predominantly introduced grasses. Those trees which are present exist as scattered individuals or in small isolated groups.

In general, cleared areas provide foraging resources for the more mobile fauna species, in particular macropods, some bird and reptile species and potentially some microchiropteran bats, although the presence of feral cats, domestic dogs and foxes in rural areas restricts the occupation of these habitats by many native fauna. Birds (including the Masked Lapwing, Crested Pigeon, Australian Magpie and Ibis) were observed foraging in grassland areas, and are commonly associated with similar habitats throughout the Sydney metropolitan area. Whilst some reptiles are expected to also occur in these habitats on occasion, the absence of substantial groundcover and debris (such as

rocks, shrubs, fallen logs etc) limits the value of these areas for most reptile species. Some microchiropteran bat species, including the threatened Greater Broad-nosed Bat, are known to forage in the ecotone area between grassland and woodland stands, as well as generally over vegetation.

The remnant isolated trees support some hollows which may be of value to hollow-dependent fauna, including some bird and microchiropteran bat species. Such trees are considered to be of less value for hollow-dependent arboreal mammals, depending on their distance from existing stands of vegetation.

4.2 Fauna Recorded

A total of 78 species of native vertebrate fauna were recorded during field investigations in the study area, including 54 birds, 5 amphibians, 4 reptiles and 15 mammals. Eight introduced species were also recorded. In general, the fauna species recorded are commonly recorded throughout western Sydney. However, some species have declined in abundance, and are considered to be of regional significance (NP&WS 1997).

In addition to the species observed during site investigations, a range of species have been recorded in the vicinity of the study area during previous studies (Gunninah 1996; NP&WS 1997) and in databases for the region (NP&WS Wildlife Atlas; AMBS Database; Birds Australia Atlas), including 23 threatened species (Appendix 4). However, the area covered by these databases encompasses a substantially greater area than just the study area, and includes a range of habitat features which are not represented in the study area. Consequently, several of the additional species are not expected to occur in the study area, given the absence of suitable habitat.

Whilst a number of additional fauna species than those directly recorded are considered likely to be present in the study area from time to time, or on a seasonal basis, the fauna assemblage described is regarded as being representative of the fauna likely to occur. Some threatened species known to occur in the region could possibly occur (at least on occasion), although the study area is not considered to support any resources of critical value for such species. These species are considered further in Section 4.3.2 of this report.

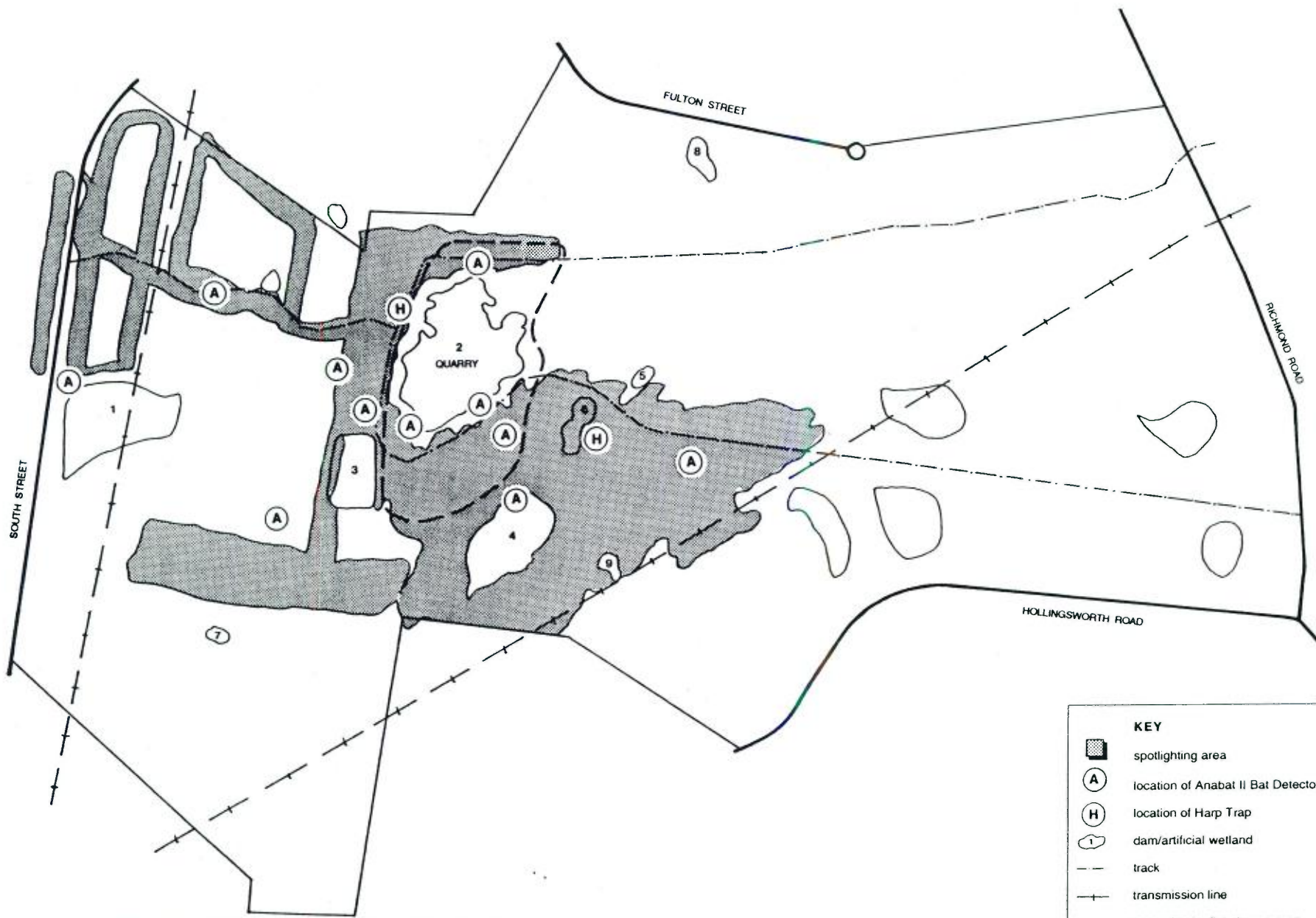
Birds

Fifty-four species of native bird were identified in the study area, either by direct observation or by identification of distinctive calls. In addition, a number of species have been previously recorded in the locality, during previous surveys nearby or in databases for the region. Many of these species would be expected to occur on a transitory or occasional basis, and 17 of these are threatened, and are discussed in detail below.

The majority of the species recorded in the study area were waterbirds, reflecting the range of suitable habitats and resources for such species. Species recorded include the Australian Pelican, ducks, grebes, herons, ibis and cormorants. Also recorded were those species which forage on mud flats (such as the Black-winged Stilt and Black-fronted Plover) and species which inhabit reed beds (the Clamorous Reed-warbler). A variety of these species were recorded foraging in the quarry during the day, and roosting in the wetland to the south of the quarry (# 4 - Figure 1, Plate 4) in the evening.

Other bird species recorded are considered "*edge specialists*" (NP&WS 1997), often occurring at the ecotone of forests and cleared areas (such as agricultural and urban environments). Such species recorded on the subject site include the Grey Butcherbird, Noisy Miner, Eastern Rosella, Australian Magpie, Australian Raven and Magpie-lark. Other species which are tolerant of some level of disturbance, and often forage in cleared grasslands and urban areas were also common on the subject site, including the Masked Lapwing, Galah, Kookaburra, Willie Wagtail, Red-rumped Parrot and Welcome Swallow, as well as introduced species such as the Common Mynah, Starling and Spotted Turtle-Dove.

The remainder of the bird species recorded are typical of the open woodland habitat present in the study area, including the Spotted Pardalote, Yellow Thornbill, Double-barred Finch, Common Bronzewing, Satin Flycatcher and White-winged Chough. In addition, five raptors were observed either soaring over the study area, or perching in dead trees.



KEY

- spotlighting area
- location of Anabat II Bat Detector
- location of Harp Trap
- dam/artificial wetland
- track
- transmission line
- approximate disturbance area

FIGURE 2 Locations of fauna survey methods employed in the Marsden Park study area.

Species recorded were the Peregrine and Brown Falcons, Nankeen Kestrel, White-bellied Sea Eagle and Whistling Kite.

No threatened bird species (as listed in the TSC Act) were recorded during the field surveys on the subject site. However, a number of threatened bird species have been recorded within 10km of the subject site (NP&WS Wildlife Atlas) and could potentially occur in the vicinity on occasion (Appendix 4), as discussed further in Section 4.3.

Mammals

Fifteen mammals were recorded during investigations in the study area. Of these, twelve were microchiropteran bats, five of which were tentatively identified using Anabat II echolocation recordings.

Two arboreal mammals, the Sugar Glider and Common Ringtail Possum, and one terrestrial mammal (the Echidna) were recorded during investigations in the study area. The Sugar Glider and Common Ringtail Possum were located during spotlighting, the former in woodland adjacent to cleared agricultural land in the western portion of the study area, and the latter in woodland to the south of the old quarry. Both species are commonly recorded in bushland remnants, being relatively tolerant of disturbance (NP&WS 1997). A dead Echidna was observed in the old quarry.

Several other mammals are known from the locality, including arboreal species (the Common Brushtail Possum, megachiropteran bats and the threatened Koala, Squirrel Glider and Yellow-bellied Glider) and terrestrial species (the Eastern Grey Kangaroo). The presence of the Common Brushtail Possum, Eastern Grey Kangaroo and megachiropteran bats is considered possible, given their tolerance to disturbance. However, the presence of the threatened species within these guilds of fauna is considered unlikely, as discussed further below.

Seven species of microchiropteran bat were positively identified on the subject site, five from Anabat II echolocation recordings, one from its audible call (the White-striped Mastiff Bat) and one by direct capture during harp trapping surveys (the Chocolate Wattled Bat). Anabat recordings are often of poor quality and duration, making positive identification difficult. In such cases, tentative identifications are made, based on the recorded call and the location and habitat characteristics of the site. Five species of microchiropteran bats were tentatively identified using such methods.

Of the species either positively or tentatively identified, four are threatened - the Large-footed Myotis, Greater Broad-nosed Bat, Eastern Freetail Bat and Large Bent-wing Bat. These species are discussed in detail below. The other species identified in the study area are relatively common, and occur in a variety of habitats and locations.

Microchiropteran bats generally roost in tree-hollows or rock caves, and occasionally in man-made constructions such as houses, sheds, mines, tunnels and culverts. There are few resources in the study area for those species which depend on caves, tunnels or similar artificial structures for roosting, other than old works sheds on the banks of the old quarry. Conversely, the tree-dwelling species recorded may roost in hollow-bearing trees in the open woodland communities on the subject site. The open woodland and the several dams throughout the subject site (including the old quarry) doubtless provide foraging resources for a variety of microchiropteran bat species.

Amphibians

Despite the abundance of suitable habitat in the study area, only six species of amphibian were recorded during the investigations. The Common Eastern Froglet, Rocket Frog, Eastern Dwarf Tree Frog and Peron's Tree Frog were commonly recorded in all of the vegetated wetlands and farm dams in the study area. The Brown Striped Frog and Spotted Grass Frog were recorded in artificial drainage lines, the former to the southeast of the existing quarry, and the latter near the South Street boundary of the study area.

Several additional species, including three threatened species, are known from the general locality. However, given the levels of disturbance and the nature of the habitats present,

not all of these species would be expected to occur in the study area. The threatened species known from the locality are discussed below.

The existing quarry did not appear to support any amphibians, probably largely as a result of the lack of aquatic or riparian vegetation. Whilst the threatened Green & Golden Bell Frog does occur in degraded sites such as this, no evidence for its presence was obtained during the investigations. This species is discussed in detail below.

Reptiles

Four species of reptile were recorded in the study area - the Long-necked Tortoise, Jacky Lizard, Eastern Water Dragon and Grass Skink. All of these species are common and widespread, and are recorded in a variety of habitats and locations.

A range of additional species are known from the locality, including the Lace Monitor, Wood Gecko, and several skinks and snakes. Many of these additional species would be expected to occur in the study area, or would have occurred prior to the increased human activity associated with grazing and clearing. No reptiles of conservation significance are known from the general locality, and none are expected to occur.

The area to be disturbed by the proposed quarry and landfill supports few shelter resources for reptiles. This area supports no groundcover, except for grazed grasses, and little ground debris, except for occasional logs and some rubbish. The remainder of the study area supports more suitable habitat, with log stockpiles, leaf litter and a dense understorey in some places providing some shelter resources for such species.

4.3 Significant Fauna

4.3.1 Species Recorded in the Study Area

State Significance

Four species of threatened fauna (as listed in the TSC Act) were recorded during the investigations in the study area. All of these species were microchiropteran bats, two of which were tentatively identified from Anabat II echolocation recordings. All of the species recorded are listed as Vulnerable (Schedule 2) under the TSC Act.

The Large Bent-wing Bat is a common inhabitant of woodland environments, and is distributed from Cape York to the Mount Lofty Ranges in South Australia (Dwyer 1995). This species roosts and nests in caves, mines and tunnels (Dwyer 1995). The Large Bent-wing Bat was recorded near the large dam in the western portion of the study area, adjacent to South Street (Figure 3). The study area does not appear to support any suitable roosting or nesting resources for this species, and given its highly mobile and wide-ranging habits, the Large Bent-wing Bat is likely to be utilising the wetlands and open woodland in the study area as part of a wider foraging resource.

The Eastern Freetail Bat occurs from southern NSW to southern Queensland, primarily inhabiting dry eucalypt forest and woodland, where it roosts in trees (Allison & Hoyer 1995). This species was recorded at three locations in the study area (Figure 3), but two of these records were tentative. The one positive record was in open woodland along the track to the north of the old quarry. The tentative records were adjacent to the large wetland near the South Street boundary of the site (#1), and in open woodland to the west of the old quarry.

The Large-footed Myotis occurs along the east and north coasts of Australia, from southeastern South Australia to northern Western Australia. This species utilises a variety of different shelter resources, including artificial structures (such as caves and tunnels) and natural features, such as tree-hollows and dense vegetation (Richards 1995). This species always occurs close to water, ranging from small creeks to large wetlands, where it rakes the surface of the water with its large clawed feet to capture aquatic insects and small fish (Richards 1995). The Large-footed Myotis was tentatively identified twice from Anabat II echolocation recordings, at the edge of the large artificial wetland near the South Street boundary (#1) and near the wetland to the south of the existing quarry (#4 - Figure 3).

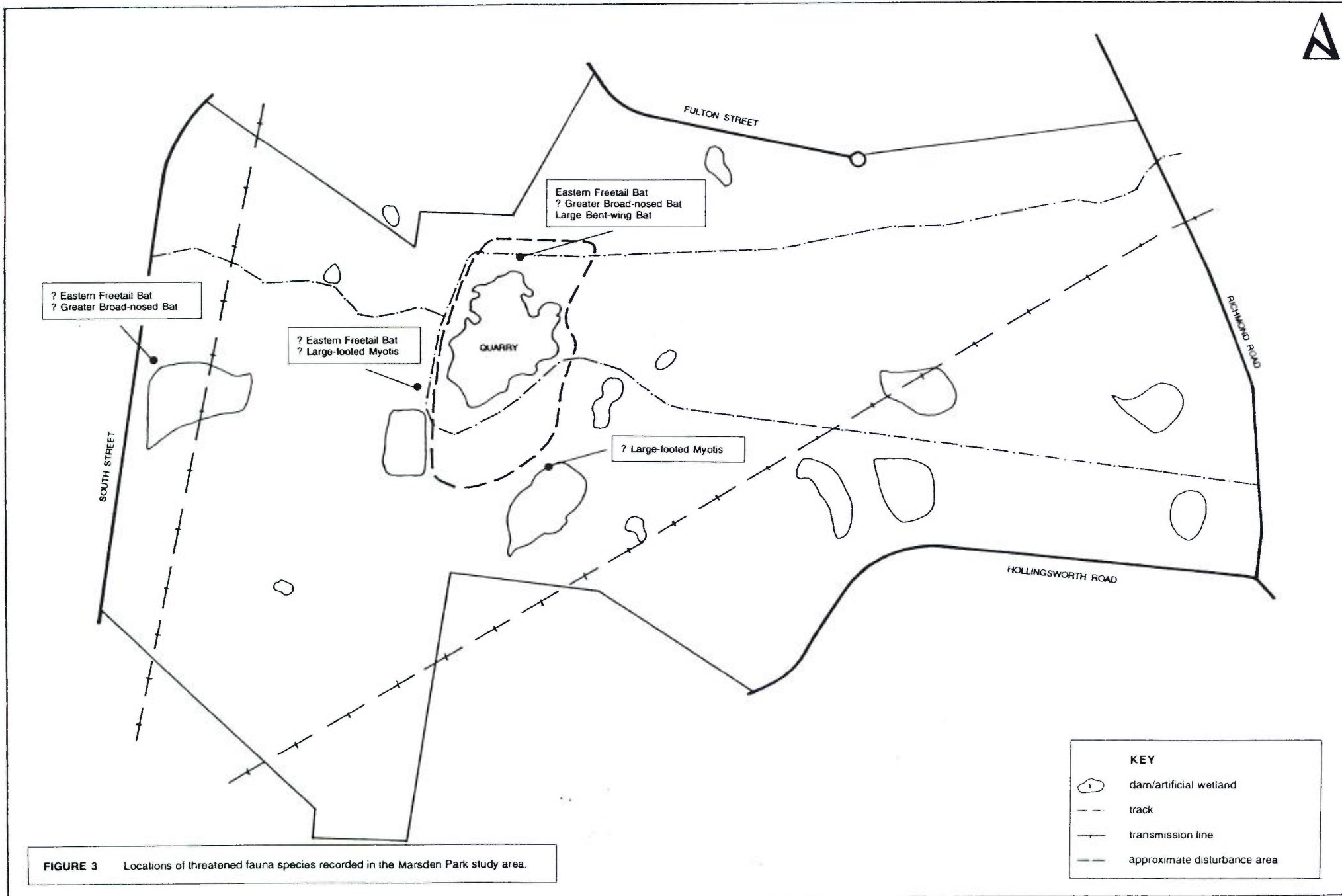


FIGURE 3 Locations of threatened fauna species recorded in the Marsden Park study area.

The Greater Broad-nosed Bat is primarily distributed along the Great Dividing Range from Victoria to Queensland, but also inhabits more coastal environments (Hoye & Richards 1995). Whilst this species occurs in a range of habitats from open woodland to rainforest, it prefers the less dense nature of open forest and woodland communities, which pose fewer obstacles to flight (Hoye & Richards 1995). The Greater Broad-nosed Bat roosts in tree-hollows, but may also utilise man-made structures (Hoye & Richards 1995). This species was tentatively identified twice in the study area, once in open woodland to the immediate north of the old quarry, and once in open woodland to the west of the old quarry (Figure 3).

Regional Significance

Eight of the species recorded during the field investigations are considered to be of regional conservation significance (NP&WS 1997). These species are considered to be regionally significant, on the basis of the extent of "*loss and fragmentation of habitat*" which has occurred in Western Sydney. Other species are considered to be regionally significant because they are "*ecological specialists*", inhabiting a specialised, and sometimes rare, habitat type, or they are "*uncommon or rare in the region*" (NP&WS 1997).

The Peregrine Falcon, White-bellied Sea Eagle and Whistling Kite were recorded either soaring over the old quarry or perching on limbs of dead trees. The White-winged Chough and Common Bronzewing were both recorded in the open woodland communities to the west of the old quarry, with the latter species identified by call. The proposed activities on the subject site are considered unlikely to adversely affect any of these species, given the intention to retain the majority of the existing woodland in the study area.

The Nankeen Night Heron was recorded foraging at the edge of the wetland to the south of the old quarry (#4 - Figure 1). The Great Crested Grebe and Great Egret were both recorded in the old quarry, with the former species breeding in this habitat and the latter species roosting in the wetland to the south in the evening. For the Great Egret, the old quarry appears to constitute a diurnal foraging site only, with the wetland to the south (#4) constituting a significant roosting site for this, and a number of additional, species. However, the Great Crested Grebe is currently breeding in the old quarry, despite the vulnerability of this area to predators, particularly the fox and dog.

4.3.2 Species which may occur

State Significance

A number of threatened fauna species are known from the general locality, including 15 birds, 3 amphibians, 3 mammals and one mollusc (NP&WS Atlas; Birds Australia database; AMBS database; NP&WS 1997). As discussed, these databases cover a substantially larger area than just the study area, and encompass a wide variety of habitats. Whilst some of these threatened species may occur, others would not be expected, given a lack of appropriate habitats or resources.

Birds

Of the threatened bird species known from the general locality, several are likely to or could possibly utilise the resources on the subject site.

Some species are unlikely to occur because of a lack of suitable resources, or because the study area is outside of their usual distribution. Examples include the Marbled Frogmouth (a rainforest-dependent species), the Pink Cockatoo (which generally occurs in the western division of NSW, and the record is considered to be that of a vagrant or captive release - NP&WS 1997) and the Glossy Black Cockatoo (an obligate *Allocasuarina* feeder). The Cumberland Plain generally is considered to support little habitat or resources of value for the Glossy Black Cockatoo (NP&WS 1997).

Several highly mobile and wide-ranging birds are known from the vicinity, and could occur in the study area on a transitory or occasional basis. Species with large home-ranges (such as the Powerful and Masked Owls and Square-tailed Kite) and nomadic or migratory birds (such as the Swift Parrot and Regent and Painted Honeyeaters) may occur on

occasions. Given that the majority of the woodland which currently exists in the study area will be retained, and given the extent of similar habitat in the immediate vicinity (including at Shanes Park and on the ADI site), none of these species are likely to be adversely impacted by the proposal, even if present on occasions.

Several species of threatened waterbirds are known from the general locality (NP&WS Atlas), including the Blue-billed and Freckled Ducks, Black Bittern and Painted Snipe. The former three species are considered rare in Western Sydney, with the Blue-billed Duck occurring as a vagrant only (NP&WS 1997). Whilst the Freckled Duck may utilise the wetlands in the study area on occasions, the Black Bittern and Painted Snipe are unlikely to occur, given their preference for densely vegetated creeks and wetlands. More suitable habitat for both species occurs to the north in Bakers, Bushells and Pitt Town Lagoons, with McGraths Hill Sewage Treatment Plant considered to be important site for the Painted Snipe in Western Sydney (NP&WS 1997).

One additional bird species known from the general locality is the Bush Stone-curlew. This species inhabits open woodland habitats, which provide tree-debris and sparse ground cover (NP&WS 1997) to provide shelter. During recent surveys of Western Sydney (NP&WS 1997), only one record of this species was collected, prior to which the most recent record was in 1986 (NP&WS Wildlife Atlas). Whilst the study area provides suitable habitat for this species, the presence of feral predators (including a den of foxes), is likely to exclude it from the study area. Even if present, the proposed disturbance area does not support suitable habitat, with potential habitat located only in the western, more intact, portions of the study area, which will remain unaffected.

Amphibians

Of the three threatened amphibians known from the general locality, only the Green & Golden Bell Frog is a potential inhabitant of the study area. Neither the Giant Burrowing Frog nor the Red-crowned Toadlet occur on the Cumberland Plain (NP&WS 1997), with both species restricted to Hawkesbury Sandstone. The Green & Golden Bell Frog occurs in a range of habitats, from natural vegetated swamps to highly disturbed artificial sites. This species appears to be out-competed by other frog species in less disturbed areas and is often found in sites which have experienced recent disturbance. Although the old quarry does appear to provide suitable habitat for the Green & Golden Bell Frog, no evidence for its presence was observed during the field investigations, despite specific searches and suitable weather conditions (sunny and warm with occasional showers).

Mammals

In addition to the threatened mammals recorded in the study area, the Koala, Yellow-bellied Glider and Squirrel Glider are also known from the locality (NP&WS Wildlife Atlas). During the recent surveys of Western Sydney, both the Koala and Yellow-bellied Glider were recorded. However, neither of these records were on the Cumberland Plain, and these species appear to be restricted to areas of Sandstone and peripheral areas of western Sydney (NP&WS 1997). The Squirrel Glider was not directly recorded during these previous investigations, but there is a record for this species on Rickabys Creek, near Castlereagh State Forest (NP&WS Wildlife Atlas - 1994). No evidence for any of these species was observed during the field investigations in the study area. Even if present, the limited extent of clearing required, and the disturbed nature of the woodland to be removed would limit the potential for impact on any of these arboreal mammals.

Invertebrates

The Large Land Snail *Meriodolum corneovirens* has recently been listed by the NSW Scientific Committee as an Endangered species, on Schedule 1 of the TSC Act. *M. corneovirens* is endemic to the Cumberland Plain, occurring within remnant woodland and open forest communities (C Allen, Australian Museum *pers comm*). This snail generally occurs under logs and around the base of plants, where it burrows into loose soil (NSW Scientific Committee). The extensive clearing which has occurred in the Cumberland Plain for agriculture and urban development has substantially reduced the extent of suitable habitat for this species. Although this species has been recorded approximately 15 times within 10km of the study area (AMBS database), and despite

thorough searches for this species under debris and at the base of plants throughout the study area, no evidence for its presence (either historical or current) was obtained.

Regional Significance

A large number of the native fauna species known from the general locality are considered of conservation significance in the Western Sydney region (NP&WS 1997), including the Wedge-tailed Eagle, Glossy Ibis, Peaceful Dove, Fuscous Honeyeater, Hooded Robin, Brown and Smooth Toadlets, Lace Monitor and Eastern Grey Kangaroo (Appendix 4). Whilst none of these additional species were recorded during the investigations in the study area, the majority of regionally significant fauna species known from the locality could occur on an occasional basis, particularly the highly mobile birds. The potential impacts on any such species which could occur are discussed below.

5 POTENTIAL IMPACTS

Given the disturbed nature and condition of the majority of the study area, and the implementation of appropriate impact amelioration measures (as detailed below), it is considered unlikely that any significant adverse effects on any native fauna or flora will be imposed by the proposed development. There is also the potential to increase the habitat values of the study area, for both native flora and fauna, with a range of appropriate impact amelioration measures.

The discussion of impacts which follows is hypothetical, and based on the potential for impacts to be imposed in the absence of amelioration measures. In most instances, measures and management regimes will be implemented as part of the "activity", to avoid the imposition of these potential effects. As a consequence, the impacts which are likely to arise as a result of conducting the "activity" with its inherent amelioration measures are considerably reduced below those considered in the following detailed discussion.

As noted above, there is some potential (theoretically at least) for adverse impacts being imposed, including the loss of some resources and habitat by clearing, direct or indirect impacts on individuals of significant species, a reduction in water quality, and invasion of weeds and feral animals.

• Loss of native vegetation communities, particularly Cumberland Plain Woodland

As discussed above, Cumberland Plain Woodland has been listed as an Endangered Ecological Community by the NSW Scientific Committee. Component communities of Cumberland Plain Woodland occur to the north and west of the old quarry (Figure 1, Plates 1 and 2). However, all areas have been subjected to considerable disturbance, including grazing and clearing of most understorey and groundcover plants.

The small area of disturbed Grey Box Woodland to the north of the old quarry will be removed by the proposed activities, as will a small patch to the southwest, adjacent to a farm dam (Figure 1). In addition, some scattered trees surrounding the old quarry will also require removal. However, the majority of the existing vegetation will be retained in the study area as a buffer, including substantially larger and more intact stands of Grey Box Woodland than those which will be removed.

The proposed activities will remove only an extremely small area of Grey Box Woodland, with respect to that which will remain both in the study area and in the general locality. Consequently, the potential for adverse impacts on Grey Box Woodland, as a component of Cumberland Plain Woodland, is considered minimal. The potential impact of the proposed development on Cumberland Plain Woodland is further discussed in detail in Appendix 5.

Similarly, with regard to native vegetation generally, the proposed activities will result in the loss only of an extremely small amount of native vegetation, both in terms of that which exists in the study area and in the general locality, despite the extent of past clearing activities.

- **Loss of nationally, state or regionally significant plant species**

Whilst no ROTAP or threatened (TSC Act) plant species were recorded in the study area, a number of regionally significant species were identified. The majority of such species were recorded in the woodland communities, with several species also occurring in the riparian communities in the study area.

As a result of the virtually complete removal by previous activities of understorey and groundcover vegetation to the north of the old quarry (the vegetation to be removed), no regionally significant species were recorded in this area. Similarly, the old quarry supports very little in the way of riparian vegetation (Plates 1 and 2). Whilst a few isolated individuals of regionally significant plant species may be disturbed by the proposed activities, the majority of the individuals and habitats will be retained. Furthermore, the implementation of impact amelioration measures (as described below) could increase the habitat values for these species in the study area.

- **Loss of habitat for native fauna**

An array of native fauna species were recorded during the field investigations in the study area, including four threatened microchiropteran bat species, and eight regionally significant bird species. Given the mobility of all of these species, and the extent of habitat to remain in the study area, no adverse impacts on these species are anticipated. Conversely, the regionally significant Great Crested Grebe is nesting in the old quarry, and some nesting habitat for this species will be removed as a result of the proposed activities.

Many additional waterbirds were observed using the old quarry during the day. However, the majority of the species recorded were using this feature as a diurnal foraging site and roosting in the wetland to the south (#4 - Figure 1, Plate 4), which appears to provide a significant roosting and nesting habitat for a variety of species.

In addition to waterbirds, a number of forest and woodland species were recorded, including birds and arboreal mammals. Very few of these species were recorded utilising the woodland to be disturbed, and although mobile birds and microchiropteran bats are likely to occur in this area, less mobile species would be largely precluded due to the sparse nature of the canopy and groundcover layers. Given the highly disturbed nature of the woodland to be disturbed by the proposal and the intention to retain larger areas of more intact woodland in the study area, no species of woodland-dwelling fauna is likely to be adversely affected.

Whilst some foraging habitat will be removed by the proposed activities, both in the old quarry and in the adjacent woodland, there are substantial areas of alternative habitat in the wetland in the western portion of the site (adjacent to South Street - #1) and the wetland to the south of the old quarry (#4). Furthermore, the quality of these habitats could be increased through impact amelioration and habitat enhancement measures, as described below.

- **Potential impacts on threatened species**

Detailed consideration of the potential effects on threatened species and provided in the Section 5A assessments of significance (Appendix 5).

Large-footed Myotis

This species was tentatively identified twice in the study area, once near the artificial wetland on the South Street Boundary of the study area (#1), and once near the wetland to the south of the old quarry (#4 - Figure 3). Whilst Anabat and Harp trapping surveys at the edge of the quarry did not locate this species, the Large-footed Myotis is likely to use this feature also as a foraging resource. However, given the retention and protection of the artificial wetlands in the study area, the removal of potential foraging habitat from the old quarry is highly unlikely to adversely impact on the conservation of this species.

Large Bent-wing Bat

This species was recorded from Anabat II echolocation recordings foraging in woodland to the immediate north of the old quarry (Figure 3), which will be disturbed as a result of the proposed quarry operations. However, given the extent of woodland to remain in the study

area, and given the wide-ranging and highly mobile nature of this species, the removal of the extremely small area of woodland necessary is highly unlikely to adversely impact on the Large Bent-wing Bat to any significant extent.

Eastern Freetail Bat

This species was recorded at three locations in the study area, in woodland to the immediate north of the old quarry, to the west of the quarry (a tentative identification) and in the vicinity of the large artificial wetland at the South Street boundary of the study area (a tentative identification - Figure 3). Whilst a small portion of possible foraging habitat for this species will be removed as a result of the proposed activities, a substantially larger area will remain intact. No significant adverse impacts on the Eastern Freetail Bat are anticipated.

Greater Broad-nosed Bat

This species was tentatively recorded twice in the study area from Anabat II echolocation recordings. Both records were from woodland, one to the immediate north of the old quarry and the second to the west of the quarry (Figure 3). Whilst the woodland to the north of the quarry will be disturbed as a result of the proposed quarry operations, the woodland to the west (where this species was also recorded) will remain intact. Given the extent of woodland to remain in the study area, and given the wide-ranging and highly mobile nature of this species, the removal of the extremely small area of woodland necessary for the activity is highly unlikely to adversely impact on the Greater Broad-nosed Bat.

• Potential impacts on regionally significant species

Great Crested Grebe

This species was recorded foraging and nesting in the old quarry during the field investigations, and the proposed activities will result in the loss of this habitat for this species. However, a number of habitat features of potential value (in particular other artificial wetlands throughout the study area) will remain, providing alternative habitat features for the Great Crested Grebe. Provided that draining of the quarry is conducted outside of the breeding season of this species, no impacts on the conservation status of this regionally significant species are anticipated.

Other Waterbirds

The Nankeen Night Heron and Great Egret were both recorded in the study area. The former species was recorded foraging on the edge of the wetland to the south of the quarry (#4), and is likely to rely on this feature (as opposed to the quarry), given the lack of dense riparian vegetation to provide shelter surrounding the old quarry. The Great Egret was recorded foraging in the old quarry (#2), and roosting in the wetland to the south (#4). Whilst the quarry is likely to provide diurnal foraging resources for both species, in particular the Great Egret, neither species is likely to rely on this feature, with the wetland to the south providing substantially more valuable habitat. No adverse impacts on the regional conservation status of either species is anticipated as a result of the proposed activities.

Forest Birds

The White-winged Chough and Common Bronzewing were both identified in woodland to the west of the old quarry. The proposed activities will remove only a small area of relatively disturbed resources for these species, and no significant effect on them is anticipated. The implementation of impact amelioration and habitat enhancement measures may increase the value of habitats for these species in the study area.

Raptors

The Peregrine Falcon, White-bellied Sea Eagle and Whistling Kite were all observed in the study area. These species are all highly mobile and wide-ranging, and are only likely to use the study area as part of a wider foraging resource, encompassing much of the surrounding area. Given the limited requirement for loss of native vegetation in the study area, and the retention of the majority of the habitat features which currently exist, any perching or foraging features utilised by these species are unlikely to be substantially reduced. As a consequence, no adverse impacts on these regionally significant species are anticipated.

- **Reduction of water quality in adjacent wetlands**

Wetlands adjacent to the old quarry provide some valuable habitat for native fauna, including foraging, roosting and nesting resources for native birds and foraging resources for microchiropteran bats. These wetlands may also provide a source of water for terrestrial mammals, such as macropods, if present.

Leachate from the landfill has the potential (theoretically at least) to adversely affect water quality in adjacent habitats. In addition, the discharge of contaminated water from roads and stockpile areas, dust from haul roads and erosion and sedimentation, could also adversely affect these areas, potentially having serious ramifications for fauna which utilise these features as a water source. These possible impacts, however, can readily be carefully controlled, using standard techniques, to avoid the reduction in the quality of adjacent habitats for native fauna and flora.

- **Reduction in quality of roosting habitat in southern wetland**

Quarrying and landfilling operations, including drilling and blasting, haul trucks and increased human access, are likely to disrupt roosting and nesting of waterbirds in the wetlands to be retained in the study area (at least in those adjacent to the activities). This is of particular concern with regard to the wetland to the south of the old quarry (#4, Plate 4), which appears to constitute an important roosting and nesting resource for a variety of waterbirds, including ibis, ducks, Pelicans and the Black-winged Stilt.

Amelioration measures (as discussed below) should reduce the potential for disturbance to this valuable roosting and nesting resource.

- **Damage to retained vegetation**

Whilst some native vegetation will require removal as a result of the proposed activities, the majority of the vegetation which is to be removed is highly degraded. Conversely, other areas of native vegetation adjacent to the proposed disturbance area (which are to be retained) are more intact and provide more valuable habitat for native flora and fauna.

Dust derived from exposed surfaces and from earthmoving and vehicles travelling on unsealed roads can significantly affect air quality and can reduce the quality of vegetation in adjacent areas. This impact may have the potential to adversely affect the natural environment, particularly by reducing the quality of habitat for native flora and fauna. Conversely, dust suppression and management techniques can readily (and will) be implemented to minimise the potential for adverse effects (as outlined in Section 7).

Remnant vegetation is also at risk from erosion and sedimentation, and from pollution arising from contaminated areas, rubbish dumping, dust from roads and direct damage through accidental or uncontrolled access by humans and machinery. These impacts will be controlled by standard impact amelioration measures, as discussed below.

- **Invasion of weed species and feral animals**

The increased levels of activity and disturbance associated with the proposal can potentially facilitate the invasion of weed and feral species. However, this concern is of greater relevance for areas which have previously been subjected to minimal disturbance and which are in relatively good condition. The proposed activities in the study area are to be located in areas which are already considerably disturbed, and have already been invaded by weeds and feral animals. Consequently, this is an existing impact, and is not likely to be significantly increased by the proposed activities.

6 SIGNIFICANCE of IMPACTS

The potential for the proposed quarry and landfill operation to impose a "*significant effect on threatened species, populations or ecological communities, or their habitats*" has been

assessed as specified in Section 5A of the EP&A Act 1979 (as modified by the TSC Act). The detailed assessment, addressing the 8 factors of Section 5A, is provided in Appendix 5.

The potential for the proposed activity to impose adverse impacts on “*threatened species, populations or ecological communities, or their habitats*” is limited both by the small area to be disturbed, and by the integration of a range of amelioration measures into the activity. The assessment with respect to the likelihood of significant effects being imposed is based on the proposed activity, which includes the implementation of the amelioration measures detailed below.

The analysis of impacts in the study area indicates that the proposed activities are not likely to impose significant adverse impacts on any “*threatened species, populations or ecological communities, or their habitats*”. Consequently, a Species Impact Statement (as defined by the TSC Act) is not required for the proposed activities at Marsden Park.

7 IMPACT AMELIORATION

The proposed activities at Marsden Park have the potential to adversely affect native flora, fauna and their habitats if not appropriately conducted. The amelioration or avoidance of potential impacts from the proposed activities can be achieved by the implementation of a range of management protocols and controls. An array of impact amelioration measures are proposed for the activities, to limit and manage any potential direct or indirect impacts on the local environment, and possibly to enhance the habitat values of the study area.

There is substantial potential to create or enhance a range of valuable habitat resources for native flora and fauna (including threatened and regionally significant species) through rehabilitation and regeneration activities. Currently, the remnant woodland in the study area is fragmented by cleared pasture and powerline easements, leaving it vulnerable to “*edge effects*”, and creating barriers to movement for less mobile species, such as the Sugar Glider. Habitat enhancement, as an element of the project, should aim to create vegetated connections between areas of remnant woodland, and to improve the quality of woodland in the study area by fencing to prevent access by stock, which inhibits regeneration of native species through grazing and trampling.

Features of the proposed amelioration measures should include:

- minimisation of the clearing of and damage to patches of remnant vegetation wherever possible. This includes the careful positioning and construction of all of the required infrastructure to avoid as much remnant woodland as possible. In this regard, clearing should not occur beyond the track to the west of the old quarry, and clearing of remnant vegetation to the southwest of the quarry (surrounding farm dam #3) should be minimised, where practicable;
- fencing of vegetation which is to be retained, prior to activities, to avoid damage from uncontrolled or accidental access. This is of particular concern surrounding the wetland to the south of the old quarry (#4), and given the proximity of areas of Grey Box Woodland to the proposed disturbance area;
- quarrying operations should remain at least 75m away from the wetland to the south of the old quarry (#4), to avoid disturbance to roosting and nesting habitat for native waterbirds. This wetland should not be disturbed in any way;
- location of the infrastructure necessary for the project to avoid fauna habitat resources, as far as possible. In particular, mature trees supporting hollows, farm dams and patches of woodland should be avoided;
- the appropriate timing of clearing activities to avoid seasons when species may be nesting in tree-hollows or in the old quarry. This is of particular importance given that the regionally significant Great Crested Grebe nests in the old quarry, and given the presence of hollow-dependent threatened microchiropteran bats;
- retention of felled trees as logs in adjacent remnant woodland communities. This will provide additional habitat resources for ground-dwelling fauna, and will allow for the cycling of nutrients;

- a detailed examination of eucalypts containing tree-hollows prior to felling should be conducted to determine the presence of birds, reptiles, microchiropteran bats (in particular threatened species) or other fauna species. If any fauna is located (and cannot be removed prior to felling), trees should be felled in a manner so as to cause the least threat to animal welfare, and be examined post-felling. Any animals located should be removed and relocated in adjacent areas clear of the operations;
- limits on vehicle speeds in the study area (as is standard safe practice) will reduce the potential for the increased vehicular traffic levels to adversely affect fauna populations in the study area by impacts such as dust, noise and fauna road deaths;
- the application of environmentally sound construction and management methods and protocols to prevent or minimise adverse impacts on adjacent habitats from erosion and sediment discharge. Appropriate management protocols in this regard will include:
 - the minimal clearing of areas of natural vegetation, especially in the vicinity of creeklines and drainage channels (to limit the exposure of areas to potential erosion);
 - the rapid stabilisation of any newly created landforms (earth embankments etc);
 - the rapid regeneration of vegetation on finished exposed soil surfaces, and a subsequent landscaping and regeneration program using local species and seed or propagule stock; and
 - the implementation of a weed control program, with particular emphasis on those species listed as noxious on the NW Act;
- the prevention of damage arising from the discharge of contaminants or pollutants into the environment, particularly from the landfill and stockpile areas, by appropriate management protocols and by the bunding of sites containing contaminants (to avoid the potential for discharge to the natural environment and the subsequent reduction in value of habitats for fauna and flora);
- the implementation of dust control measures to protect adjacent retained vegetation communities and to retain the value of habitats for native flora and fauna. Dust control measures should primarily involve the watering of exposed dust-generating surfaces (including stockpiles and unsealed roads), the covering of loads on trucks and conveyors, and the progressive re-vegetation of finished soil surfaces throughout the project area. Water for dust suppression should be obtained from the old quarry for as long as possible, and not from the wetland to the south of the quarry;
- proper management of rubbish, human waste, and other waste products to prevent their uncontrolled discharge into the environment. Management protocols should involve treatment and disposal of waste (as appropriate); and
- the direction of stormwater run-off from potentially contaminated sites, such as stockpile areas, to retention and treatment ponds. Fresh stormwater that has not passed across contaminated sites should be directed away from the operations and into natural drainage channels.

As mentioned above, there is the opportunity for rehabilitation and regeneration of the open woodland communities, and for a reduction in the current fragmentation of habitat in the study area. Features of a rehabilitation and habitat enhancement program should include the creation of alternative habitat and movement paths for native fauna and flora. In this regard, measures would include:

- fencing of the larger, more intact wetlands, particularly in the western portion of the site, adjacent to South Street (#1) and to the south of the old quarry (#4), to prevent stock access, where practicable. This will substantially increase the

habitat values of these areas. Supplementary planting of native riparian species, such as reeds, sedges and paperbarks, would also increase the resources for native fauna;

- fencing of remnant woodland to prevent stock access, which is inhibiting the regeneration of native plant species. Creation of connections between remnants can be achieved by fencing off 'corridors' and allowing natural regeneration of native species, supplemented with replanting, in currently cleared areas. If possible, native groundcovers and shrubs should be established in these 'corridors' under the powerline easements to provide some protection for fauna using this area to move between woodland remnants;
- planting of native vegetation between the new quarry and the wetland to the south to provide a buffer to minimise disturbance to roosting and nesting habitat for waterbirds. Native trees and shrubs (particularly those endemic to the study area) should be planted at the beginning of operations, including the paperbarks *Melaleuca nodosa*, *M. decora* and *M. sieberi*, eucalypts (such as Grey Box, Forest Red Gum and Broad-leaved Ironbark), and native shrubs and groundcovers (as included in Appendix 1). This will also provide additional foraging and roosting resources for a number of species;
- the design and construction of sediment and stormwater ponds to ultimately provide supplementary habitats, including the planting of native wetland plants, the creation of islands in the centre (to provide protection from terrestrial predators) and the provision of rocks and logs for shelter;
- the use of culverts where the haul road crosses drainage lines to facilitate fauna movements and to provide supplementary habitat, including roosting habitat for some microchiropteran bats (such as the Large-footed Myotis and Large Bent-wing Bat). Rocks should be used within culverts to provide shelter sites for amphibians and reptiles;
- the removal and relocation of tree-hollows from felled trees into retained trees, to maintain nesting and shelter resources for hollow-dependent fauna (such as arboreal mammals and microchiropteran bats). Given the value of retained tree hollows for fauna in considerably cleared and disturbed environments, such as those within and surrounding the study area, the relocation of hollows should be conducted throughout the site; and
- the use of flora species which are native to the region in rehabilitation and replanting regimes. Appropriate species include Grey Box *Eucalyptus moluccana*, Narrow-leaved Ironbark *E. crebra*, Broad-leaved Ironbark *E. fibrosa*, Forest Red Gum *E. tereticornis* and the paperbarks listed above.



PLATES 1 & 2 The existing quarry contains water and provides some limited resources for native fauna, including waterbirds. The artificial nature of the quarry and the lack of riparian or aquatic vegetation substantially reduces its quality as a resource for native fauna. The majority of the woodland in Plate 1 is to be retained, whilst some of the trees in the background of Plate 2 will require removal.





PLATE 3

The majority of the area to be disturbed by the proposed quarry is characterised by highly modified grassland. The woodland in the background is to remain intact.



PLATE 4

The artificial wetland to the south of the existing quarry provides an array of resources for native fauna, particularly waterbirds which roost in the dead trees. Reeds, sedges and mudflats provide foraging and shelter resources for native fauna. This wetland is to be avoided and conserved.

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PROPOSED QUARRY and LANDFILL
RICHMOND ROAD, MARSDEN PARK

FLORA & FAUNA ASSESSMENT

APPENDIX 1

Flora Species Recorded in the Study Area during the Current and a
Previous Investigation (NP&WS 1997)

Key

- Introduced species

CPW listed as a characteristic species of Cumberland Plain
Woodland (as defined by the NSW Scientific Committee)

A Recorded during previous investigations (NP&WS 1997)

B recorded during this investigation, in the following
communities:

- 1** Grey Box Woodland
- 2** Grey Box - Ironbark Woodland
- 3** Shale/Gravel Transition Forest
- 4** Wetland/Artificial Dam
- 5** Cleared/Disturbed

APPENDIX 1 Flora species recorded in the study area at Marsden Park.

Botanical Name	Common Name	CPW	A	B				
				1	2	3	4	5
Filicopsida								
Adiantaceae								
<i>Cheilanthes sieberi</i>	Mulga fern	✓	×	×	×	×		×
Magnoliopsida								
Monocotyledons								
Agavaceae								
* <i>Agave americana</i>	Century Plant					×		×
Anthericaceae								
<i>Arthropodium milleflorum</i>	Vanilla Lily	✓		×	×	×		
<i>Arthropodium minus</i>	Small Vanilla Lily			×	×			
<i>Laxmannia gracilis</i>	Slender Wire Lily		×	×	×	×		
Asphodelaceae								
* <i>Aloe saponaria</i>	Soap Aloe							×
Asparagoides								
* <i>Myrsiphyllum asparagoides</i>	Bridal Creeper							×
Commelinaceae								
<i>Aneilema acuminatum</i>	-				×	×	×	
<i>Commelina cyanea</i>	Commelina	✓			×	×	×	
Cyperaceae								
* <i>Cyperus eragrostis</i>	Umbrella Sedge						×	×
<i>Cyperus gracilis</i>	-	✓	×					
<i>Cyperus polystachyos</i>	-						×	
<i>Cyperus prismatocarpus</i>	-						×	
* <i>Cyperus rotundus</i>	Nut Grass						×	×
<i>Eleocharis acuta</i>	-		×					
<i>Eleocharis cylindrostachys</i>	-						×	
<i>Eleocharis sphacelata</i>	Tall Spike Rush		×				×	
<i>Lepidosperma laterale</i>	Sword Sedge	✓	×	×	×		×	
<i>Schoenoplectus mucronatus</i>	-		×					
Hydrocharitaceae								
<i>Ottelia ovalifolia</i>	Swamp Lily		×					
Hypoxidaceae								
<i>Hypoxis hygrometrica</i>	Yellow Star	✓		×	×	×		
Juncaceae								
* <i>Juncus acutus</i>	-					×	×	
* <i>Juncus continuus</i>	-						×	
<i>Juncus polyanthemos</i>	-						×	
<i>Juncus prismatocarpus</i>	Branching Rush						×	
<i>Juncus usitatus</i>	Common Rush		×				×	
Juncaginaceae								
<i>Triglochin procerum</i>	Water Ribbons						×	
Lomandraceae								
<i>Lomandra filiformis</i> ssp <i>filiformis</i>	Wattle Mat-rush	✓	×	×	×	×		
<i>Lomandra longifolia</i>	Spiny-headed Mat-rush					×	×	
<i>Lomandra multiflora</i>	Many-flowered Mat-rush	✓	×	×	×			
Phormiaceae								
<i>Dianella caerulea</i> var <i>producta</i>	Blue Flax Lily					×		
<i>Dianella longifolia</i> var <i>longifolia</i>	Flax Lily	✓	×	×	×	×		

APPENDIX 1 contd Flora species recorded in the study area at Marsden Park.

Botanical Name	Common Name	CPW	A	B				
				1	2	3	4	5
Poaceae								
<i>Aristida ramosa</i>	Three-awn Speargrass	✓	×	×	×	×		
<i>Aristida vagans</i>	Three-awn Speargrass	✓	×	×	×	×		
<i>Bothriochloa macra</i>			×					
* <i>Chloris gayana</i>	Rhodes Grass					×	×	×
<i>Chloris ventricosa</i>		✓	×					
<i>Cymbopogon refractus</i>	Barbed-wire Grass		×					
<i>Cynodon dactylon</i>	Common Couch		×	×		×	×	×
<i>Danthonia linkii</i> var <i>linkii</i>	Wallaby Grass			×	×	×		
<i>Danthonia pilosa</i>	Smooth-flowered Wallaby Grass			×				
<i>Danthonia tenuior</i>	Wallaby Grass			×	×			
<i>Dichelachne micrantha</i>	Shorthair Plume Grass	✓	×	×	×			
<i>Echinopogon caespitosus</i> var <i>caespitosus</i>	Tufted hedgehog Grass	✓	×	×	×	×		
<i>Entolasia marginata</i>	Bordered Panic	✓		×		×		
<i>Eragrostis brownii</i>	Browns Love Grass			×		×		
<i>Imperata cylindrica</i> var <i>major</i>	Blady Grass					×	×	×
<i>Microlaena stipoides</i> var <i>stipoides</i>	Meadow Rice Grass	✓	×	×	×			
<i>Oplismenus aemulus</i>	Basket Grass	✓			×	×	×	
<i>Panicum simile</i>	Two Colour Panic	✓	×					
<i>Paspalidium distans</i>	-		×					
* <i>Paspalum dilatatum</i>	Paspalum			×			×	×
* <i>Pennisetum clandestinum</i>	Kikuyu						×	×
* <i>Setaria</i> sp	Pigeon Grass					×		×
* <i>Sporobolus indicus</i> var <i>capensis</i>	Parramatta Grass							×
* <i>Stenotaphrum secundatum</i>	Buffalo Grass							×
<i>Themeda australis</i>	Kangaroo Grass	✓	×	×	×	×	×	×
Potamogetonaceae								
<i>Potamogeton tricarlinatus</i>	Floating Pond Weed						×	
Typhaceae								
<i>Typha orientalis</i>	Broad-leaf Cumbungi		×				×	
Magnoliopsida								
Dicotyledons								
Acanthaceae								
<i>Brunontella australis</i>	Blue Trumpet	✓	×	×	×	×		
Amaranthaceae								
<i>Alternanthera denticulata</i>	Lesser Joyweed		×					
Aplaceae								
<i>Centella asiatica</i>	Centella					×	×	
Asclepiadaceae								
<i>Araujia sericiflora</i>	Moth Vine			×				×
* <i>Gomphocarpus fruticosus</i>	Narrow-leaf Cotton Bush			×	×			×
Asteraceae								
* <i>Bidens pilosa</i>	Cobblers' Pegs			×	×	×		×
* <i>Brachycome angustifolia</i> var <i>angustifolia</i>	-			×	×	×		
<i>Calotis cuneifolia</i>	Blur Daisy Burr			×	×	×		
<i>Calotis dentex</i>	White Daisy Burr			×	×			×
* <i>Cirsium vulgare</i>	Spear Thistle			×				×
* <i>Conzya bonariensis</i>	Flaxleaf Fleabane			×				×
* <i>Conyza canadensis</i> ssp <i>canadensis</i>	Canadian Fleabane			×				×
<i>Glossogyne tannensis</i>	Cobblers Tack		×					

APPENDIX 1 contd Flora species recorded in the study area at Marsden Park.

Botanical Name	Common Name	CPW	A	B				
				1	2	3	4	5
Asteraceae contd								
* <i>Hypochaeris radicata</i>	Cats' Ears			x	x	x		x
<i>Lagenifera stipitata</i>	-		x					
<i>Ozothamnus diosmifolius</i>	Everlasting		x	x	x	x		x
<i>Senecio diaschides</i>	-			x	x	x		x
<i>Senecio hispidulus</i> var <i>dissectus</i>	Rough Groundsel			x				
<i>Senecio hispidulus</i> var <i>hispidulus</i>	Rough Groundsel			x		x		
* <i>Senecio madagascariensis</i>	Fire Weed			x	x	x		x
* <i>Sonchus oleraceus</i>	Sow Thistle					x		x
<i>Vernonia cinerea</i>	-	✓	x	x	x			
<i>Vittadinia pustulata</i>	Fuzzweed		x					
Boraginaceae								
* <i>Echium lycopsis</i>	Patersons' Curse							x
Campanulaceae								
<i>Wahlenbergia gracilis</i>	Native Bluebell	✓	x	x	x			
Casuarinaceae								
<i>Allocasuarina littoralis</i>	Black She-oak		x	x	x	x		x
<i>Allocasuarina</i> sp						x		
<i>Casuarina glauca</i>	Swamp Oak		x			x	x	
Chenopodiaceae								
<i>Atriplex semibaccata</i>	Half-berried Salt-bush			x	x	x		
* <i>Chenopodium album</i>	Fat Hen			x	x	x		
<i>Einadia hastata</i>	-			x	x	x		
<i>Einadia polygonoides</i>	-			x	x	x		
Convolvulaceae								
<i>Dichondra repens</i>	Kidney Weed	✓	x	x	x	x	x	x
Dilleniaceae								
<i>Hibbertia diffusa</i>	Guinea Flower	✓	x	x				
Euphorbiaceae								
<i>Phyllanthus virgatus</i>	-	✓		x	x	x		
Fabaceae: Faboideae								
<i>Bossiaea prostrata</i>	-		x					
<i>Chorizema parviflorum</i>	-		x					
<i>Daviesia ulicifolia</i>	Gorse Bitter Pea	✓	x	x	x	x		
<i>Desmodium brachypodum</i>	-		x					
<i>Dillwynia sieberi</i>	Prickly Parrot Pea	✓	x	x	x			
<i>Glycine clandestina</i>	Love Creeper	✓	x	x	x	x		
<i>Glycine microphylla</i>	-	✓		x				
<i>Glycine tabacina</i>	-	✓		x				
<i>Hardenbergia violacea</i>	False Sarsaparilla	✓	x	x	x	x	x	x
<i>Indigofera australis</i>	-	✓						
* <i>Medicago arabica</i>	Spotted Medic							x
<i>Pultenaea microphylla</i>	-		x	x				
Fabaceae: Mimosoideae								
<i>Acacia binervia</i>	Coast Myall		x					x
<i>Acacia brownii</i>	-		x					
<i>Acacia decurrens</i>	Sydney Green Wattle	✓		x	x			
<i>Acacia falcata</i>	Sickle Wattle	✓	x	x				x
<i>Acacia floribunda</i>	Sally Wattle					x		
<i>Acacia longissima</i>	-					x		
<i>Acacia parramattensis</i>	Parramatta Green Wattle	✓	x	x	x	x		
Gentianaceae								
* <i>Centaurium tenuiflorum</i>	-						x	x

APPENDIX 1 contd Flora species recorded in the study area at Marsden Park.

Botanical Name	Common Name	CPW	A	B				
				1	2	3	4	5
Goodeniaceae <i>Goodenia hederacea</i>	Violet-leaved Goodenia	✓	×					
Haloragaceae <i>Myriophyllum variifolium</i>	Milfoil						×	
Hypericaceae <i>Hypericum gramineum</i>	Small St Johns' Wort	✓	×	×				
Lamiaceae <i>Ajuga australis</i>	Bugle		×					
Lobeliaceae <i>Pratia purpurascens</i>	White Root	✓	×	×	×	×		
Loranthaceae <i>Amyema gaudichaudii</i> <i>Amyema pendula</i> ssp <i>pendula</i>	Paper-bark Mistletoe -			×		×		
Malvaceae <i>Malva neglecta</i> <i>Sida rhombifolia</i>	Dwarf Mallow Paddy's Lucerne					×		×
Meliaceae * <i>Melia azedarach</i>	White Cedar					×		
Menyanthaceae * <i>Nymphoides geminata</i> <i>Nymphoides indica</i> <i>Villarsia exaltata</i>	Yellow Marshwort Water Snowflake Yellow Marsh Flower		×				×	×
Myoporaceae <i>Eremophila debilis</i>	Winter Apple	✓	×	×	×			
Myrtaceae <i>Eucalyptus crebra</i> <i>Eucalyptus eugenioides</i> <i>Eucalyptus fibrosa</i> <i>Eucalyptus longifolia</i> <i>Eucalyptus moluccana</i> <i>Eucalyptus tereticornis</i> <i>Kunzea ambigua</i> <i>Melaleuca decora</i> <i>Melaleuca nodosa</i> <i>Melaleuca sieberti</i> <i>Melaleuca styphelioides</i>	Narrow-leaved Ironbark Thin-leaved Ironbark Broad-leaved Ironbark Woollybutt Grey Box Forest Red Gum Tick Bush White Feather Honeymyrtle Ball Honeymyrtle Siebers' Paperbark Prickly-leaved Paperbark	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	×		×	×		
Nymphaeaceae * <i>Nymphaea mexicana</i>	Water Lily						×	
Oleaceae * <i>Ligustrum sinense</i> * <i>Olea europea</i> ssp <i>africana</i>	Small-leaved Privet African Olive			×	×	×		×
Onagraceae <i>Ludwigia peploides</i> ssp <i>montevidensis</i>	Water Primrose		×				×	
Oxalidaceae * <i>Oxalis corniculata</i> var <i>repens</i>	Yellow Wood-sorrel		×		×			×
Pittosporaceae <i>Bursaria spinosa</i> var <i>spinosa</i> <i>Pittosporum undulatum</i>	Blackthorn Sweet Pittosporum	✓	×	×	×	×	×	×

APPENDIX 1 contd Flora species recorded in the study area at Marsden Park.

Botanical Name	Common Name	CPW	A	B				
				1	2	3	4	5
Plantaginaceae <i>Plantago debilis</i> <i>*Plantago lanceolata</i>	Slender Plantain Common Plantain		×	×		×		×
Polygonaceae <i>Persicaria decipiens</i> <i>*Rumex crispus</i>	Slender Knotweed Curled Dock						×	×
Primulaceae <i>*Anagallis arvensis</i>	Scarlet Pimpernel					×	×	×
Proteaceae <i>Grevillea juniperina</i>	Prickly Spider-flower		×	×	×	×		
Ranunculaceae <i>Clematis glycinoides</i>	Forest Clematis				×		×	
Rosaceae <i>*Rubus fruticosus</i> species <i>aggregate</i>	Blackberry							×
Rubiaceae <i>Asperula conferta</i> <i>Opercularia diphyllo</i> <i>Pomax umbellata</i>	Common Woodruff Stinkweed Pomax	✓	×	×	×	×		
Santalaceae <i>Exocarpos cupressiformis</i>	Cherry Ballart	✓	×	×	×	×		
Sapindaceae <i>Dodonaea viscosa</i> ssp <i>cuneata</i>	Hop Bush		×					
Scrophulariaceae <i>Veronica plebeia</i>	Speedwell	✓	×	×				
Solanaceae <i>*Lycium ferocissimum</i> <i>*Nicotiana glauca</i> <i>Solanum prinophyllum</i> <i>*Solanum pseudocapsicum</i> <i>Solanum pungetium</i>	African Boxthorn Tree Tobacco Forest Nightshade Madeira Winter Cherry Eastern Nightshade			×	×	×		×
Verbenaceae <i>*Verbena bonariensis</i> <i>*Verbena rigida</i>	Purpletop Vieined Verbena		×	×	×	×		×

PROPOSED QUARRY and LANDFILL
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APPENDIX 2

Characteristics of the Cumberland Plain Woodland
(NSW Scientific Committee)

APPENDIX 2 The New South Wales Scientific Committee's Final Determination to list the Cumberland Plain Woodland as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995* (NSW Government Gazette 1997).

THE Scientific Committee, established by the Threatened Species Conservation Act has made a Final Determination to list the Cumberland Plain Woodland as an ENDANGERED ECOLOGICAL COMMUNITY on Part 3 of Schedule 1 of the Act. Listing of Endangered Ecological Communities is provided for by section 12 of the Act.

Any submissions received following advertisement of the Preliminary Determination have been considered by the Scientific Committee.

The Scientific Committee has found that:

1. The Cumberland Plain Woodland is the accepted name for the plant community that occurs on soils derived from shale on the Cumberland Plain.
2. The Cumberland Plain Woodland is characterised by the following assemblage of plant species:

Cheilanthes sieberi, *Aristida ramosa*, *Aristida vagans*, *Arthropodium milleflorum*, *Chloris truncata*, *Chloris ventricosa*, *Commelina cyanea*, *Cyperus gracilis*, *Dianella longifolia*, *Dianella revoluta*, *Dichelachne micrantha*, *Echinopogon caespitosus*, *Echinopogon ovatus*, *Entolasia marginata*, *Eragrostis leptostachya*, *Hypoxis hygrometrica*, *Lepidosperma laterale*, *Lomandra filiformis*, *Lomandra multiflora*, *Microlaena stipoides*, *Oplismenus aemulus*, *Panicum simile*, *Themeda australis*, *Tricoryne elatior*, *Acacia decurrens*, *Acacia falcata*, *Acacia implexa*, *Acacia parramattensis*, *Asperula conferta*, *Brunoniella australis*, *Bursaria spinosa*, *Daviesia ulicifolia*, *Dichondra repens*, *Dillwynia sieberi*, *Eucalyptus crebra*, *Eucalyptus eugenioides*, *Eucalyptus fibrosa*, *Eucalyptus maculata*, *Eucalyptus moluccana*, *Eucalyptus tereticornis*, *Exocarpos cupressiformis*, *Glycine clandestina*, *Glycine tabacina*, *Goodenia hederacea*, *Hardenbergia violacea*, *Hibbertia diffusa*, *Hypericum gramineum*, *Indigofera australis*, *Lissanthe strigosa*, *Melaleuca decora*, *Eremophila debilis*, *Oxalis exilis*, *Phyllanthus filicaulis*, *Pratia purpurascens*, *Solanum pungetium*, *Vernonia cinerea*, *Wahlenbergia gracilis*.

The total list of plant species which occur in the community is much larger, with many species occurring in one or a few sites, or in very low abundance. Not all species listed above occur in every single stand of the Community.

3. The Cumberland Plain Woodland sites are characteristically of woodland structure, but may include both more open and more dense areas, and the canopy is dominated by species including one or more of the following: *Eucalyptus moluccana*, *Eucalyptus tereticornis*, *Eucalyptus crebra*, *Eucalyptus eugenioides* and *Eucalyptus maculata*.
4. The understorey is generally grassy to herbaceous with patches of shrubs, or if disturbed, contains components of indigenous native species sufficient to re-establish the characteristic native understorey.
5. The Cumberland Plain Woodland includes regrowth which is likely to achieve a near natural structure or is a seral stage towards that structure.
6. The Community has been reported as occurring in the local government areas of Auburn, Bankstown, Baulkham Hills, Blacktown, Camden, Campbelltown, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta, Penrith and Wollondilly.

The Scientific Committee noted that a more detailed description of the community is provided in:

Benson (1992) The natural vegetation of the Penrith 1:100,000 map sheet. See particularly p. 556-7, p. 558, p. 566-575.

APPENDIX 2 cont The New South Wales Scientific Committee's Final Determination to list the Cumberland Plain Woodland as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995* (NSW Government Gazette 1997).

In addition, general information on the Cumberland Plain Woodland is also provided in:

Benson, D. & Howell, J. 1990. *"Taken for Granted - The Bushland of Sydney and its Suburbs"*. Kangaroo Press, Kenthurst

Benson, D., Howell, J., and McDougall, L., 1996, *Mountain Devil to Mangrove: a guide to the natural vegetation in the Hawkesbury-Nepean Catchment*. Royal Botanic Gardens, Sydney

The Scientific Committee has found that:

7. The Community, as defined by the proposal, satisfies the definition of an Ecological Community under the Act, i.e. an assemblage of species occupying a particular area.
8. Only 6% of the original extent of the community remained in 1988 (Benson, D. & Howell, J. 1990 Proc. Ecol. Soc. Aust. 16, 115-127) in the form of small and fragmented stands. Although some areas occur within conservation reserves, this in itself is not sufficient to ensure the long term conservation of the Community unless the factors threatening the integrity and survival of the Community are ameliorated.
9. Threats to the survival of the community include clearance for agriculture, grazing, hobby and poultry farms, housing and other developments, invasion by exotic plants, and increased nutrient loads due to fertiliser run off from gardens and farmland, dumped refuse or sewer discharge.
10. In view of the substantial reduction in the area occupied by the Community, its fragmentation and the numerous threats to the integrity of the Community, the Scientific Committee is of the opinion that the Cumberland Plain Woodland is likely to become extinct in nature in New South Wales unless the factors threatening its survival cease to operate.

PROPOSED QUARRY and LANDFILL
RICHMOND ROAD, MARSDEN PARK

FLORA & FAUNA ASSESSMENT

APPENDIX 3

Fauna Survey Methods and Weather Conditions

APPENDIX 3

Fauna survey methods employed during the field investigations in the Marsden Park study area.

Nocturnal Species (arboreal mammals, birds, amphibians):

spotlighting throughout study area for a total of 10.5 person-hours:

12th November	3.5 person-hours spotlighting
19th November	4 person-hours spotlighting
12th December	3 person-hours spotlighting

searches for indirect evidence (ie scats, scratchings, prints etc);
opportunistic observations;

taped Powerful and Masked Owl calls were played during spotlighting (12/12) in an attempt to elicit a response.

Microchiropteran Bats:

Harp traps placed in prominent flyways;
total of 2 trap-nights

Anabat II detectors were placed in areas of suitable habitat;
total of 6.5 hours.

12th November	5 detectors employed; 30 mins each.
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19th November	5 detectors employed; 30 mins each.
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12th December	3 detectors employed; 30 mins each.
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Diurnal Bird & Herpetofauna Surveys:

Diurnal surveys conducted over approximately 2 days to give a total of 40 person hours;

12th November	16 person-hours
19th November	8 person-hours
12th December	16 person-hours

Birds

surveys throughout the study area;
identification by call and observation;

Herpetofauna and molluscs specific searches in various habitat types and structures, with particular attention focussed on waterbodies, wet soaks and log stockpiles;
surveys included turning rocks and logs, investigations at the base of trees and shrubs and disturbing leaf litter;
opportunistic observations.

Approximately 5 person-hours spent on specific litter searches;
approximately 4 person-hours spent on specific amphibians surveys.

APPENDIX 3 contd Weather conditions experienced during the fauna and flora field investigations in the Marsden Park study area.

12/11	Afternoon	Clear and warm, becoming overcast with storms approaching.
	Evening	stormy, warm, overcast.
19/11	Afternoon	warm to hot and clear with no breeze.
	Evening	warm to hot and clear with a moderate breeze.
20/11	Morning	warm and clear with no breeze.
12/12	Morning	warm and humid with no breeze.
	Afternoon	warm to hot and clear with a slight breeze.
	Evening	warm and clear with a slight breeze.

PROPOSED QUARRY and LANDFILL
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FLORA & FAUNA ASSESSMENT

APPENDIX 4

Fauna Species Recorded in the Study Area and
Known from the General Locality

KEY

- * Introduced species
- ★ Threatened species, as listed on the *Threatened Species Conservation Act* 1995 (TSC Act)
 - E Schedule 1 - endangered
 - V Schedule 2 - vulnerable
- + Regionally significant (NP&WS 1997)
- A Species recorded in the study area during current field investigations.
- B Species recorded in the vicinity during previous investigations
 - 1 NPWS. 1997. Urban Bushland Biodiversity Survey. Fauna recorded within the Blacktown Local Government Area.
 - 2 Gunninah. 1995. Fauna and Flora Assessment for the Western Sydney Orbital.
 - 3 NPWS Wildlife Atlas. Records of threatened fauna within 10km of the study area, from the Penrith 1:100000 topographic map sheet. Data accessed October 1997.
 - 4 Flora and Fauna surveys conducted on the proposed PGH quarry expansion site at Schofields (Mitchell McCotter 1996; Clements & Stephens 1989).
 - 5 Birds Australia Atlas records from the area within 33°40'S to 33°50'S and 150°40'E to 150°60'E.

APPENDIX 4 Fauna species recorded in the study area at Marsden Park, or in the general vicinity.

COMMON NAME	SCIENTIFIC NAME	A	B
BIRDS			
Phasianidae			
Stubble Quail	<i>Coturnix pectoralis</i>		5
Brown Quail	<i>Coturnix ypsilophora</i>		2
Anatidae			
Plumed Whistling-Duck	<i>Dendrocygna eytoni</i>		1,5
★(V) Blue-billed Duck	<i>Oxyura australis</i>		1,3,5
+ Musk Duck	<i>Biziura lobata</i>		5
★(V) Freckled Duck	<i>Stictonetta naevosa</i>		3,5
Black Swan	<i>Cygnus atratus</i>	×	5
Australian Shelduck	<i>Tadorna tadornoides</i>		5
Australian Wood Duck	<i>Chenonetta jubata</i>	×	1,2,4,5
* Mallard	<i>Anas platyrhynchos</i>		5
Pacific Black Duck	<i>Anas superciliosa</i>	×	1,2,4,5
Australasian Shoveler	<i>Anas rhynchotis</i>		5
Grey Teal	<i>Anas gracilis</i>	×	5
Chestnut Teal	<i>Anas castanea</i>	×	1,5
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>		1,5
Hardhead	<i>Aythya australis</i>	×	5
Podicipedidae			
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>	×	1,2,5
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>		5
+ Great Crested Grebe	<i>Podiceps cristatus</i>	×	1,5
Anhingidae			
Darter	<i>Anhinga melanogaster</i>		1,5
Phalacrocoracidae			
Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>	×	1,4,5
Pied Cormorant	<i>Phalacrocorax varius</i>		2,5
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	×	1,5
Great Cormorant	<i>Phalacrocorax carbo</i>	×	1,5
Pelecanidae			
Australian Pelican	<i>Pelecanus conspicillatus</i>	×	1,5
Ardeidae			
White-faced Heron	<i>Egretta novaehollandiae</i>	×	1,2,5
Little Egret	<i>Egretta garzetta</i>		5
White-necked Heron	<i>Ardea pacifica</i>		5
+ Great Egret	<i>Ardea alba</i>	×	5
Intermediate Egret	<i>Ardea intermedia</i>	×	5
Cattle Egret	<i>Ardea ibis</i>	×	1,2,4,5
+ Nankeen Night Heron	<i>Nycticorax caledonicus</i>	×	5
★(V) Black Bittern	<i>Ixobrychus flavicollis</i>		1
★(V) Australasian Bittern	<i>Botaurus poiciloptilus</i>		5
Threskiornithidae			
+ Glossy Ibis	<i>Plegadis falcinellus</i>		5
Australian White Ibis	<i>Threskiornis molucca</i>	×	5
Straw-necked Ibis	<i>Threskiornis spinicollis</i>	×	1,5
Royal Spoonbill	<i>Platalea regia</i>		5
Yellow-billed Spoonbill	<i>Platalea flavipes</i>	×	1,5
Ciconiidae			
★(V) Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>		5
Accipitridae			
+ Pacific Baza	<i>Aviceda subcristata</i>		1
Black-shouldered Kite	<i>Elanus axillaris</i>		1,2,5
★(V) Square-tailed Kite	<i>Lophoictinia isura</i>		3
Black Kite	<i>Milvus migrans</i>		1
+ Whistling Kite	<i>Haliastur sphenurus</i>	×	5

APPENDIX 4 contd Fauna species recorded in the study area at Marsden Park, or in the general vicinity.

COMMON NAME	SCIENTIFIC NAME	A	B
Accipitridae contd			
+ White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	×	1.5
Spotted Harrier	<i>Circus assimilis</i>		5
Swamp Harrier	<i>Circus approximans</i>		5
Brown Goshawk	<i>Accipiter fasciatus</i>		1.5
+ Grey Goshawk	<i>Accipiter novaehollandiae</i>		5
Collared Sparrowhawk	<i>Accipiter cirrhocephalus</i>		5
+ Wedge-tailed Eagle	<i>Aquila audax</i>		1.5
+ Little Eagle	<i>Hieraaetus morphnoides</i>		1.5
Falconidae			
Brown Falcon	<i>Falco berigora</i>	×	5
Australian Hobby	<i>Falco longipennis</i>		2.5
Black Falcon	<i>Falco subniger</i>		1
+ Peregrine Falcon	<i>Falco peregrinus</i>	×	1.5
Nankeen Kestrel	<i>Falco cenchroides</i>	×	5
Rallidae			
Baillon's Crake	<i>Porzana pusilla</i>		5
Australian Spotted Crake	<i>Porzana fluminea</i>		5
Purple Swamphen	<i>Porphyrio porphyrio</i>	×	1,2,4,5
Dusky Moorhen	<i>Gallinula tenebrosa</i>	×	2.5
Eurasian Coot	<i>Fulica atra</i>	×	2.5
Turnicidae			
Painted Button-quail	<i>Turnix varia</i>		1
Scolopacidae			
+ Latham's Snipe	<i>Gallinago hardwickii</i>		2.5
+ Marsh Sandpiper	<i>Tringa stagnatilis</i>		5
+ Common Greenshank	<i>Tringa nebularia</i>		5
+ Wood Sandpiper	<i>Tringa glareola</i>		5
+ Sharp-tailed Sandpiper	<i>Calidris acuminata</i>		5
Rostratulidae			
★(V) Painted Snipe	<i>Rostratula benghalensis</i>		3
Burhinidae			
★(E) Bush Stone-curlew	<i>Burhinus grallarius</i>		1.3
Recurvirostridae			
Black-winged Stilt	<i>Himantopus himantopus</i>	×	5
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>		1
Charadriidae			
Black-fronted Plover	<i>Elsayornis melanops</i>	×	5
Red-kneed Dotterel	<i>Erythronyx cinctus</i>		5
Banded Lapwing	<i>Vanellus tricolor</i>		5
Masked Lapwing	<i>Vanellus miles</i>	×	1,2,5
Laridae			
Silver Gull	<i>Larus novaehollandiae</i>		5
Columbidae			
* Rock Dove	<i>Columba livia</i>	×	1,2,5
White-headed Pigeon	<i>Columba leucomela</i>		5
* Spotted Turtle-Dove	<i>Streptopelia chinensis</i>	×	1,2,5
+ Brown Cuckoo-Dove	<i>Macropygia amboinensis</i>		5
+ Common Bronzewing	<i>Phaps chalcoptera</i>	×	1.5
Crested Pigeon	<i>Ocyphaps lophotes</i>	×	1,2,5
+ Peaceful Dove	<i>Geopelia placida</i>		1.5
Wonga Pigeon	<i>Leucosarcia melanoleuca</i>		5
Topknot Pigeon	<i>Lopholaimus antarcticus</i>		5
Cacatuidae			
★(V) Glossy Black-Cockatoo	<i>Calyptorhynchus lathami</i>		1,3,5
Yellow-tailed Black-Cockatoo	<i>Calyptorhynchus funereus</i>		1.5

APPENDIX 4 contd Fauna species recorded in the study area at Marsden Park, or in the general vicinity.

COMMON NAME	SCIENTIFIC NAME	A	B
Cacatuidae contd			
Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>		5
Galah	<i>Cacatua roseicapilla</i>	×	1,2,5
Long-billed Corella	<i>Cacatua tenuirostris</i>		1,2
Little Corella	<i>Cacatua sanguinea</i>		5
★(V) Pink Cockatoo	<i>Cacatua leadbeateri</i>		3,5
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	×	1,2,5
Psittacidae			
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>		1,2,5
Musk Lorikeet	<i>Glossopsitta concinna</i>		5
Little Lorikeet	<i>Glossopsitta pusilla</i>		1,5
Australian King-Parrot	<i>Alisterus scapularis</i>		5
★(V) Superb Parrot	<i>Polytelis swainsonii</i>		3
Cockatiel	<i>Nymphicus hollandicus</i>		1,5
Budgerigar	<i>Melopsittacus undulatus</i>		5
★(V) Swift Parrot	<i>Lathamus discolor</i>		1,3,5
Crimson Rosella	<i>Platycercus elegans</i>		1,2,5
Eastern Rosella	<i>Platycercus eximius</i>	×	1,2,4,5
Red-rumped Parrot	<i>Psephotus haematonotus</i>	×	1,2,5
Blue Bonnet	<i>Northiella haematogaster</i>		1
Cuculidae			
Pallid Cuckoo	<i>Cuculus pallidus</i>		1,5
Brush Cuckoo	<i>Cuculus variolosus</i>		5
Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>		1,2,5
+ Black-eared Cuckoo	<i>Chrysococcyx osculans</i>		1
Horsfield's Bronze-Cuckoo	<i>Chrysococcyx basalis</i>		1,5
Shining Bronze-Cuckoo	<i>Chrysococcyx lucidus</i>		1,5
Common Koel	<i>Eudynamis scolopacea</i>		5
Channel-billed Cuckoo	<i>Scythrops novaehollandiae</i>		1
Strigidae			
★(V) Powerful Owl	<i>Ninox strenua</i>		1,3
Southern Boobook	<i>Ninox novaeseelandiae</i>		1,2,5
Barking Owl	<i>Ninox connivens</i>		1?
Tytonidae			
Barn Owl	<i>Tyto alba</i>		1
★(V) Masked Owl	<i>Tyto novaehollandiae</i>		3
Podargidae			
Tawny Frogmouth	<i>Podargus strigoides</i>		1,2,5
★(V) Marbled Frogmouth	<i>Podargus ocellatus</i>		3
Apodidae			
+ White-throated Needletail	<i>Hirundapus caudacutus</i>		5
+ Fork-tailed Swift	<i>Apus pacificus</i>		1
Alcedinidae			
Azure Kingfisher	<i>Alcedo azurea</i>		1,5
Halcyonidae			
Laughing Kookaburra	<i>Dacelo novaeguineae</i>	×	1,2,5
Red-backed Kingfisher	<i>Todiramphus pyrrhopygia</i>		5
Sacred Kingfisher	<i>Todiramphus sanctus</i>		5
Meropidae			
Rainbow Bee-eater	<i>Merops ornatus</i>		5
Coraciidae			
Dollarbird	<i>Eurystomus orientalis</i>		5
Climacteridae			
White-throated Treecreeper	<i>Cormobates leucophaeus</i>		1,2,5
+ Brown Treecreeper	<i>Climacteris picumnus</i>		1

APPENDIX 4 contd Fauna species recorded in the study area at Marsden Park, or in the general vicinity.

COMMON NAME	SCIENTIFIC NAME	A	B
Maluridae			
Superb Fairy-wren	<i>Malurus cyaneus</i>	×	1,2,5
Variegated Fairy-wren	<i>Malurus lamberti</i>		5
Pardalotidae			
Spotted Pardalote	<i>Pardalotus punctatus</i>	×	1,4,5
Striated Pardalote	<i>Pardalotus striatus</i>		1,5
White-browed Scrubwren	<i>Sericornis frontalis</i>		1,2,5
+ Speckled Warbler	<i>Chthonicola sagittata</i>		1,5
Weebill	<i>Smicromis brevirostris</i>		1,5
Brown Gerygone	<i>Gerygone mouki</i>		1,5
Western Gerygone	<i>Gerygone fusca</i>		1
White-throated Gerygone	<i>Gerygone olivacea</i>		1,5
+ Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>		5
Brown Thornbill	<i>Acanthiza pusilla</i>		1,2,5
+ Buff-rumped Thornbill	<i>Acanthiza reguloides</i>		1,5
Yellow Thornbill	<i>Acanthiza nana</i>	×	2,4,5
Striated Thornbill	<i>Acanthiza lineata</i>		1,5
Meliphagidae			
Red Wattlebird	<i>Anthochaera carunculata</i>		2,5
Little Wattlebird	<i>Anthochaera chrysoptera</i>		1,2,5
Noisy Friarbird	<i>Philemon corniculatus</i>		1,5
Little Friarbird	<i>Philemon citreogularis</i>		5
★(E) Regent Honeyeater	<i>Xanthomyza phrygia</i>		1,3
Bell Miner	<i>Manorina melanophrys</i>		5
Noisy Miner	<i>Manorina melanocephala</i>	×	1,2,4,5
Lewin's Honeyeater	<i>Meliphaga lewinii</i>		5
Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>		1,2,5
White-eared Honeyeater	<i>Lichenostomus leucotis</i>		1,5
Yellow-tufted Honeyeater	<i>Lichenostomus melanops</i>		5
+ Fuscous Honeyeater	<i>Lichenostomus fuscus</i>		1,5
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>		1,2,5
Brown-headed Honeyeater	<i>Melithreptus brevirostris</i>		1,5
White-naped Honeyeater	<i>Melithreptus lunatus</i>		5
★(V) Painted Honeyeater	<i>Grantiella picta</i>		1,3
New Holland Honeyeater	<i>Phylidonyris novaehollandiae</i>		1,2,5
White-cheeked Honeyeater	<i>Phylidonyris nigra</i>		1,5
Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>		1,2,5
Scarlet Honeyeater	<i>Myzomela sanguinolenta</i>		1,5
Petroicidae			
Rose Robin	<i>Petroica rosea</i>		1,5
+ Scarlet Robin	<i>Petroica multicolor</i>		1,5
+ Red-capped Robin	<i>Petroica goodenovii</i>		1,5
+ Hooded Robin	<i>Melanodryas cucullata</i>		1
Eastern Yellow Robin	<i>Eopsaltria australis</i>		1,2,5
+ Jacky Winter	<i>Microeca fascians</i>		5
Cinclosomatidae			
Eastern Whipbird	<i>Psophodes olivaceus</i>		1,5
Neosittidae			
Varied Sittella	<i>Daphoenositta chrysoptera</i>		1,5
Pachycephalidae			
+ Crested Shrike-tit	<i>Falcunculus frontatus</i>		1,5
Golden Whistler	<i>Pachycephala pectoralis</i>		1,5
Rufous Whistler	<i>Pachycephala rufiventris</i>		1,2,5
Grey Shrike-thrush	<i>Colluricincla harmonica</i>		1,2,5
Dicruridae			
Black-faced Monarch	<i>Monarcha melanopsis</i>		1
Leaden Flycatcher	<i>Myiagra rubecula</i>		5
Satin Flycatcher	<i>Myiagra cyanoleuca</i>	×	1,5
+ Restless Flycatcher	<i>Myiagra inquieta</i>		1,2,5
Magpie-lark	<i>Grallina cyanoleuca</i>	×	1,2,4,5

APPENDIX 4 contd Fauna species recorded in the study area at Marsden Park, or in the general vicinity.

COMMON NAME	SCIENTIFIC NAME	A	B
Dicruridae contd			
Rufous Fantail	<i>Rhipidura rufifrons</i>		5
Grey Fantail	<i>Rhipidura fuliginosa</i>		1,2,5
Willie Wagtail	<i>Rhipidura leucophrys</i>	×	1,2,5
Spangled Drongo	<i>Dicrurus bracteatus</i>		1,5
Campephagidae			
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>	×	1,2,5
+ White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>		1,5
Cicadabird	<i>Coracina tenuirostris</i>		2
+ White-winged Triller	<i>Lalage sueurti</i>		1,5
Oriolidae			
Olive-backed Oriole	<i>Oriolus sagittatus</i>		1,2,5
Figbird	<i>Sphecotheres viridis</i>		5
Artamidae			
Masked Woodswallow	<i>Artamus personatus</i>		1,2
White-browed Woodswallow	<i>Artamus superciliosus</i>		1,5
Dusky Woodswallow	<i>Artamus cyanopterus</i>		1,5
Grey Butcherbird	<i>Cracticus torquatus</i>	×	1,2,4,5
Australian Magpie	<i>Gymnorhina tibicen</i>	×	1,2,4,5
Pied Currawong	<i>Strepera graculina</i>		1,2,5
Corvidae			
Australian Raven	<i>Corvus coronoides</i>	×	1,2,4,5
Torresian Crow	<i>Corvus orru</i>		1
Corcoracidae			
+ White-winged Chough	<i>Corcorax melanorhamphos</i>	×	1,5
Apostlebird	<i>Struthidea cinerea</i>		1
Ptilonorhynchidae			
Satin Bowerbird	<i>Ptilonorhynchus violaceus</i>		5
Motacillidae			
Richard's Pipit	<i>Anthus novaeseelandiae</i>		2,5
Alaudidae			
* Skylark	<i>Alauda arvensis</i>		5
Passeridae			
* House Sparrow	<i>Passer domesticus</i>	×	1,2,5
+ Zebra Finch	<i>Taeniopygia guttata</i>		5
Double-barred Finch	<i>Taeniopygia bichenovii</i>	×	1,2,5
Red-browed Finch	<i>Neochmia temporalis</i>		1,2,5
+ Diamond Firetail	<i>Stagonopleura guttata</i>		5
* Nutmeg Mannikin	<i>Lonchura punctulata</i>		1,5
+ Chestnut-breasted Mannikin	<i>Lonchura castaneothorax</i>		5
Fringillidae			
* European Goldfinch	<i>Carduelis carduelis</i>		1,5
* European Greenfinch	<i>Carduelis chloris</i>		2
Dicaeidae			
Mistletoebird	<i>Dicaeum hirundinaceum</i>		1,5
Hirundinidae			
White-backed Swallow	<i>Cheramoeca leucosternus</i>		1,5
Welcome Swallow	<i>Hirundo neoxena</i>	×	1,2,4,5
Tree Martin	<i>Hirundo nigricans</i>		1,2,5
Fairy Martin	<i>Hirundo ariel</i>	×	1,5
Pycnonotidae			
* Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>		1,2,5
Sylviidae			
Clamorous Reed-Warbler	<i>Acrocephalus stentoreus</i>	×	1,2,5

APPENDIX 4 contd Fauna species recorded in the study area at Marsden Park, or in the general vicinity.

COMMON NAME	SCIENTIFIC NAME	A	B
Sylviidae contd			
Little Grassbird	<i>Megalurus gramineus</i>		5
Golden-headed Cisticola	<i>Cisticola exilis</i>		1,5
+ Rufous Songlark	<i>Cincloramphus mathewsi</i>		5
+ Brown Songlark	<i>Cincloramphus cruralis</i>		5
Zosteropidae			
Silvereye	<i>Zosterops lateralis</i>		1,2,5
Muscicapidae			
+ Bassian Thrush	<i>Zoothera lunulata</i>		1,5
* Common Blackbird	<i>Turdus merula</i>		1,5
Sturnidae			
* Common Starling	<i>Sturnus vulgaris</i>	×	1,2,4,5
* Common Mynah	<i>Acridotheres tristis</i>	×	1,4,5
AMPHIBIANS			
Myobatrachidae			
Common Eastern Froglet	<i>Crinia signifera</i>	×	1,2
★(V) Giant Burrowing Frog	<i>Heleioporus australiacus</i>		3
Eastern Banjo Frog	<i>Limnodynastes dumerilii</i>		1
Brown-striped Frog	<i>Limnodynastes peronii</i>	×	1,2
Spotted Grass Frog	<i>Limnodynastes tasmaniensis</i>	×	1
★(V) Red-crowned Toadlet	<i>Pseudophryne australis</i>		3
+ Brown Toadlet	<i>Pseudophryne bibronii</i>		1
+ Smooth Toadlet	<i>Uperoleia laevisgata</i>		1?
Hylidae			
★(E) Green & Golden Bell Frog	<i>Litoria aurea</i>		1,3
Bleating Tree Frog	<i>Litoria dentata</i>		1,2
Eastern Dwarf Tree Frog	<i>Litoria fallax</i>	×	1,2
Freyinet's Frog	<i>Litoria freycineti</i>		1
Gunther's Frog	<i>Litoria latopalmata</i>		1
Lesueur's Frog	<i>Litoria lesueuri</i>		2
Rocket Frog	<i>Litoria nasuta</i>	×	
Peron's Tree Frog	<i>Litoria peronii</i>	×	1,2
Leaf Green Tree Frog	<i>Litoria phyllochroa</i>		1
Verreaux's Frog	<i>Litoria verreauxii</i>		1
REPTILES			
Chelidae			
Long-necked Tortoise	<i>Chelodina longicollis</i>	×	1
Gekkonidae			
Wood Gecko	<i>Diplodactylus vittatus</i>		1
Agamidae			
Jacky Lizard	<i>Amphibolurus muricatus</i>	×	2
Eastern Water Dragon	<i>Physignathus lesueuri</i>	×	1
Varanidae			
+ Lace Monitor	<i>Varanus varius</i>		1
Scincidae			
Striped Skink	<i>Ctenotus robustus</i>		1
Eastern Water Skink	<i>Eulamprus quoyii</i>		1,2
Garden Skink	<i>Lampropholis delicata</i>		1,2
Grass Skink	<i>Lampropholis guichenoti</i>	×	1,2
Eastern Blue-tongued Lizard	<i>Tiliqua scincoides</i>		1
Elapidae			
+ Common Death Adder	<i>Acanthophis antarcticus</i>		1
+ Red-naped Snake	<i>Furina diadema</i>		1
Red-bellied Black Snake	<i>Pseudechis porphyriacus</i>		1,2

APPENDIX 4 contd Fauna species recorded in the study area at Marsden Park, or in the general vicinity.

COMMON NAME	SCIENTIFIC NAME	A	B
Elapidae Eastern Brown Snake	<i>Pseudonaja textilis</i>		1
MAMMALS			
Tachyglossidae Short-beaked Echidna	<i>Tachyglossus aculeatus</i>	×	
Phascolarctidae ★(V) Koala	<i>Phascolarctos cinereus</i>		3
Petauridae ★(V) Yellow-bellied Glider Sugar Glider ★(V) Squirrel Glider	<i>Petaurus australis</i> <i>Petaurus breviceps</i> <i>Petaurus norfolcensis</i>	×	3 1,2 1,3
Pseudocheiridae Common Ringtail Possum	<i>Pseudocheirus peregrinus</i>	×	1
Phalangeridae Common Brushtail Possum	<i>Trichosurus vulpecula</i>		1
Macropodidae + Eastern Grey Kangaroo	<i>Macropus giganteus</i>		1
Pteropodidae Flying-fox Grey-headed Flying-fox	<i>Pteropus sp</i> <i>Pteropus poliocephalus</i>		1 1,2
Molossidae ★(V) Eastern Freetail Bat Freetail Bat White-striped Freetail Bat	<i>Mormopterus norfolkensis</i> <i>Mormopterus sp1</i> <i>Nyctinomus australis</i>	×	
Vespertilionidae ★(V) Large Bent-wing Bat Unidentified Long-eared Bat Gould's Wattled Bat Chocolate Wattled Bat ★(V) Large-footed Myotis ★(V) Greater Broad-nosed Bat Eastern Broad-nosed Bat Large Forest Bat Little Forest Bat	<i>Miniopterus schreibersii</i> <i>Nyctophilus sp</i> <i>Chalinolobus gouldii</i> <i>Chalinolobus morio</i> <i>Myotis adversus</i> <i>Scoteanax rueppellii</i> <i>Scotorepens orion</i> <i>Vespadelus darlingtoni</i> <i>Vespadelus vulturnus</i>	×	2,3 2 2 3 X? X? X? X?
Muridae * House Mouse * Black Rat	<i>Mus musculus</i> <i>Rattus rattus</i>		1 1
Introduced Mammals * Dog * Fox * Cat * Rabbit * Brown Hare * Horse * Cattle * Fallow Deer	<i>Canis familiaris</i> <i>Vulpes vulpes</i> <i>Felis catus</i> <i>Oryctolagus cuniculus</i> <i>Lepus capensis</i> <i>Equus caballus</i> <i>Bos taurus</i> <i>Dama dama</i>	×	1,2 1,2 1,2 1,2 1 1 2

PROPOSED QUARRY and LANDFILL
RICHMOND ROAD, MARSDEN PARK

FLORA & FAUNA ASSESSMENT

APPENDIX 5

Assessments of Significance under Section 5A of
the *Environmental Planning & Assessment Act 1979*

PROPOSED QUARRY and LANDFILL

RICHMOND ROAD, MARSDEN PARK

Assessments of Significance under Section 5A of the EP&A Act

March 1998

1 INTRODUCTION

The NSW Threatened Species Conservation Act 1995 (TSC Act) has modified the NSW Environmental Planning & Assessment Act 1979 (EP&A Act) by including (in Section 5A) eight factors which are to be considered when determining "whether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats" with respect to any "development" or "activity". These factors "must be taken into account" by a consent or determining authority in administering Sections 77, 90 and 112 of the EP&A Act.

This assessment addresses the proposal by Galian Pty Ltd to establish a non-putrescible landfill in a disused quarry off Richmond Road at Marsden Park, in western Sydney. To increase the current capacity of the proposed landfill, quarrying operations will be re-established prior to landfilling. Clay/shale and breccia will be extracted, increasing the depth and size of the existing quarry at this location. The project will also involve some stockpiling of materials, the construction of haul roads for both the quarry and landfill, and the establishment of a processing plant in the southeastern corner of the proposed disturbance area.

This assessment of the significance of potential impacts on threatened fauna or flora which could arise from activities on the proposed quarry and landfill site is based on information obtained for this report, data included in previous investigations conducted in the vicinity (Clements & Stephens 1989; Gunninah 1996; Mitchell McCotter 1996; NP&WS 1997) and database information (from the NP&WS Wildlife Atlas, AMBS and Birds Australia databases). The assessment is based on the proposed "activity", which includes implementation of the impact amelioration measures which are included in the main Fauna & Flora Assessment Report (*ie* these measures are an integral part of the "activity").

Two threatened microchiropteran bat species (the Large Bent-wing Bat and Eastern Freetail Bat) were positively identified in the study area (*ie* the whole landholding)¹. Two additional species (the Large-footed Myotis and Greater Broad-nosed Bat) were tentatively identified from Anabat recordings. No other threatened fauna species were recorded, and no threatened plant species were identified in the study area. However, the study area supports stands of Grey Box Woodland, a component community of Cumberland Plain Woodland², which has been listed as an Endangered Ecological Community by the NSW Scientific Committee.

In addition to the threatened fauna species recorded in the study area, a number of other species are known from the locality. Several threatened flora species are known from the locality, but none were recorded in the study area or on the subject site³. Whilst some of these species are not likely to occur, given a lack of suitable habitat requirements, a number of threatened species could (theoretically at least) utilise the study area on occasions, as discussed in the main report.

¹ The 'study area' comprises the whole property (bounded by South Street to the west, Fulton Road to the north, Richmond Road to the east and Hollinsworth Road to the south), as well as the subject site itself.

² Cumberland Plain Woodland occurs on soils derived from shale on the Cumberland Plain and comprises Map Units 9b (Spotted Gum Forest), 9c (Ironbark Forest), 10c (Grey Box Woodland) and 10d (Grey Box-Ironbark Woodland), as described by Benson (1992). Cumberland Plain Woodland (as defined by the NSW Scientific Committee) is dominated by one or more of the following canopy species: Grey Box *Eucalyptus moluccana*, Forest Red Gum *E. tereticornis*, Narrow-leaved Ironbark *E. crebra*, Thin-leaved Stringybark *E. eugenioides* and Spotted Gum *Corymbia maculata*.

³ The 'subject site' is defined as the actual area that is likely to be directly affected by the "activity", comprising the quarry itself, and the immediately surrounding area which is proposed for quarrying, haul roads and other infrastructure

2 FACTORS for CONSIDERATION

- (a) **in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction**

A "threatened species" is defined in the TSC Act as "a species specified in Part 1 or 4 of Schedule 1 or in Schedule 2" of the Act.

No threatened flora species were identified in the study area during the current or previous investigations. Consequently, no "viable local population" of any threatened flora species is present, and no such population can be "placed at risk of extinction" by the proposal.

- (b) **in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised**

An "endangered population" is defined in the TSC Act as "a population specified in part 2 of Schedule 1".

At the time of preparation of this report, no relevant "endangered population" of any species of native flora has been defined (ie there is no "endangered population" in the immediate vicinity). Consequently, this issue is not of relevance to the proposed quarry and landfill project at Marsden Park.

- (c) **in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed**

Region is defined in the TSC Act as "a bioregion defined in a national system of bioregionalisation that is determined (by the Director-General by order published in the Gazette) to be appropriate for those purposes". The only "national system of bioregionalisation" which has been universally adopted by state and federal government authorities is the *Interim Biogeographic Regionalisation for Australia* (IBRA), published by the Australian Nature Conservation Agency (now Environment Australia). This has been identified as the relevant definition of "region" for the TSC Act by the NP&WS Director-General (24th of May 1996).

On the basis of the IBRA, the study area is located within the Sydney Basin region, which stretches from approximately Batemans Bay in the south to Port Stephens in the north, and includes essentially the whole of the Hunter Valley, the Sydney Basin and the Blue Mountains.

Whilst no "known habitat" for any threatened flora species was identified during the field investigations, two of the component vegetation communities of Cumberland Plain Woodland (an "endangered ecological community" as defined by the NSW Scientific Committee) occurs in the study area and on the subject site.

The "regional distribution" of Cumberland Plain Woodland is defined by the NSW Scientific Committee as involving the Local Government Areas (LGAs) of Auburn, Bankstown, Baulkham Hills, Blacktown, Camden, Campbelltown, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta, Penrith and Wollondilly. The proposed quarry and landfill on the Marsden Park subject site is located within the Blacktown LGA.

The NSW Scientific Committee indicates that "only 6% of the original extent of the community remain in 1988" (citing Benson & Howell 1990), which has been estimated to

comprise approximately 7000 hectares. The stand on the Marsden Park site has been included in that mapping, and doubtless forms part of that estimate (derived from the mapping of Benson 1992).

However, only an extremely small portion of the Grey Box Woodland which occurs in the study area will be removed. Furthermore, the area of Grey Box woodland which is to be removed from the subject site is highly modified and weed-infested, having been subjected to long-term grazing and other disturbances.

Whilst the Marsden Park study area may support "*a significant area of known habitat*" (or at least a notable area) for Cumberland Plain Woodland², in terms of the "*regional distribution of habitat*", only an extremely small area is to be removed from the subject site for the proposed "*activity*". This small area cannot be regarded as constituting "*a significant area of known habitat*", particularly given the extent of larger tracts of relevant woodland to remain both in the study area and in the general vicinity. On this basis, the area of vegetation to be "*modified or removed*" as a result of the proposed development is not considered of significance "*in relation to the regional distribution of the habitat*" for this community.

With respect to the potential for this development to contribute to a significant cumulative impact upon Cumberland Plain Woodland in western Sydney, it is of relevance to note:

- the extremely small extent of Grey Box Woodland to be removed;
- its highly disturbed and degraded condition;
- the extent of other stands to remain both in the study area and in the general locality which are in better condition (and are either already reserved or are unlikely to be developed);
- and the absence of any features or elements within the regenerating stands on the site which could be considered of particular significance.

As a consequence, removal of this small portion of Grey Box Woodland is not regarded as likely to contribute significantly to the adverse cumulative impacts upon Cumberland Plain Woodland.

Conversely, a commitment to reductions in clearing and grazing in the stands of woodland to remain in the study area, and replanting and regeneration programs to link currently isolated stands of vegetation, will increase the conservation value of the stands on the Marsden Park site, and will contribute to the conservation of this community in the region.

There is no likelihood that, "*in relation to the regional distribution*" of potential or suitable habitat, "*a significant area of known habitat is to be modified or removed*" for any threatened flora species, "*population or ecological community*" by the proposed "*activity*".

(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

The study area comprises cleared agricultural land with isolated patches of remnant and regenerating woodland present in several locations. As a result of the long-term clearing and habitat modification which has occurred in the study area, the remnant stands of Cumberland Plain Woodland² are already fragmented and isolated from each other, and from other stands in the locality.

Given that the proposed development will involve the direct removal of only a very small area of native vegetation, there is no potential for an "*area of known habitat*" to "*become isolated from currently interconnecting or proximate areas of habitat*" for Cumberland Plain Woodland, beyond the isolation which currently exists.

² Cumberland Plain Woodland occurs on soils derived from shale on the Cumberland Plain and comprises Map Units 9b (Spotted Gum Forest), 9c (Ironbark Forest), 10c (Grey Box Woodland) and 10d (Grey Box-Ironbark Woodland), as described by Benson (1992). Cumberland Plain Woodland (as defined by the NSW Scientific Committee) is dominated by one or more of the following canopy species: Grey Box *Eucalyptus moluccana*, Forest Red Gum *E. tereticornis*, Narrow-leaved Ironbark *E. crebra*, Thin-leaved Stringybark *E. eugenioides* and Spotted Gum *Corymbia maculata*.

(e) whether critical habitat will be affected

The TSC Act defines "critical habitat" as "habitat declared to be critical habitat under Part 3" of the Act.

At the time of preparation of this report, no "critical habitat" had been declared by the Director-General of the NSW NP&WS. As a consequence, it is not possible to assess whether "critical habitat will be affected" by the proposed development.

(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In general, threatened flora species are not likely to be "adequately conserved in conservation reserves (or other similar protected areas) in the region". Furthermore, it is unlikely that there are sufficient data available from the NP&WS to indicate the adequacy of representation in conservation reserves of most of the threatened species which may occur in the study area.

With respect to Cumberland Plain Woodland, the NSW Scientific Committee states that "although some areas [of Cumberland Plain Woodland] occur within conservation reserves, this in itself is not sufficient to ensure the long-term conservation of the Community unless the factors threatening the integrity and survival of the community are ameliorated". The NSW Scientific Committee does not provide a list of the conservation reserves in which Cumberland Plain Woodland may be found. Representatives of the array of vegetation communities which comprise Cumberland Plain Woodland are known to occur in the Scheyville and Cattai National Parks, Castlereagh Nature Reserve, Mulgoa Nature Reserve, and a number of other Nature Reserves and reserved Crown Lands. Despite the listing by the NSW Scientific Committee of Cumberland Plain Woodland as an "endangered ecological community", it would appear that the adequacy of conservation of this community has not yet been properly assessed.

Irrespective of the above considerations, the small and highly degraded nature of vegetation which is to be affected by the proposed development is not regarded as of consequence with respect to the conservation of threatened flora species or Cumberland Plain Woodland "in the region".

(g) whether the development or activity is of a class of development or activity that is recognised as a threatening process

The TSC Act defines "threatening process" as "a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities".

Schedule 3 of the TSC Act is intended to provide a list of the threatening processes which are regarded of relevance to the Act and its implementation. Activities and actions currently listed or being considered for listing by the NSW Scientific Committee as a "threatening process" include:

- the bycatch of seabirds resulting from long-line fishing;
- predation by the European Red Fox *Vulpes vulpes*; and
- the removal of bush rock.

None of these threatening processes are of relevance to the proposed "activity".

Whilst clearing and residential development are generally regarded as threatening processes for native fauna and flora, and the NSW Scientific Committee notes that "threats to the survival of the community [Cumberland Plain Woodland] include clearance for ... housing and other developments", there are no mechanisms or protocols for assessing the significance of any proposed development or activity with respect to this or any other endangered ecological community. With respect to the small and heavily grazed portion of Grey Box Woodland to be affected on the Marsden Park subject site, its removal is not

regarded as constituting a threat to the survival of Cumberland Plain Woodland in the general locality or throughout its distribution.

(h) whether any threatened species, population or ecological community is at the limit of its known distribution

Given that Cumberland Plain Woodland is defined by the NSW Scientific Committee as involving the Local Government Areas of Auburn, Bankstown, Baulkham Hills, Blacktown, Camden, Campbelltown, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta, Penrith and Wollondilly, the stand of this community in the study area at Marsden Park is not located "*at the limit of its known distribution*" (Benson 1992).

The threatened flora species known from the vicinity occur in western Sydney (on the Cumberland Plain), and are consequently likely to have a similar or wider distribution to that of Cumberland Plain Woodland, as described above. Consequently, no threatened flora species or ecological community known from the general vicinity would be "*at the limit of its known distribution*" in the study area, even if present.

3 FACTORS for CONSIDERATION

- (a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

SPECIES RECORDED in the STUDY AREA

Two threatened microchiropteran bat species (the Large Bent-wing Bat and Eastern Freetail Bat) were positively identified in the study area, and two additional species (the Large-footed Myotis and Greater Broad-nosed Bat) were tentatively identified from Anabat recordings. Despite a substantial survey effort for microchiropteran bats and records for both of these latter species in the general locality, neither could not be positively identified, and it is not possible to determine whether a "*viable local population*" of either species occurs in the study area.

The Large Bent-wing Bat requires caves or man-made structures (such as mine shafts, tunnels and human habitations) in which to roost. Such features are not present in the study area and, whilst these species obviously utilises the study area for foraging, it is considered unlikely that "*a viable local population*" of this species relies on the limited resources to be affected by the proposed activities. Furthermore, foraging resources will remain both in the study area and in the immediate vicinity, and this species will not be "*placed at risk of extinction*" by the proposed quarry and landfill.

The Large-footed Myotis roosts in tunnels, culverts, caves and occasionally in tree-hollows. No roosting sites for this species are present on the subject site, and it is not likely that "*a viable local population*" of the Large-footed Myotis is present on or reliant the site. This species, or any "*viable local population*" of this species, will not be "*placed at risk of extinction*" as a result of the proposed activity.

The Eastern Freetail Bat and Greater Broad-nosed Bat roost in tree-hollows. Whilst the study area supports numerous small tree-hollows, the small area of vegetation to be removed for the proposed quarry and landfill largely consists of semi-mature and juvenile trees, which have not yet reached hollow-forming age. Consequently, no roosting resources of value for these or other species will be removed as a result of the proposed activity.

The study area provides a range of foraging resources for microchiropteran bats. The Eastern Freetail Bat, Large Bent-wing Bat and Greater Broad-nosed Bat hunt flying insects from around and above the tree canopy and over water bodies, which generally supply a concentrated source of insects. The Large-footed Myotis forages over bodies of water, scraping the surface for aquatic invertebrates and small fish with its large feet. All of these species are likely to utilise the existing quarry and the several farm dams in the study area for foraging, roosting either in the surrounding vegetation and tree-hollows or off-site in other more suitable areas. Although a potentially valuable foraging resource for these species (in particular for the Large-footed Myotis) will be removed, the other farm dams and wetlands both in the study area and in the general locality will continue to provide resources for these species. Furthermore, the majority of the woodland in the study area will be retained and will continue to provide foraging and roosting resources for those species which currently occur.

On the basis of the extent of suitable habitat for all of these microchiropteran bats to remain both in the study area and in the general locality, the life cycle of no microchiropteran bat species will be "*disrupted*" such that a "*viable local population*" will be "*placed at risk of extinction*".

SPECIES LIKELY to OCCUR

A variety of threatened bird species are known from the general locality, and whilst some species are likely to occur in the study area on occasions, a number of these additional

species are not likely to occur, given their specific habitat requirements and usual distributions (as discussed in the main report).

Of the species which are likely to occur, most are highly mobile and wide-ranging (such as the Powerful and Masked Owls and Square-tailed Kite) or nomadic (such as the Swift Parrot and Regent and Painted Honeyeaters). The Bush Stone-curlew is also a potential inhabitant of the study area. No evidence for a "*viable local population*" (or even a single individual) of any of these species was recorded in the study area. On the basis that the majority of the woodland which currently exists in the study area will be retained, and given the extent of similar habitat in the immediate vicinity (Shanes Park and the ADI site), none of these species will be "*placed at risk of extinction*", even if present on occasions.

A range of threatened waterbirds are known from the locality (including the Blue-billed and Freckled Ducks, Black Bittern and Painted Snipe), some of which could utilise the existing quarry and the other farm dams and wetlands in the study area and general vicinity. Again, no evidence for a "*viable local population*" of any of these species was obtained during field investigations, and these species are more likely to rely on Bakers, Bushells and Pitt Town Lagoons and McGraths Hill Sewage Treatment Plant to the north of the study area. Even if present on occasions, the general lack of resources in the existing quarry (such as riparian and aquatic vegetation to provide shelter) would reduce its value for these species, and it is considered highly unlikely that any species of waterbird would be "*placed at risk of extinction*" by the proposed quarry and landfill.

Of the additional species known from the locality (as discussed in the main report and in Appendix 4), the only ones which are considered potential inhabitants of the study area are the Green & Golden Bell Frog, the Squirrel Glider and the Large Land Snail. Although the study area does provide suitable habitats and resources for all of these species, no evidence for a "*viable local population*" (or even a single individual) was observed, despite targeted surveys. Even if present, the limited extent of clearing required, and the disturbed nature of the woodland to be removed would limit the potential for impact on the Squirrel Glider or Large Land Snail. Although the old quarry does appear to provide potentially suitable habitat for the Green & Golden Bell Frog, there was no evidence for a "*viable local population*" of this species in this locality (despite surveys under appropriate conditions). On the basis of the limited requirement for clearing of native vegetation, and given that a variety of habitat resources of value for these species will remain both in the study area and in the general locality, none of these species will be "*placed at risk of extinction*" as a result of the proposed quarry and landfill.

There was no evidence in the study area for a "*viable local population*" of any of these additional species, and although some may occur on an occasional or transitory basis, habitat will remain in the general locality (including in the study area) and will continue to provide resources for those species which do occur. The habitat features present are not restricted to the study area, but occur widely throughout the general locality, and in many cases are of better quality elsewhere. Given that suitable habitat will remain both in the study area and in the general locality, it is not likely that "*a viable local population*" of any of these additional threatened fauna species would be "*disrupted*" by the proposed activities.

- (b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised**

An "*endangered population*" is defined in the TSC Act as "*a population specified in part 2 of Schedule 1*".

At the time of preparation of this report, no relevant "*endangered population*" of any fauna or flora species has been defined. Consequently, this issue is not of relevance to the proposed quarry and landfill at Marsden Park.

- (c) **in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed**

Region is defined in the TSC Act as "a bioregion defined in a national system of bioregionalisation that is determined (by the Director-General by order published in the Gazette) to be appropriate for those purposes". The only "national system of bioregionalisation" which has been universally adopted by state and federal government authorities is the *Interim Biogeographic Regionalisation for Australia* (IBRA), published by the Australian Nature Conservation Agency (ANCA). This has been identified as the relevant definition of "region" for the TSC Act by the NP&WS Director-General (24th of May 1996).

On the basis of the IBRA, the study area is located within the Sydney Basin region, which stretches from approximately Batemans Bay in the south to Port Stephens in the north, and includes essentially the whole of the Hunter Valley, the Sydney Basin and the Blue Mountains.

The study area at Marsden Park supports "known habitat" for two threatened microchiropteran bats (the Eastern Freetail Bat and Large Bent-wing Bat), and potential habitat for two others (the Large-footed Myotis and Greater Broad-nosed Bat). All of these species (both positively and tentatively recorded) are known from throughout the Sydney Basin Bioregion, and are not restricted to the vicinity of the study area. Furthermore, microchiropteran bats are highly mobile and relatively wide-ranging, and given the small area of suitable habitat to be removed, and the presence of suitable habitat to remain in the study area, in the immediate vicinity (eg Shanes Park to the west) and in the general locality (including on the ADI site and Castlereagh State Forest), a "significant area of known habitat" will not be "modified or removed" for any of these species, in terms of the "regional distribution of habitat".

Similar considerations apply to other threatened fauna species which could potentially or theoretically occur on the subject site. There is no likelihood that the site, or the resources "to be modified or removed" constitute a "significant area of known habitat" for any threatened fauna.

- (d) **whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community**

The study area comprises cleared agricultural land with isolated stands of remnant and regenerating woodland present in several locations. As a result of the long-term clearing and habitat modification which has occurred in the study area and in the general locality, the remnant woodland stands are already fragmented and isolated from each other, and from other stands in the locality. This existing fragmentation would restrict the movement of less mobile fauna species (such as gliders and other arboreal mammals and small terrestrial species) between forested areas within the study area and patches of remnant woodland to the east and west.

Conversely, highly mobile microchiropteran bats (such as those recorded in the study area) and birds would be largely unaffected by the existing fragmentation which currently occurs. Furthermore, the limited removal of vegetation required for the proposed activities will not impose any barriers to movement for these species.

Given that the proposed development will involve the direct removal of only a very small area of native vegetation, there is no potential for an "area of known habitat" to "become isolated from currently interconnecting or proximate areas of habitat" for any species, beyond the isolation which currently exists.

- (e) **whether critical habitat will be affected**

The TSC Act defines "critical habitat" as "habitat declared to be critical habitat under Part 3" of the Act.

At the time of preparation of this report, no "critical habitat" had been declared by the Director-General of the NSW NP&WS. As a consequence, it is not possible to assess whether "critical habitat will be affected" by the proposed activity.

(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In general, threatened fauna species are not likely to be "adequately conserved in conservation reserves (or other similar protected areas) in the region". Furthermore, it is unlikely that there are sufficient data currently available from the NP&WS to indicate the adequacy of representation in conservation reserves of most of the threatened species which may occur in the study area.

Whilst all of the threatened fauna species recorded in the study area and general locality doubtless occur within National Parks or other conservation reserves in the region (the Sydney Basin region, as defined above), or are likely to do so, it is generally considered unlikely that any of these species would be "adequately represented" in such reserves. Moderate to large home-ranges and wide-ranging habits for some species (eg the Powerful Owl, Regent Honeyeater, Swift Parrot and microchiropteran bats), and (in many cases) a relatively sparse abundance and/or localised concentrations, even where relatively widely distributed (eg the Squirrel Glider), indicates that conservation reserves are generally unlikely to support significant populations of most or all of these species.

(g) whether the development or activity is of a class of development or activity that is recognised as a threatening process

The TSC Act defines "threatening process" as "a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities".

Schedule 3 of the TSC Act is intended to provide a list of the threatening processes which are regarded of relevance to the Act and its implementation. Activities and actions currently listed or being considered for listing by the NSW Scientific Committee as a "threatening process" include:

- the bycatch of seabirds resulting from long-line fishing;
- predation by the European Red Fox *Vulpes vulpes*; and
- the removal of bush rock.

None of these threatening processes are of relevance to the proposed "activity".

Whilst clearing and residential development are generally regarded as threatening processes for native fauna, there are no mechanisms or protocols for assessing the significance of any proposed development with respect to threatened fauna species. Furthermore, given the extremely small extent and the already disturbed condition of the woodland to be removed in the study area, the activities are unlikely to significantly contribute to the "threatening process[es]" acting on any threatened fauna species.

(h) whether any threatened species, population or ecological community is at the limit of its known distribution

All of the threatened microchiropteran bat species recorded, or tentatively identified, in the study area are distributed widely along the east coast of Australia. The Large Bent-wing Bat is distributed from Cape York to the Mount Lofty Ranges in South Australia (Dwyer 1995), the Eastern Freetail Bat occurs from southern Queensland to southern NSW (Allison & Hoyer 1995), the Greater Broad-nosed Bat occurs from Cape York to northeastern Victoria (Hoyer & Richards 1995) and the Large-footed Myotis is distributed widely along the coast of Australia, from northern Western Australia to the southeast of South Australia (Richards 1995).

Similarly, all of the species which are known from the general locality, and which may utilise the study area on occasions, are distributed relatively widely (although in many cases sparsely) throughout the region.

Consequently, no species of threatened fauna is "*at the limit of its known distribution*" in the study area.

4 CONCLUSIONS

The eight factors which are required to be considered under Section 5A of the EP&A Act in the determination of "*whether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats*" as a result of the proposed activity at Marsden Park are discussed in detail above.

Two species of threatened fauna (the Large Bent-wing Bat and the Eastern Freetail Bat) were positively identified in the study area. In addition, the Large-footed Myotis and Greater Broad-nosed Bat were tentatively recorded. Whilst some resources of relevance for these species will be removed, in particular the existing quarry, a range of habitat features will remain both in the study area and general locality. Given the highly mobile and wide-ranging nature of microchiropteran bats, and the extent of suitable habitat for these species in the locality, the removal of habitat associated with the proposed activities is highly unlikely to adversely affect the long-term survival of these species, either in the general locality or region. No other threatened fauna are known to occur on the site, and there is no likelihood of "*a significant effect*" being imposed upon any such species.

No threatened flora species were recorded on the subject site or in the study area. On this basis, the proposed activity will not impose "*a significant effect*" on any species of threatened flora.

With regard to Cumberland Plain Woodland, component vegetation communities of this "*endangered ecological community*" occur throughout the study area. However, only an extremely small proportion of the stand in the study area will be removed as a result of the proposed quarry, with the remainder being retained as a visual buffer. The likelihood that the proposed quarry and landfill will adversely affect the conservation status of Cumberland Plain Woodland is considered extremely small. Conversely, amelioration measures to be implemented throughout the study area may increase the quality of the remnant woodland.

On the basis that no "*significant effect*" will be imposed upon any "*threatened species, populations or ecological communities, or their habitats*", a Species Impact Statement is not required for the proposed development at Marsden Park.

APPENDIX 5 NOISE ASSESSMENT

Prepared by:
RICHARD HEGGIE ASSOCIATES PTY LTD



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Standards Australia

REPORT 7244-R1

Revision: 1

**NOISE IMPACT ASSESSMENT
PROPOSED EXTRACTION/LANDFILL OPERATIONS
AT MARSDEN PARK**

Prepared for

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20 April 1998

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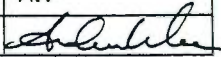
Quality System

Richard Heggie Associates Pty Ltd operates under a Quality System which has been certified by Quality Assurance Services Pty Limited to comply with all the requirements of ISO 9001:1994 "Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation and Servicing" (Licence No 3236).

This document has been prepared in accordance with the requirements of that System.

Association of Australian Acoustical Consultants - AAAC

Richard Heggie Associates is a Member Firm of the Association of Australian Acoustical Consultants.

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NOISE IMPACT ASSESSMENT PROPOSED EXTRACTION/LANDFILL OPERATIONS AT MARSDEN PARK

ENVIRO-MANAGERS PTY LTD

1 INTRODUCTION

Ganian Pty Ltd are seeking approval to operate a quarry and landfill operation at the site of a former quarry off Windsor Road, Marsden Park as shown in the Area Map presented as **Appendix A**.

The entire project site occupies a total area of approximately 141.65 Ha. The quarrying and landfilling operations are limited to an area of less than 12 Ha.

The existing former quarry site is partially filled with water and will be dewatered prior to the commencement of works. It is proposed to extract clay/shale and breccia material in 10 m benches commencing from the northern end of the existing quarry and progressing south. Excavation will extend to a Relative Level (RL) of approximately 0 m.

Quarry product will be transported by truck to the processing area in the south-east corner of the site, as shown in **Appendix B**. Once quarrying has progressed south, so that a clear distance of 100 m is established, landfilling operations will commence. At all times a 100 m separation buffer distance will be maintained.

It is expected that the material will be amenable to ripping and priority will be given to ripping rather than blasting. However, if blasting is to occur, then no blasting will be conducted on the first two working bench levels.

In relation to the potential noise and vibration associated with the site operation, Richard Heggie Associates (RHA) have been commissioned to assess the likely impacts on the surrounding residential receivers from the proposed extraction/landfilling operations.

2 SITE LAYOUT OPERATIONS

2.1 Site Layouts

Appendix B presents the location and layout of the former quarry, the extent of future extraction, the location of the processing plant and the internal road access.

2.2 Major Plant Items

A processing plant will be established (refer to **Appendix B**) which will comprise a primary jaw crusher, a secondary cone crusher and a tertiary impactor. A series of screen decks will separate the various size materials comprising: dust (less than 5 mm); oversize; 75 mm, 40 mm and 20 mm base materials; fill; and paving base material. Stock piles of product will be no greater than 8 m high (approximately 1500 tonne).

The following mobile plant will be used in association with the landfill/quarry operations;

- 475 Komatsu Dozer
- CAT 966 (or equivalent) Loaders (2 off)
- 30 t Dump Truck
- 30 t Excavator
- Sheeps foot - Compactor
- Water Truck
- 450 KVA Generator for weighbridge and administration
- Processing Plant
- Drill
- A pugmill may be located on site to product a stabilised road base

2.3 Proposed Hours of Operation

The facility will operate during the following hours:

Day of Operation	Quarry	Landfill
Monday to Friday	6.00 am to 6.00 pm	6.00 am to 6.00 pm
Saturdays	6.00 am to 12.00 noon	7.00 am to 4.00 pm
Sundays	n/a	9.00 am to 3.00 pm

In addition to the above hours, maintenance will be conducted on an as needed basis commencing 12.00 noon on Saturdays.

2.4 Traffic Flows

All vehicles entering the site will enter from Richmond Road and follow a dedicated internal route to the landfill or quarry area. Vehicles accessing the quarry and landfilling operations will share a common section of the internal road up to the weighbridge, where separate routes will be adopted.

Generally, vehicles accessing the landfilling operations will enter the site by travelling around the southern perimeter of the existing operations, whilst vehicles accessing quarrying areas will head north after the weighbridge.

The expected vehicle movements to and from the site are presented in the table below:

Table 2.4.1 Vehicle Movements

Quarry Operations		Landfill Operations	
Daily Average	Peak 1 hour flow	Daily Average	Peak 1 hour flow
40	8	40	8

There will be minimal car movements associated with the quarry operations. For the purpose of this assessment, it is assumed that all vehicles are classed as trucks. A breakdown of the vehicle mix using the landfill operations has been estimated at:

- 21% Cars and cars with trailers etc
- 63% Open trucks
- 16% Closed trucks

A traffic survey conducted by the RTA on Richmond Road (near Grange Street) in 1993 indicated that the Annual Average Daily Traffic (AADT) flow was 18,587 vehicles. It has been assumed that traffic has increased at an annual average rate of 3%.

2.5 Nearby Residential Receivers and Topography

The project site is centred about a former sand and gravel quarry. There are a small number of commercial/residential areas surrounding the site, which can be described as follows:

- To the north, approximately midway between Fulton Road and Glengarrie Road, is an established piggery and residence.
- A poultry farm and factory to the north-northeast of the site.
- A caravan park due south of the site.
- Three residences on Hollingsworth Road, south to east-southeast of the site.
- The subdivision of Shalvey, located south of the site, beyond the railway corridor reserved for the Castlereagh Freeway.

To the north of the site the land is mildly undulating to flat, increasing to a gently undulating topography to the south.

3 QUARRYING AND LANDFILL OPERATIONS

3.1 Introduction

Following the implementation of the proposed development, three main operations will take place at the site:

- Extraction of clay shale and breccia.
- Material not suitable for use as road base and/or brickmaking will be stockpiled to the north east for later use as cover material.
- Filling the air space created with solid waste imported to the site in combination with overburden from the extraction process.
- Rehabilitating the site after each stage of the landfill is complete and the land has been re-contoured to levels equivalent to the height of existing stockpiles (RL 52 m)

3.2 Staging

Production of quarry products will be a maximum of 300,000 tonnes per annum. Landfill disposal will be approximately 5,000 to 10,000 tonnes per month initially, increasing to 30,000 tonnes per month over approximately 5 years.

4 EXISTING ACOUSTICAL ENVIRONMENT

4.1 General

In order to quantify the existing acoustical environment in the areas surrounding the proposed operations, ambient noise surveys were conducted over the period Friday 14 November 1997 to Friday 24 November 1997.

There are currently no operations being conducted at the site. The results of the noise monitoring are therefore representative of the background noise environment. These background noise levels can be used to determine the operational noise limits in accordance with the procedure contained in the EPA's Environmental Noise Control Manual.

Two of the existing premises representative of those potentially most affected by the proposed quarrying and landfilling operations were selected for ambient noise monitoring. These premises are shown on the site map (refer to **Appendix B**) and are described in **Table 4.1.1**.

Table 4.1.1 Ambient Noise Monitoring Locations

Location	Residence	Monitoring Duration
Location A	311 South Street	Friday 14 November 1997 to Monday 24 November 1997
Location B	Hollingsworth Road (representative of the Caravan Park)	Friday 14 November 1997 to Monday 24 November 1997

Ambient noise monitoring procedures were conducted in accordance with Australian Standard 1055-1989, "Acoustics - Description and Measurement of Environmental Noise" and the Environment Protection Authority's (EPA) Environmental Noise Control Manual.

ARL Environmental noise loggers were deployed at each of the nominated receiver locations in order to obtain continuous statistical noise exceedance levels over consecutive 15 minute intervals. The noise loggers were calibrated before and after measurement surveys and the variation in calibration did not exceed ± 0.5 dBA.

The results from the two monitoring locations are presented graphically in **Appendices C and D** respectively.

4.2 Statistical Analysis

Environmental noise levels vary with time and consequently it is necessary to describe the noise in terms of statistical descriptors. The noise exceedance levels commonly used are:

- LA1 Noise level exceeded for 1% of the sample time (loudest 9 seconds).
- LA10 Noise level exceeded for 10% of the sample time, and is commonly referred to as the average maximum noise level.
- LA90 The noise level exceeded for 90% of the interval period and is commonly referred to as the average minimum or background noise level.
- LAeq Is the equivalent continuous sound pressure level and represents the steady sound level which is equal in energy to the fluctuating level over the interval period.

4.3 Ambient Noise Survey Results

A summary of the "minimum repeated" background LA90 noise levels at each of the monitoring locations for a range of periods in which the quarrying and landfill operations may occur is presented in **Table 4.3.1**.

Table 4.3.1 Summary of Existing Minimum Repeated Ambient LA90 Noise Levels

Location	EPA Daytime			EPA Night-time	
	Mon to Fri 7.00 am to 6.00 pm	Sat 7.00 am to 4.00 pm	Sun 9.00 am to 3.00 pm	Sat 6.00 am to 7.00 am	Mon to Fri 6.00 am to 7.00 am
311 South Street	39 dBA	41 dBA	41 dBA	43 dBA	45 dBA
Hollingsworth Road	34 dBA	38 dBA	34 dBA	37 dBA	39 dBA

5 AIRBORNE NOISE IMPACT ASSESSMENT PROCEDURES

5.1 Airborne Noise Emission General Objectives

Responsibility for the control of noise emissions in New South Wales is vested in Local Government and the Environment Protection Authority (EPA) which administers the Noise Control Act, 1975. In implementing its environmental noise control policy, the EPA has two broad objectives:

- That the noise from any single source does not intrude greatly above the prevailing background noise level.
- That the background noise level does not exceed the level appropriate for the particular locality and land use.

5.2 Quarry Operation Noise Emission Design Goal

To assist in balancing possibly adverse effects on individuals and potential benefits to the broader community arising from infrastructure development and resource use (especially in the light of its social worth or as a result of government decisions), the Environment Protection Authority (EPA) has drafted a schedule of recommended LA90 background noise levels for various land-use categories. An extract from the schedule relating to the three most stringent classifications appears in **Table 5.2.1**.

Table 5.2.1 EPA Recommended Outdoor Background Noise Levels

Zoning Description	Time Period	Recommended Limit - LA90	
		Acceptable	Maximum
Residences in Rural Areas (approximately R1 in AS 1055)	Day Night	45 dBA 35 dBA	50 dBA 40 dBA
Residences in Residential Areas (approximately R1 - R2 in AS 1055)	Day Night	45 dBA 35 dBA	50 dBA 40 dBA
Residential area on a busy road or near an industrial area (approximately R2 - R3 in AS 1055)	Day Night	50 dBA 40 dBA	55 dBA 45 dBA

- Notes: 1 For Monday to Saturday, "day" is defined at 7.00 am to 10.00 pm
 2 On Sundays and Public Holidays, "day" is defined as 8.00 am to 10.00 pm

In order to satisfy Item a. of **Section 5.1**, the EPA recommends that the LA10 noise level contribution from the source or sources under consideration should not exceed the LA90 background level by more than 5 dBA.

In localities where there is likely to be ongoing industrial or commercial development, consideration also needs to be given to the cumulative effects of noise from successive development in order to avoid what is known as a "creeping background noise" effect.

For quarrying or landfill operations, where only a few plant items are being used, experience indicates that the LA10 is usually the controlling design goal.

The results of the LA90 ambient noise measurements at the nominated locations in the vicinity of the project site are presented in **Table 4.2.1**. On the basis of the minimum repeated LA90 ambient noise levels and in accordance with the EPA's Environmental Noise Control Manual (Chapter 20), the acceptable LA10 contributed noise level design goals for the proposed hours of operation are presented in **Table 5.2.3**

Table 5.2.3 EPA Acceptable LA10 Contributed Noise Level Design Goals

Location	EPA Daytime			EPA Night-time	
	Mon to Fri 7.00 am to 6.00 pm	Sat 7.00 am to 4.00 pm	Sun 9.00 am to 3.00 pm	Sat 6.00 am to 7.00 am	Mon to Fri 6.00 am to 7.00 am
311 South Street	44 dBA	46 dBA	46 dBA	48 dBA	50 dBA
Hollingsworth Road	39 dBA	43 dBA	39 dBA	42 dBA	44 dBA

5.3 Road Traffic Noise Design Goals

In the vicinity of privately owned property, the noise assessment procedure adopted for product and waste trucks is as outlined in **Section 5.2**, that is, the predicted LA10 noise contributions are added to the predicted LA10 noise level of the items of mobile equipment and processing plant and compared to the design goal.

Away from the quarrying operations, when vehicles travel on public roads (or when the trucks are on a private access road where the noise emission characteristics would be perceived in a similar fashion to normal traffic), different criteria apply for vehicle noise impact assessment.

The EPA's criteria for truck operations on roads having traffic flows of less than about 1,000 vehicles per day are described under the section "Intermittent or Low Traffic Flow" in Chapter 157 of its Environmental Noise Control Manual. The noise level descriptor employed is LAeq,T and the time interval generally used is 60 minutes.

The EPA's preferred hours for truck movements are presented in Table 5.3.1.

Table 5.3.1 EPA's Preferred Hours for Truck Movements

Frequency of Vehicle Movement	Preferred Hours of operation	
	Monday to Saturday	Sunday and Public Holidays
Normal frequency	0700 hr to 1800 hr	Minimal movement, subject to individual assessment
At substantially reduced frequency	0600 hr to 0700 hr 1800 hr to 2200 hr	0800 hr to 1800 hr
Minimal or isolated occurrence	2200 hr to 0600 hr	1800 hr to 0800 hr

For rural situations, the EPA recommends that residences should not be exposed to an $L_{Aeq,T}$ of more than 50 dBA for new developments and 55 dBA for existing operations during daytime hours. During night-time hours (10.00 pm to 7.00 am) the received $L_{Aeq,T}$ criterion for truck movements is generally taken as being 5 dBA less than the criterion applying to daytime operations.

On roads with existing traffic flows greater than about 1,000 vehicles per day, the EPA advocates the use of the Calculation of Road Traffic Noise (CORTN) method to evaluate the $LA_{10(18hour)}$ noise levels for existing traffic flows and proposed increased traffic volumes.

The criteria generally recommended are that the increases in the $LA_{10(18hour)}$, due to traffic generated by a proposed development, does not exceed 2 dBA. Also, that the overall maximum $LA_{10(18hour)}$ traffic noise level does not exceed 63 dBA. This latter environmental goal is almost numerically equivalent to the RTA's 60 dBA $L_{Aeq(24hour)}$ design goal for new roads.

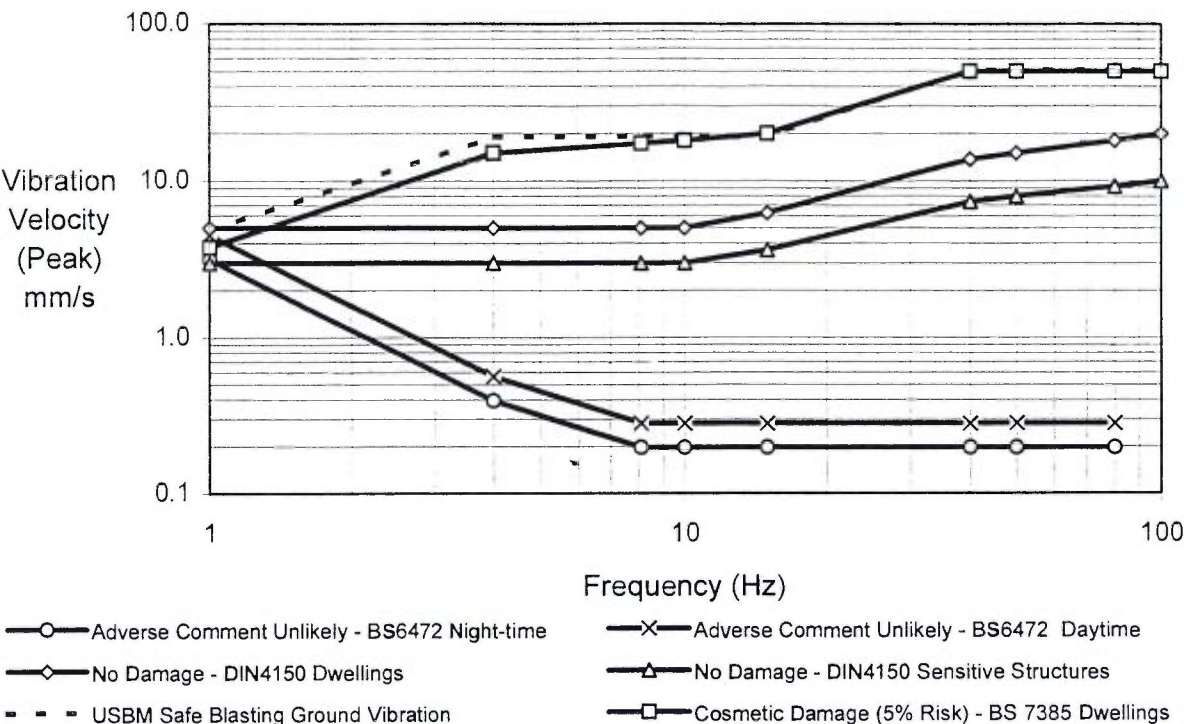
6 BLAST EMISSIONS CRITERIA

6.1 Human Comfort and Disturbance Considerations

The ground vibration and airblast levels which cause concern or discomfort to residents are significantly lower than the damage limits. Humans are far more sensitive to some types of vibration than is commonly realised. They can detect and possibly even be annoyed at vibration levels which are well below those causing any risk of damage to a building or its contents.

Figure 6.1.1 illustrates this difference in susceptibility by comparing widely accepted human disturbance criteria (BS 6472) with various threshold damage levels (DIN 4150, US Bureau of Mines, BS 6472 and BS 7385).

Figure 6.1.1 Human Disturbance Criteria and Building Damage Limits



Notes: BS 6472 "Adverse Comment" disturbance criteria are for continuous vertical vibration at point of entry to body DIN 4150 "No Damage" threshold criteria are peak particle velocity on building footings BS 7385 5% Risk of Cosmetic Damage criteria are peak particle velocity on building footings (or in ground nearby) US Bureau of Mines Safe Blasting criteria are peak particle velocity in the ground.

The recommended criteria for blasting in NSW, based on human discomfort, are contained in the EPA's Noise Control Manual (Chapter 154). The limiting criteria for the control of blasting impact at residences is reproduced in **Table 6.1.1**.

Table 6.1.1 Limiting Criteria for the Control of Blasting Impact at Residences

Time of Blasting	Airblast (dB Linear)	Ground Vibration, Peak Particle Velocity (mm/sec)
Monday - Saturday 0900 hrs to 1500 hrs	115	5
Monday - Saturday 0600 hrs to 0900 hrs 1500 hrs to 2000 hrs	105	2
Sunday and Public Holidays Any day 0600 hrs to 2000 hrs 2000 hrs to 0600 hrs	95	1

Airblast exceedance is to be limited to 120 dB (Linear) for not more than 5% of the total number of blasts.

Ground vibration exceedance is to be limited to 10 mm/s (PPV) for not more than 5% of the total number of blasts.

The Australian Standard 2187.2-1993 does not give human comfort criteria for ground vibration from blasting. It does however make mention of human comfort level for airblast in saying that "A limit of 120 dB for human comfort is commonly used".

Note: The 95 dB to 105 dB airblast levels set down by the EPA for extended hours or weekends are considered overly restrictive, and are lower than the thresholds at which building occupants would perceive any appreciable effect of the blast event. Should blasting be anticipated to occur during periods when these limits would apply, then application should be made to the EPA (with supporting technical data), for a variation in the limits.

6.2 Effects of Blasting on Animals

6.2.1 Poultry

The most extensive relevant studies found on the effects of blast emission from blasting were those of the effects of sonic booms from aircraft on poultry (sonic booms being similar in character to airblast from blasting).

Over 600 low-level missions were flown eleven poultry farms all having two or more poultry barns housing over 10,000 birds in each which produced sound pressure levels of between 85 dB to 140 dB within the barns. During the overflights the bird community stopped their usual activities and exhibited what could be termed an "alert" reaction. They quietened down, attempted to locate the source of the noise, and then either maintained their position or moved away from the area from which the aircraft was approaching.

Crowding and piling up was never a problem. No injured, smothered, or crushed birds were ever seen falling on overflight. There was no evidence from production records that egg production, weight gains, feed efficiency or flock mortality were altered by the aerial operations.

A second study, by Stadleman, showed that aircraft noise of 96 dB inside an incubator and 131 dB outside caused no damaging effects to eggs. Sounds of 115 dB did, however, interrupt the setting tendencies of broody hens. His experiments with day-old broiler chicks continuing through to market age showed no adverse effect from recorded aircraft noise.

6.2.2 Swine

To determine possible harmful effects of aircraft noise (similar in character to airblast from blasting), pigs, boars, and sows were exposed to reproduced aircraft and other loud sounds at various stages of the life cycle. The swine unit, animals, and diets used were typical of those found at most swine production operations.

The typical reaction of a nursing sow to the sounds was initial alarm during which she arose to her feet and appeared to search for the source of sound, followed by resumption of suckling by the baby pig and apparent indifference to the sound. When suckling pigs were exposed to the sound in the absence of the dam they appeared to be alarmed and crowded together. No differences were detected in the responses to the various sounds used; sounds of frequencies ranging from 200 Hz to 5 kHz at 100 dB to 120 dB intensity elicited like responses, while the effect of a recorded squeal of a baby pig reproduced at 100 dB was similar to that of the other sounds used.

Measurements of heart rate before, during and after sound exposure were made of a large number of weaning pigs to supplement the prior production results. These studies showed that the heart rate was significantly increased during exposure but that it decelerated rapidly after the sound was discontinued while the pattern of the electrocardiogram appeared to be unchanged. In trials in which previously unexposed pigs were exposed to loud noise, differences in response between intensities ranging from 100 dB to 130 dB were just below the level of significance. A significant intensity effect was found when previously exposed animals were subjected to sounds of 120 dB, 130 dB and 135 dB. No significant difference was found in responses of unexposed pigs to frequencies ranging from 50 Hz to 2 kHz at 110 dB to 120 dB.

6.2.3 Effects of Noise and Blasting on Farm Animals

One of the earliest studies (Ely and Petersen 1941) directly related to this area of research was a study concerned primarily with the factors involved in the ejection of milk in an effort to learn why cows habitually "let down" or "hold up" their milk. In one phase of their study, these researchers created fright stimuli caused by exploding paper bags every 10 seconds for 2 minutes just prior to attaching the mechanical milker. Such stimuli resulted in an immediate cessation of milk ejection. Thirty minutes after the fright stimuli, hand milking produced only 70% of the normal amount of milk. Intrajugular injections of adrenalin produced somewhat the same results.

A later study (US Department of Agriculture 1957) was conducted to determine if there was any measurable effect of jet aircraft noise and flyovers on the milk production of dairy herds. Data covering a period of 12 months were obtained on the daily milk deliveries from 182 herds located within three miles of 8 Air Force bases using jet aircraft. An analysis of data from 42 herds did not show any evidence that flyovers or proximity to the ends of the active runways had an effect on the milk production of the herds.

In another study (Casaday and Lehmann 1967) animal installations were selected for observations on animal behaviour under sonic boom conditions. Observers were stationed to watch specified groups of animals (including lactating dairy cattle) and to note behaviour patterns of the animals just prior to, during and immediately following each boom. They also noted disturbances caused by low flying aircraft used in noise tests.

Results of the study showed that the reactions of the sheep and horses to sonic booms were slight. Dairy cattle were little affected by sonic booms (125 dB to 136 dB). Only 19 of 104 booms produced even a mild reaction, as evidenced by a temporary cessation of eating, raising of heads, or slight startle effects in a few of those being milked. Milk production was not affected during the test period, as evidenced by total and individual milk yield.

7 MAJOR SOURCES OF BLASTING AND AIRBORNE NOISE EMISSION

The major sources of noise emissions may be grouped into three distinct areas for the purpose of impact assessment and are as follows:

- a. Noise emission from quarrying and landfilling operations, ie mobile equipment and product trucks.
- b. Noise emission from traffic on public roads ie product trucks.
- c. Overpressure and ground borne vibration from blasting

8 ASSESSMENT OF AIRBORNE NOISE IMPACTS

8.1 Evaluation of Noise Emission Levels - General Discussion

In order to determine the acoustical impact of the quarrying, landfilling and product transportation operations, a computer model was developed incorporating the significant noise sources, the surrounding terrain and nearby potentially affected receivers and, where required, noise mitigation.

A computer model was prepared using the Environmental Noise Model (ENM) Version 3.06, program, a commercial software system developed in conjunction with the State Pollution Control Commission of NSW (now the EPA). The acoustical algorithms utilised by this software result in this noise model being one of the most appropriate predictive methodologies currently available.

The model calculated the maximum contributed noise emission levels (approximately equivalent to an L_{A1} level) in octave bands from each source to the receiver locations considered potentially most affected by the quarrying project.

Based on field measurements of noise emissions from large resource excavation/processing projects, the difference between the maximum overall level and the average maximum (LA10) noise levels can be up to about 10 dBA, depending on the number of items of mobile equipment, their relative contributions and the variation in the intensity of the work. The difference between the maximum overall and LA10 noise levels for small quarries/landfilling operations is greater than the difference arising from large operations as the former is more sporadic and variable in nature. The variation between the calculated maximum overall level and the LA90 can also be highly variable.

For plant and equipment items of the number and operational nature as those at the subject site, a conservative reduction of 8 dBA has been applied to convert the maximum overall noise emission to an LA10 level.

All calculations were based on "neutral" atmospheric conditions in accordance with the EPA's requirements

8.2 Landfill and Quarry Operations

Noise levels for items of mobile equipment operating on the site were based on our library of in-house measurements. A summary of the overall sound power levels used in the model are:

□	Komatsu Dozer	116 dBA
□	CAT 966 Loader	110 dBA
□	30 t Excavator	105 dBA
□	30 Tonne Dump Truck	111 dBA
□	Sheeps foot compactor	110 dBA
□	Water Truck	110 dBA
□	Hydraulic Track Drill	120 dBA
□	Primary Jaw Crusher	121 dBA
□	Secondary Cone Crusher	115 dBA
□	Tertiary Impactor	116 dBA

The mobile equipment for quarrying and landfilling were located at representative locations for the various stages of the operation, with all mobile plant items operating at or near maximum load. It is therefore considered that predicted noise levels are representative of the "worst-case" scenarios for the various stages.

Subsequently, as the depths of extraction increase, the received noise levels will decrease due to the acoustic shielding provided by the intervening topography.

The location of the mobile equipment for each modelling scenario are summarised in **Table 8.2.1**.

Table 8.2.1 Location of Mobile Equipment for Noise Modelling Scenarios

Scenario and Stage	Location / Description
Scenario 1, Stage 1 (Initial Quarrying works)	Initial quarrying operations, with all plant on existing ground levels. No landfilling operations yet in progress.
Scenario 1, Stage 2 (Quarrying and Landfilling)	Landfilling operations at final RL levels, whilst quarrying operations at approximately one-half operating depth
Scenario 2, Stage 1 (Quarrying and Landfilling)	Landfilling and quarrying operations approximate 2/3 of maximum operating depth
Scenario 2, Stage 2 (Quarrying and Landfilling)	Landfilling operations at final RL levels. Quarrying operation at one bench height down
Scenario 3, Stage 1 (Quarrying and Landfilling)	Landfilling operations at existing ground heights, whilst quarrying operations at one bench height down from existing ground level
Scenario 3, Stage 2 (Landfilling only)	No quarrying operations, with all landfilling operations at floor of pit.
Scenario 3, Stage 3 (Landfilling Only)	No quarrying operations, with all landfilling operations at final RL levels.

The resultant overall A-weighted sound pressure levels have been calculated to the three potentially most affected residential receivers.

Considering the maximum overall sound power detailed earlier in this section, the contributed LA10 noise emission levels are presented in **Table 8.2.2**.

Table 8.2.2 Predicted LA10 Noise Emission Contributions - Quarrying and Landfilling

Receiver Location	Operation	Scenario 1 Stage 1	Scenario 1 Stage 2	Scenario 2 Stage 1	Scenario 2 Stage 2	Scenario 3 Stage 1	Scenario 3 Stage 2	Scenario 3 Stage 3
Hollingsworth Road	Landfilling and quarrying	39 dBA	39 dBA	33 dBA	39 dBA	39 dBA	37 dBA	42 dBA
	Quarrying only	38 dBA	36 dBA	28 dBA	34 dBA	28 dBA	-	-
Caravan Park	Landfilling and quarrying	43 dBA	43 dBA	40 dBA	47 dBA	44 dBA	41 dBA	48 dBA
	Quarrying only	42 dBA	29 dBA	29 dBA	42 dBA	30 dBA	-	-
311 South Street	Landfilling and quarrying	44 dBA	46 dBA	33 dBA	41 dBA	32 dBA	30 dBA	36 dBA
	Quarrying only	43 dBA	28 dBA	28 dBA	37 dBA	29 dBA	-	-

Impact Assessment

The **Tables 8.2.3 to 8.2.5** summarises the extent of exceedances that the contributed LA10(15minute) noise emission levels presented in **Table 8.2.2** exceed the EPA criteria discussed in **Section 5.2**.

Table 8.2.3 Exceedances of the LA10 Noise Criteria - Hollingsworth Road Residence

Scenario	Exceedance of EPA's LA10 Noise Criterion				
	Mon to Fri 6.00 am to 7.00 am	Mon to Fri 7.00 am to 6.00 pm	Sat 6.00 am to 7.00 am	Sat 7.00 am to 4.00 pm	Sun 9.00 am to 3.00 pm
<i>LA10 Design Goals</i>	44 dBA	39 dBA	42 dBA	43 dBA	39 dBA
Scenario 1 Stage 1	-	-	-	-	-
Scenario 1 Stage 2	-	-	-	-	-
Scenario 2 Stage 1	-	-	-	-	-
Scenario 2 Stage 2	-	-	-	-	-
Scenario 3 Stage 1	-	-	-	-	-
Scenario 3 Stage 2	-	-	-	-	-
Scenario 3 Stage 3	-	3 dBA	-	-	3 dBA

Table 8.2.4 LA10 Exceedances of the Noise Criteria - 311 South Street Residence

Scenario	Exceedance of EPA's LA10 Noise Criterion				
	Mon to Fri 6.00 am to 7.00 am	Mon to Fri 7.00 am to 6.00 pm	Sat 6.00 am to 7.00 am	Sat 7.00 am to 4.00 pm	Sun 9.00 am to 3.00 pm
<i>LA10 Design Goals</i>	50 dBA	44 dBA	48 dBA	46 dBA	46 dBA
Scenario 1 Stage 1		-	-	-	-
Scenario 1 Stage 2		2 dBA	-	-	-
Scenario 2 Stage 1		-	-	-	-
Scenario 2 Stage 2		-	-	-	-
Scenario 3 Stage 1		-	-	-	-
Scenario 3 Stage 2		-	-	-	-
Scenario 3 Stage 3		-	-	-	-

Table 8.2.5 LA₁₀ Exceedances of the Noise Criteria - Caravan Park

Scenario	Exceedance of EPA's LA ₁₀ Noise Criterion				
	Mon to Fri 6.00 am to 7.00 am	Mon to Fri 7.00 am to 6.00 pm	Sat 6.00 am to 7.00 am	Sat 7.00 am to 4.00 pm	Sun 9.00 am to 3.00 pm
<i>LA₁₀ Design Goals</i>	44 dBA	39 dBA	42 dBA	43 dBA	39 dBA
Scenario 1 Stage 1	-	4 dBA	-	-	-
Scenario 1 Stage 2	-	4 dBA	-	-	4 dBA
Scenario 2 Stage 1	-	1 dBA	-	-	1 dBA
Scenario 2 Stage 2	3 dBA	8 dBA	-	4 dBA	6 dBA
Scenario 3 Stage 1	-	5 dBA	-	1 dBA	5 dBA
Scenario 3 Stage 2	-	2 dBA	-	-	2 dBA
Scenario 3 Stage 3	4 dBA	9 dBA	-	7 dBA	9 dBA

- For the residence on Hollingsworth Road, the predicted LA₁₀(15minute) noise emissions from the operation of the facility complies with the EPA's criteria, except for some minor exceedances (of up to 3 dBA) in the final stages of the development
- Predicted LA₁₀(15minute) noise emission contributions at the residence in South Street, exceed the criteria by up to 2 dBA when the landfilling operations are above the existing ground level, for the initial phase of the project. As the landfill operations move south, the top edge of the landfill will provide an acoustical barrier to the residence, shielding the next phase of the works.
- At the Caravan Park a number of exceedances of the noise criteria are predicted when the landfilling operations approach or are higher than the existing ground level. Exceedances of up to 9 dBA are predicted over the various stages of the development.

In order to minimise the number of noise exceedances detailed above, the following management practices and mitigation measures should be examined:

- a. A permanent "lip" to be maintained on the working level of the landfill site, of minimum height 4 m, along the southern limit. The construction of this lip should commence when the landfill is within 3 m of the existing ground level and be maintained as the working length increases. Depending upon the location and RL of the plant within the development site, this will provide up to 6 dBA additional attenuation to the receivers.
- b. Earth mounds are to be constructed along the northern and southern sections of the processing area. The minimum height is to be 2 m above the top of the highest unit. The extent of barriers will need to be refined in the detailed design phase, when the orientation and associated process operations have been fully determined. This is expected to provide between 10 dBA and 12 dBA attenuation to the residents in 311 South Street and to the Caravan Park.
- c. Field tests should be conducted to of all plant items and an examination made of all mobile plant items to determine the feasibility to installing high performance exhaust mufflers and engine inlet louvres to each of the mobile plant units used in the landfill operation.
- d. A low to medium height earth mound of minimum height 2.5 m (acting as an acoustical barrier) should be constructed along the southern side of the access road to the landfill site in the vicinity of the former quarry site. This will provide a minimum 5 dBA additional attenuation to the Caravan Park from truck movements to and from the landfill operations.
- e. All truck access routes near the landfill and quarrying areas should be free of pot holes and regularly graded.
- f. The quarrying operations are expected to comply with all the LA10 criteria (assuming no truck movements) in the 6.00 am to 7.00 am period on Saturdays. It is however recommended that all early morning Saturday (6.00 am to 7.00 am) quarrying activities be limited to activities which are located at or below the first bench height.

The incorporation of the above recommendations are expected to result in compliance with the EPA's noise emission levels at the residences at 311 South Street and Hollingsworth Road.

At the Caravan Park, the exceedances detailed in **Table 8.2.5** would be substantially eliminated for the Scenario 1 and Scenario 2 conditions which we modelled.

During the final stages of the development, the noise mitigation measures detailed above will assist in minimising any impact. During this period, the noise emissions from the development will frequently comply with the EPA guidelines however, even with the incorporation of the noise control measures, operational noise exceedances of up to 5 dBA may be expected, depending upon the working level and location of the various plant items. Exceedances of this magnitude are likely to have the highest impact during the morning period, 6.00 am to 7.00 am rather than through the daytime period.

The magnitude of exceedances indicated in **Table 8.2.5** may result for short periods whilst construction of the "lip" detailed in (a) above is being constructed, as during this time no shielding from the topography is being provided.

8.3 Traffic Noise

The nearest residence to the access road is located on Richmond Road.

The 1993 Average Annual Daily Traffic (AADT) flow figures for Richmond Road are 18,587. These figures have been increased assuming a normal yearly growth of 3%. The CORTN method was adopted to predict the change in the LA10(18hour) (or LAeq(24hour)) noise level due to the contribution to the traffic volume from external truck movements associated with the operations.

The closest residence to the facility on Richmond Road appears to be located approximately 15 m from the traffic stream. Based on the CORTN methodology, and the production capacity detailed **Table 2.4.1**, an increase of less than 0.1 dBA has been calculated of the daily traffic (LAeq(24hour)) noise level. Assuming the maximum flow occurs during the night-time period, an increase in the LAeq(1hour) noise level of 0.2 dBA is expected. This increase is well within the recommended 2 dBA tolerance limit.

9 ASSESSMENT OF BLAST EMISSION IMPACTS

9.1 Indicative Blast Design and Levels

The maximum production rate will be approximately 300,000 tonnes per annum. A proposed production blast design has therefore been developed to meet this production rate.

The blast pattern, consisting of 2 rows of 13 holes, has been designed to comply with the ground vibration and airblast limits at the nearby residential receiver locations. This blast design allows for one blasthole per delay producing a maximum instantaneous charge (MIC) of 13 kg.

A summary of the blast design parameters as detailed in **Table 9.1.1**.

Table 9.1.1 Proposed Blast Design Details

Blast Design Parameter	Typical Dimension
Hole Diameter	76 mm
Burden	3.9 m
Spacing	4.1 m
Charge Length	m
Stemming Depth	2.2 m
Delay Timing	none
Column Explosive	ANFO
Powder Factor	0.08 kg/m ³
Subdrilling	none
Bench Height	10 m
Decking	1 m
Hole angle to vertical	10°
Maximum Instantaneous Charge (MIC)	13 kg

Each of the two charges (per hole) will require individual delay detonators.

By adopting the suggested blast design, the level of blast emissions can be predicted using Figure J3 of AS 2187-1993, applicable to free face blasting in "average field conditions". A similar approach is advocated by ICI Australia in regard to prediction of airblast emissions. The relevant formulae used are as follows:

$$\begin{aligned} \text{PVS} &= 1140 (R/Q^{0.5})^{-1.6} \\ \text{dB} &= 164.2 - 24(\log_{10} R - 0.33 \log_{10} Q) \end{aligned}$$

Where,

$$\begin{aligned} \text{PVS} &= \text{Peak Vector Sum ground vibration level (mm/s)} \\ \text{dB} &= \text{Peak airblast level (dB Linear)} \\ R &= \text{Distance between charge and receiver (m)} \\ Q &= \text{Charge mass per delay (kg)} \end{aligned}$$

The relationship between distance and the peak vector sum (PVS) ground vibration and peak airblast from blasting on the subject site are presented in **Figure 9.1.1** and **Figure 9.1.2** respectively, for a maximum instantaneous charge weight of 13 kg.

Figure 9.1.1 Peak Vector Sum Ground Vibration

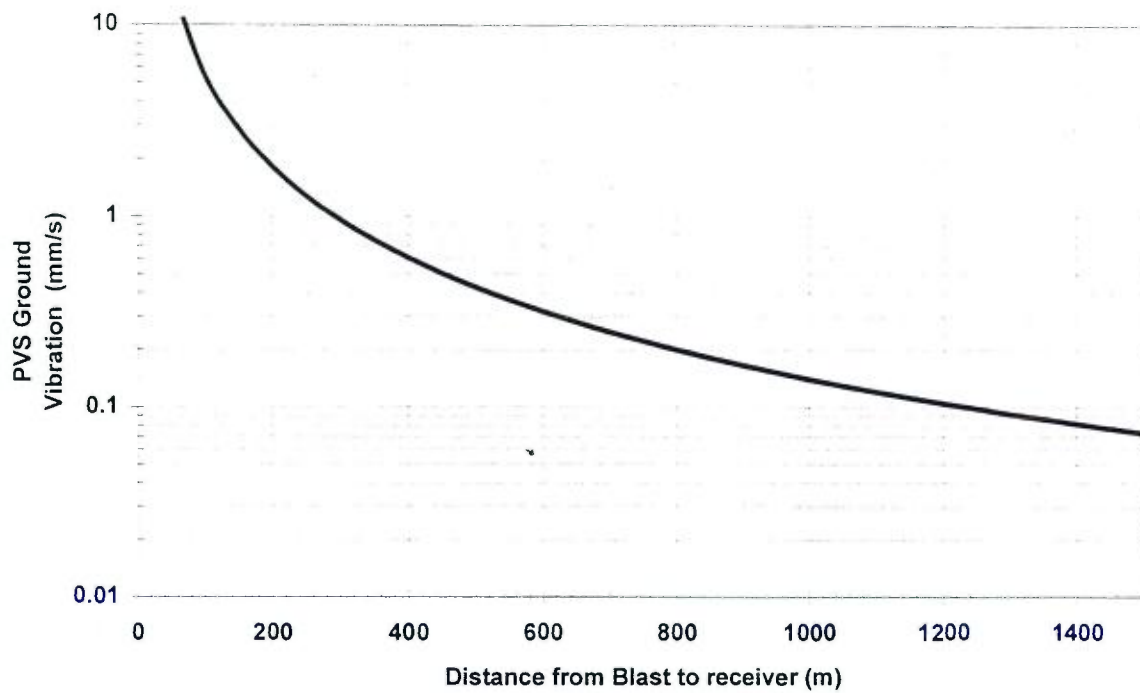
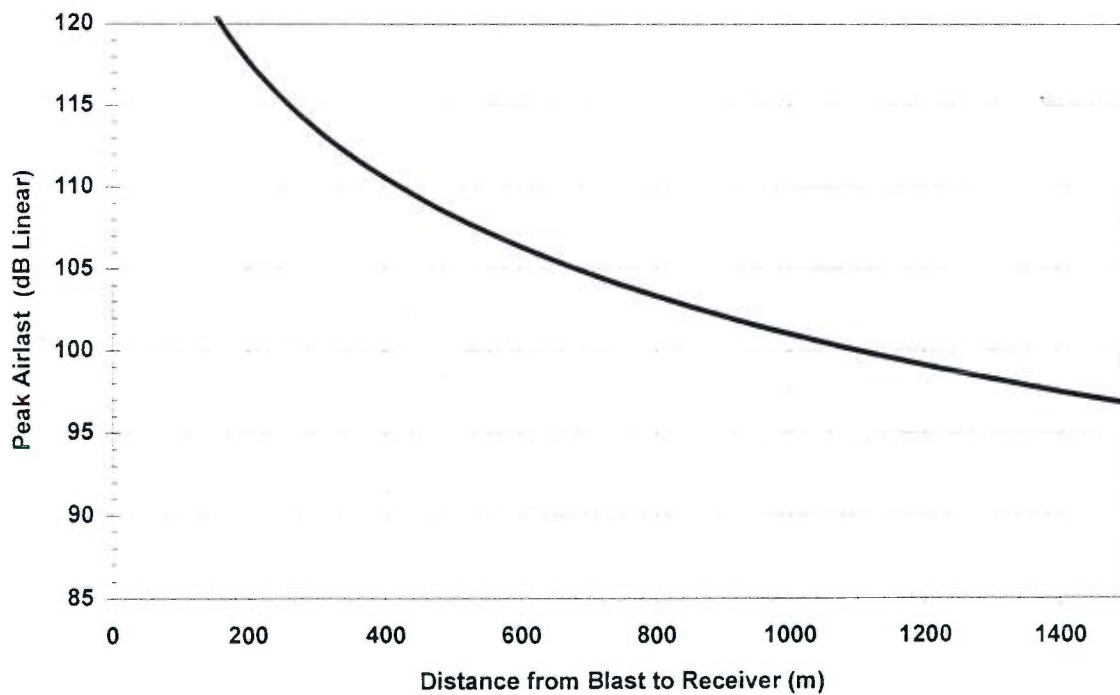


Figure 9.1.2 Peak Airblast



The predicted level of blast emissions at the nearest potentially affected properties can be determined using the appropriate distances to extractive areas provided in **Table 9.1.1**. The predicted levels of PVS ground vibration velocity and peak airblast based on an MIC of 13 kg are presented in **Table 9.1.1** for the blast location in closest proximity to the property.

Table 9.1.1 Predicted Levels of Blast Emission

Residence	Distance from Blasting	PVS Ground Vibration Velocity	Peak Airblast
311 South Street	490 m	0.4 mm/s	109 dB Linear
Caravan Park	265 m	1.8 mm/s	115 dB Linear
Hollingsworth Road	880 m	0.2 mm/s	102 dB Linear

9.2 Impact of Blast Emissions

The following information is derived from the predicted levels of blast emissions given in **Table 9.1.1**:

- The predicted levels of ground vibration at all nearby properties comply with the EPA human comfort criterion of 5 mm/s.
- The maximum predicted ground vibration level of 1.78 mm/s occurs at the Caravan Park and clearly complies with even the stringent structural damage criterion recommended for historic buildings of 3 mm/s to 5 mm/s.
- The predicted levels of peak airblast at all properties comply with the recommended EPA general human comfort criterion of 115 dB Linear.
- The predicted levels of peak airblast are therefore well below the US Bureau of Mines structural damage limit of 132 dB Linear (2 Hz cut off).
- Given the close proximity of blasting operations, and the possibility that blast emission levels may, at times, exceed the predicted levels, it is recommended that a thorough blast emission monitoring programme be implemented for the duration of the proposed quarry operation.

10 CONCLUSION

Richard Heggie Associates was commissioned to conduct a noise and vibration impact assessment of the proposed quarry and landfilling operations at the site of a former quarry off Windsor Road, Marsden Park.

Noise emissions from the operations have the potential to adversely impact on the acoustical amenity of the caravan park located south of the site. Specific noise control measures will be required in order to minimise potential noise exceedance and any associated impact. A range of management practices and mitigation measures are presented in **Section 8.2** of this report.

The traffic noise associated with the vehicular access to the site complies with the appropriate EPA guidelines.

Airblast and ground vibration generated by the possible adoption of blasting practices can be designed to comply with the requirements of the EPA subject to appropriate practices being adopted, as detailed in **Section 9.1**.

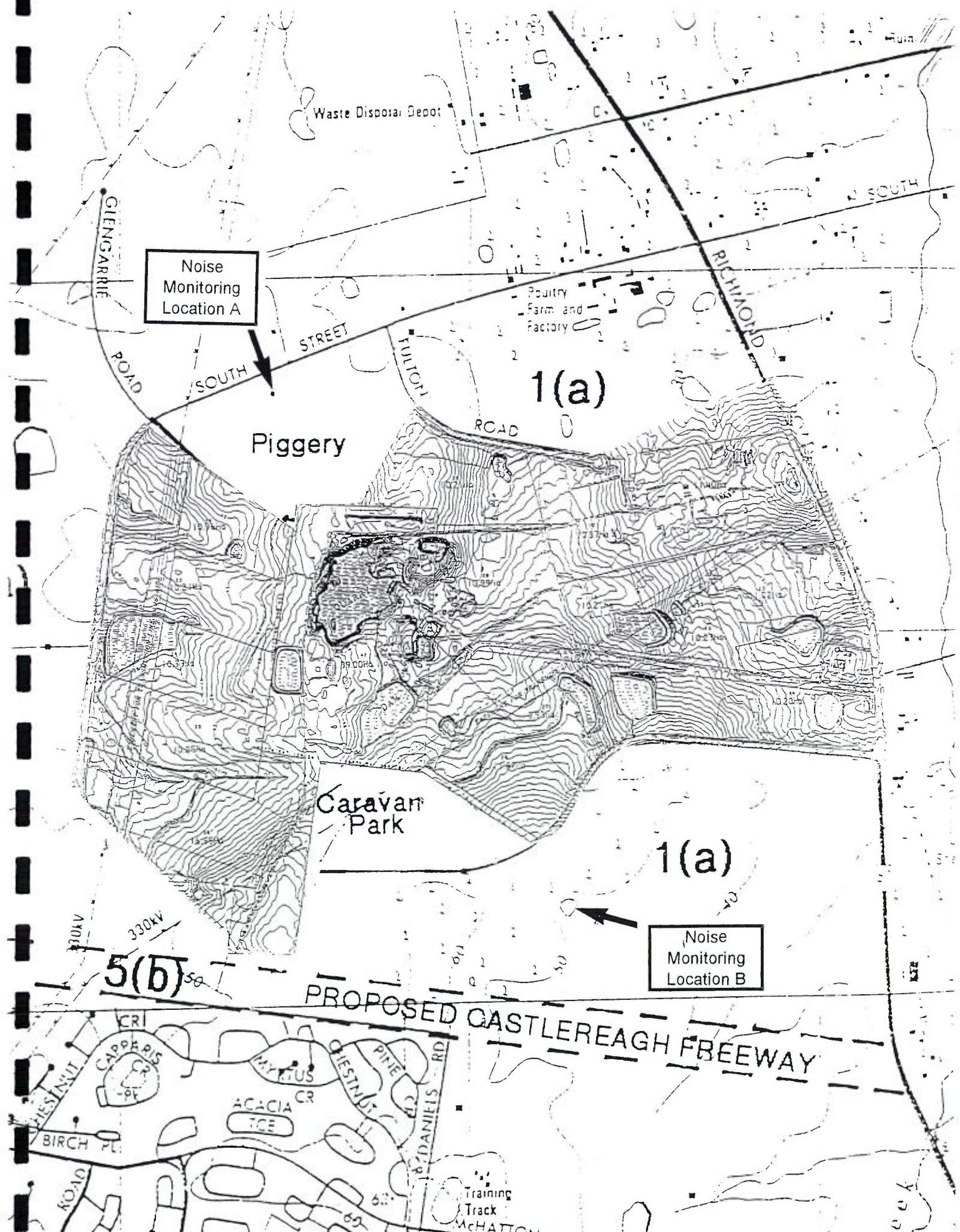
The implementation of the noise and management measures detailed in **Section 8.2**, will result in compliance with the EPA guidelines at the residence at 311 South Street and on Hollingsworth Road excepting for the Caravan Park. During the early phases of this project, the noise emissions can be made to comply at the caravan park, however during the later phases, due to its proximity to the development, the operational noise emission levels are, on occasions, likely to exceed the EPA guidelines by up to 5 dBA, and up to 9 dBA, whilst construction of the bund walls is occurring. This has potential to cause annoyance to some of the occupants of the caravan park, particularly in the 6.00 am to 7.00 am morning periods.

Appendix A

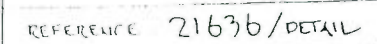
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AREA MAP

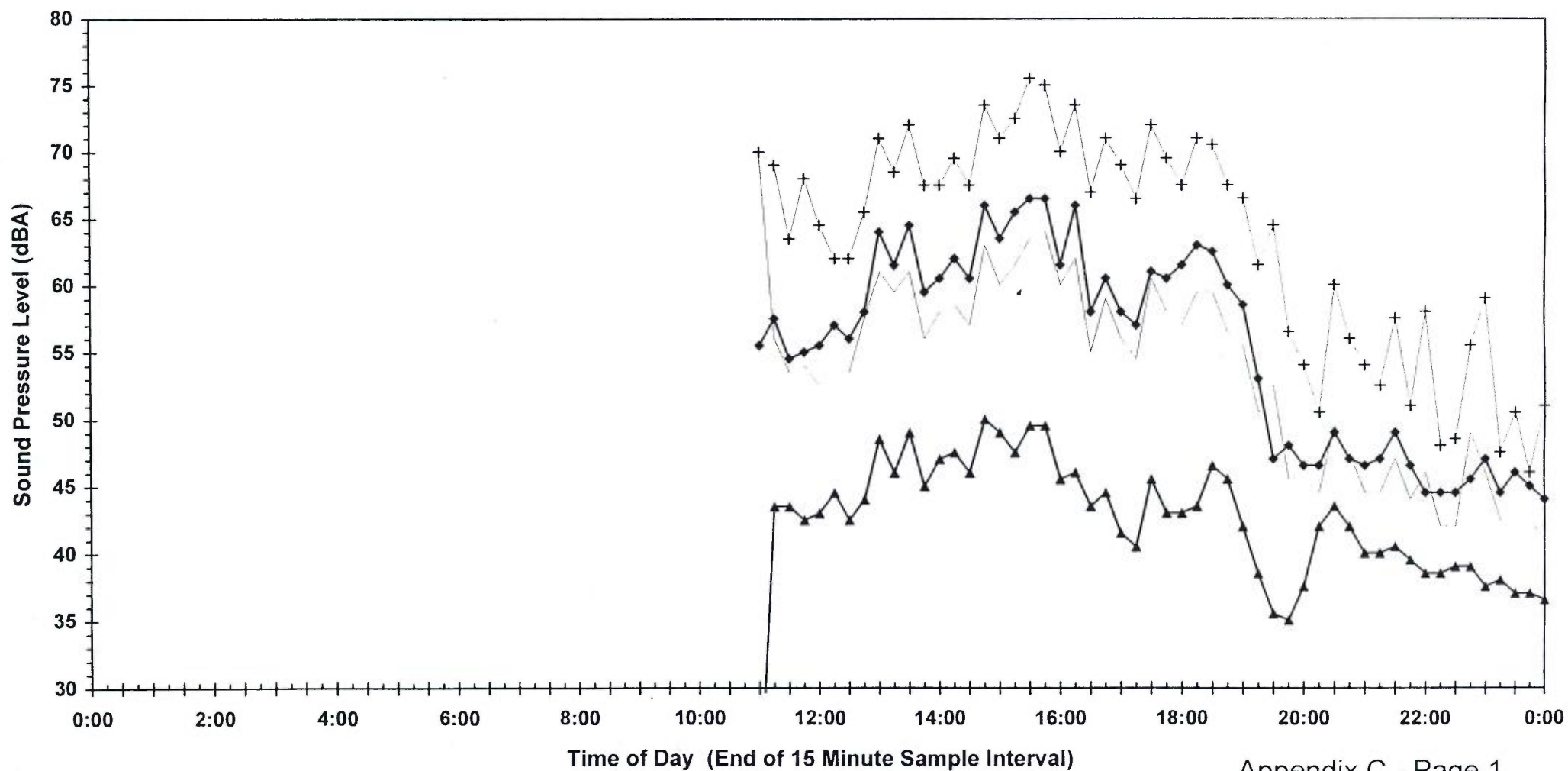


SITE LAYOUT



Statistical Ambient Noise Levels Noise Monitoring Location A, 311 South Street - Friday 14 November 1997

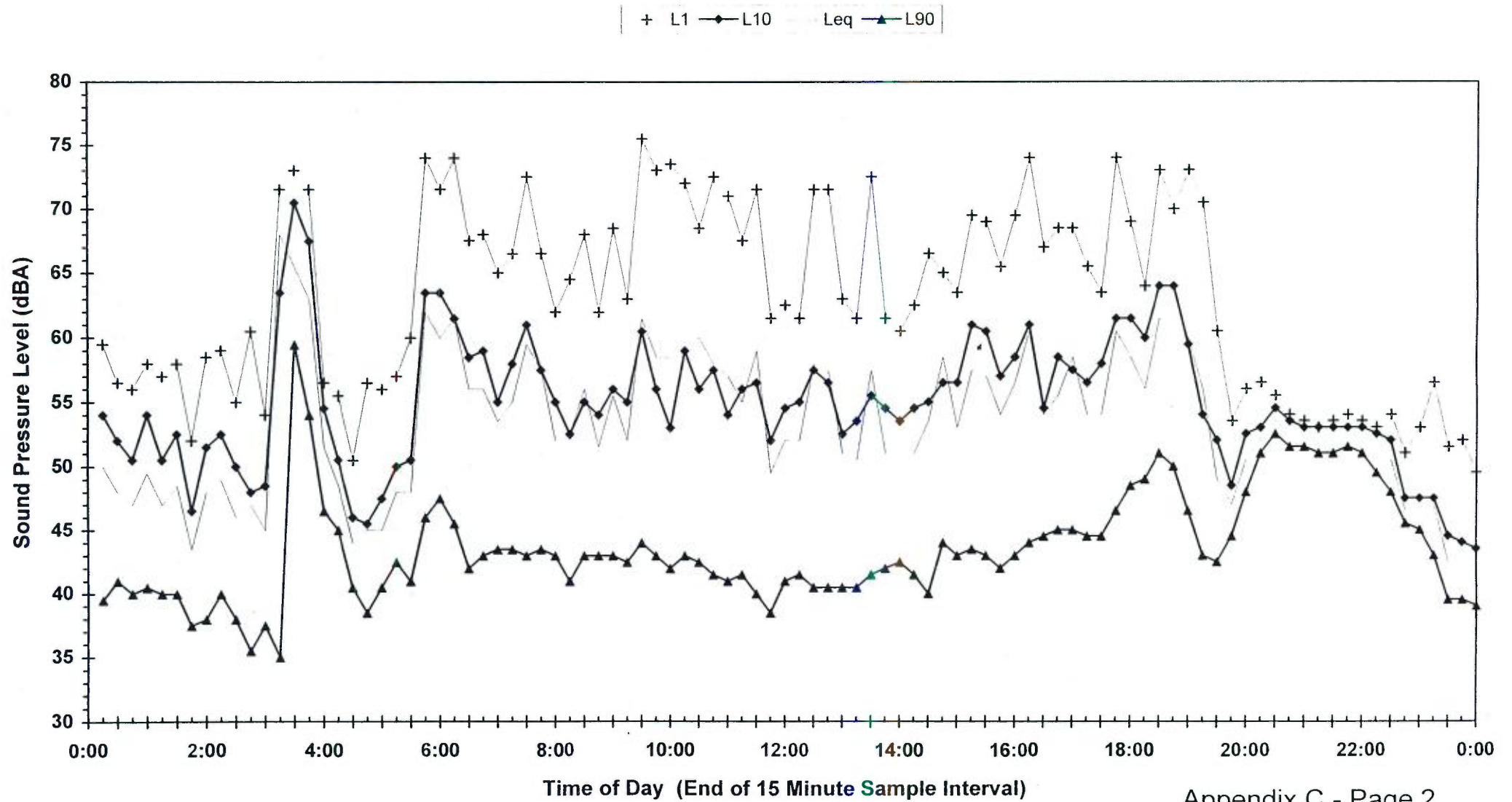
+ L1 — L10 Leq — L90



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Statistical Noise Levels
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Statistical Ambient Noise Levels
Noise Monitoring Location A, 311 South Street - Saturday 15 November 1997

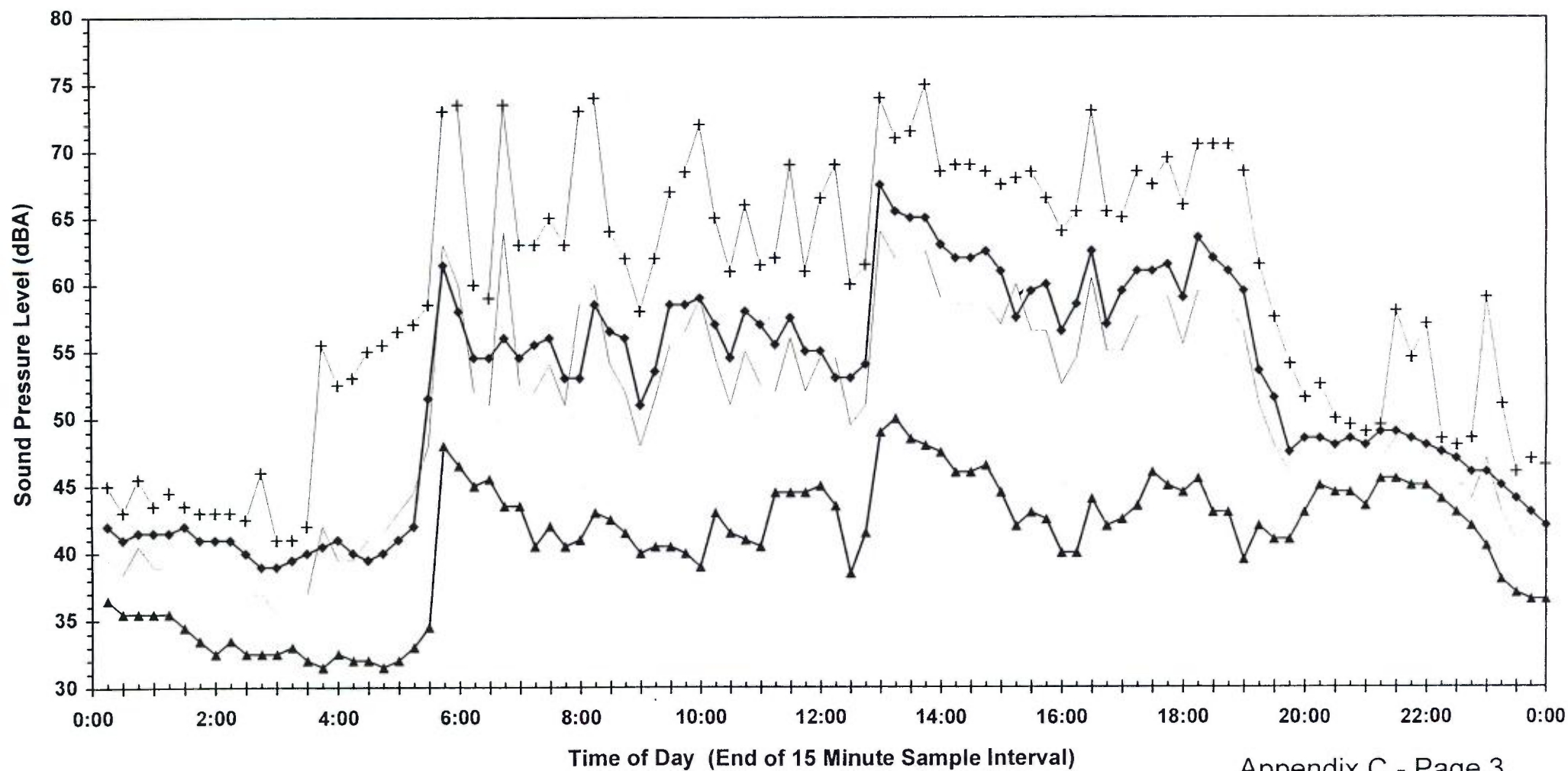


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Statistical Noise Levels
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Statistical Ambient Noise Levels **Noise Monitoring Location A, 311 South Street - Sunday 16 November 1997**

+ L1 — L10 — Leq — L90

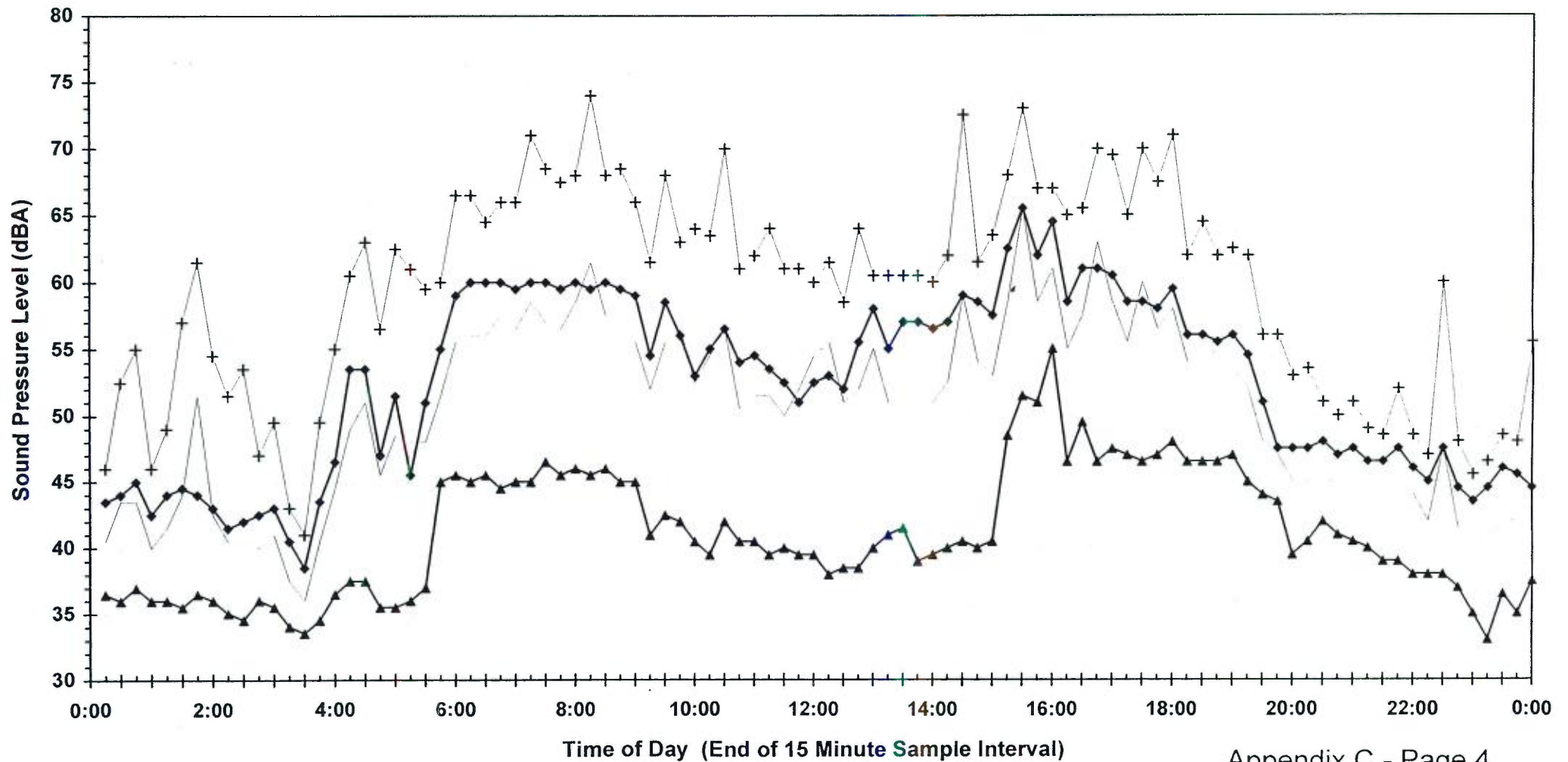


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Statistical Noise Levels
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Statistical Ambient Noise Levels
Noise Monitoring Location A, 311 South Street - Monday 17 November 1997

+ L1 — L10 Leq — L90

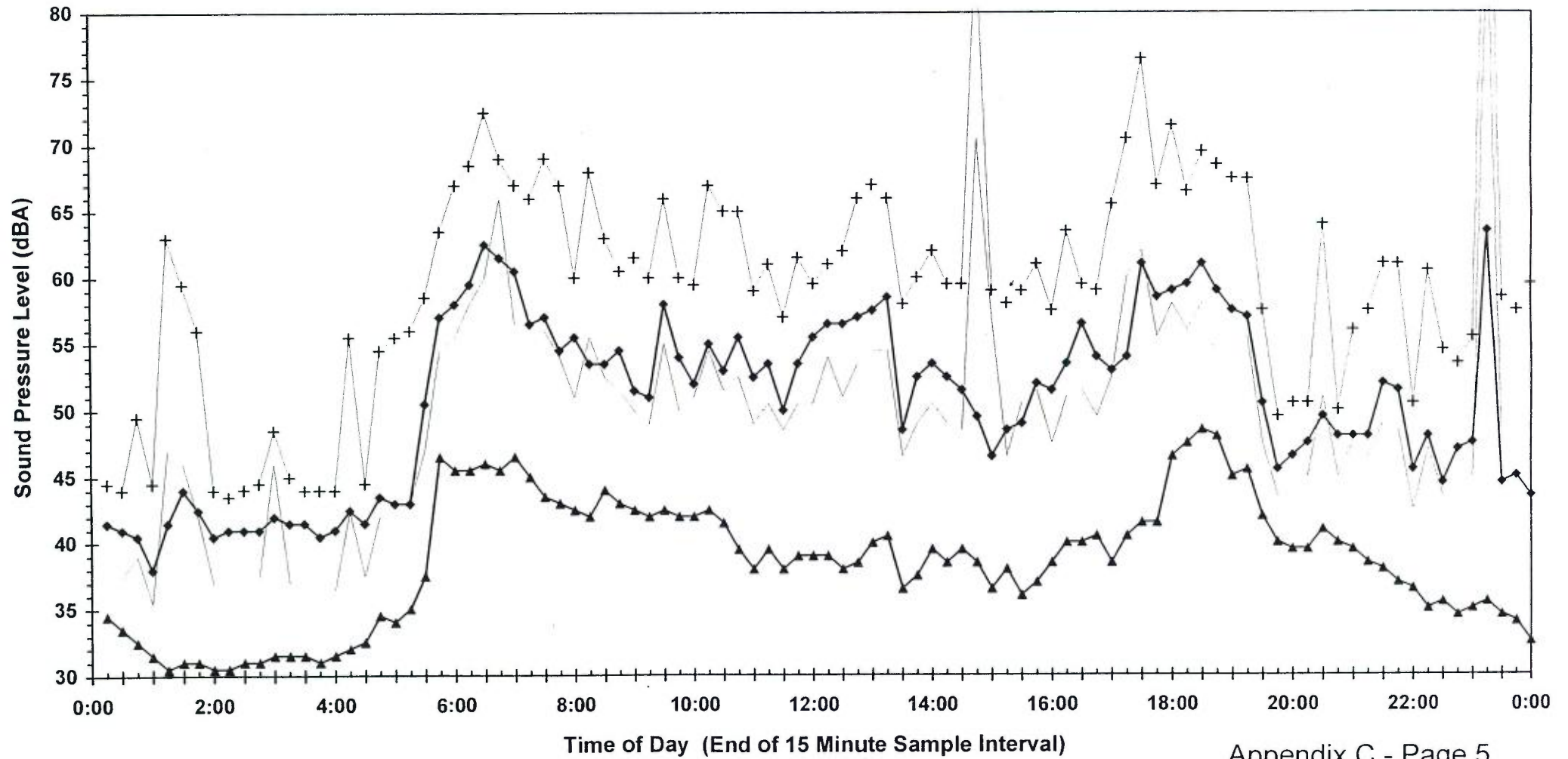


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Statistical Noise Levels
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Statistical Ambient Noise Levels
Noise Monitoring Location A, 311 South Street - Tuesday 18 November 1997

+ L1 —●— L10 —▲— Leq



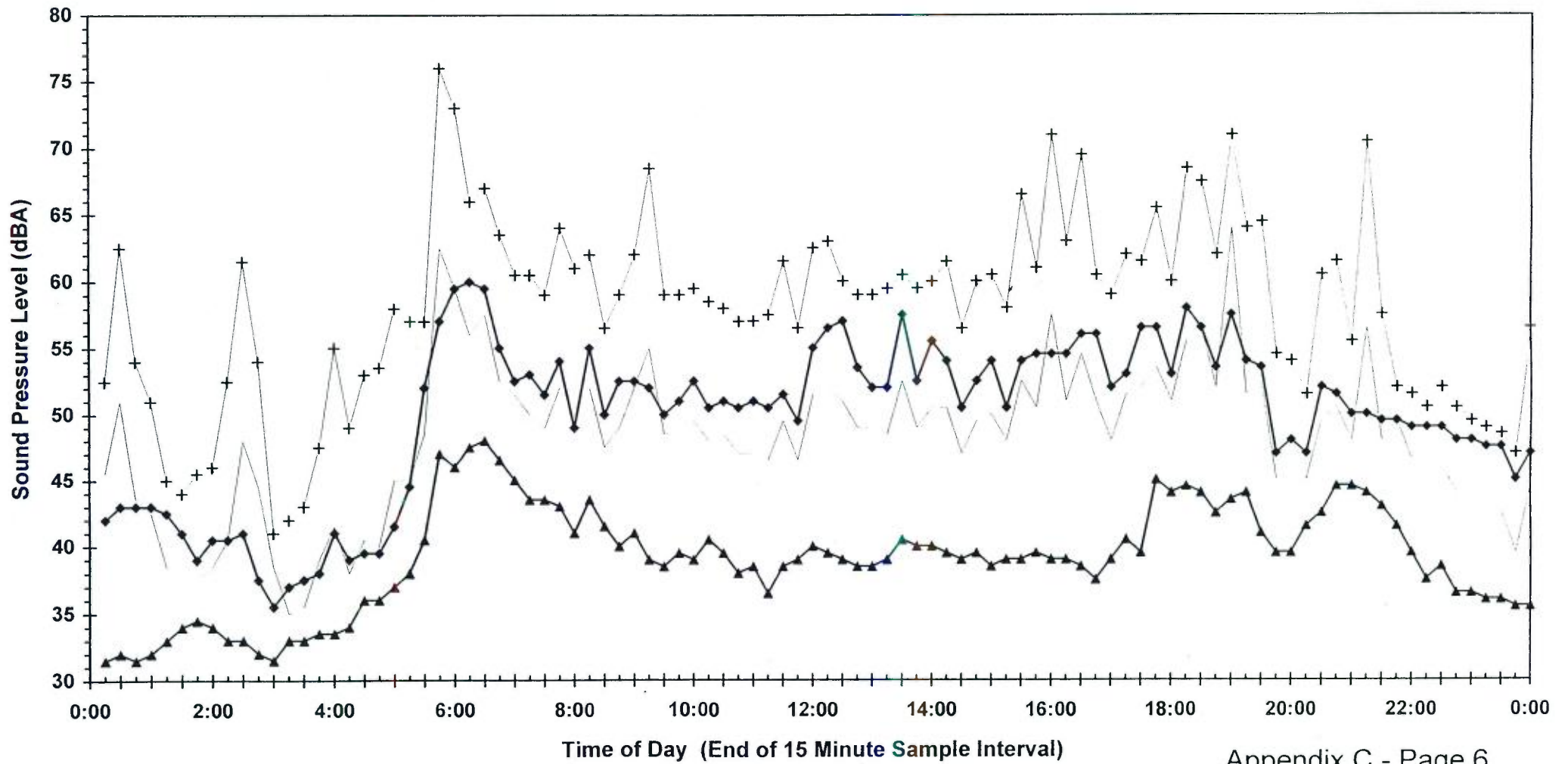
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Statistical Noise Levels

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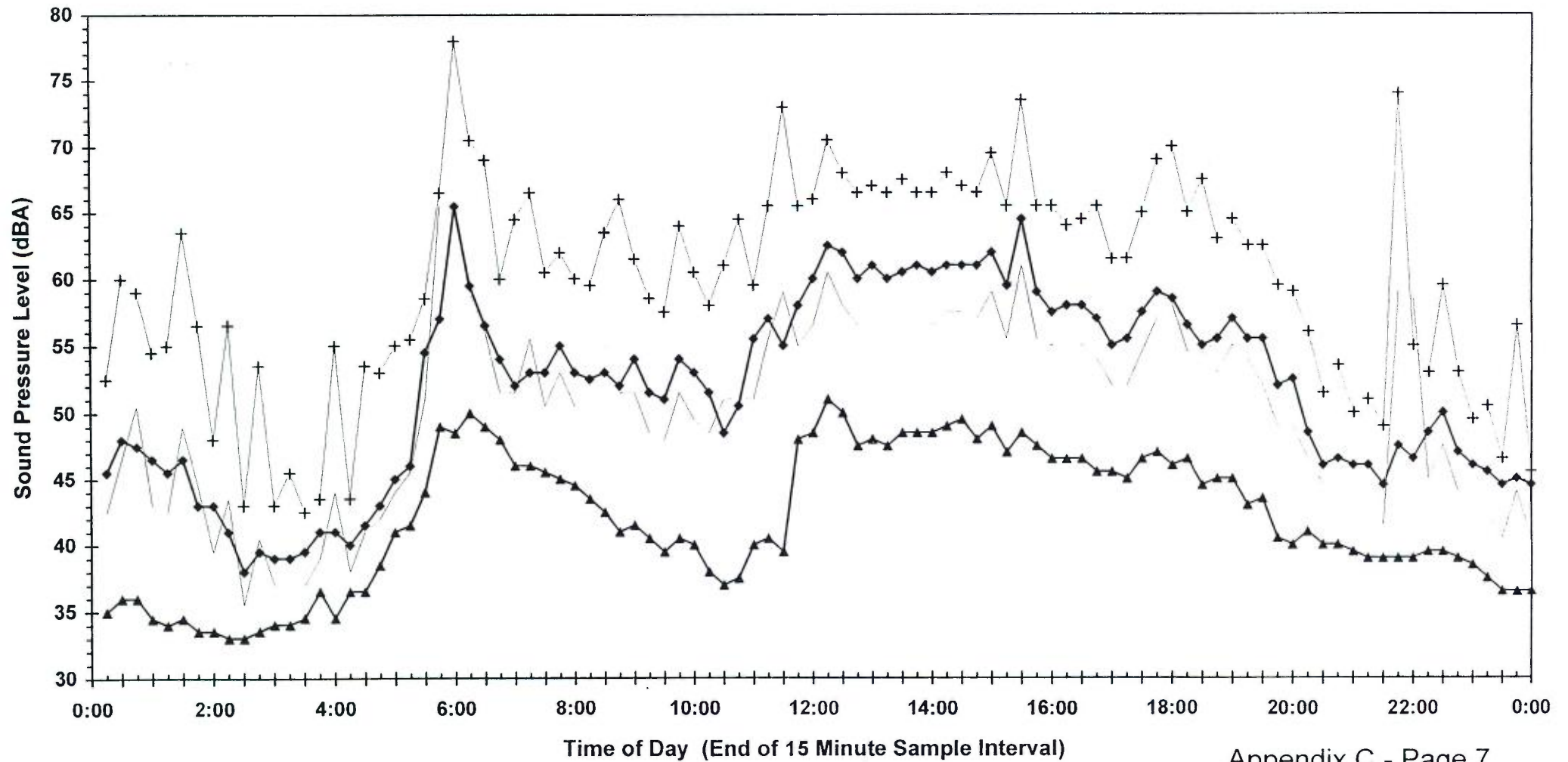
Statistical Ambient Noise Levels
Noise Monitoring Location A, 311 South Street - Wednesday 19 November 1997

+ L1 —●— L10 Leq —▲— L90



Statistical Ambient Noise Levels
Noise Monitoring Location A, 311 South Street - Thursday 20 November 1997

+ L1 — L10 — Leq — L90



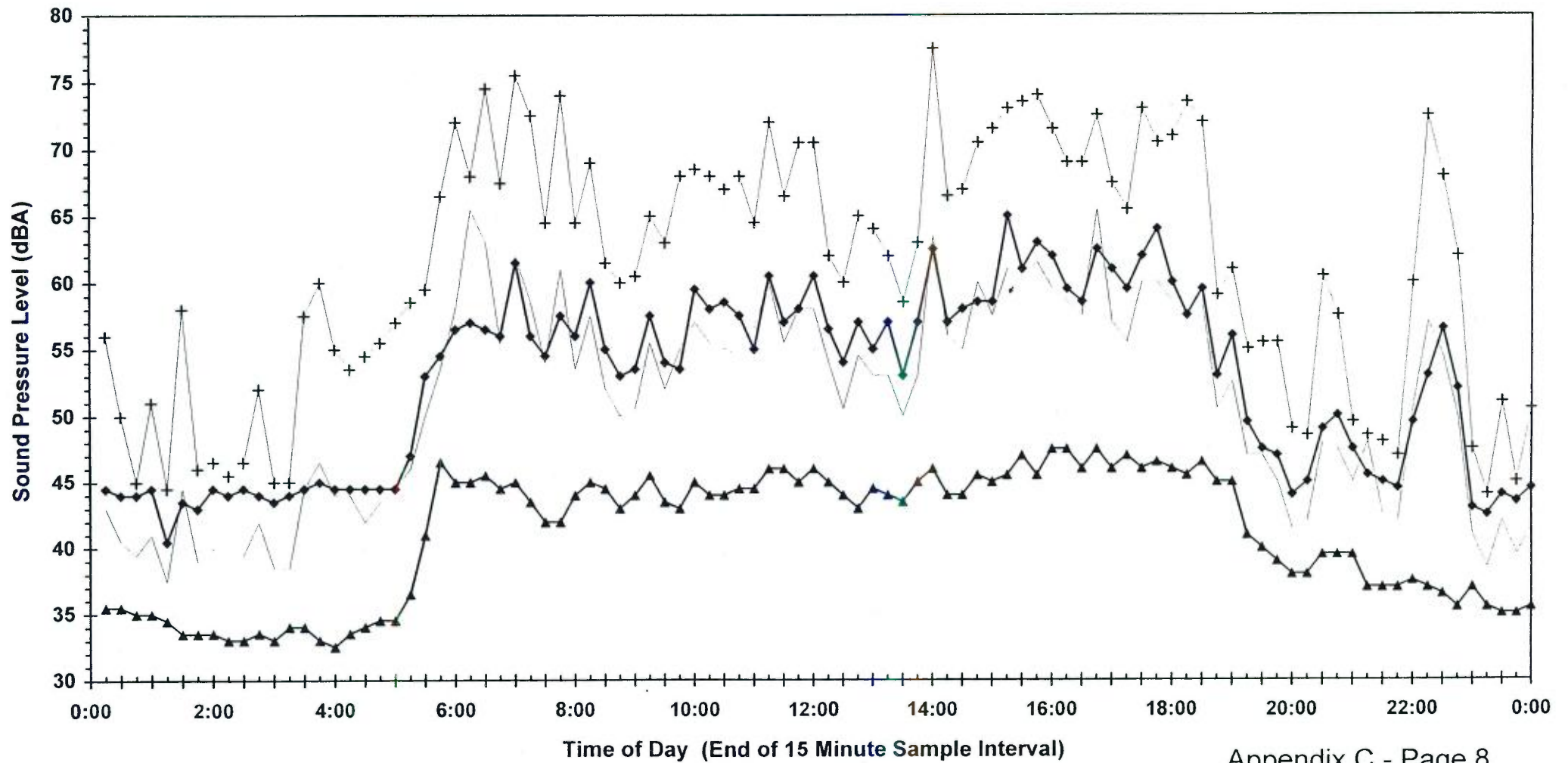
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Statistical Noise Levels

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Statistical Ambient Noise Levels
Noise Monitoring Location A, 311 South Street - Friday 21 November 1997

+ L1 — L10 — Leq — L90

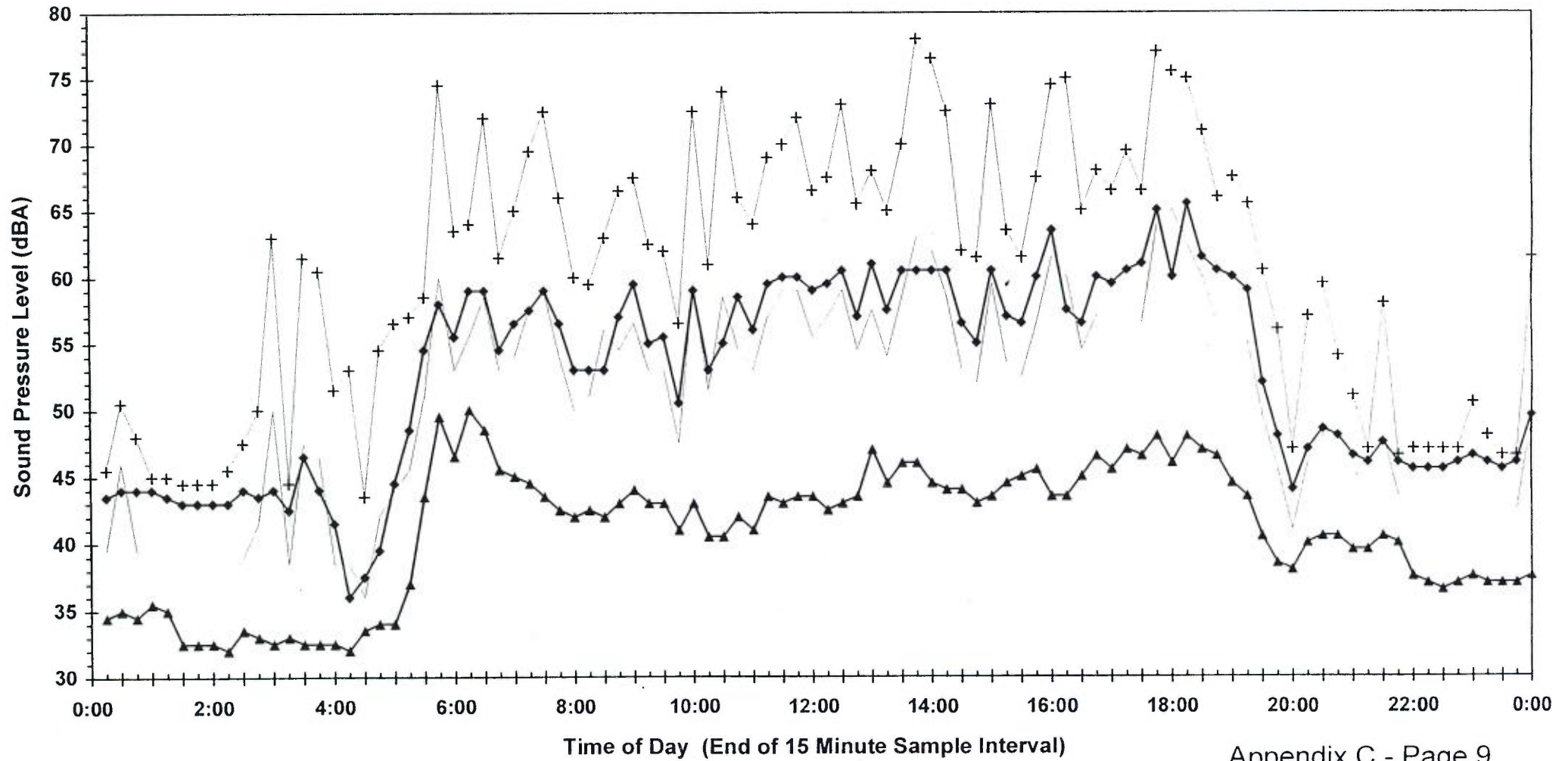


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Statistical Noise Levels
Report 7244

Statistical Ambient Noise Levels
Noise Monitoring Location A, 311 South Street - Saturday 22 November 1997

+ L1 —◆— L10 Leq —▲— L90

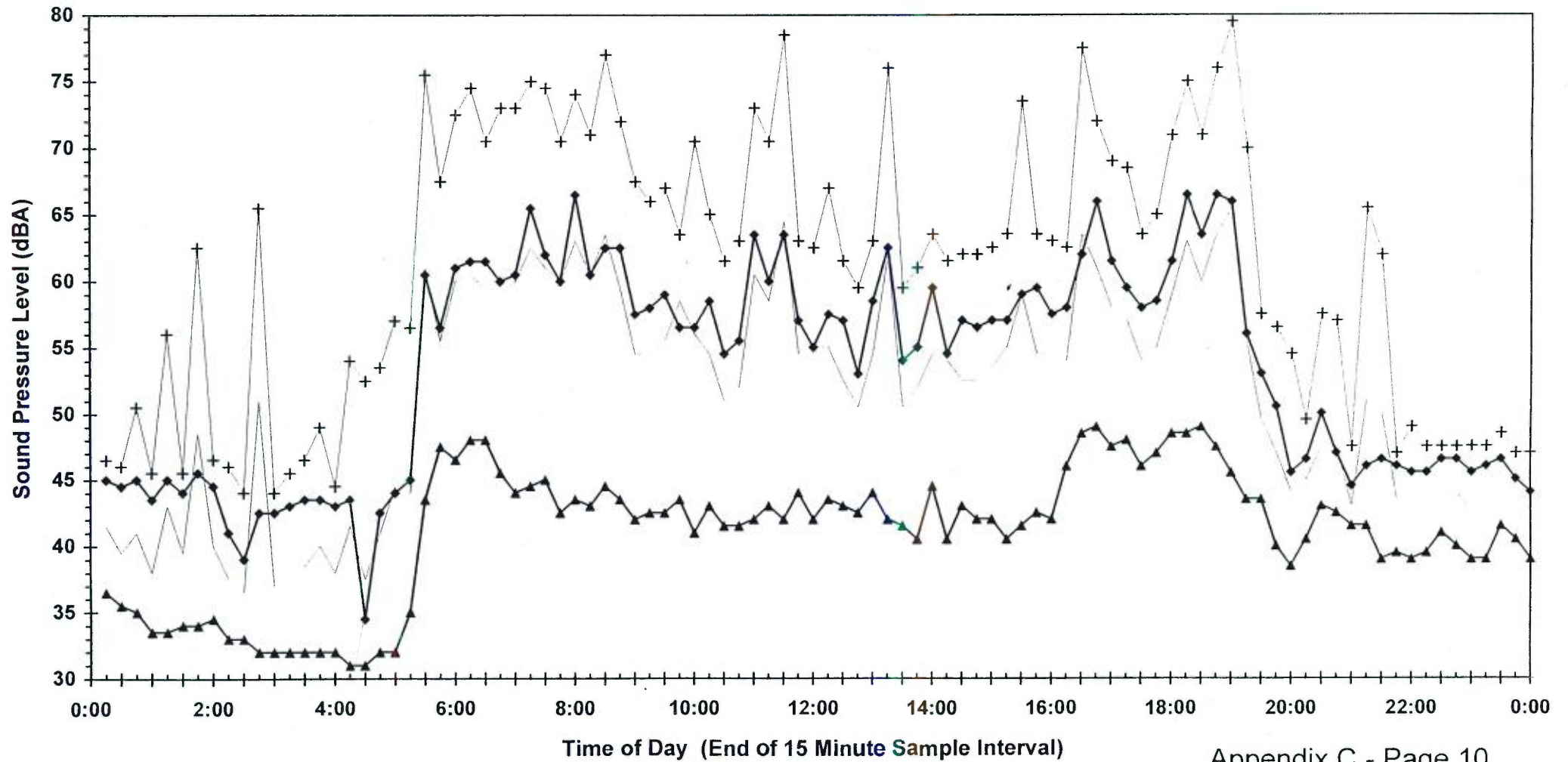


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Statistical Noise Levels
Report 7244

Statistical Ambient Noise Levels
Noise Monitoring Location A, 311 South Street - Sunday 23 November 1997

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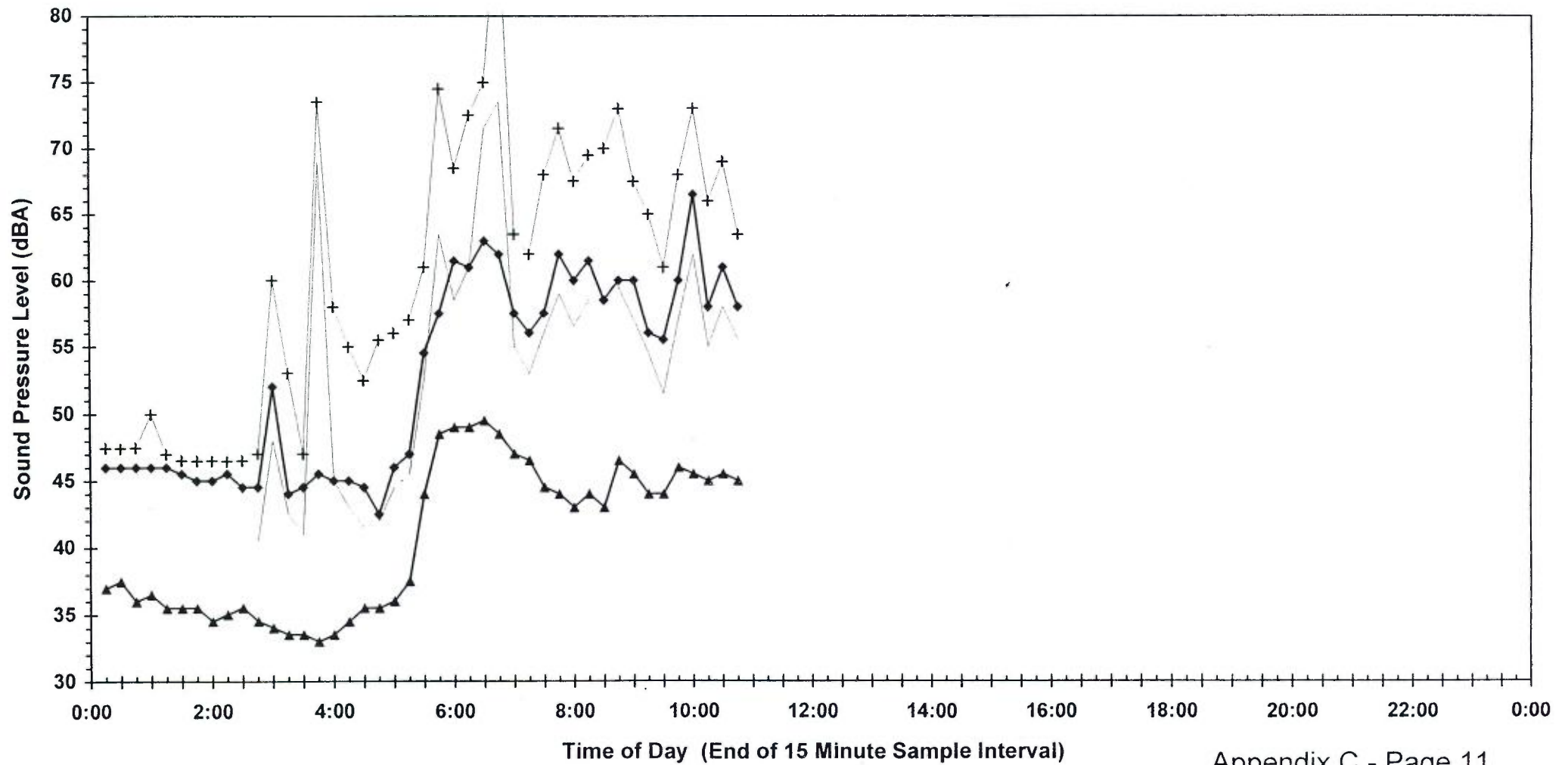


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Statistical Noise Levels
 Report 7244

Statistical Ambient Noise Levels **Noise Monitoring Location A, 311 South Street - Monday 24 November 1997**

+ L1 —◆— L10 —▲— L90

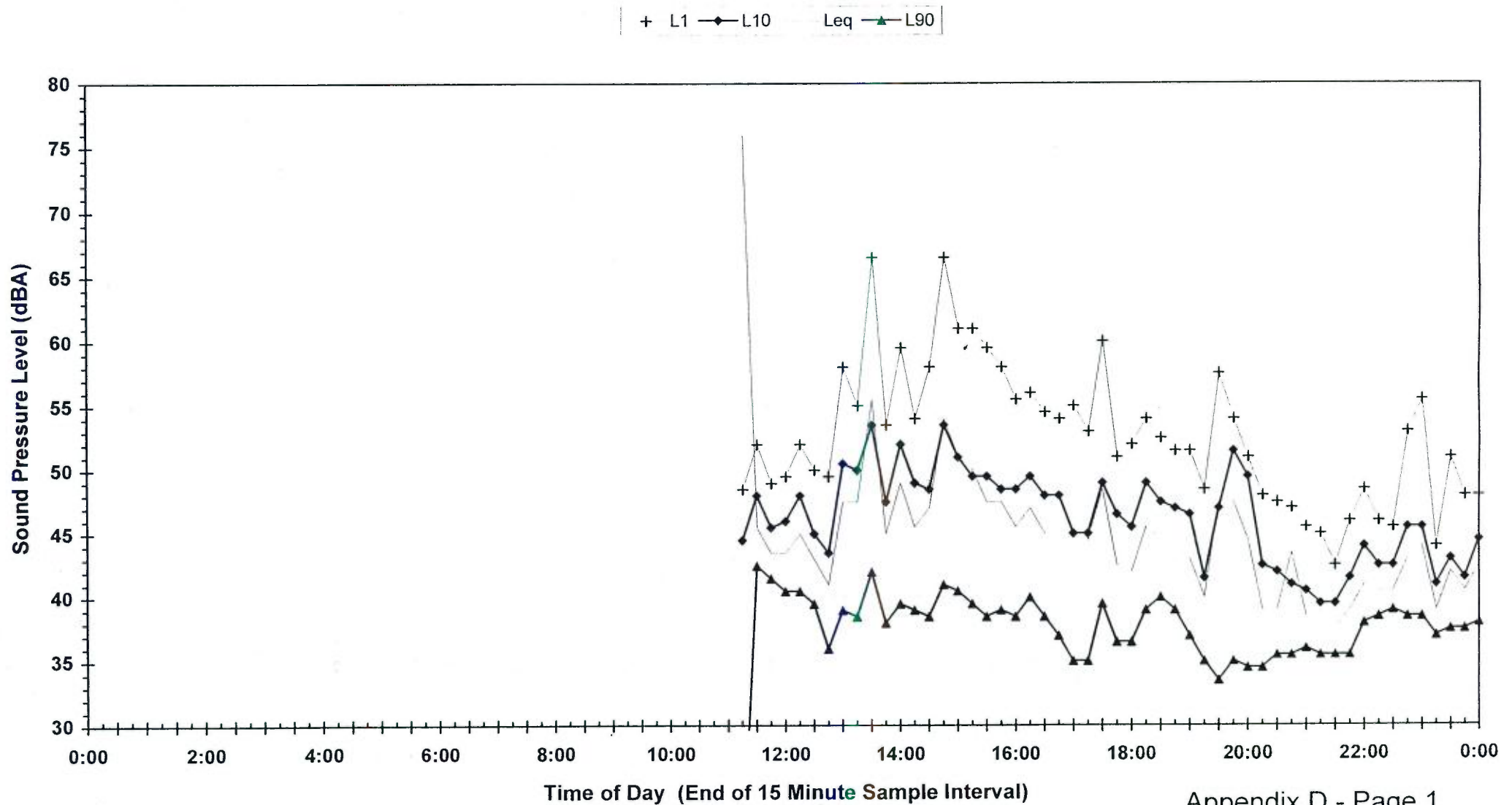


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Statistical Noise Levels

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Statistical Ambient Noise Levels
Noise Monitoring Location B, Hollingsworth Road - Friday 14 November 1997

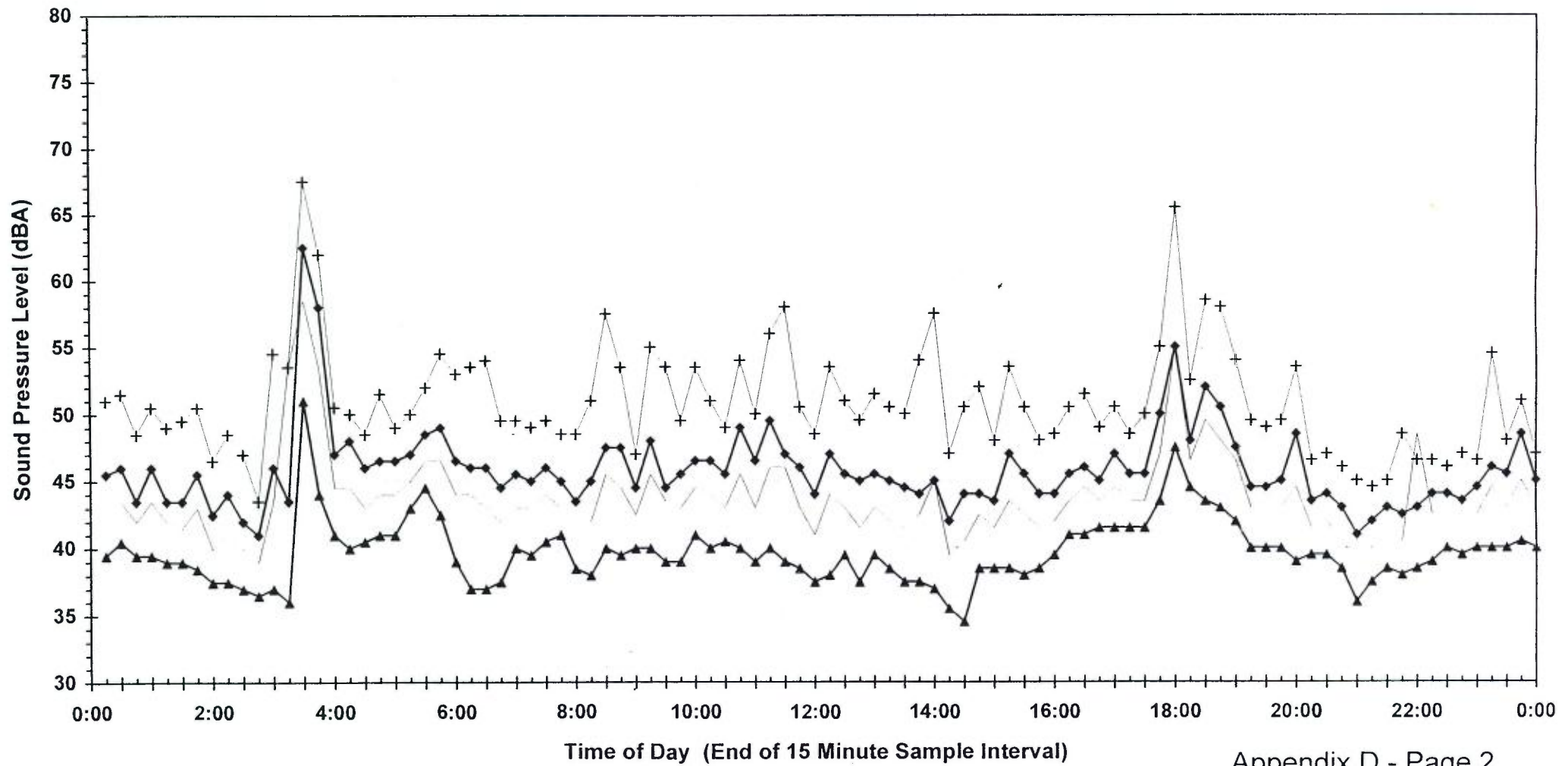


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Statistical Noise Levels
 Report 7244

Statistical Ambient Noise Levels
Noise Monitoring Location B, Hollingsworth Road - Saturday 15 November 1997

+ L1 ◆ L10 Leq ▲ L90



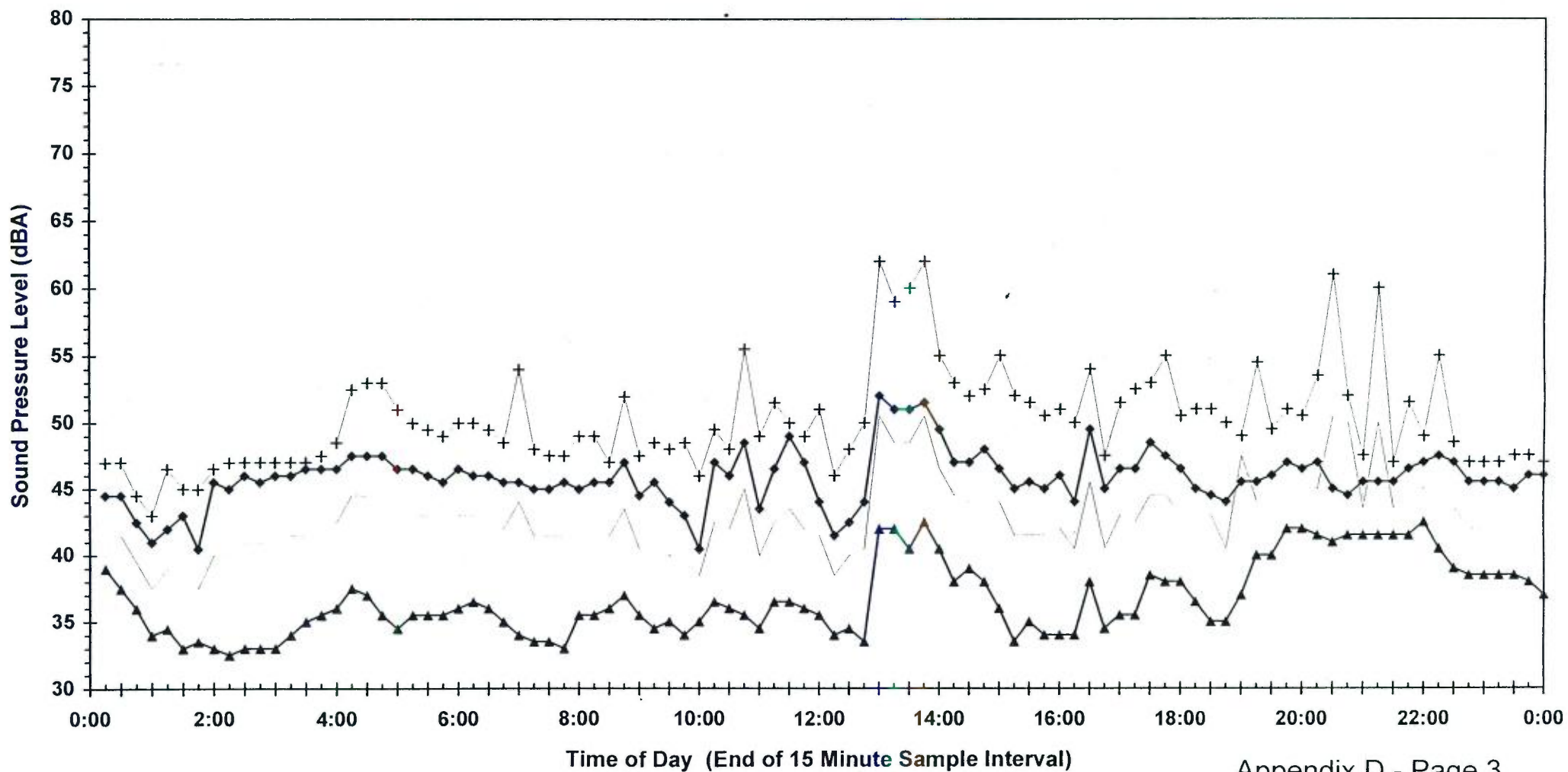
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Statistical Noise Levels

Report 7244

Statistical Ambient Noise Levels **Noise Monitoring Location B, Hollingsworth Road - Sunday 16 November 1997**

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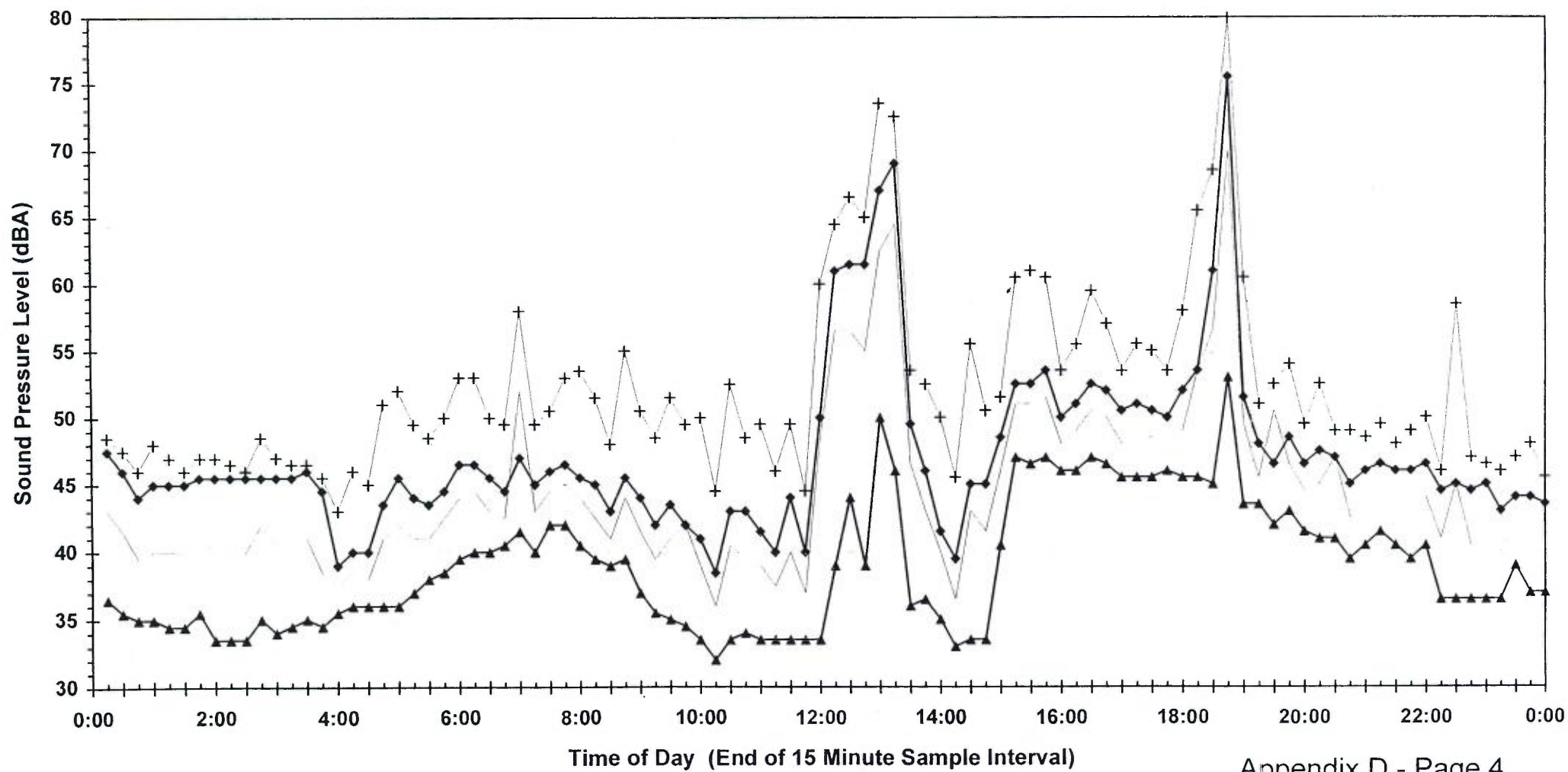


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Statistical Noise Levels
 Report 7244

Statistical Ambient Noise Levels **Noise Monitoring Location B, Hollingsworth Road - Monday 17 November 1997**

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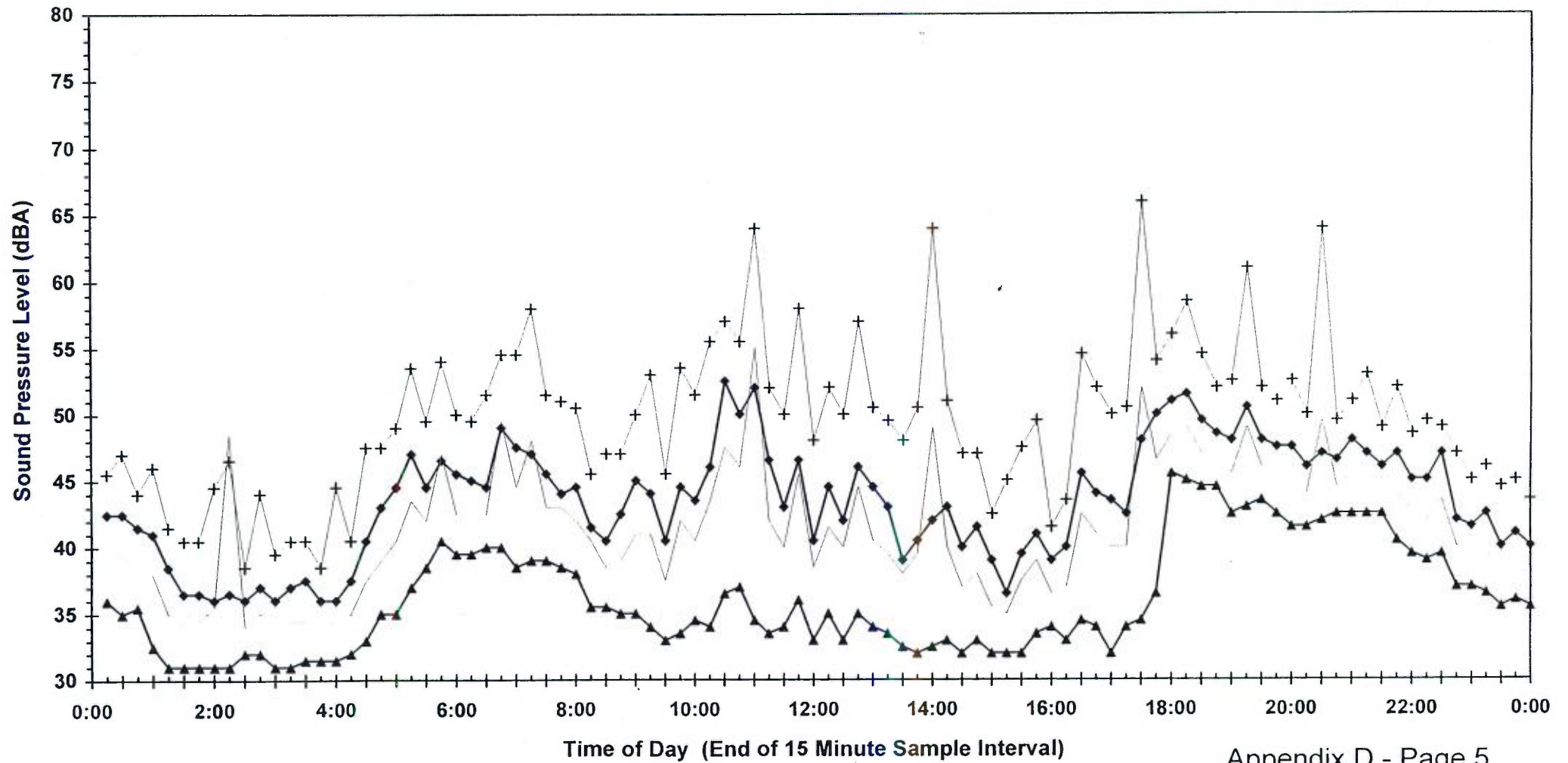


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Statistical Noise Levels
 Report 7244

Statistical Ambient Noise Levels
Noise Monitoring Location B, Hollingsworth Road - Tuesday 18 November 1997

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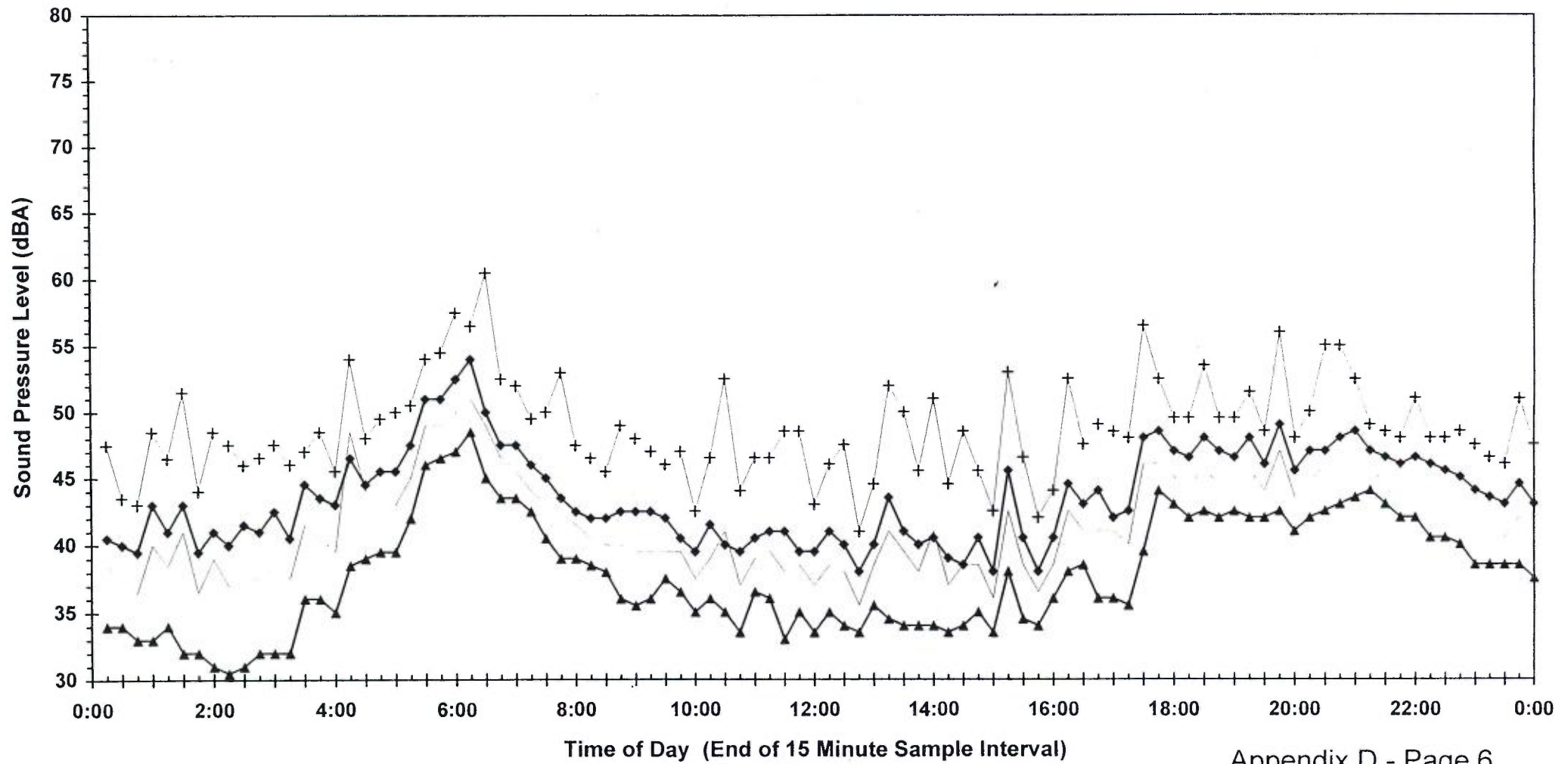


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Statistical Noise Levels
Report 7244

Statistical Ambient Noise Levels
Noise Monitoring Location B, Hollingsworth Road - Wednesday 19 November 1997

+ L1 —◆— L10 - - - Leq —▲— L90

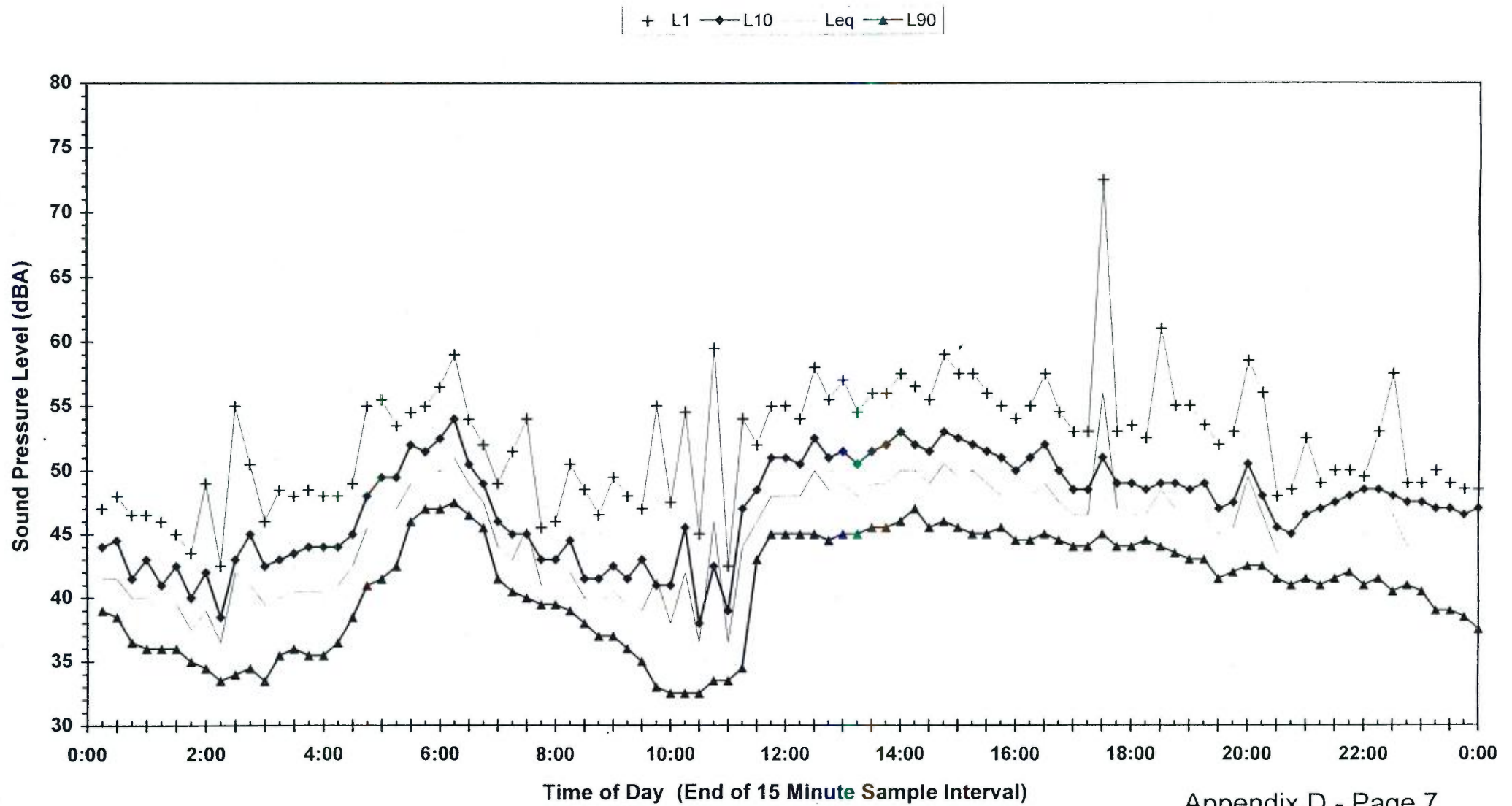


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Statistical Noise Levels

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Statistical Ambient Noise Levels
Noise Monitoring Location B, Hollingsworth Road - Thursday 20 November 1997

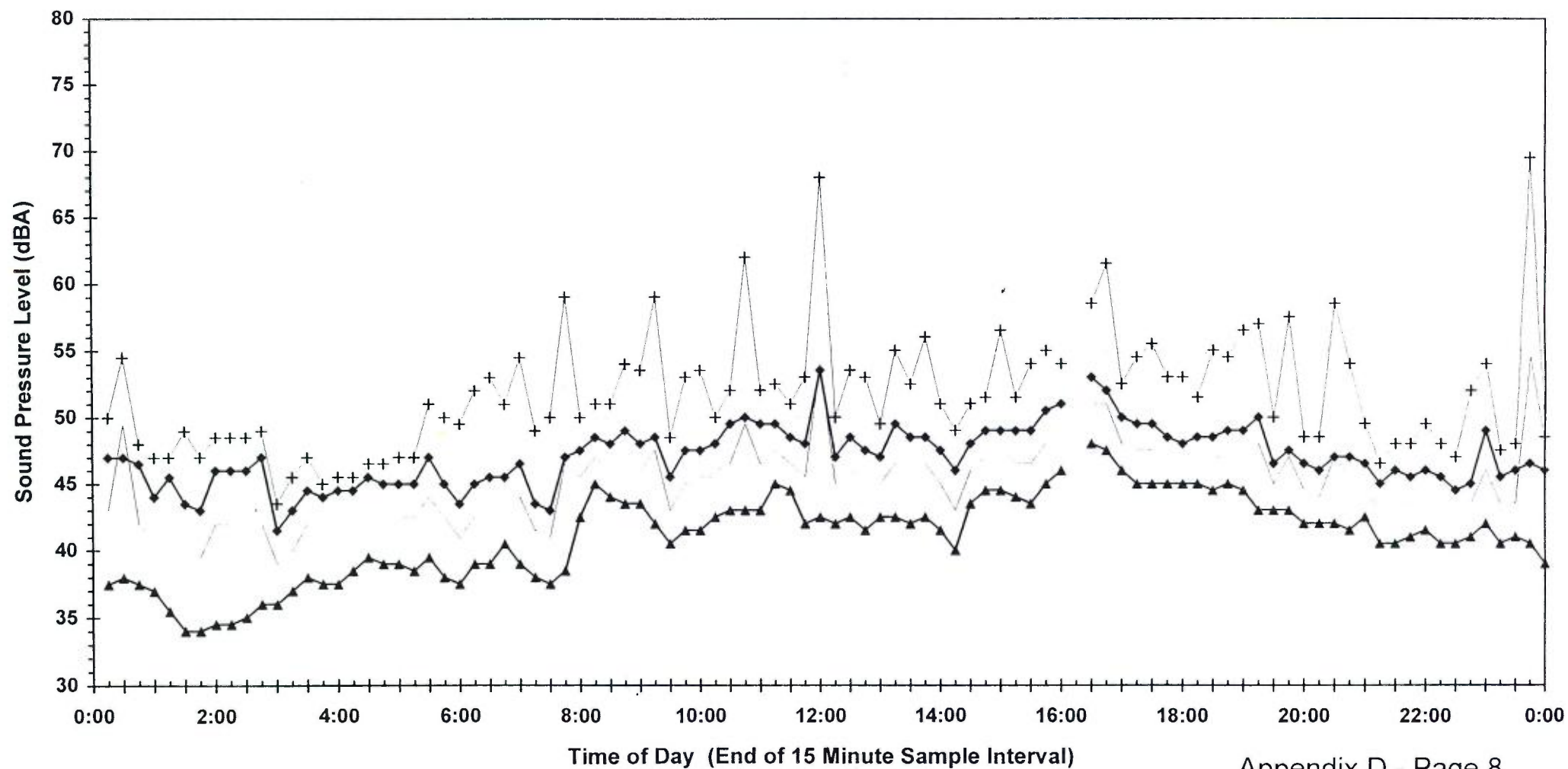


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Statistical Noise Levels
 Report 7244

Statistical Ambient Noise Levels **Noise Monitoring Location B, Hollingsworth Road - Friday 21 November 1997**

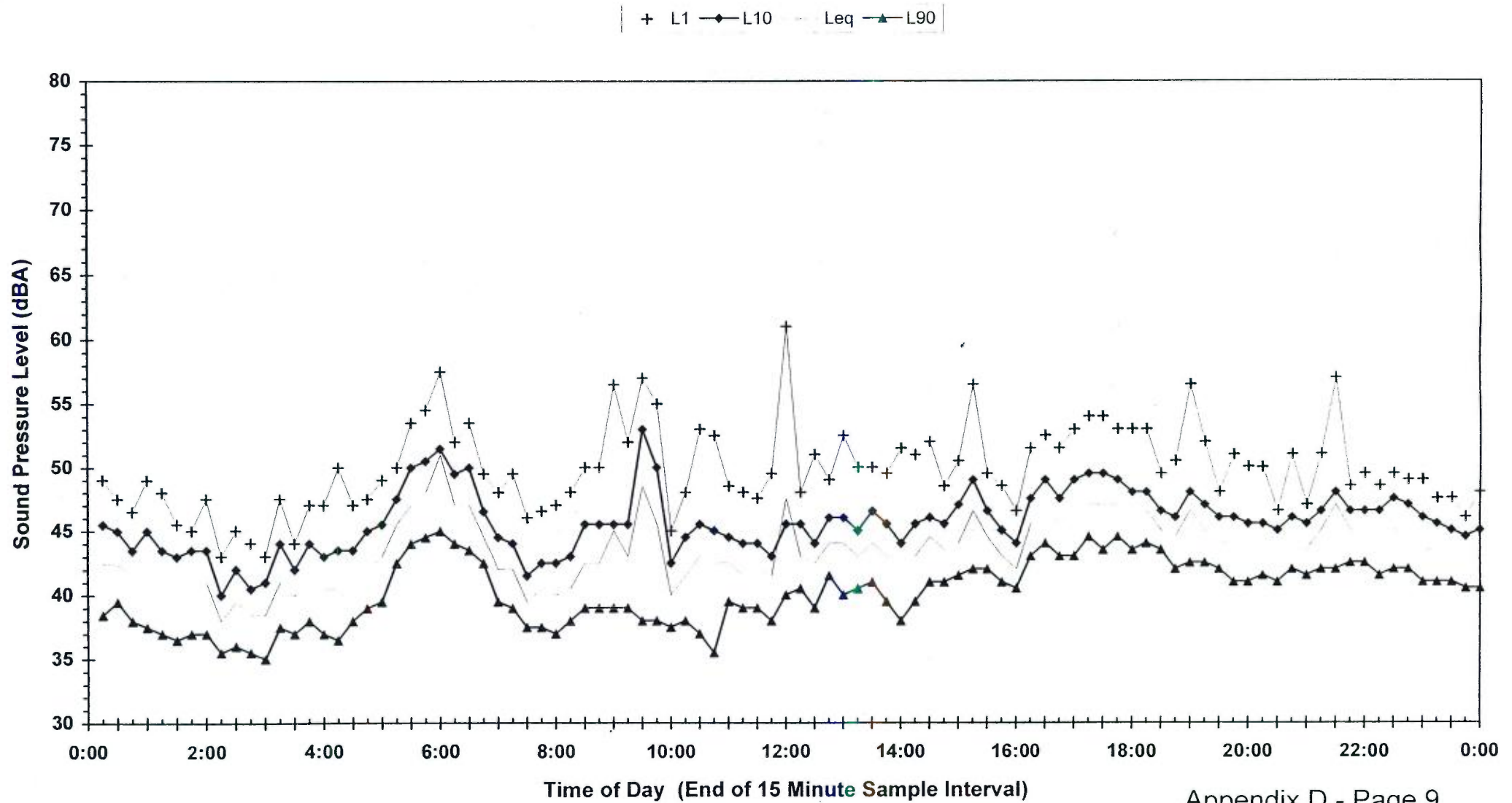
+ L1 —●— L10 — Leq —▲— L90



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Statistical Noise Levels
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Statistical Ambient Noise Levels
Noise Monitoring Location B, Hollingsworth Road - Saturday 22 November 1997

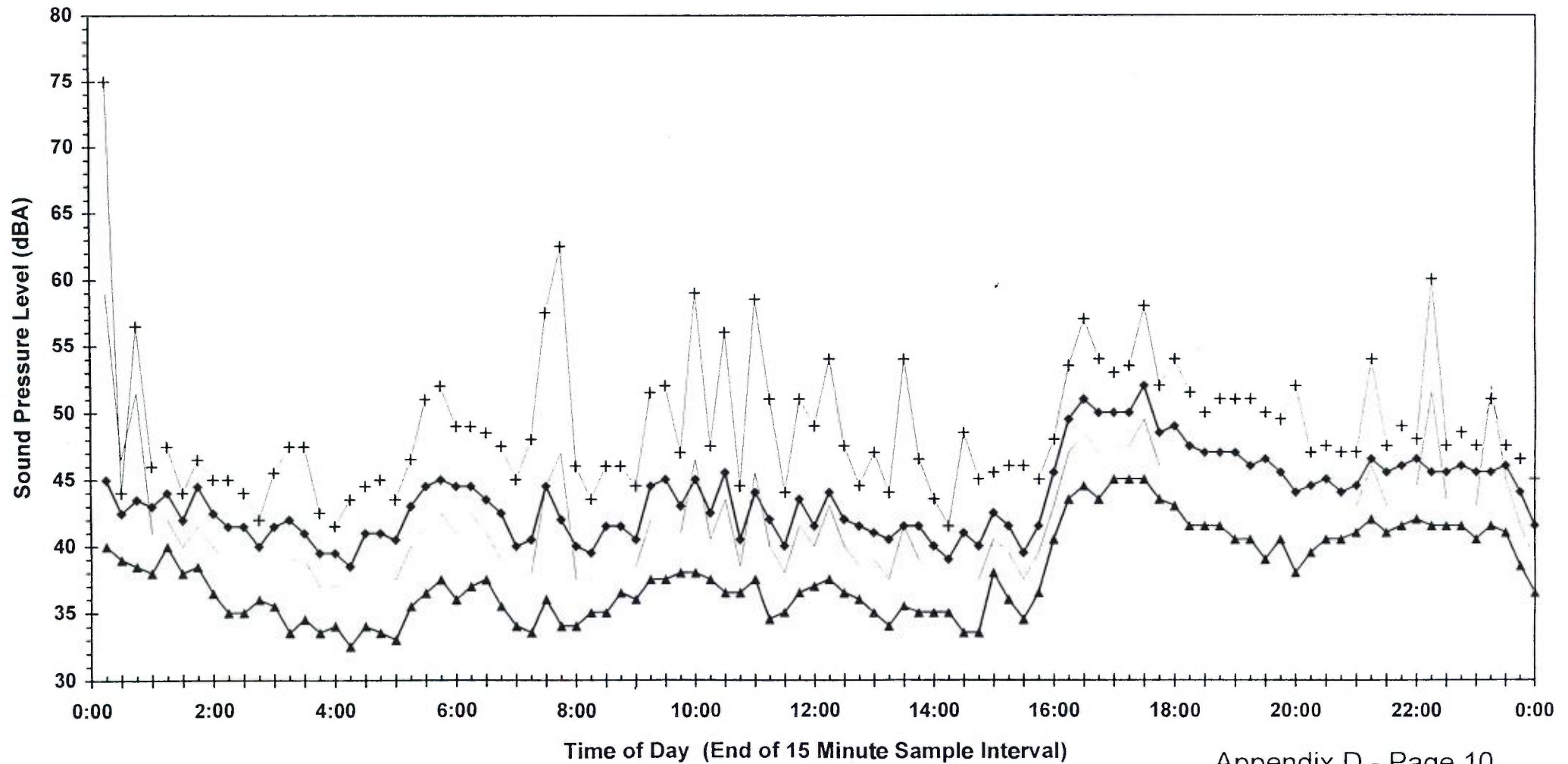


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Statistical Noise Levels
Report 7244

Statistical Ambient Noise Levels
Noise Monitoring Location B, Hollingsworth Road - Sunday 23 November 1997

+ L1 ◆ L10 — Leq ▲ L90

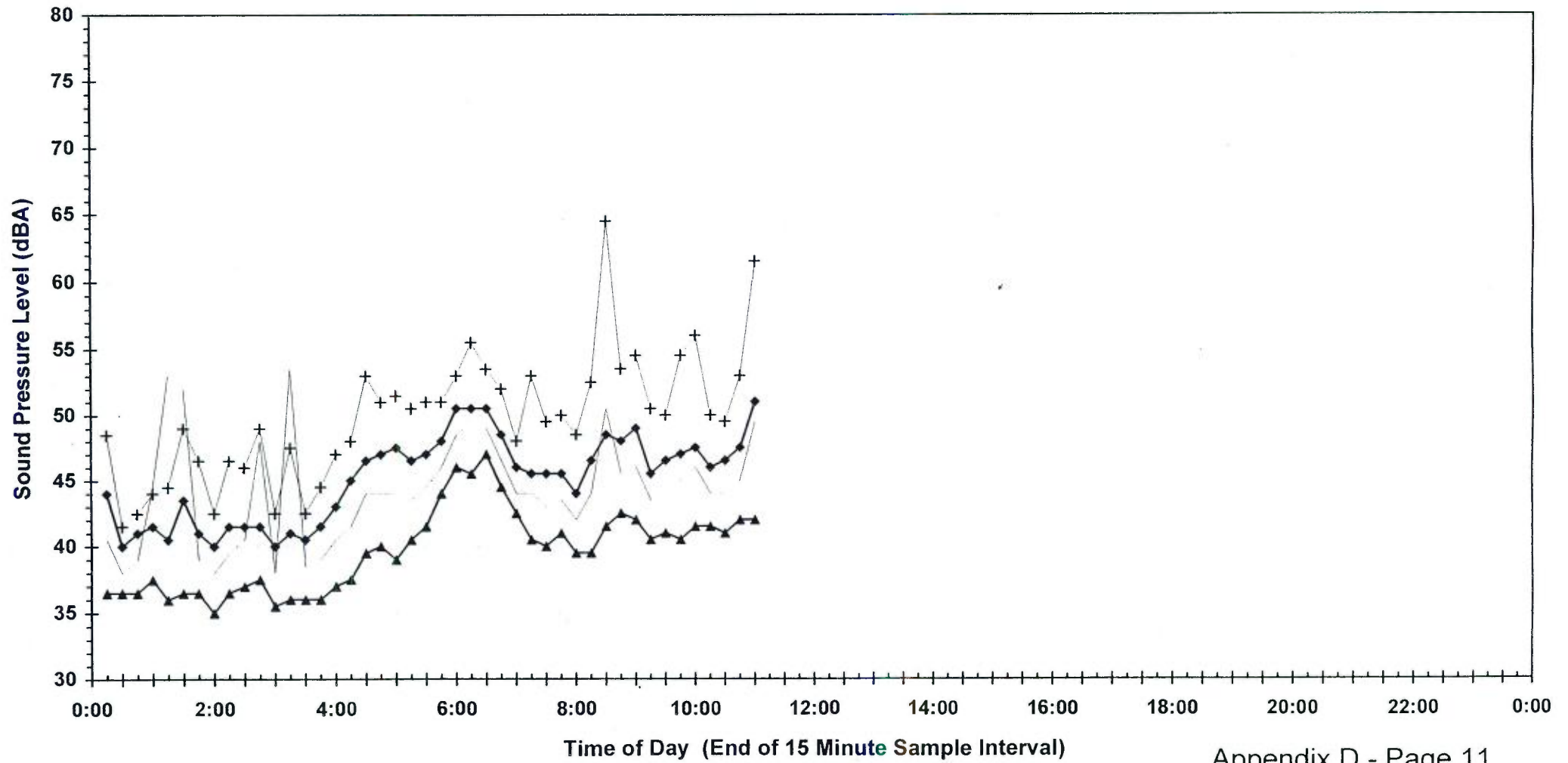


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Statistical Noise Levels
 Report 7244

Statistical Ambient Noise Levels
Noise Monitoring Location B, Hollingsworth Road - Monday 24 November 1997

+ L1 — L10 — Leq — L90



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Statistical Noise Levels
Report 7244

APPENDIX 6
ARCHAEOLOGICAL ASSESSMENT

Prepared by:
HELEN BRAYSHAW HERITAGE CONSULTANTS

**PROPOSED LANDFILL OPERATION
RICHMOND ROAD
MARSDEN PARK NSW
ARCHAEOLOGICAL SURVEY FOR ABORIGINAL SITES**

**by
HELEN BRAYSHAW & LAILA HAGLUND
November 1997**

**Report to Ganian Pty Ltd
through Enviro-Managers Pty Ltd**

HELEN BRAYSHAW HERITAGE CONSULTANTS

**PTY LTD ACN 003 169 622
51 Thompson St Drummoyne 2047 Phone 02 98197962 Fax 02 97198007**

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APPENDIX D: NPWS SITE RECORDING FORMS

1 INTRODUCTION

1.1 Background

The subject of this report is an archaeological field survey carried out at Richmond Road, Marsden Park, on behalf of Ganian Pty Limited [Figure1]. The survey was commissioned by Enviro-Managers, who are preparing an EIS on the proposed development.

Ganian proposes to extract up to 300,000 tonnes of quarry products from the site and establish a Class 2 [all solid waste except putrescible material as defined by the EPA] landfill depot within the quarry void. Waste will be disposed of in a former quarry, which will be expanded and deepened as required to provide quarry products and cover material [Figure 2]. Approval will be sought to dispose of approximately 30,000 tonnes of waste per month with the operation having a life in the order of 10-15 years. A buffer zone is to be retained as woodland. Access to the site will be via Richmond Road.

1.2 Project Brief

The scope of the work was to be undertaken in accordance with the requirements of the National Parks and Wildlife Service, including mapping of the location of all Aboriginal sites [including archaeological sites and potential sites] and an assessment of the significance of these sites. Recommendations regarding management of any sites found or measures to minimise impacts were also required.

1.3 Executive Summary

Artefacts and silcrete pieces were found at thirteen locations. All locations where artefacts were identified had sustained moderate or significant damage. Of a total of 72 artefacts recorded, 80% had sustained significant damage. No areas of potential archaeological deposit were identified, since no locations within the area surveyed appeared likely to be undisturbed. It has therefore been recommended on archaeological grounds that no further investigation is warranted, and application should be made for Consent to Destroy sites or relics which are likely to be affected by the proposed development.

1.4 Aboriginal Community Liaison

The study area is within the area administered by the Deerubbin Local Aboriginal Land Council [DLALC]. Deerubbin LALC representatives Mr Luke Hickey, Sites Officer, and Mr Tony Randall participated in the field survey. The DLALC will be producing a report independently to discuss the Aboriginal significance of the area.

Copies of the archaeological report will also be sent to two other local Aboriginal communities, the Darug Custodian Aboriginal Corporation and the Darug Tribal Aboriginal Corporation [see below Section 6].

1.5 Report Authorship

Archaeologists carrying out the field survey were Dr Laila Haglund and Dr Helen Brayshaw. In the field artefact recordings were made by Laila Haglund and Helen Brayshaw recorded general site characteristics. Helen Brayshaw has written the report, with editing and selected input by Laila Haglund.

2 STUDY AREA LOCATION AND DESCRIPTION

2.1 Location and General Characteristics

Marsden Park is situated on the north western Cumberland Plain, some 44 kilometres north west of Sydney. The study area is located west of Richmond Road and north of the proposed Castlereagh Freeway, also adjoining Hollinsworth Road to the south and Fulton Road to the north.

Ganian Pty Ltd has access to a number of Lots in the area [Figure 3], including the former quarry site located on Lot 47, which comprises 39 hectares, as well as a number of lots for buffer and access. These include Lots 26, 27, 28, 29, 32, 33, 34, 35 and 36, comprising a total area of 141.65 hectares.

The proposed site comprises a former quarry [PI 1] which operated between 1964 and approximately 1990 supplying quarry products principally for use in road construction. Initially breccia was quarried from the site, and then sand and gravels were transported from the Nepean River and processed on the site [PI 2]. The quarry area is now abandoned and left unrehabilitated. The former excavation is filled with water and the surrounding landscape is hummocky and scattered with numerous former plant items and stockpiles. Parts of the surrounding unquarried land [including parts of Lots 35 and 36] were used for night soil disposal prior to 1980.

The site is surrounded by regenerating forest stands, which have been extensively logged in the past. The site is isolated from nearest residences and 1 kilometre from the nearest zoned residential land to the south at Bidwill, and separated from it by the proposed Castlereagh Freeway and a caravan park. The site is zoned 1[a] General Rural.

On the advice of the client, Ms Val Smith of Enviro-Managers, Lots 32, 33, 34, 35 and 36, on the western side of the area and adjoining South Street, were omitted from the field survey, since these were not to be affected by the proposed development. Access to the site is to be via Richmond Road, but at the time of the field survey an option for access to be via Hollinsworth Road was under consideration. This was taken into account with regard to sampling coverage for the area. The area covered by the field survey is indicated on Figure 4.

2.2 Study Area Description

The subject land is situated on a broad crest on the watershed between Bells Creek, 200 metres east of the Richmond Road entrance, and a north westerly flowing tributary of South Creek. There are a number of dams on the site, but no permanent water. The only drainage line runs north from the eastern side of the quarry. It is dammed in several places and generally disturbed. Maximum elevation on the site is 48m AHD. On the east towards Richmond Road and Bells Creek beyond there is a gentle slope to <30m. In the unsurveyed buffer zone to the west gradients are generally steeper.

The eastern half of the study area overlies the residual Blacktown landscape [Bannerman and Hazelton 1990]. Bedrock in this area is comprised of Wiannamatta Group shale, probably Bringelly, in the view of Val Smith of Enviro-Managers. Shale soils in the area are of a duplex nature, being a buff silty loam [Unit A] overlying a yellow/red basal clay [Unit B]. In places there are two distinct layers within Unit A [A₁ and A₂]. To the west the fluvial Berkshire Park Landscape overlies Tertiary deposits which include the St Mary's Formation, Rickabys Creek gravels and Londonderry Clay. Soils are weakly pedal orange heavy clays and clayey sands. Ironstone nodules are common and silcrete boulders up to 20cm can occur in sand/clay matrix. Widespread and dense paperbark stands, even on crests, suggests the clay content to be high and water retentive.

The Cumberland Plain originally supported a complex of woodland and forest associations adapted to the mostly clayey soils. This original vegetation has been cleared, in the past to make way for pastoral activities and more recently for urban development. The original woodland and open-forest were dominated by forest red gum *Eucalyptus tereticornis*, narrow-leaved ironbark *E. crebra*, grey box *E. moluccana* and spotted gum *E. maculata* [Benson and Howell 1990]. Paperbarks, *Melaleuca decora* and *M. nodosa*, often occur as a small tree layer.

As indicated above, previous land uses have had obvious and extensive effects upon the study area. The former quarry excavation is filled with water and there are at least eight dams within the area surveyed. The area surrounding the excavation is covered with mounds of overburden and uneven surfaces indicate bulldozing. Residues of introduced river gravels lie on the ground surface. Soils over much of the area appear to be water retentive, as evidenced by the proliferation of paperbarks and uneven surface where wet soils have been trodden by cattle. A network of drainage channels and levees is evidence of efforts to increase water run off. A transmission line easement extends from the south west across the site to the north western corner. Another north-south easement crosses the property in the unsurveyed western section. Extensive clearing has taken place, much of the cleared area has been ploughed and levelled, and most of the timber present is regrowth. Areas used for night soil disposal are clear, level and covered with green grass. While there may be small pockets of undisturbed deposits, from surface manifestations it is not clear where they might be. Almost everywhere topsoil is thin or absent and the ground surface appears to have been moderately or severely disturbed.

3 ARCHAEOLOGICAL CONTEXT

3.1 Regional Context

Archaeological research in the last twenty years has provided evidence for the Aboriginal occupation of the Cumberland Plain. A recent analysis of the Cumberland Plain using the NPWS Site Register [McDonald 1997a] found records for 666 sites. The most common site type was found to be the open site [89%], followed by scarred trees [2.1%]. Isolated finds and combination open/other site types accounted for another 3.5% of the recorded features. Shelter sites and grinding grooves, found mainly around the periphery of the plain at the shale-sandstone junction, accounted for another 3.6% of recorded sites.

In terms of site location, this analysis indicated that open sites were located in all landscapes on the Cumberland Plain. The very high proportion of sites recorded on creek banks, however, was considered to be more indicative of surface visibility and taphonomic factors than the distribution by humans of artefacts across the landscape.

A number of important findings in regard to site location, type and preservation, and consequently cultural heritage management, were made by the Rouse Hill [Stage I] archaeological works [McDonald and Rich 1993]:

- Most of the areas tested [either with sparse or no surface manifestations] contained sub-surface archaeological deposits.
- Sites on permanent water are more complex [ie they represent foci for larger groups or are used repeatedly by smaller groups over a long period of time] than sites on ephemeral or temporary water lines. Major confluences are often prime site locations, however, sparse sites also occur on major creeklines, and not all confluences are locations of prime sites.
- Alluvial terraces [and other depositional environments] contain the best potential for intact archaeological remains. Some hillslope zones may also be intact and have good potential. In areas where there is deep alluvium many sites also have intact material below the plough zone. These sites often have artefact bearing deposit to a depth of 70-90cm; the plough zone is [max] 25cm deep.
- Temporary and minor gullies tend to have one-off or occasionally repeated Aboriginal visits reflected by low density sites.

Few ridge top sites were located by the testing programme mostly because the associated development was located close to the creeklines, but also because of the higher levels of destructive disturbance in the more elevated locations, eg housing and ploughing of shallower deposit.

Intact knapping floors, backed blade manufacturing sites, heat treatment locations, a number of apparently specialised tool types, and generalised camp sites were all located by the project. Two Early Bondaian dates [between 5,000-3,000 BP] provide a context for some backed blade manufacture.

More recent test excavations carried out at the ADI site 3-9 kilometres south west of the present study area [McDonald 1997b] provide supporting evidence for these propositions:

- There is evidence that sites near more permanent water sources are more intensively occupied, than those located on more ephemeral water courses.
- Creek junctions do appear to provide foci for site activity.
- Ridgetop locations between drainage lines are indicated to contain limited archaeological evidence of isolated knapping floors and other forms of one-off occupation.

3.2 Local Context

Many archaeological investigations have been carried out in the vicinity of the present study area. These include Byrne [1995a,b], Dallas and Witter [1983], Haglund [1983], Happ and Brayshaw [1982a,b], Mills [1997], Nicholson [1990] and various other studies in the area of Plumpton Ridge [see reference list].

A printout of sites obtained from the NPWS site register for the 36km² area between coordinates 2/955-3/015 62/6400-62/7000, centred on the study area, listed a total of 73 locations. Of these 65 are open sites or recordings of isolated artefacts. The remainder are extraction sites, including the silcrete extraction site on Plumpton Ridge, and the site of the former Blacktown Native Institute 1826-33 [Bickford 1983] which is situated at the top of Rooty Hill Road, approximately 2 kilometres from the present study area.

An overall study of the northern Cumberland Plain carried out by Smith [1989], on behalf of NPWS, included surface survey of a 2.7km² area 1-2.5km west of the present study area. The tributary of South Creek which rises within the present study area flows through the area she investigated, and 49% of Smith's [1989:171] sites were located within 50m of a water source. Twelve sites were identified, including an extensive extraction site [MP48] where various raw materials had been selected from exposed Rickabys Creek gravels and made into artefacts. Evidence of artefact knapping was noted, and a number of the sites were assessed as likely to contain *in situ* archaeological deposits.

Kohen [1986:43] had concluded, after surveying areas within Blacktown LGA that 'with few exceptions, all of the sites so far located on the Cumberland Plain are within a few metres of a creek or on top of a ridge or hill'. Smith [1989] had found that recorded sites predating her survey 'were fairly evenly distributed across each of the topographic units' [1989: 175]. As a result of her own survey, Smith [1989: 175] noted that sites were more often found on creek flats and hill slopes rather than on creek banks or hill tops.

Kelton [1996] carried out a survey on the western side of South Street, adjoining the western boundary of the present study area and the eastern boundary of Smith's study area described above. In a study area of approximately 63ha seven

artefact locations were identified. Three of the locations represented isolated artefacts, and 12 of a total of 25 artefacts recorded were at one site, SR-OS-4. Two of the locations were within 50 metres of a watercourse, and the remainder were on low ridge crests. Ground surface visibility was generally poor, and artefact densities were low. Naturally occurring silcrete fragments across the study area in low numbers was inferred from the presence of non-artefactual silcrete fragments at many of the identified sites. Four of the sites were assessed as being of low significance and three as having potential for subsurface deposits.

Kelton [1996:9] suggests that the greater frequency of sites found on creek flats and hill slopes by Smith [1989] may have resulted from underlying Rickabys Creek Formation gravels, which sometimes crop out on slopes, or may be due to sites being found on high ground around swamp margins, such as those within his study area at Marsden Park.

Less than 1 kilometre north west of the present study area Baker and Courtenay [Baker 1997] carried out a survey of a proposed subdivision on the western side of Glengarrie Road, north of Kelton's study area and also adjoining the eastern boundary of Smith's. In a study area of approximately 35ha 15 artefact locations were recorded [at the time of writing the site forms from this survey had been lodged with NPWS but the report was not available]. One site, GR-OS-1, was estimated to have a total of 20-30 artefacts, and another, GR-OS-4, was estimated to have a total of 100. Almost all of the other sites had less than ten artefacts. Six of the sites were located on alluvial deposits by or near creeks and a further six were on low slopes, only three being located on crests. With few exceptions the artefacts were identified in areas which had sustained moderate to severe disturbance. Naturally broken silcrete was noted at several of the locations.

3.3 Predictions for the Study Area

Due to extensive logging and clearing in the past, scarred trees are unlikely to be present, and in the absence of suitable geology, shelter sites and grinding grooves would not occur. Extraction sites are present in the region, for example at Plumpton Ridge <2km to the east, on Smith's area to the west, and in the ADI site at St Mary's. However, bedrock is not exposed in the study area, so extraction sites are unlikely to occur. Considering the nature of the landscape in the study area outlined in Section 2, open campsites are highly likely to occur. Although chert and other materials would be available from gravels such as those exposed in Smith's study area to the west, the presence of naturally occurring silcrete on the adjoining study areas [Kelton 1996, Baker 1997] suggest that most stone artefacts within the study area are likely to be of that material.

The study area is almost entirely situated on an elevated landform with very gentle slopes and only one defined watercourse. Occupation models based on surface survey would suggest that artefacts could occur anywhere within the study area, perhaps with some concentration around the watercourse. Models based on subsurface testing suggest that throughout the study area artefact distribution is likely to be relatively sparse, representing examples of one-off visitation.

4 SURVEY AND RESULTS

4.1 Methodology

The field survey was carried out on Thursday and Friday 16th and 17th October, 1997. The survey team was shown over the area by the client, geomorphologist Val Smith of Enviro-Managers, who indicated areas to be affected by the proposal and therefore to be covered by the survey [see above Section 2.1].

The Riverstone 1:25,000 topographical map, together with the Riverstone U8267-7 and Rooty Hill U8260-1 1:4,000 orthophoto maps were used in the field. The client also supplied a 1:5,000 topographical plan of the study area. Details of identified locations were entered onto NPWS site recording forms [Appendix D].

4.2 Survey Effectiveness

As indicated in section 1.1 above, there were four participants in the survey. With the survey team walking in transects across each component of the study area, it was possible to achieve a good coverage, particularly in view of the generally good surface visibility. The landforms, level of disturbance and visibility in component sectors of the study area are outlined below, together with an indication of coverage and finds in each.

Table 1: Survey Area Units and Coverage

Sector	Area ha	Description	Landform	Visibility	Coverage	Located
S of main access	14	70% ploughed; dams, road works; 30% regrowth	gentle slope, low and boggy at eastern end	> 40%	8 transects + all exposures	MP8 MP9 MP10
Former quarry	30	totally modified	very broad crest	> 80%		
SE of quarry	27	Paperbark/ironbark forest, kV easement, bulldozed channels, dams, little topsoil	very broad crest	15%	8 transects + all exposures	MP3 MP11 MP12 MP13
N of main access	8	Paperbark/ironbark forest, disturbed, bulldozed channels; very little topsoil	gentle slope and small, modified, now swampy, drainage line	35-70%	8 transects + all exposures	MP4 MP5 MP6 MP7
NE of main access	12	80% cleared and modified; little topsoil	lower on same drainage line, gentle slopes	5-25%	4 transects + all exposures	MP1 MP2
	91					

Because of the generally lower visibility south east of the quarry relatively less coverage was achieved in this area. However visibility was sufficient to characterise environmental and cultural aspects of the area. Access could be constructed through here, otherwise there will be no impact from the development proposed [refer also to Recommendation 2, Section 6].

4.3 Results

Stone artefacts were found in 13 locations, three representing isolated finds and 15 being the largest number of artefacts identified. Site descriptions are listed below, and details of artefact recordings are in Appendix C.

MP1

Grid Ref: 29906 626734 Riverstone 1:25,000

Location: On the eastern bank of a small drainage line with recent gully erosion, about 200 metres south of a dam near Fulton Road [PI3].

Description: Artefacts were scattered within a 50x15 metre area at a maximum density of 2/m². All eleven identified artefacts were recorded, two core fragments being of chert and the remainder, including another two core fragments and seven flake fragments, were of silcrete. Ground visibility amongst a stand of regrowth box and grey gum was 80-90%, but most artefacts were in areas of less visibility. In the surrounding area visibility was generally 0-10%. The soil was a veneer of washed silty unit A sediments. That the area had been disturbed was clear from the absence of trees at that location on the orthophotomap, and bulldozed mounds of earth and tree stumps.

MP2

Grid Ref: 29913 626733 Riverstone 1:25,000

Location: About 70 metres east of MP1, in a 20x150 metre strip extending east along a broad crest, partly on a vehicle track adjacent to the boundary fence.

Description: Some of the artefacts were found amongst paperbarks and ironbarks [PI 4], where ground visibility was 30-50%, sometimes greater at the base of trees, others were on the track, where visibility was 80%, elsewhere visibility was 5-25%. Fourteen artefacts were recorded, all of silcrete, including a core fragment, a modified flake with heat pitting and debitage, three pieces of which were of similar material. Maximum artefact density was 2/m². Soils were a thin and intermittent unit A overlying periodically exposed clay.

MP3

Grid Ref: 29856 626677 Riverstone 1:25,000

Location: On a gentle south eastern slope, south of the main quarry area and about 160 metres north of the caravan park.

Description: Three artefacts were found clustered at the base of a tree [PI 5], near a vehicle track, within one square metre. All of silcrete, one was a core fragment and one of two flake fragments was part of a microblade of the same material as the core. Three other artefacts were found within a 4m² area on the eastern side of the track, including flake fragments of silcrete, quartzite and milky quartz. Mounded earth and an uneven surface suggested that the area had been disturbed during previous quarrying. Ground visibility on the track was 60-80%, and off the track it was about 40%. A thin veneer of unit A soil overlay the clay.

MP4

Grid Ref: 29904 626705 Riverstone 1:25,000

Location: About 80 metres north north east of the road junction at the eastern side of the quarry.

Description: One artefact of silcrete, a section of a large blade used as a micro-blade core and a scraper, was found amongst paperbark trees, in an area where the ground visibility was 40%. A second silcrete flaked piece [or tractorfact?] was 35 metres to the east on a bulldozed drainage line, along which visibility was up to 90% [PI 6].

MP5

Grid Ref: 29905 626717 Riverstone 1:25,000

Location: Just over 100 metres north of MP4, 20 metres east of a dammed swamp, on a shallow drainage channel [PIs 7-8].

Description: Three artefacts were found within a metre square in an area of 20-40% ground visibility amongst woodland of paperbarks and casuarinas, another two were found 10 and 20 metres west and 10 metres south. Another ten were sparsely scattered along a small bulldozed drainage line. One artefact was of quartz, the remainder were silcrete, including two core fragments, several flakes and flake fragments, and pieces of unflaked raw material.

MP6

Grid Ref: 29917 626701 Riverstone 1:25,000

Location: About 200 metres south east of MP5 and about 80 metres north of the quarry access road.

Description: On a faint track amongst paperbarks, where ground visibility was generally 50-70%, two artefacts of silcrete were found no more than a metre apart. One was a flake fragment and the other a core fragment or tractorfact.

MP7

Grid Ref: 29923 626702 Riverstone 1:25,000

Location: About 70 metres east of MP6 and also about 80 metres north of the quarry access road.

Description: One artefact of silcrete, a fragment of a thin blade flake, was identified on a vehicle track amongst the trees. Ground visibility was 70-80% on the track and about 40-60% off it.

MP8

Grid Ref: 29985 626670 Riverstone 1:25,000

Location: On the northern side of the boundary fence adjoining Hollinsworth Road, extending approximately 50-150 metres west of Richmond Road and 30 metres north of Hollinsworth Road [PI 9].

Description: Artefacts were observed along a disturbed strip which is largely gravel lag on clay, unit A being absent. This disturbance may have resulted from road construction. Ground visibility was generally 40-100%. Several artefacts were also observed north of the strip, in a grassed paddock, where visibility was still about 40%. Twelve artefacts were identified, all of silcrete, including a core [PI 10], a core fragment and a number of flake fragments. The core had been heat treated, as had one or two of the flake fragments.

MP9

Grid Ref: 29937 626681 Riverstone 1:25,000

Location: On the western side of a large dam 70-100 metres south of the quarry access road and 20-50 metres north of Hollinsworth Road [PI 11].

Description: Two artefacts, both large flakes of silcrete, were identified 50 metres apart, about 8 metres from the water's edge and 30 metres east of a fence. Ground visibility amongst ironbarks was 30-60%. Unit A was intermittently distributed, the area having been disturbed, probably during dam construction.

MP10

Grid Ref: 29935 626690 Riverstone 1:25,000

Location: Near the north western corner of the paddock in which MP9 is located, less than 100 metres to the north west of that location [PI 12].

Description: Two flake fragments of silcrete were identified 10 metres apart and four metres south of the fence adjoining the quarry access road. Ground visibility in the area is approximately 70%, and mounded earth indicate the area to have been disturbed.

MP11

Grid Ref: 29927 626685 Riverstone 1:25,000

Location: Approximately 140 metres west of MP9, on the southern edge of the transmission line clearing.

Description: One flake fragment of silcrete was identified in a 6x3 metre area of 60% ground visibility.

MP12

Grid Ref: 29901 626669 Riverstone 1:25,000

Location: Some 240-300 metres west of MP13 and 10-20 metres south of the transmission line easement.

Description: Three artefacts of silcrete, including two core fragments and a flake fragment, were found at a maximum density of about 1/30m² amongst paperbarks, where ground visibility was 10-30%. The ground surface amongst the leaf litter was comprised of a very thin veneer of possibly washed unit A and a lag of fine gravel. Heaped paperbark logs, bulldozed drainage levees and channels indicated much of the area to have been disturbed.

MP13

Grid Ref: 29930 626671 Riverstone 1:25,000

Location: About 220 metres south west of MP9 and 100 metres north of Hollinsworth near the bend.

Description: One red silcrete cobble fragment/damaged core was found amongst paperbarks and ironbarks, where ground visibility was about 15%. As at MP12, the ground surface amongst the leaf litter was comprised of a thin veneer of washed unit A and a lag of fine gravel. Heaped paperbark logs, bulldozed drainage levees and channels indicated much of the area to have been disturbed.

4.4 Discussion

A total of 72 stone artefacts were recorded at the thirteen locations. Very few artefacts were intact, about 80% having been damaged by tractors or bulldozers. Several of those recorded could not be confidently identified as having been flaked by human agency, such was the damage many had sustained. Fourteen cores/core fragments were identified, and several pieces with retouch or usewear, and evidence of heat treatment was detected on a number of the silcrete artefacts. As anticipated the preponderance of stone artefacts [66 - over 90%] were of silcrete. Other materials present were quartz [3], chert [2] and quartzite [1]. An occasional piece of probably naturally fractured silcrete was identified.

The artefact fragments seen appeared typical of well developed Bondaian technology, ie probably dating to within the last three millennia. However allocation of a stone industry to particular stages of Bondaian technology is generally based on proportions or frequency of technological traits and raw materials, and in this instance the numbers of intact artefacts were insufficient for reliable conclusions to be drawn.

All actual or probable artefacts observed were recorded. As indicated above, three of the 13 locations represented isolated finds, a further six locations had less than 10 artefacts, and 15 was the largest number of artefacts recorded at any location. Densities were low. At two locations a maximum density of three artefacts/metre square was noted, but generally the level of disturbance was such that artefacts were not definitely *in situ*. Visibility at the artefact locations and throughout most of the study area was sufficient to indicate that the general sparseness of artefact distribution was real [see Section 4.2 above].

It is difficult to detect a pattern of artefact distribution within the landscape, since the study area is largely located on a broad crest with poorly defined or modified drainage lines. While there was variability of artefact distribution, the preponderance of artefacts being found in the north eastern corner of the study area, along a minor drainage line and on a broad crest, no artefact location suggested a focus of activity. Major water sources, such as Bells Creek, 200 metres to the east of Richmond Road, or raw material outcrops, as at Plumpton Ridge, a further 600 metres to the east, or the Rickabys Creek gravels to the west, would provide a focus of occupation and activity which appears to be absent from the study area.

It is generally assumed that density of stone artefacts can be taken as an indication of the intensity of past Aboriginal activity in any one area. Furthermore, different classes of activity appear to be represented by distinct differences in artefact density. For example McDonald and Rich [1993:59] indicated a density range of 190-429 artefacts per m² for knapping floors investigated at Rouse Hill and a range of 34-264 artefacts per m² for general campsites. Most of the 596 trenches they excavated [74%] contained artefact densities of less than 20 artefacts per m². They state that densities of less than 10/m² can be taken as 'suggestive of "background scatters"'.

Results of the present investigation appear to conform to this picture of low density "background scatters". Certainly artefact densities are all at the lower end of the spectrum and on surface manifestations well below the 10/m² which McDonald and Rich [1993b] suggest to be 'beyond the edges of activity areas'.

5 MANAGEMENT ISSUES

Management of Aboriginal sites is carried out within a legislative framework and management policy is based upon the assessed or potential significance or value of the sites.

5.1 Legislative Context

Development is regulated by state and Federal legislation, some of which plays a direct and specific role in managing Aboriginal heritage.

The state legislation of most direct relevance is the *National Parks & Wildlife Act, 1974*, [as amended], whereby it is illegal to damage, deface or destroy an Aboriginal relic without written permission of the Director. Any person aware of the location of a relic is required to report its existence to the Director. Relics may be portable [ie stone artefacts] or fixed [ie rock art sites]. They may consist, for example, of archaeological deposits in shelters or in the open, or of grinding grooves [occurring on sandstone outcrops]. Most fixed Aboriginal sites have the status of real property and thus belong to whoever owns the land on which they occur. They may not, however, be disturbed or destroyed without written consent.

If sites with portable contents, potential archaeological deposits [PADs], or other areas of site potential are identified prior to proposed development, some form of assessment and/or investigation, eg sub-surface testing, will be recommended [unless the sites/material are very disturbed and/or insignificant]. It is necessary to obtain a *Preliminary Research Permit* [PRP] from the National Parks & Wildlife Service before such testing can be carried out. If testing confirms a negative surface survey finding then there would be no archaeological constraint upon proposed development. If testing detects sites then these and any previously identified sites will be subject to determination as to whether they will be impacted by the proposed development. If impact is likely then *Consent to Destroy* must be sought from the NSW National Parks & Wildlife Service. PRP and Consent applications must be accompanied by supportive documentation from the relevant Local Aboriginal Land Council. In the case of Consent to Destroy appropriate salvage may be required. For open sites judged to be of low significance this might simply take the form of collection of visible artefacts; in other cases salvage would be in the form of an archaeological excavation and analysis of excavation results.

The Act enables the NSW National Parks & Wildlife Service to acquire land containing significant relics: these may be dedicated as *Aboriginal Areas* or *Historic Sites*. The National Parks & Wildlife Service may also enter into *Conservation Agreements* with landowners for the protection of relics and/or, with the consent of owners, may declare particular places to be *Protected Aboriginal Areas* while remaining in private ownership. Where a site exists which is significant to Aboriginal people but is unmarked by the existence of physical relics National Parks & Wildlife Service may declare the area an *Aboriginal Place*, thus conferring on it the same protection as a relic.

It is the policy of the NSW National Parks & Wildlife Service that local Aboriginal communities should be consulted about matters affecting sites in their area. Although the Director is not bound by their views, written notification from communities is required to accompany all applications to the Service for permits to investigate or destroy sites or potential sites.

The *Heritage Commission Act, 1975*, establishes the Australian Heritage Commission which maintains a Register of the National Estate. The Register includes many Aboriginal sites which are covered by provisions of relevant state legislation. The Commission offers advice on the conservation of listed sites. The Act constrains Federal Ministers in relation to matters which might affect sites.

Under the terms of the *Federal Aboriginal and Torres Strait Islander Heritage Protection Act, 1984*, the Minister of Aboriginal Affairs may, upon application by Aborigines, intervene to protect objects deemed to be of traditional significance to Aborigines and which are under threat.

The *Native Title Act, 1993*, focuses on continuity of links with an area [Butt 1993]. Where this can be demonstrated Aborigines of local derivation and ancestry will have a case for making claims for land interests arising from it.

5.2 Significance Values

The heritage value, ie the assessed Aboriginal, scientific and public significance of archaeological sites, provides the basis for their management [Sullivan & Bowdler 1984].

1. Scientific or archaeological significance relates to the potential of a site to answer timely and future research questions, and is based on condition/integrity, structure, content and representativeness, the latter being partially defined by its rarity or commonness. Rock shelter sites have considerable potential to provide information about early occupation of an area because their deposits are stable and can preserve cultural and organic materials for long periods of time in chronologically stratified and datable contexts. Open sites have the potential to provide complementary material allowing study of a fuller range of cultural elements.

At all locations, *MP1-13*, artefact densities and absolute numbers are low, and each location exhibits evidence of disturbance. The potential scientific significance of the sites therefore appears to be minimal.

2. Aboriginal significance involves the cultural and archaeological elements which form links with the past for Aboriginal groups. These elements may or may not accord with interpretations made by archaeologists and must be assessed by the Aboriginal people themselves.

In this case assessment would be provided by the Deerubbin Local Aboriginal Land Council.

3. Public significance concerns the potential for use of a site to educate people about the past in cultural and environmental terms. It also relates to the heritage value of particular sites as representative examples of past lifestyles.

The public significance of the individual sites is likely to be low, but combined they do provide insights into past Aboriginal occupation of the area.

6 MANAGEMENT RECOMMENDATIONS

The following recommendations are made on the basis of

- the National Parks & Wildlife Act of 1974 [as amended], whereby it is illegal to damage, deface or destroy an Aboriginal relic without written consent of the Director;
- consultation with the Deerubbin Local Aboriginal Land Council;
- results of the archaeological survey;
- the nature of the development proposed.

The recommendations are based on the assessed archaeological significance of the study area and the recorded sites. This assessment is not to pre-empt any Aboriginal value attributed to the area or to the sites.

1. As a general principle every effort should be made to avoid known Aboriginal sites. However, *MP1-MP13* consist of sparsely distributed artefacts in locations which are at least in part disturbed. Artefact densities at all locations appear to represent little more than background scatter, and as such do not warrant subsurface investigation.

If any of these sites is to be affected by development proposed Ganian Pty Limited should apply in advance to the National Parks & Wildlife Service for Consent to Destroy.

No other locations appeared likely to contain definable undisturbed deposits.

Any Consent to Destroy applications should be directed to the Regional Resources Co-ordinator in the Sydney Zone office of the National Parks & Wildlife Service. Applications should be accompanied by a statement from the Deerubbin LALC.

2. If access were to be via Hollinsworth Road, it would be appropriate for representatives of the DLALC to monitor initial road works for cultural remains, which the finds at *MP11-MP13* indicate to be sparsely scattered through the area.

3. Copies of this report should be forwarded to
Cultural Heritage Co-Ordinator
Sydney Zone
National Parks & Wildlife Service
PO Box 1967
HURSTVILLE 2220.

4. Copies of this report should be forwarded to local Aboriginal community organisations

Mr Frank Vincent, Chairperson
Deerubbin Local Aboriginal Land Council
PO Box V184
MOUNT DRUITT VILLAGE 2770.

Mr Colin Gale, Chairperson
Darug Tribal Aboriginal Corporation
PO Box 441
BLACKTOWN 2148

Mr Bundeluk, Chairperson
Darug Custodian Aboriginal Corporation
PO Box 36
KELLYVILLE 2155

7 REFERENCES

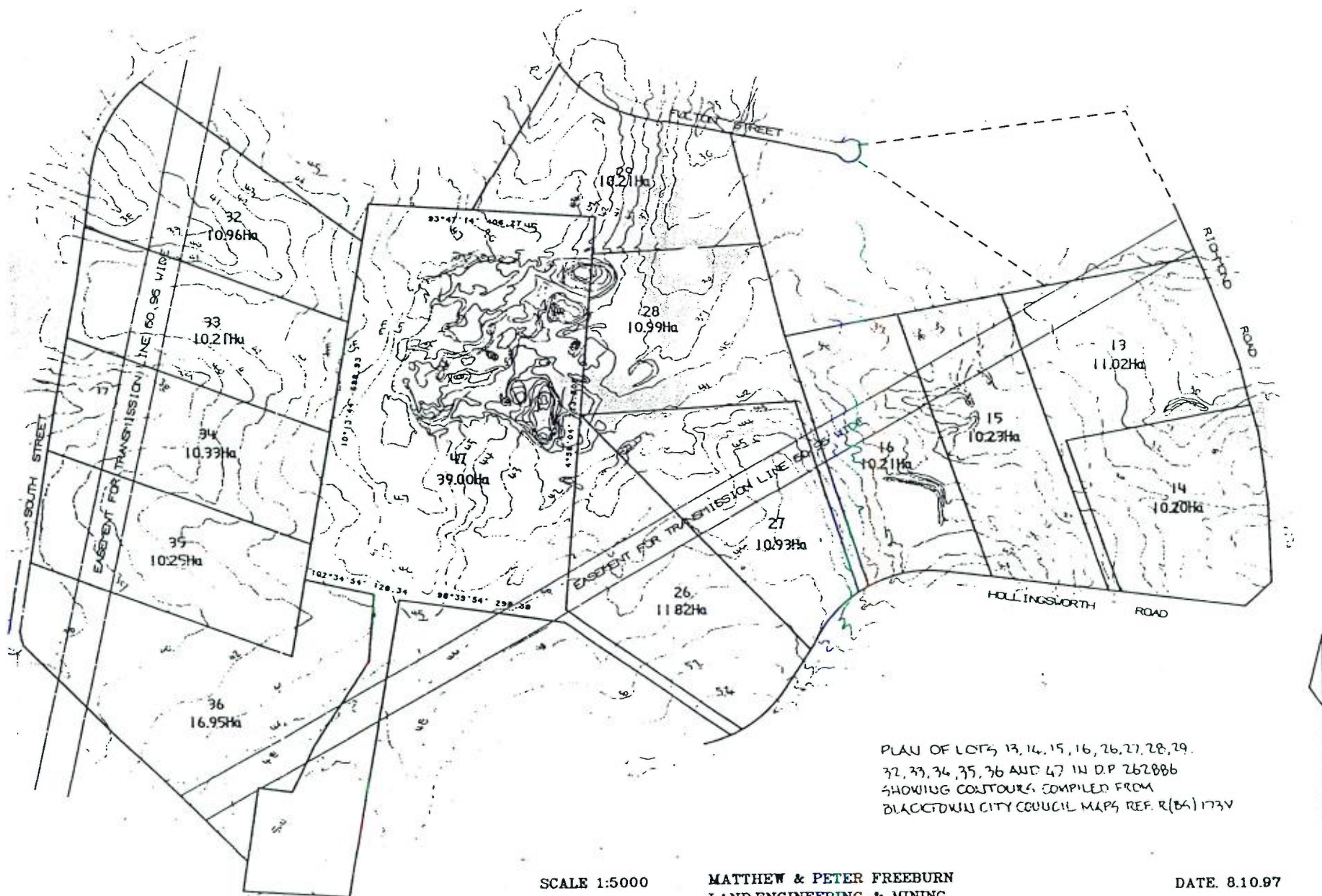
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APPENDIX A: FIGURES



Figure 1: Location Map
Sydney 1:250,000



SCALE 1:5000

DATUM: A.H.D.

DRAWN RW

MATTHEW & PETER FREEBURN
LAND, ENGINEERING & MINING
SURVEYOR
2 CASTLEREAGH STREET
PENRITH 2750

DATE: 8.10.97

REFERENCE No. 21636/DA

Figure 3: Plan of Development Area

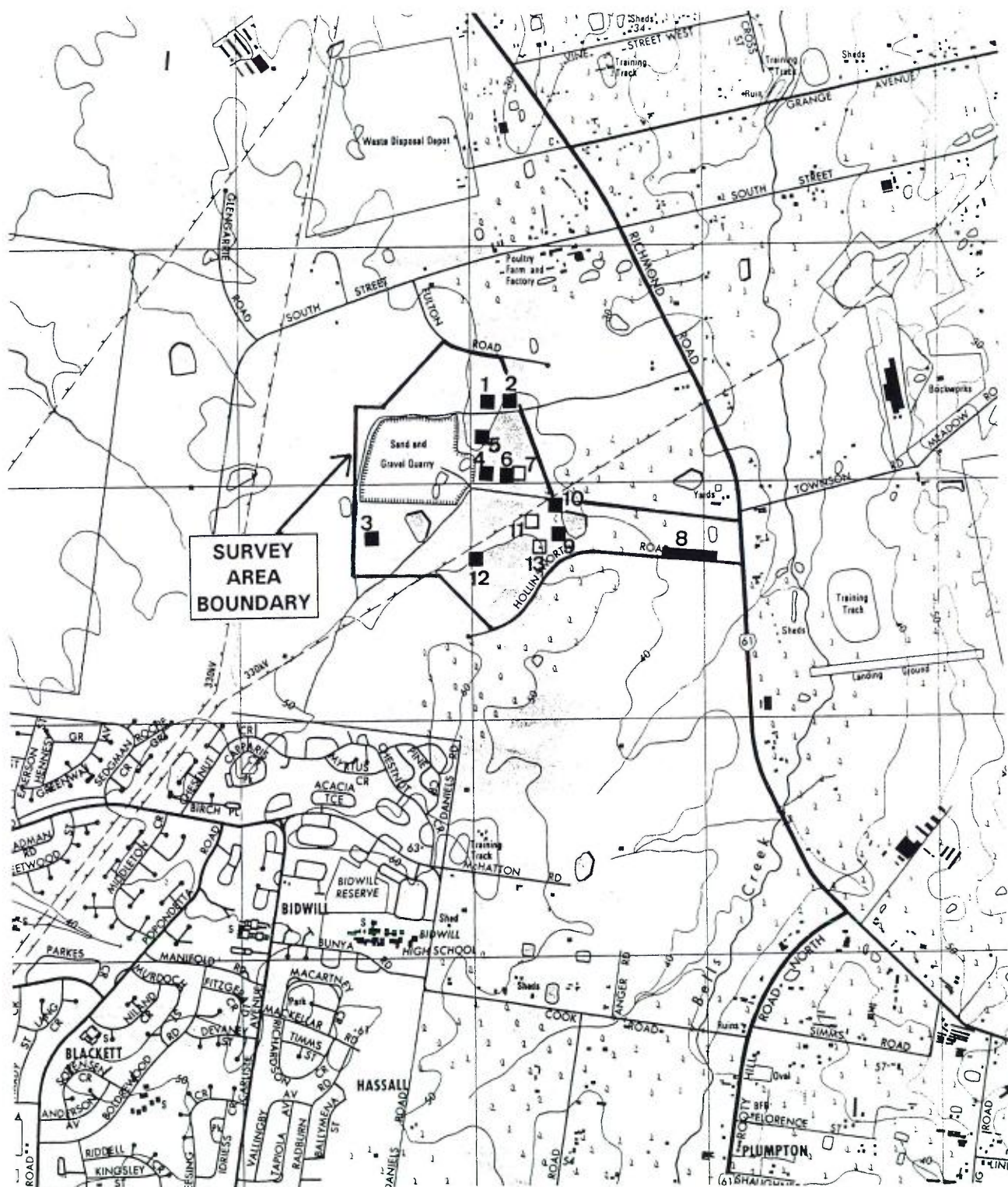


Figure 4: Study Area and Find Locations
Riverstone 1:25,000

APPENDIX B: PLATES



Plate 1: Former Quarry



Plate 2: River gravels imported from the Nepean



Plate 3: *MP1*, camera facing north



Plate 4: Artefacts amongst paperbarks at *MP2*, camera facing south east



Plate 5: *MP3*, camera facing north



Plate 6: *MP4*, camera facing north west



Plate 7: *MP5*, camera facing east



Plate 8: Several of the [damaged] artefacts at *MP5*



Plate 9: *MP8*, camera facing west



Plate 10: Heat treated core at *MP8*



Plate 11: *MP9*, camera facing north



Plate 12: *MP10*, camera facing east

APPENDIX C: ARTEFACT RECORDINGS

Locus	#	Type	Material	Size (range) in mm	Platform(s)	Shape and/or termination	Cortex, use; retouch	Comments
MP1	1	core frag.	chert	(35 x 24 x 23)	multi-?	LFA = 35, LFS = 19	?	recent damage, one core face removed
MP1	2	core frag.	Si, red	< 20	?	?	?	severely damaged
MP1	3	core frag.	Si, dark red	< 17	?	?	?	severely damaged
MP1	4	FF	Si, red	< 23	B1, plain	L > W; no tip	?	conchoidal fracture
MP1	5	FF	Si, red	< 28	B1, plain	L > W; no tip	?	thick, wide angle platform
MP1	6	FF	Si, purple	< 20	?	mid-part	?	v. fine-grained material
MP1	7	FF	Si, purple	< 13	damaged	?	Plfm:cx?	severely damaged
MP1	8	FF	Si, red	< 12	-	?	?	severely damaged
MP1	9	FF	Si, grey/red	< 17	-	?	?	v. fine-grained material
MP1	10	FF	Si, red	< 21	?	L > W	Feather term.	
MP1	11	core frag.	Chert, orange	(24 x 23) x 6	multi-	'fabricator' style core	(Feather?)	Bifacial flaking from margins towards centre; anvil rested? on flake.
MP2	1	FF	Si, red	(30 x 30) x 7	modified	1/4 of round flake?	scalar, steep, inverse	retouch on flake margins present on the fragment and on platform
MP2	2	FF	Si, dark red	< 36	B2, plain	?	-	v. fine-grained material
MP2	3	core frag.	Si, purple	(47 x 40 x 24)	?	?	-	fresh break
MP2	4	FF, mod.	Si, dark red	(56 x 38 x 12)	?	?	scalar retouch	thin, flat, RU = 1 margin; heat pitted
MP2	5	FF	Si, grey	< 27	?	?	?	
MP2	6	FP	Si, grey	< 21	-	amorphous	-	raw material, cf. #5,7
MP2	7	FF	Si, grey	< 20	B2, ss	L > W, no tip		2-ridge blade; recent damage
MP2	8	FF	Si, red	< 14	?	L > W; feather		tip of blade; damaged
MP2	9	FF	Si, red	< 21	?	?		mid-section of blade
MP2	10	FF	Si, red	< 16	?	? ; feather	?	
MP2	11	F	Si, red	47 x 47 x 25	B2, plain	modified but damaged	-	Chunky flake; dorsal ridge = former striking platform
MP2	12	F	Si, red	26 x 22 x 12	B1, plain	L > W; feather		damaged
MP2	13	FP	Si, red	(40 x 18 x 18)		amorphous	steep, scalar	23 mm of margin/edge has retouch
MP2	14	F	Si, red	< 17	?	L > W; feather		pointed flake

Si - silcrete, F - flake, FF - flake fragment, FP - flaked piece, plain plfm - plfm = 1 negative scar, ss plfm - plfm = > 1 negative scar, term. = flake termination, mod.- modified = R/U = retouch/use-wear, v. = very, L > W = longer than wide etc, df = dorsal face, cx - cortex, LFA, LFS = longest flaking axis/negative flake scar.

Locus	#	Type	Material	Size (range) in mm	Platform(s)	Shape and/or termination	Cortex, use; retouch	Comments
MP3	1	FF	Si, red	< 28	B2, plain	L>W; no tip	df: 10 %	very flat flake
MP3	2	core frag.	Si, grey	(25 x 18 x 12)	multi-?	?	1 face = cx	same material as # 3
MP3	3	FF	Si, grey	< 14	B1, plain	L>W; no tip		micro-blade
MP3	4	FF	Si, grey	< 26	?	?		part of chunky flake
MP3	5	FF	Quartzite, grey	< 21	?	L>W; tip snapped		mid-part of 2- ridge blade
MP3	6	FF	Quartz, milky	< 10	B1, shattered	W>L; feather		chip
MP4	1	core	Si, red	25 x 25 x 8	Plfm + margin removed = burin edge	tip modified (scraper?)	scalar retouch on distal end	section of large blade used as micro- blade core & scraper
MP4	2	FF	Si, red	< 33				flaked piece or tractor fact?
MP5	1	FF	Si, pink	< 23	?	?	-	fragment of thin flake
MP5	2	FF	Si, red	< 33	B1, plain	L>W; no tip	df: 60% cx	chunky flake
MP5	3	F	Si, red	40 x 14 x 10	B1, plain	L>W; feather	df: 100% cx	
MP5	4	core frag.	Si, red	< 18	?	?	?	fragment of core on flake
MP5	5	FP	Si, red	35 x 18 x 11	-	-	steep flaking on frag. tip	one flat face = cleavage; triangular cross section
MP5	6	FF	Quartz, white	< 23	?	?	?	conchoidal fracture but badly damaged
MP5	7	-	Si, red	< 33	-	-	-	piece of raw material
MP5	8	FF	Si, red	< 23	B2, plain	L>W, no tip	-	blade, triangular section
MP5	9	F	Si, red	23 x 16 x 4	B2, plain	L>W; feather	-	blade, 2-ridge section
MP5	10	FF	Si, red	< 21	?	?		non-descript flake fragment
MP5	11	F	Si, red	22 x 14 x 4	B2, plai	L>W; feather	df: 70%	skew flake; triangular section
MP5	12	FF	Si, red	< 23	?	?	cx present	10% remaining margin = cx
MP5	13	F	Si, red	29 x 22 x 13	B1, plain	L>W; feather	df: 70% cx	blade, 2-ridge section
MP5	14	core frag.	Si, red	39 x 27 x 17	multi- (> 2)			badly damaged
MP5	15	FP	Si, grey	< 30		amorphous		raw material?

Si - silcrete, F - flake, FF - flake fragment, FP - flaked piece, plain plfm - plfm = 1 negative scar, ss plfm - plfm = > 1 negative scar,
term. = flake termination, mod.- modified = R/U = retouch/use-wear, v. = very, L>W = longer than wide etc, df = dorsal face, cx - cortex,
LFA, LFS = longest flaking axis/negative flake scar.

Locus	#	Type	Material	Size (range) in mm	Platform(s)	Shape and/or termination	Cortex, use; retouch	Comments
MP6	1	FF	Quartz, white	< 18	Focal, plain	? ; no tip	-	thin flake
MP6	2	FP	Si, red	< 45	-	amorphous	-	core fragment or tractorfact?
MP7	1	FF	Si, red	< 20	B1, ss	L>W; no tip	-	thin blade, triangular section
MP8	1	FF	Si, red	< 34	B1, plain	L>W?; no tip	df: 100% cx	thick flake-rectangular fragment; some use-wear or damage?
MP8	2	F	Si, red	25 x 17 x 4	Focal, broken	L>W; feather	-	skew flake
MP8	3	FF	Si, red	< 22	B1, ss	?	-	chunky flake
MP8	4	FF	Si, red	< 8	-	feather	-	tip of thin flake, glossy = heat treated?
MP8	5	FF	Si, red	< 34	?	?	-	chunky flake, much recent damage
MP8	6	cor frag.	Si, grey	25 x 13 x 12	?	?	-	probable core fragment
MP8	7	FF	Si, red	< 16	B1, plain	L>W; ?	-	blade, triangular section
MP8	8	FF	Si, red	< 19	?	L>W; ?	-	blade fragment, 2-ridge section
MP8	9	F	Si, red	< 25	Focal, plain	splayed	-	heat spalling = due to exposure?
MP8	10	FF	Si, grey	< 13	?	?	-	fragment of thin flake
field:								
MP8	11	Core	Si, red	68 x 60 x 58	multi - (3)	columnar but from cobble	3 faces show traces of cleavage	1 plfm = cleavage, 2plfm = alternating flaking, LFA = 66, LFS = 30mm; many small irregular facets = heat treated.
MP8	12	FF	Si, red	< 24	?	?	-	possible artefact
MP9	1	F	Si, red	21 x 15 x 12	Focal, plain	L>W; feather	df = 30%	segment shape, thick margin = 100% cortex
MP9	2	F	Si, red/yellow	40 x 34 x 12	Focal, plain	W>L; hinge	df:10%	irregular, lumpy flake = outer layer; dorsal face partly cleavage; probably heat treated.

Si - silcrete, F - flake, FF - flake fragment, FP - flaked piece, plain plfm - plfm = 1 negative scar, ss plfm - plfm = >1 negative scar, term. = flake termination, mod. - modified = R/U = retouch/use-wear, v. = very, L>W = longer than wide etc, df = dorsal face, cx - cortex, LFA, LFS = longest flaking axis/negative flake scar.

Locus	#	Type	Material	Size (range)	Platform(s)	Shape and/or termination	Cortex, use; retouch	Comments
MP10	1	FF.	Si, red	< 17	?			Circa 1/4 of a chunky flake?
	2	FF	Si, red	< 19	damaged			core tablet: dorsal ridge = remains of older platform, apparently from columnar core
MP11	1	FF	Si, grey	< 26	?			tip of thin flake/blade with 2-ridge section
MP12	1	Core frag.	Si, grey/pink	< 27				no platform; possibly tractorfact
	2	Core frag.	Si, grey	< 20				no platform; possibly tractorfact
	3	FF	Si, pink/red	< 22	B2, plain	? : feather		thin flake; cone split fragment
MP13	1	Core?	Si, red	32x28x18	?	cobble	40% cortex	tractorfact?

Si - silcrete, F - flake, FF - flake fragment, FP - flaked piece, plain plfm - plfm = 1 negative scar, ss plfm - plfm = > 1 negative scar, term. = flake termination, mod.- modified = R/U = retouch/use-wear, v. = very, L>W = longer than wide etc, df = dorsal face, cx - cortex, LFA, LFS = longest flaking axis/negative flake scar.

APPENDIX D: NPWS SITE RECORDING FORMS



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

NPWS Code

1:250,000 map sheet:

SYDNEY

145

AMG Grid reference

Full reference - please include leading digits

250K 250K
 299060 mE 6267340 mN
 25K 5/6 25K

Scale of map used for grid reference
 Please use largest scale available

[] 25K, 50K [] 100K [] 250K
 (Preferred)

1:25K, 50K, 100K map name:

RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no:

Site types

Accessioned by:

Date:

Data entered by:

Date:

Owner/Manager

Address:

Site name:

MP 1

Locality/property name:

Marsden Park

NPWS District:

North West

Region:

Sydney Zone

Reason for investigation

EIS

Portion no.

Parish:

Photos taken? Y

How many attached? See report

How to get to the site (refer to permanent features, give best approach to site eg. from above, below, along cliff
 (Draw diagram on separate sheet))

Site is on water course c 100m south of Fulton Rd, Marsden Park

Other sites in locality?

Y

Site Types include open sites

Are sites in NPWS Register?

Have artefacts been removed from site?

N

When?

By whom?

Deposited where?

Is site important to local Aborigines?

Luke Hickey & Tony Randall

Give contact(s) name(s) + address(es)

Jesurubin LALC

PO Box 1184

Mt Druitt Village

Additional, see report

Contacted for this recording?

Y

Attach additional information separately) If not, why not?

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Road Marsden Park NSW
 Archaeological survey H. Grayshaw & L. Haglund Nov. 1997
 for Aboriginal Sites.

NPWS Report
Catalogue #

Checklist

surface visibility
 damage/disturbance/
 threat to site

Condition of site

Disturbed, very little topsoil

Recommendations for management & protection (attach separate sheet if necessary)

Consent to Destroy if req.

Site recorded by:

H. Grayshaw & L. Haglund

Date: 16.10.97

Address/institution:

51 Thompson St
 Drummoyne 2047

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc: *creek side* b. site aspect: c. slope:
- d. mark on diagram provided or on your own sketch the position of the site: e. Describe briefly: *see below*



- f. Local rock type: *Bringingelly shale* g. Land use/effect: *cleared, bulldozed?*

2. Distance from drinking water: *25 m* Source: *Tributary of South Ck*

3. Resource Zone associated with site (estuarine, riverine, forest etc): *woodland*

4. Vegetation: *Box*

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Open Site

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP1

Grid Ref: 29906 626734 Riverstone 1:25,000

Location: On the eastern bank of a small drainage line with recent gully erosion, about 200 metres south of a dam near Fulton Road.

Description: Artefacts were scattered within a 50x15 metre area at a maximum density of 2/m². All eleven identified artefacts were recorded, two core fragments being of chert and the remainder, including another two core fragments and seven flake fragments, were of silcrete. Ground visibility amongst a stand of regrowth box and grey gum was 80-90%, but most artefacts were in areas of less visibility. In the surrounding area visibility was generally 0-10%. The soil was a veneer of washed silty unit A sediments. That the area had been disturbed was clear from the absence of trees at that location on the orthophotomap, and bulldozed mounds of earth and tree stumps.

CHECKLIST TO HELP:

length, width, depth, height of site, shelter, deposit, structure, element eg. tree scar, grooves in rock.

DEPOSIT: colour, texture, estimated depth, stratigraphy, contents-shell, bone, stone, charcoal, density & distribution of these, stone types, artefact types.

ART area of surface decorated, motifs, colours, wet, dry pigment, technique of engraving, no. of figures, sizes, patination.

BURIALS: number & condition of bone, position, age, sex, associated artefacts.

TREES: number, alive, dead, likely age, scar shape, position, size, patterns, axe marks, regrowth.

QUARRIES: rock type, debris, recognisable artefacts, percentage quarried.

OTHER SITES EG. structures (fish traps, stone arrangements, bora rings, mia mias), mythological sites, rock holes, engraved groove channels, contact sites (missions massacres cemeteries) as appropriate

Attach sketches etc. eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

1:250,000 map sheet: SYDNEY

NPWS Code

145

AMG Grid reference

Full reference - please include leading digits

250K 250K
 299130 mE 6267330 mN
 25K 5/6 25K

 Scale of map used for grid reference
 Please use largest scale available

☒ 25K, 50K (preferred)
 ☐ 100K
 ☐ 250K

☒ 25K, 50K, 100K map name: RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types: _____

Accessioned by: _____ Date: _____

Data entered by: _____ Date: _____

Owner/Manager

Address: _____

Site name: MP2Locality/property name: Marsden ParkNPWS District: North MtRegion: Spray Zone

Reason for investigation

EIS

Portion no: _____

Parish: _____

Photos taken? YHow many attached? see report
 How to get to the site (refer to permanent features, give best approach to site eg. from above, below, along cliff)
 (Draw diagram on separate sheet)

Site is on a cross, 100+ m south of Fulton Rd, Marsden Park
Other sites in locality? Y

Site Types include: _____

Are sites in NPWS Register? _____

Have artefacts been removed from site? N

When? _____

By whom? _____

Deposited where? _____

Is site important to local Aborigines? _____

Give contact(s) name(s) + address(es)

Luke Hickey & Tony RandallDeerubbin LALCPO Box 1184Mt Druitt VillageAdditional, see report

Contacted for this recording? _____

Attach additional information separately if not, why not? _____

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Road Marsden Park NSW
Archaeological survey for Aboriginal sites
H. Brayshaw & L. Haglund
November 1997
NPWS Report
Catalogue #

Checklist

 surface visibility,
 damage/disturbance/
 threat to site

Condition of site:

At least partially disturbed, thin topsoil

Recommendations for management & protection (attach separate sheet if necessary)

Consent to Destroy if req.Site recorded by: H Brayshaw & L HaglundDate: 16.10.97Address/institution: S. Thompson StDrumoyne 2047

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc:
- b. site aspect:
- c. slope:
- d. mark on diagram provided or on your own sketch the position of the site
- e. Describe briefly:



- f. Local rock type: *Bringingelly shale*
- g. Land use/effect:

2. Distance from drinking water: *100m*
- Source: *Tributary of South Creek*

3. Resource Zone associated with site (estuarine, riverine, forest etc): *woodland*

4. Vegetation *Paper barks*

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

*Open
Site*

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP2

Grid Ref: 29913 626733 Riverstone 1:25,000

Location: About 70 metres east of MP2, in a 20x150 metre strip extending east along a broad crest, partly on a vehicle track adjacent to the boundary fence.

Description: Some of the artefacts were found amongst paperbarks and ironbarks, where ground visibility was 30-50%, sometimes greater at the base of trees, others were on the track, where visibility was 80%, elsewhere visibility was 5-25%. Fourteen artefacts were recorded, all of silcrete, including a core fragment, a modified flake with heat pitting and debitage, three pieces of which were of similar material. Maximum artefact density was 2/m². Soils were a thin and intermittent unit A overlying periodically exposed clay.

CHECKLIST TO HELP:

length, width, depth.
height of site, shelter.
deposit, structure.
element eg. tree scar.
grooves in rock.
DEPOSIT: colour.
texture, estimated
depth, stratigraphy.
contents-shell, bone.
stone, charcoal, density
& distribution of these.
stone types, artefact
types.

ART area of surface
decorated, motifs.
colours, wet, dry
pigment, technique of
engraving, no. of
figures, sizes,
patination.

BURIALS: number &
condition of bone.
position, age, sex,
associated artefacts.

TREES: number, alive,
dead, likely age, scar
shape, position, size,
patterns, axe marks,
regrowth

QUARRIES: rock type,
debris, recognisable
artefacts, percentage
quarried.

OTHER SITES EG.
structures (fish traps,
stone arrangements,
bora rings, mia mias),
mythological sites, rock
holes, engraved groove
channels, contact sites
(missions massacres
cemeteries) as
appropriate

Attach sketches etc, eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

1:250,000 map sheet: SYDNEY NPWS Code 1451

AMG Grid reference

Full reference - please include leading digits

250K 250K
 298560 mE 6266770 mN
 25K 5/6 25K

Scale of map used for grid reference
Please use largest scale available
☒ 25K, 50K (preferred) [☐] 100K [☐] 250K
1:25K, 50K, 100K map name: RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types

Accessioned by: _____ Date: _____

Data entered by: _____ Date: _____

Owner/Manager

Address

Site name

MP3

Locality/property name

Marsden Park

NPWS District

North West

Region

Sydney Zone

Reason for investigation

EIS

Portion no

Parish

Photos taken? YHow many attached? See reportHow to get to the site (refer to permanent features, give best approach to site eg from above, below, along cliff
(Draw diagram on separate sheet))Site is c. 100m south of former quarry, accessed from Richmond Rd

Other sites in locality?

Y

Site Types include

open sites

Are sites in NPWS Register?

Have artefacts been removed from site?

N

When?

By whom?

Deposited where?

Is site important to local Aborigines?

Give contact(s) name(s) + address(es)

Lyle Hickey & Tony Randall
Deerubbin LALC
PO Box 1184
Mt Druitt Village

Additional, see report

Contacted for this recording?

Y

Attach additional information separately if not, why not?

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Rd Marsden Park NSW
archaeological survey for Aboriginal sites. H. Brayshaw & L. Haglund
Nov. 1997

NPWS Report
Catalogue #

Checklist

 surface visibility
 damage/disturbance/
 threat to site

Condition of site

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by:

H. Brayshaw & L. Haglund
51 Thompson St
Drumoyne 2047

Date: 16.10.97

Address/institution:

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc: *slope* b. site aspect: c. slope:
- d. mark on diagram provided or on your own sketch the position of the site: e. Describe briefly:



see below

- f. Local rock type: *Bringingelly shale* g. Land use/effect:

2. Distance from drinking water: *5-600m?* Source: *Tributary of South Creek*

3. Resource Zone associated with site (estuarine, riverine, forest etc): *woodland*

4. Vegetation: *Ironbark box*

5. Edible plants noted:

6. Faunal resources (include shellfish)

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Open site

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP3

Grid Ref: 29856 626677 Riverstone 1:25,000

Location: On a gentle south eastern slope, south of the main quarry area and about 160 metres north of the caravan park.

Description: Three artefacts were found clustered at the base of a tree, near a vehicle track, within one square metre. All of silcrete, one was a core fragment and one of two flake fragments was part of a microblade of the same material as the core. Three other artefacts were found within a 4m² area on the eastern side of the track, including flake fragments of silcrete, quartzite and milky quartz. Mounded earth and an uneven surface suggested that the area had been disturbed during previous quarrying. Ground visibility on the track was 60-80%, and off the track it was bout 40%. A thin veneer of unit A soil overlay the clay.

CHECKLIST TO HELP:
length, width, depth,
height of site, shelter,
deposit, structure,
element eg. tree scar,
grooves in rock.

DEPOSIT: colour,
texture, estimated
depth, stratigraphy,
contents-shell, bone,
stone, charcoal, density
& distribution of these,
stone types, artefact
types.

ART: area of surface
decorated, motifs,
colours, wet, dry
pigment, technique of
engraving, no. of
figures, sizes,
patination.

BURIALS: number &
condition of bone,
position, age, sex,
associated artefacts.

TREES: number, alive,
dead, likely age, scar
shape, position, size,
patterns, axe marks,
regrowth

QUARRIES: rock type,
debris, recognisable
artefacts, percentage
quarried.

OTHER SITES EG.
structures (fish traps,
stone arrangements,
bora rings, mia mias),
mythological sites, rock
holes, engraved groove
channels, contact sites
(missions massacres
cemeteries) as
appropriate

Attach sketches etc. eg. plan & section of shelter, show relation between site contents,
indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

1:250,000 map sheet:

SYDNEY

NPWS Code

14.5

AMG Grid reference

Full reference - please include leading digits

250K

299040

mE

250K

6267050

mN

25K

5/6

25K

Scale of map used for grid reference
Please use largest scale available☒25K, 50K
(preferred)☐ 100K☐ 250K☒ 25K, 50K, 100K map name:

RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types _____

Accessioned by: _____

Date: _____

Data entered by: _____

Date: _____

Owner/Manager _____

Address _____

Site name: AP4

Locality/property name: Marsden Park

NPWS District: North Mt

Region: Sydney Zone

Reason for investigation

EIS

Portion no

Parish:

Photos taken? Yes

How many attached? See report

How to get to the site (refer to permanent features, give best approach to site eg from above, below, along cliff
(Draw diagram on separate sheet))

L40 m N of access to quarry from Richmond Road.

Other sites in locality? Y

Site Types include open sites

Are sites in NPWS Register?

Have artefacts been removed from site? N

When?

By whom?

Deposited where?

Is site important to local Aborigines?

Give contact(s) name(s) + address(es)

Luke Hickey & Tony Randall
Deerubbin LALC
PO Box V.184
Mt Druitt Village

Additional, see report

Contacted for this recording? Y

Attach additional information separately) If not, why not?

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Rd Marsden Park
archaeological survey for Aboriginal sites H. Brayshaw & L. Haglund
Nov. 1997NPWS Report
Catalogue #

Checklist

surface visibility,
damage/disturbance/
threat to site

Condition of site

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by:

Helen Brayshaw & Laila Haglund

Date: 16.10.97

Address/institution:

51 Thompson St
Drumoyne 2047

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc:

b. site aspect:

c. slope:

d. mark on diagram provided or on your own sketch the position of the site:

e. Describe briefly:



See below

f. Local rock type: *Bringingelly shale*

g. Land use/effect: *part bulldozed*

2. Distance from drinking water: *< 50m*

Source: *Tributary of South Creek*

3. Resource Zone associated with site (estuarine, riverine, forest etc):

4. Vegetation:

Paperbark

woodland/forest

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Open Site

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP4

Grid Ref: 29904 626705 Riverstone 1:25,000

Location: About 80 metres north north east of the road junction at the eastern side of the quarry.

Description: One artefact of silcrete, a section of a large blade used as a micro-blade core and a scraper, was found amongst paperbark trees, in an area where the ground visibility was 40%. A second silcrete flaked piece [or tractorfact?] was 35 metres to the east on a bulldozed drainage line, along which visibility was up to 90%.

CHECKLIST TO HELP:

length, width, depth, height of site, shelter, deposit, structure, element eg. tree scar, grooves in rock.

DEPOSIT: colour, texture, estimated depth, stratigraphy, contents-shell, bone, stone, charcoal, density & distribution of these, stone types, artefact types.

ART area of surface decorated, motifs, colours, wet, dry pigment, technique of engraving, no. of figures, sizes, patination.

BURIALS: number & condition of bone, position, age, sex, associated artefacts.

TREES: number, alive, dead, likely age, scar shape, position, size, patterns, axe marks, regrowth

QUARRIES: rock type, debris, recognisable artefacts, percentage quarried.

OTHER SITES EG. structures (fish traps, stone arrangements, bora rings, mia mias), mythological sites, rock holes, engraved groove channels, contact sites (missions massacres cemeteries) as appropriate

Attach sketches etc. eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

1:250,000 map sheet:

SYDNEY

NPWS Code

145

AMG Grid reference

Full reference - please include leading digits

250K

299050 mE

25K

250K

6267170 mN

25K

Scale of map used for grid reference

Please use largest scale available

☒ 25K, 50K
(preferred)

☐ 100K

☐ 250K

1:25K, 50K, 100K map name:

RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types _____

Accessioned by: _____

Date: _____

Data entered by: _____

Date: _____

Owner/Manager _____

Address _____

Site name

MP5

Locality/property name

Marsden Park

NPWS District

North Met

Region

Sydney Zone

Reason for investigation

EIS

Portion no: _____

Parish: _____

Photos taken? ☒

How many attached?

see report

How to get to the site (refer to permanent features, give best approach to site eg from above, below, along cliff)
(Draw diagram on separate sheet)

Site is 200m north of quarry access from Richmond Road

Other sites in locality?

Y

Site Types include

open sites

Are sites in NPWS Register?

Have artefacts been removed from site?

N

When?

By whom?

Deposited where?

Is site important to local Aborigines?

Give contact(s) name(s) + address(es)

Luke Hickey & Tony Randall

Deerubbin LALC

PO Box 1184

Mt Druitt Village

Additional, see report

Contacted for this recording?

Attach additional information separately if not, why not?

Verbal/written reference sources (including full title of accompanying report)

Proposed land fill operation Richmond Road Marsden Park NSW
archaeological survey for Aboriginal sites. H. Brayshaw & L. Haglund
Nov. 1997NPWS Rep
Catalogue #

Checklist

surface visibility
damage/disturbance/
threat to site

Condition of site

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by: Helen Brayshaw & Laila Haglund

Date: 16.10.97

Address/institution: 51 Thompson St
Drumoyne 2097

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc:

woodland gentle slope

b. site aspect:

c. slope:

d. mark on diagram provided or on your own sketch the position of the site:

e. Describe briefly:

see below



f. Local rock type:

g. Land use/effect:

2. Distance from drinking water:

300m

Source:

Stn Ck trib.

3. Resource Zone associated with site (estuarine, riverine, forest etc):

woodland/forest

4. Vegetation:

Paperbarks

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Open Site

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP5

Grid Ref: 29905 626717 Riverstone 1:25,000

Location: Just over 100 metres north of MP4, 20 metres east of a dammed swamp, on a shallow drainage channel.

Description: Three artefacts were found within a metre square in an area of 20-40% ground visibility amongst woodland of paperbarks and casuarinas, another two were found 10 and 20 metres west and 10 metres south. Another ten were sparsely scattered along a small bulldozed drainage line. One artefact was of quartz, the remainder were silcrete, including two core fragments, several flakes and flake fragments, and pieces of unflaked raw material.

CHECKLIST TO HELP:

length, width, depth, height of site, shelter, deposit, structure, element eg. tree scar, grooves in rock.

DEPOSIT: colour, texture, estimated depth, stratigraphy, contents-shell, bone, stone, charcoal, density & distribution of these, stone types, artefact types.

ART area of surface decorated, motifs, colours, wet, dry pigment, technique of engraving, no. of figures, sizes, patination.

BURIALS: number & condition of bone, position, age, sex, associated artefacts.

TREES number, alive, dead, likely age, scar shape, position, size, patterns, axe marks, regrowth

QUARRIES rock type, debris, recognisable artefacts, percentage quarried.

OTHER SITES EG. structures (fish traps, stone arrangements, bora rings, mia mias), mythological sites, rock holes, engraved groove channels, contact sites (missions massacres cemeteries) as appropriate

Attach sketches etc. eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

1:250,000 map sheet:

SYDNEY

NPWS Code

14, 5

AMG Grid reference

Full reference - please include leading digits

250K

2 4 9 1 7 0

mE

250K

6 2 6 7 0 1 0

mN

25K

5/6

25K

Scale of map used for grid reference
Please use largest scale available[☒] 25K/50K (preferred) [☐] 100K [☐] 250K

25K/50K, 100K map name:

RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types: _____

Accessioned by: _____

Date: _____

Data entered by: _____

Date: _____

Owner/Manager: _____

Address: _____

Site name:

MP 6

Locality/property name:

Marsden Park

NPWS District:

North Mt

Region:

Sydney zone

Reason for investigation

EIS

Portion no: _____

Parish: _____

Photos taken? _____

How many attached? _____

How to get to the site (refer to permanent features, give best approach to site eg. from above, below, along cliff.
(Draw diagram on separate sheet)

Site is 80m north of quarry access road

Other sites in locality?

Y

Site Types include:

open sites

Are sites in NPWS Register?

Have artefacts been removed from site?

N

When?

By whom?

Deposited where?

Is site important to local Aborigines?

Give contact(s) name(s) + address(es)

Luke Hickey & Tony Randall

Deerubbin LALC

PO Box 1184

Mt Druitt Village

Additional, see report

Contacted for this recording?

Attach additional information separately) If not, why not?

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Rd Marsden Park NSW
Archaeological survey for Aboriginal sites H. Grayshaw & L. Haglund
November 1997NPWS Report
Catalogue #

Checklist

surface visibility
damage/disturbance/
threat to site

Condition of site

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by:

Helen Grayshaw & Lorla Haglund

Date:

16.10.97

Address/institution:

51 Thompson St
Munnabry 2047

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc: *gautle slope*
d. mark on diagram provided or on your own sketch the position of the site:

- b. site aspect: c. slope:
e. Describe briefly:



see below

- f. Local rock type: *Bringingelly shale* g. Land use/effect:

2. Distance from drinking water: *< 200m* Source:

- 3 Resource Zone associated with site (estuarine, riverine, forest etc): *woodland/forest*

- 4 Vegetation: *Paperbarks*

5. Edible plants noted:

- 6 Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Open Site

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP6

Grid Ref: 29917 626701 Riverstone 1:25,000

Location: About 200 metres south east of MP5 and about 80 metres north of the quarry access road.

Description: On a faint track amongst paperbarks, where ground visibility was generally 50-70%, two artefacts of silcrete were found no more than a metre apart. One was a flake fragment and the other a core fragment or tractorfact.

CHECKLIST TO HELP:

length, width, depth, height of site, shelter, deposit, structure, element eg. tree scar, grooves in rock.

DEPOSIT: colour, texture, estimated depth, stratigraphy, contents-shell, bone, stone, charcoal, density & distribution of these, stone types, artefact types.

ART area of surface decorated, motifs, colours, wet, dry pigment, technique of engraving, no. of figures, sizes, patination.

BURIALS: number & condition of bone, position, age, sex, associated artefacts.

TREES: number, alive, dead, likely age, scar shape, position, size, patterns, axe marks, regrowth

QUARRIES: rock type, debris, recognisable artefacts, percentage quarried.

OTHER SITES EG. structures (fish traps, stone arrangements, bora rings, mia mias), mythological sites, rock holes, engraved groove channels, contact sites (missions massacres cemeteries) as appropriate

Attach sketches etc, eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

1:250,000 map sheet: SYDNEY

NPWS Code

14.5

AMG Grid reference

Full reference - please include leading digits

250K 250K
 299230 mE 6267020 mN
 25K 5/6 25K

Scale of map used for grid reference

Please use largest scale available

☒ 25K, 50K (preferred) [] 100K [] 250K

☒ 25K, 50K, 100K map name: RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types: _____

Accessioned by: _____

Date: _____

Data entered by: _____

Date: _____

Owner/Manager: _____

Address: _____

Site name: MP 7Locality/property name: Marsden ParkNPWS District: North MtRegion: Sydney zone

Reason for investigation

EIS

Portion no: _____

Parish: _____

Photos taken? _____

How many attached? _____

How to get to the site (refer to permanent features, give best approach to site eg. from above, below, along cliff
 (Draw diagram on separate sheet))

c 100m N of quarry access roadOther sites in locality? YSite Types include: open sites

Are sites in NPWS Register? _____

Have artefacts been removed from site? N

When? _____

By whom? _____

Deposited where? _____

Is site important to local Aborigines? _____

Give contact(s) name(s) + address(es)

Like Hickey + Tony Randall
Deerubbin LALC
PO Box 1184
Mt Druitt Village

Additionally, see
report

Contacted for this recording? _____

(Attach additional information separately) If not, why not? _____

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Road Marsden Park NSW
archaeological survey for Aboriginal sites. N Grayshaw + C Haglund
November 1997

NPWS Report
Catalogue #

Checklist

surface visibility
 damage/disturbance/
 threat to site

Condition of site:

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by:

Helen Grayshaw + Lorika Haglund Date: 16.10.97

Address/institution:

St Thompson St
Drummoyle 2047

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc: gentle slope b. site aspect: c. slope:
d. mark on diagram provided or on your own sketch the position of the site: e. Describe briefly:



- f. Local rock type: Bringley Shale g. Land use/effect:

2. Distance from drinking water: 4250m Source: SH Ck T.V.S.

- 3 Resource Zone associated with site (estuarine, riverine, forest etc): woodland/forest

- 4 Vegetation: paper bark

5. Edible plants noted:

- 6 Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Isolated
Find

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP7

Grid Ref: 29923 626702 Riverstone 1:25,000

Location: About 70 metres east of MP6 and also about 80 metres north of the quarry access road.

Description: One artefact of silcrete, a fragment of a thin blade flake, was identified on a vehicle track amongst the trees. Ground visibility was 70-80% on the track and about 40-60% off it.

CHECKLIST TO HELP:

length, width, depth,
height of site, shelter,
deposit, structure,
element eg. tree scar,
grooves in rock.

DEPOSIT: colour,
texture, estimated
depth, stratigraphy,
contents-shell, bone,
stone, charcoal, density
& distribution of these,
stone types, artefact
types.

ART area of surface
decorated, motifs,
colours, wet, dry
pigment, technique of
engraving, no. of
figures, sizes,
patination.

BURIALS: number &
condition of bone,
position, age, sex,
associated artefacts.

TREES: number, alive,
dead, likely age, scar
shape, position, size,
patterns, axe marks,
regrowth

QUARRIES: rock type,
debris, recognisable
artefacts, percentage
quarried.

OTHER SITES EG.
structures (fish traps,
stone arrangements,
bora rings, mia mias),
mythological sites, rock
holes, engraved groove
channels, contact sites
(missions massacres
cemeteries) as
appropriate

Attach sketches etc. eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

1:250,000 map sheet:

SYDNEY

NPWS Code

19.5

AMG Grid reference

Full reference - please include leading digits

250K 250K
 299880 mE 6266700 mN
 25K 5/6 25K

Scale of map used for grid reference
Please use largest scale available
☒ 25K, 50K (preferred)
 ☐ 100K
 ☐ 250K

☒ 25K, 50K, 100K map name: RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types: _____

Accessioned by: _____ Date: _____

Data entered by: _____ Date: _____

Owner/Manager: _____

Address: _____

Site name:

MP8

Locality/property name:

Marsden Park

NPWS District:

Sydney Zone

Region: _____

Reason for investigation

EIS

Portion no: _____

Parish: _____

Photos taken? Y

How many attached? see report

How to get to the site (refer to permanent features, give best approach to site eg. from above, below, along cliff)
(Draw diagram on separate sheet.)

Site is adjacent to northern side of Hollisworth Road

Other sites in locality? Y

Site Types include: open sites

Are sites in NPWS Register? _____

Have artefacts been removed from site? N

When? _____

By whom? _____

Deposited where? _____

Is site important to local Aborigines? _____

Give contact(s) name(s) + address(es)

Like Hickey + Tony Rendell
 Jeerubbin LALC
 PO Box V.184
 Mt Drutt Village

Additional, see report

Contacted for this recording? _____

(Attach additional information separately) If not, why not? _____

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Road Marsden Park NSW
 Archaeological survey for Aboriginal sites. H. Brayshaw + L. Hargrave
 November 1997

NPWS Report
Catalogue #

Checklist

 surface visibility,
 damage/disturbance/
 threat to site

Condition of site

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by: Helen Brayshaw + Laila Hargrave

Date: 17.10.97

Address/institution: 51 Thompson St

Drumoyne 2048

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc: *gentle slope* b. site aspect: c. slope:
- d. mark on diagram provided or on your own sketch the position of the site: e. Describe briefly:



see below

- f. Local rock type: *Bringingly Shale* g. Land use/effect: *cleared bulldozed - roadworks?*

2. Distance from drinking water: *< 300m* Source: *Bells Creek Tributary*

3. Resource Zone associated with site (estuarine, riverine, forest etc): *woodland forest*

4. Vegetation: *Peperbanks adjacent*

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Open Site

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP8

Grid Ref: 29985 626670 Riverstone 1:25,000

Location: On the northern side of the boundary fence adjoining Hollinsworth Road, extending approximately 50-150 metres west of Richmond Road and 30 metres north of Hollinsworth Road [PI 9].

Description: Artefacts were observed along a disturbed strip which is largely gravel lag on clay, unit A being absent. This disturbance may have resulted from road construction. Ground visibility was generally 40-100%. Several artefacts were also observed north of the strip, in a grassed paddock, where visibility was still about 40%. Twelve artefacts were identified, all of silcrete, including a core, a core fragment and a number of flake fragments. The core had been heat treated, as had one or two of the flake fragments.

CHECKLIST TO HELP:

length, width, depth, height of site, shelter, deposit, structure, element eg. tree scar, grooves in rock.

DEPOSIT: colour, texture, estimated depth, stratigraphy, contents-shell, bone, stone, charcoal, density & distribution of these, stone types, artefact types.

ART area of surface decorated, motifs, colours, wet, dry pigment, technique of engraving, no. of figures, sizes, patination.

BURIALS: number & condition of bone, position, age, sex, associated artefacts.

TREES: number, alive, dead, likely age, scar shape, position, size, patterns, axe marks, regrowth

QUARRIES: rock type, debris, recognisable artefacts, percentage quarried.

OTHER SITES EG. structures (fish traps, stone arrangements, bora rings, mia mias), mythological sites, rock holes, engraved groove channels, contact sites (missions massacres cemeteries) as appropriate

Attach sketches etc. eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.

[✓] New recording

[] Additional Info



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444
Standard Site Recording Form Revised 5/88

NPWS Code

1:250,000 map sheet: SYDNEY 14,5

AMG Grid reference

Full reference - please include leading digits

250K 250K
 299370 mE 6266810 mN
 25K 5/6 25K

Scale of map used for grid reference
 Please use largest scale available

☒ 25K, 50K (preferred) [] 100K [] 250K

1:25K, 50K, 100K map name: RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types: _____

Accessioned by: _____ Date: _____

Data entered by: _____ Date: _____

Owner/Manager _____

Address: _____

Site name: MP 9 Locality/property name: Marsden ParkNPWS District: North Mt Region: Sydney Zone

Reason for investigation

EIS

Portion no: _____

Parish: _____

Photos taken? YHow many attached? see report

How to get to the site (refer to permanent features, give best approach to site eg. from above, below, along cliff
 (Draw diagram on separate sheet))

Site is c 100 m south of quarry access road near
 HV line crossing.

Other sites in locality? Y

Are sites in NPWS Register?

Site Types include: open sitesHave artefacts been removed from site? N

By whom?

When?

Deposited where?

Is site important to local Aborigines?

Give contact(s) name(s) + address(es)

Luke Hickey + Tony Randall
Deerubbin LALC
PO Box 1184
Mt Druitt Village

Additional, see reportContacted for this recording? Y

(Attach additional information separately) If not, why not?

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Road Marsden Park NSW
Archaeological survey for Aboriginal sites. N. Brayshaw + L. Haglund
November 1997

NPWS Report
Catalogue #

Checklist

surface visibility.
 damage/disturbance/
 threat to site

Condition of site:

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by: Helen Brayshaw + Lucila Haglund Date: 17.10.97

Address/institution: 51 Thompson St
Drumoyne 2047

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc:

b. site aspect:

c. slope:

d. mark on diagram provided or on your own sketch the position of the site:

e. Describe briefly:



f. Local rock type: *Bringingelly shale*

g. Land use/effect:

2. Distance from drinking water:

< 200m ?

Source:

Bells Creek tributary

3. Resource Zone associated with site (estuarine, riverine, forest etc):

woodland

4. Vegetation:

ironbarks

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Open site

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP9

Grid Ref: 29937 626681 Riverstone 1:25,000

Location: On the western side of a large dam 70-100 metres south of the quarry access road and 20-50 metres north of Hollinsworth Road.

Description: Two artefacts, both large flakes of silcrete, were identified 50 metres apart, about 8 metres from the water's edge and 30 metres east of a fence. Ground visibility amongst ironbarks was 30-60%. Unit A was intermittently distributed, the area having been disturbed, probably during dam construction.

CHECKLIST TO HELP:

length, width, depth.
height of site, shelter,
deposit, structure,
element eg. tree scar,
grooves in rock.

DEPOSIT: colour,
texture, estimated
depth, stratigraphy,
contents-shell, bone,
stone, charcoal, density
& distribution of these,
stone types, artefact
types.

ART area of surface
decorated, motifs,
colours, wet, dry
pigment, technique of
engraving, no. of
figures, sizes,
patination.

BURIALS: number &
condition of bone,
position, age, sex,
associated artefacts.

TREES: number, alive,
dead, likely age, scar
shape, position, size,
patterns, axe marks,
regrowth.

QUARRIES: rock type,
debris, recognisable
artefacts, percentage
quarried.

OTHER SITES EG.
structures (fish traps,
stone arrangements,
bora rings, mia mias),
mythological sites, rock
holes, engraved groove
channels, contact sites
(missions massacres
cemeteries) as
appropriate.

Attach sketches etc. eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

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Standard Site Recording Form Revised 5/88

1:250,000 map sheet:

SYDNEY

NPWS Code

14.5

AMG Grid reference

Full reference - please include leading digits

250K 250K
 2 9 9 3 5 0 mE 6 2 6 6 9 0 0 mN
 25K 5/6 25K

Scale of map used for grid reference
Please use largest scale available

[] 25K 50K [] 100K [] 250K
 (preferred)

1:25K, 50K, 100K map name:

RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types: _____

Accessioned by: _____

Date: _____

Data entered by: _____

Date: _____

Owner/Manager: _____

Address: _____

Site name:

MP 10

Locality/property name:

Marsden Park

NPWS District:

North Mt

Region:

Sydney zone

Reason for investigation

EIS

Portion no: _____

Parish: _____

Photos taken? Y

How many attached? see report

How to get to the site (refer to permanent features, give best approach to site eg. from above, below, along cliff)
(Draw diagram on separate sheet)

Site is adjacent to southern side of quarry access road
near KV line crossing.

Other sites in locality? Y

Are sites in NPWS Register? _____

Site Types include:

open sites

Have artefacts been removed from site? N

By whom? _____

When? _____

Deposited where? _____

Is site important to local Aborigines?

Give contact(s) name(s) + address(es)

Luke Hickey + Tony Randall

Pearubin LALC

51 Thompson St

Drummoyle 2047

Additional, see report

Contacted for this recording? Y

(Attach additional information separately) If not, why not?

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Road Marsden Park NSW
 Archaeological survey for Aboriginal sites. Hobbayshaw + Haglund
 November 1997

NPWS Report
Catalogue #

Checklist

surface visibility,
damage/disturbance/
threat to site

Condition of site:

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by:

Helen Greyshaw + Lorile Haglund

Date:

17.10.97

Address/institution:

51 Thompson St

Drummoyle 2047

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc:
- b. site aspect:
- c. slope:
- d. mark on diagram provided or on your own sketch the position of the site:
- e. Describe briefly:



- f. Local rock type: *thin gelly shale*
- g. Land use/effect: *cleaved, vehicle track gate way*

2. Distance from drinking water: *< 300m?* Source: *Bells Ck trib.*

3. Resource Zone associated with site (estuarine, riverine, forest etc): *woodland*

4. Vegetation: *iron bark*

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Open site

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP10

Grid Ref: 29935 626690 Riverstone 1:25,000

Location: Near the north western corner of the paddock in which MP9 is located, less than 100 metres to the north west of that location.

Description: Two flake fragments of silcrete were identified 10 metres apart and four metres south of the fence adjoining the quarry access road. Ground visibility in the area is approximately 70%, and mounded earth indicate the area to have been disturbed.

CHECKLIST TO HELP:

length, width, depth, height of site, shelter, deposit, structure, element eg. tree scar, grooves in rock.

DEPOSIT: colour, texture, estimated depth, stratigraphy, contents-shell, bone, stone, charcoal, density & distribution of these, stone types, artefact types.

ART area of surface decorated, motifs, colours, wet, dry pigment, technique of engraving, no. of figures, sizes, patination.

BURIALS: number & condition of bone, position, age, sex, associated artefacts.

TREES: number, alive, dead, likely age, scar shape, position, size, patterns, axe marks, regrowth

QUARRIES: rock type, debris, recognisable artefacts, percentage quarried.

OTHER SITES EG. structures (fish traps, stone arrangements, bora rings, mia mias), mythological sites, rock holes, engraved groove channels, contact sites (missions massacres cemeteries) as appropriate

Attach sketches etc. eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

1:250,000 map sheet:

SYDNEY

NPWS Code

14.5

AMG Grid reference

Full reference - please include leading digits

250K 250K

299270 mE 6266850 mN

25K 5/6 25K

Scale of map used for grid reference
Please use largest scale available
☒ 25K, 50K (preferred)
 ☐ 100K
 ☐ 250K

1:25K, 50K, 100K map name:

RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types: _____

Accessioned by: _____

Date: _____

Data entered by: _____

Date: _____

Owner/Manager _____

Address: _____

Site name:

MP 11

Locality/property name:

Marsden Park

NPWS District:

North Mt

Region:

Sydney zone

Reason for investigation

EIS

Portion no: _____

Parish: _____

Photos taken? ☒ NoHow many attached? see reportHow to get to the site (refer to permanent features, give best approach to site eg from above, below, along cliff)
(Draw diagram on separate sheet.)

c 150 m SE of quarry access road junction = kv line,
on southern side of kv line clearing.

Other sites in locality? ☒ Y

Site Types include: open sites

Are sites in NPWS Register? _____

Have artefacts been removed from site? ☒ N

When? _____

By whom? _____

Deposited where? _____

Is site important to local Aborigines? _____

Give contact(s) name(s) + address(es)

Luke Hickey & Tony Bendall
Degruttin LALC
PO Box 1184
Mt Druitt Village

Additional, see report

Contacted for this recording? ☒ Y

(Attach additional information separately) If not, why not? _____

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Rd Marsden Park NSW
Archaeological survey for Aboriginal sites. H Brayshaw & L Haglund
November 1997

NPWS Report
Catalogue #

Checklist

surface visibility,
damage/disturbance/
threat to site

Condition of site:

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by:

Carla Haglund & Helen Brayshaw

Date: 17.10.97

Address/institution:

1 Cameron St
Balmain 2041

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc: *very broad crest* b. site aspect: c. slope:
- d. mark on diagram provided or on your own sketch the position of the site: e. Describe briefly:



see below

- f. Local rock type: *Brigelly shale* g. Land use/effect: *some bulldozing*

2. Distance from drinking water: *c 500 m* Source: *Bells Creek tributary*

3. Resource Zone associated with site (estuarine, riverine, forest etc): *woodland/forest*

4. Vegetation: *Paperbark*

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

*Isolated
Find*

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP11

Grid Ref: 29927 626685 Riverstone 1:25,000

Location: Approximately 140 metres west of MP9, on the southern edge of the transmission line clearing.

Description: One flake fragment of silcrete was identified in a 6x3 metre area of 60% ground visibility.

CHECKLIST TO HELP:
length, width, depth,
height of site, shelter,
deposit, structure,
element eg. tree scar,
grooves in rock.

DEPOSIT: colour,
texture, estimated
depth, stratigraphy,
contents-shell, bone,
stone, charcoal, density
& distribution of these,
stone types, artefact
types.

ART area of surface
decorated, motifs,
colours, wet, dry
pigment, technique of
engraving, no. of
figures, sizes,
patination.

BURIALS: number &
condition of bone,
position, age, sex,
associated artefacts.

TREES: number, alive,
dead, likely age, scar
shape, position, size,
patterns, axe marks,
regrowth

QUARRIES: rock type,
debris, recognisable
artefacts, percentage
quarried.

OTHER SITES EG.
structures (fish traps,
stone arrangements,
bora rings, mias),
mythological sites, rock
holes, engraved groove
channels, contact sites
(missions massacres
cemeteries) as
appropriate

Attach sketches etc. eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

Box 1967, Hurstville NSW 2220. Tel: (02) 585 6444

Standard Site Recording Form Revised 5/88

1:250,000 map sheet:

SYDNEY

NPWS Code

14.5

AMG Grid reference

Full reference - please include leading digits

250K 250K

294010 mE 6266850 mN

25K 5/6 25K

Scale of map used for grid reference
Please use largest scale available
☐ 25K ☒ 50K (preferred) ☐ 100K ☐ 250K

☒ 25K, 50K, 100K map name: RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no: _____

Site types: _____

Accessioned by: _____ Date: _____

Data entered by: _____ Date: _____

Owner/Manager _____

Address _____

Site name:

MP12

Locality/property name:

Marsden Park

NPWS District:

North West

Region:

Sydney zone

Reason for investigation

EIS

Portion no:

Parish:

Photos taken?

No

How many attached?

How to get to the site (refer to permanent features, give best approach to site eg. from above, below, along cliff)
(Draw diagram on separate sheet)

10-20m south of transmission line easement v 350m north
Hollinsworth Rd, Marsden Park

Other sites in locality?

Y

Site Types include:

open sites

Are sites in NPWS Register?

Have artefacts been removed from site?

N

When?

By whom?

Deposited where?

Is site important to local Aborigines?

Give contact(s) name(s) + address(es)

Luke Hickey + Tony Randall

Deerubbin LALC

PO Box 1184

Mt Druitt Village

Additional, see report

Contacted for this recording?

Y

(Attach additional information separately) If not, why not?

Verbal/written reference sources (including full title of accompanying report)

Proposed land fill operation Richmond Road Marsden Park NSW
Archaeological survey for Aboriginal sites. H Grayshaw + L Haglund
Nov. 1997

NPWS Report
Catalogue #

Checklist

surface visibility,
damage/disturbance/
threat to site

Condition of site:

Disturbed

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by:

Laila Haglund + Helen Grayshaw

Date: 17.10.97

Address/institution:

1 Carrington St
Balmain 2041

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc: *very broad crest* b. site aspect: c. slope:
- d. mark on diagram provided or on your own sketch the position of the site: e. Describe briefly:



see below

- f. Local rock type: *Argillaceous shale* g. Land use/effect:

2. Distance from drinking water: *c 500m?* Source: *Bells Ck trib.*

- 3 Resource Zone associated with site (estuarine, riverine, forest etc): *woodland/forest*

- 4 Vegetation: *Paperbarks*

5. Edible plants noted:

- 6 Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

Open Site

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP12

Grid Ref: 29901 626669 Riverstone 1:25,000

Location: Some 240-300 metres west of MP13 and 10-20 metres south of the transmission line easement.

Description: Three artefacts of silcrete, including two core fragments and a flake fragment, were found at a maximum density of about 1/30m² amongst paperbarks, where ground visibility was 10-30%. The ground surface amongst the leaf litter was comprised of a very thin veneer of possibly washed unit A and a lag of fine gravel. Heaped paperbark logs, bulldozed drainage levees and channels indicated much of the area to have been disturbed.

CHECKLIST TO HELP:
length, width, depth,
height of site, shelter,
deposit, structure,
element eg. tree scar,
grooves in rock.

DEPOSIT: colour,
texture, estimated
depth, stratigraphy,
contents-shell, bone,
stone, charcoal, density
& distribution of these,
stone types, artefact
types.

ART area of surface
decorated, motifs,
colours, wet, dry
pigment, technique of
engraving, no. of
figures, sizes,
patination.

BURIALS: number &
condition of bone,
position, age, sex,
associated artefacts.

TREES: number, alive,
dead, likely age, scar
shape, position, size,
patterns, axe marks,
regrowth

QUARRIES: rock type,
debris, recognisable
artefacts, percentage
quarried.

OTHER SITES EG.
structures (fish traps,
stone arrangements,
bore rings, mia mias),
mythological sites, rock
holes, engraved groove
channels, contact sites
(missions massacres
cemeteries) as
appropriate

Attach sketches etc. eg. plan & section of shelter, show relation between site contents, indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



National Parks and Wildlife Service

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Standard Site Recording Form Revised 5/88

1:250,000 map sheet:

SYDNEY

NPWS Code

14.5

AMG Grid reference

Full reference - please include leading digits

250K

2 9 9 3 0 0

mE

250K

6 2 6 6 7 1 0

mN

25K

5/6

25K

Scale of map used for grid reference
Please use largest scale available

[☒] 25K 50K [☐] 100K [☐] 250K
(preferred)

25K, 50K, 100K map name:

RIVERSTONE

HEAD OFFICE USE ONLY:

NPWS Site no:

Site types

Accessioned by: Date:

Data entered by: Date:

Owner/Manager

Address:

Site name: MP 13

Locality/property name: Marsden Park

NPWS District: North Met

Region: Sydney Zone

Reason for investigation

EIS

Portion no

Parish

Photos taken? Y

How many attached? See report

How to get to the site (refer to permanent features, give best approach to site eg. from above, below, along cliff
(Draw diagram on separate sheet.)

c 100m N of Hollingworth Rd, Marsden Park.

Other sites in locality?

Y

Site Types include: open sites

Are sites in NPWS Register?

Have artefacts been removed from site? N

When?

By whom?

Deposited where?

Is site important to local Aborigines?

Give contact(s) name(s) + address(es)

Luke Hickey & Tony Randall
Doerupoi LALC
PO Box V.184
Mt Druitt Village

Additional, see report

Contacted for this recording? Y

(Attach additional information separately) If not, why not?

Verbal/written reference sources (including full title of accompanying report)

Proposed landfill operation Richmond Rd Marsden Park NSW
Archaeological survey for Aboriginal sites. H. Grayshaw & L. Haglund
Nov 1987

NPWS Report
Catalogue #

Checklist

surface visibility,
damage/disturbance/
threat to site

Condition of site

Recommendations for management & protection (attach separate sheet if necessary)

Site recorded by:

H. Grayshaw

Date: 17.12.97

Address/institution:

51 Thompson St
Drumoyne 2044

SITE POSITION & ENVIRONMENT

OFFICE USE ONLY: NPWS site no:

1. Land form a. beach/hill slope/ridge top, etc: *very broad creek*
- b. site aspect:
- c. slope:
- d. mark on diagram provided or on your own sketch the position of the site:
- e. Describe briefly:



see below

- f. Local rock type: *Argillaceous shale*
- g. Land use/effect:

2. Distance from drinking water: *~300m?* Source: *Bells Creek tributary*

3. Resource Zone associated with site (estuarine, riverine, forest etc): *woodland/forest*

4. Vegetation: *paperbarks*

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type:

*Isolated
Find*

DESCRIPTION OF SITE & CONTENTS.

Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

MP13

Grid Ref: 29930 626671 Riverstone 1:25,000

Location: About 220 metres south west of MP9 and 100 metres north of Hollinsworth near the bend.

Description: One red silcrete cobble fragment/damaged core was found amongst paperbarks and ironbarks, where ground visibility was about 15%. As at MP12, the ground surface amongst the leaf litter was comprised of a thin veneer of washed unit A and a lag of fine gravel. Heaped paperbark logs, bulldozed drainage levees and channels indicated much of the area to have been disturbed.

CHECKLIST TO HELP:
length, width, depth,
height of site, shelter,
deposit, structure,
element eg. tree scar,
grooves in rock.

DEPOSIT: colour,
texture, estimated
depth, stratigraphy,
contents-shell, bone,
stone, charcoal, density
& distribution of these,
stone types, artefact
types.

ART area of surface
decorated, motifs,
colours, wet, dry
pigment, technique of
engraving, no. of
figures, sizes,
patination.

BURIALS: number &
condition of bone,
position, age, sex,
associated artefacts.

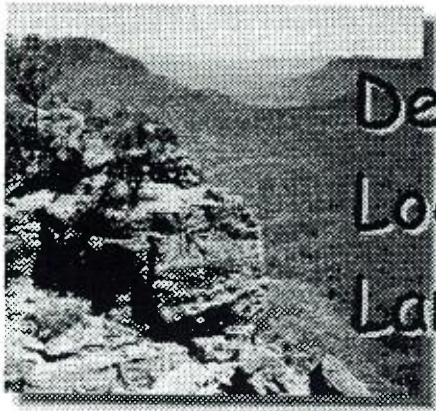
TREES: number, alive,
dead, likely age, scar
shape, position, size,
patterns, axe marks,
regrowth

QUARRIES: rock type,
debris, recognisable
artefacts, percentage
quarried.

OTHER SITES EG.
structures (fish traps,
stone arrangements,
bore rings, mias mias),
mythological sites, rock
holes, engraved groove
channels, contact sites
(missions massacres
cemeteries) as
appropriate

Attach sketches etc, eg. plan & section of shelter, show relation between site contents,
indicate north, show scale.

Attach annotated photos (stereo where useful) showing scale, particularly for art sites.



Deerubbin Local Aboriginal Land Council

5/271 Beames Ave
P.O. Box V184
Mt Druitt Village
NSW 2770, Australia

Ph: (02) 9832 2457
Fax: (02) 9832 2496
Email: - Staff@Deerubbin.org.au
Web: <http://www.deerubbin.org.au>

COPY

Helen Brayshaw
Heritage Consultants
51 Thompson Street,
DRUMMOYNE NSW 2047

27 November, 1997

**SUBJECT: ABORIGINAL CULTURAL HERITAGE ASSESSMENT
OF PROPOSED LANDFILL SITE AT
RICHMOND AND HOLLINGSWORTH ROADS, MARSDEN PARK
(FOR AN ENVIRONMENTAL IMPACT STATEMENT).**

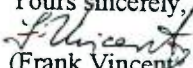
Dear Helen,

We have reviewed your report entitled "Proposed landfill operation, Richmond Road, Marsden Park, NSW: Archaeological survey for Aboriginal sites" in light of our survey, conducted on 16 and 17 October, 1997.

Except as indicated below, Deerubbin Local Aboriginal Land Council (DLALC) agrees with your findings and is in support of your recommendations.

The one amendment we wish to make is in respect of recommendation 1. DLALC is strongly of the view that a program of subsurface investigation is warranted. Our previous recommendation for such subsurface investigations in other areas (e.g. Richmond Markets, George and Barker Sts Windsor, ADI site, and S.I.E.C. Horsley Park) have all been substantiated by the results and we believe that the potential for locating further artefacts below the surface is high.

If this recommendation is accepted, we would not be opposing the consent you recommend, provided that a salvage is undertaken and any cultural material found is analyzed. We would naturally wish to be involved in both the subsurface investigation and the analysis.

Yours sincerely,

(Frank Vincent
Chairperson)

c.c Phil Hunt NPWS Hurstville

APPENDIX 7
TRAFFIC ASSESSMENT

Prepared by:
CHRISTOPHER HALLAM & ASSOCIATES

GANIAN PTY LTD

**TRAFFIC IMPACT ASSESSMENT
OF PROPOSED QUARRY AND
LANDFILL OPERATION,
MARSDEN PARK**

APRIL 1998

**CHRISTOPHER HALLAM & ASSOCIATES PTY LTD
PO BOX 199,
KURRAJONG NSW 2758
DX 8617 WINDSOR
Telephone: 0245 731619**

JOB: 9755

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1.0 INTRODUCTION

Penrith Waste Services Pty Ltd currently operate a landfill operation at Penrith. This facility is likely to be full in the short to medium term. An associated company, Ganian Pty Ltd propose to develop another landfill site, to ensure continuity in their services. The proposed landfill site is located at Marsden Park, to the west of Richmond Road, on the site of a disused quarry. This location is shown on Figure 1. The site currently has its own direct access off Richmond Road, between Hollinsworth Road and Townson Road. There is also a second access some 600 m north of Townson Road.

As part of the preparatory work for the development of the landfill and to provide additional landfill capacity, it is proposed to continue the previous quarrying activities and extract rock, to sell for building and roadmaking activities.

Enviro-Managers Pty Ltd were commissioned by Ganian Pty Ltd to prepare an environmental impact statement for the proposed development. Christopher Hallam & Associates Pty Ltd were commissioned to provide expert advice on the traffic implications of the proposed development and to prepare a traffic impact assessment report. This report is set out through the following Sections:

- * Section 2 reviews the current situation in relation to the adjacent road network and current traffic flows;
- * Section 3 assesses the traffic implications of the proposed development, with regard to the access location, the impact on road capacity and amenity and the impact on the road pavement; and
- * Section 4 summarises conclusions.

2.0 CURRENT SITUATION

2.1 Road Network

The site is located just west of Richmond Road, Marsden Park. Richmond Road is a State Road, maintained and controlled by the Roads & Traffic Authority of NSW (RTA). It serves as an important arterial route between Blacktown and Richmond, and areas further to the West. Access to Liverpool and Penrith to the South and West is via Rooty Hill Road. Access to the developing areas of the North-West is available via Garfield Road.

The ultimate extension of the M2 Motorway to Richmond Road would further assist inter-regional access. However the timing of this extension is not known. The RTA have no proposals to upgrade Richmond Road in the vicinity of the site in their current five-year programme.

Richmond Road generally has a two lane undivided carriageway, with auxiliary lanes provided at main intersections. At the intersection of Richmond Road with Hollinsworth Road there is a right turn lane about 60 m long for the right turn into Hollinsworth Road. At the intersection of Richmond Road with Townson Road there is a right turn lane of about 90 m in length. North of Townson Road, Richmond Road has one traffic lane per direction. Through traffic lanes on Richmond Road are 3.2-3.5 m wide. The speed limit in this area is 80 km/hr.

Hollinsworth Road is a local road serving a caravan park, a mosque and about five dwellings. It has a sealed carriageway width of 7.6 m near its junction with Richmond Road, set within a reserve of 20 m. The carriageway width further to the west is about 6.8 m. Hollinsworth Road is some 1.3 km long, ending at the turning circle at the caravan park. Bus route 757 provides a service to Riverstone and Rooty Hill stations from the caravan park.

Townson Road is a local road that provides access to rural and industrial properties, including the PGH Brickworks.

2.2 Traffic Flows

To provide an understanding of the current traffic conditions in the vicinity of the site, an automatic traffic counter was laid in Richmond Road south of Hollinsworth Road in October 1997. Table 2.1 lists the daily traffic flows per direction in the week Wednesday 15th to Tuesday 21st October 1997.

TABLE 2.1 Current Daily Traffic Flows in Richmond Road south of Hollinsworth Road: Wednesday 15/10/97-Tuesday 21/10/97

Day	Northbound	Southbound	Total
Wednesday	11,801	12,154	23,955
Thursday	12,187	12,379	24,566
Friday	12,572	12,616	25,188
Saturday	10,265	10,032	20,297
Sunday	8,301	8,731	17,032
Monday	11,256	11,574	22,830
Tuesday	11,493	11,758	23,251

The peak daily flows occurred on the Friday, with 25,188 veh/day. The average daily traffic flow was 22,446 veh/day while the average weekday flow was 23,958 veh/day. These flows are relatively high for what is a two-lane undivided rural road, reflecting the regional importance of Richmond Road.

The counts also recorded hourly traffic flows. Table 2.2 lists the average hourly flows for the five weekdays in the week 15-21 October 1997.

TABLE 2.2 Current Weekday Hourly Traffic Flows in Richmond Road south of Hollinsworth Road: Wednesday 15/10/97-Tuesday 21/10/97

Period	Northbound	Southbound	Total	Period	Northbound	Southbound	Total
0-1am	85	45	130	1-2pm	560	570	1130
1-2	35	37	72	2-3	586	569	1155
2-3	32	42	74	3-4	720	659	1379
3-4	42	70	112	4-5	967	756	1723
4-5	68	163	231	5-6	1161	827	1988
5-6	252	608	860	6-7	1186	760	1946
6-7	602	1003	1605	7-8	929	561	1490
7-8	657	1285	1942	8-9	543	374	917
8-9	706	1158	1864	9-10	359	235	594
9-10	555	735	1290	10-11	337	214	551
10-11	514	599	1113	11-12	235	169	404
11-12	560	575	1135		172	83	255

Table 2.2 indicates that the northbound traffic peaks at 5-6pm, with a flow of about 1190 veh/hr, with a morning peak at 8-9am of just over 700 veh/hr. In the southbound direction the morning peak hour average flow was about 1280 veh/hr in the period 7-8am,

with an afternoon peak flow of about 830 veh/hr in the period 4-5 pm. These hourly flows are relatively high, for single traffic lanes. Ultimately, the capacity of a road is determined by its intersection capacity. Where side traffic disrupts through traffic, the overall level of service of the through traffic is reduced. Side traffic interruptions occur when the form of traffic control delays the through traffic, such as with traffic signals or a roundabout. Where the side street traffic is subject to Stop or Give Way controls, there is less impact on the through traffic but greater impact on the side street traffic, with this traffic suffering delays in trying to join the major road.

To provide an understanding of the traffic capacity constraints at the Richmond Road/Hollinsworth Road intersection, manual traffic counts were undertaken at this intersection on Tuesday 14th October 1997 in the periods 6.30-9.30am and 3.30-6.30pm. Peak hour flows occurred in the periods 7.45-8.45am and 4.45-5.45pm, with these peak hour flows shown on Figure 2. Figure 2 also shows traffic flows at the Richmond Road/Townson Road intersection, as counted on Wednesday 11 December 1996 by CMPS & F.

Figure 2 indicates Richmond Road flows similar to those shown in Table 2.2, with peak movements of 1250-1350 veh/hr in the peak direction. The flows into and out of Hollinsworth Road were relatively minor, with a two-way flow in this road of 46 veh/hr in the morning and 81 veh/hr in the afternoon peak hours, with the majority of the movements being to/from the South. The current capacity of this intersection was reviewed using the INTANAL program, for the current intersection layout, and taking current heavy vehicle movements into account. Table 2.3 summarises the results. This table also presents results for the implications of traffic growth on Richmond Road, of +10% and +20% through traffic on Richmond Road.

TABLE 2.3 INTANAL Assessment of Richmond Road/Hollinsworth Road

Factor	Current Situation		Richmond Rd+10%		Richmond Rd+ 20%	
	AM	PM	AM	PM	AM	PM
Level of Service	D	E	E	F	F	F
Total Delay (veh.hrs/hr)	0.3	0.6	0.4	0.7	0.5	0.9
Avg Delay (secs/veh)	0.5	0.8	0.5	1.0	0.6	1.1
Delay to Right turn out of Hollinsworth Rd	49	61	63	80	84	108

Table 2.3 indicates that the current level of service is being driven down by the delays to the right turn movement out of Hollinsworth Road. While the delays to the Richmond Road through traffic are negligible, the average peak hour delays of 50-60 seconds to the traffic turning right out of Hollinsworth Road are affecting the level of service. Appendix A provides a guide to the significance of the levels of service, where it can be seen that the existing situation is very close to or at capacity for a sign-controlled situation. Traffic growth on Richmond Road will exacerbate this situation, with a level of service of F being the lowest level. Thus, there are existing capacity problems with this intersection.

The situation is similar at the Richmond Road/Townson Road intersection, where delays to side street – Townson Road – traffic push down the level of service. Table 2.4 summarises the results of the INTANAL assessment of this intersection.

TABLE 2.4 INTANAL Assessment of Richmond Road/Townson Road

Factor	Current Situation		Richmond Rd+10%		Richmond Rd+20%	
	AM	PM	AM	PM	AM	PM
Level of Service	E	C	F	D	F	D
Total Delay (veh.hrs/hr)	1.1	0.4	1.4	0.5	2.0	0.5
Avg.Delay (secs/veh)	1.7	0.7	2.0	0.8	2.6	0.8
Delay to Right turn out Of Townson Rd	68	36	91	44	127	55

Table 2.4 indicates an existing unsatisfactory situation in the morning peak, with Townson road right turn traffic being delayed. The low right turn volume probably reflects this difficulty, rather than reflecting the latent demand for this movement. With general traffic growth on Richmond Road the situation would be exacerbated.

The automatic traffic counts also provided information on vehicle types, broken down into the standard AUSTROADS 12 types. Full survey results are reproduced in Appendix B, giving hourly flows by direction by vehicle type, for Richmond Road south of Hollinsworth Road. Table 2.5 summarises these results on a daily basis, for the week Wednesday 15th October to Tuesday 21st October 1997, with the vehicle types grouped into Light Vehicles (Types 1,2 and undefined Type 13), Heavy Rigid Vehicle (Types 3,4) and Heavy Articulated Vehicles (Types 5-12).

**TABLE 2.5 Vehicle Classification on Richmond Road south of
Hollinsworth Road: Wednesday 15/10/97 - Tuesday 21/10/97**

Day	Direction	Light	Heavy Rigid	Heavy Artic.	Total
Wednesday	Northbound	9,909	1,307	585	11,801
Thursday		10,196	1,360	631	12,187
Friday		10,660	1,317	595	12,572
Saturday		9,181	739	345	10,265
Sunday		7,836	334	131	8,301
Monday		9,439	1,318	499	11,256
Tuesday		9,625	1,344	524	11,493
Seven Day	Northbound	66,846	7,719	3,310	77,875
Wednesday	Southbound	10,554	1,005	595	12,154
Thursday		10,798	995	586	12,379
Friday		11,055	966	595	12,616
Saturday		9,293	423	316	10,032
Sunday		8,424	163	144	8,731
Monday		10,079	976	519	11,574
Tuesday		10,241	996	521	11,758
Seven Day	Southbound	70,444	5,524	3,276	79,244

As would be expected, the heavy vehicle movements are lighter on the weekend than on weekdays, with generally consistent figures on the weekdays. Over the full week, some 14% of northbound vehicles are heavy vehicles, while 11% of southbound vehicles are heavy vehicles.

These figures can be used to provide estimates of the existing pavement loadings, in terms of Equivalent Standard Axles (ESAs). The ESA equivalence's assumed are:

Vehicle Type	Laden	Unladen	Average
Light	0	0	0
Heavy rigid	1.65	0.25	0.95
Heavy articulated	3.0	0.4	1.7

With the existing traffic, it is not known whether the trucks surveyed were laden or not, and hence the average figures should be used. Combined with the seven day summary data in Table 2.4, the current northbound weekly pavement loading is 12,960 ESA while the current southbound weekly pavement loading is 10,817 ESA. Based on seasonal traffic count data, the annual figures would be about 50 times the October figures, so the

current annual pavement loadings on Richmond Road south of Hollinsworth Road are 648,000 ESA northbound and 540,850 ESA southbound. These figures provide a background to the review of the additional pavement loadings due to the proposed development.

3.0 TRAFFIC IMPLICATIONS OF PROPOSED DEVELOPMENT

3.1 Description

The proposed development is a landfill and quarry, with quarrying activities recommencing at the start of operations, to provide additional landfill volume and to extract the available resource in an efficient manner. The extraction from the quarry operation would be about 300,000 tonnes per annum.

The landfill operation would not start immediately, with the company's existing landfill site at Penrith used for about 7-10 years. Some landfilling could occur earlier, after three to five years, as backfill to the quarrying, and to take material from sources closer to Marsden Park than to Penrith. The amount of landfill material brought onto the site will initially be about 120,000 tonnes per annum, increasing to about 360,000 tonnes per annum.

The extracted quarry material would be transported by articulated vehicles, with average loads of 25 tonnes. The landfill material transported to the site would arrive in a range of vehicle types and loads. Based on records of the current landfill operation at Penrith, the breakdown would be 21% of vehicles being small vehicles (car, van/ute/trailer), 63% in open trucks, either rigid or tipping articulated trucks, and 16% in enclosed trucks/compactors, these including standard local government garbage trucks. The average load per vehicle would be about 10 tonnes.

The staffing on the site would be 6-7, mainly equipment operators for quarry machinery in the first years of operation while the quarry was being developed. After about three years, landfill will commence on the site. The same operators will be used to prepare the landfill area and provide cover and compaction. At that time, the existing house on the site on Richmond Road will become the main administration office for Galian Pty Ltd and an additional 5 administration staff will relocate to the site.

The proposed hours of operation are: a) Quarry: Monday to Friday 6am to 6pm, Saturday 6am to 12 noon; b) Landfill: 6am to 6pm Monday to Friday, Saturday 7am to 4pm, Sunday 9am to 3pm.

3.2 Access

There are four logical vehicular access options to Richmond Road for the site:

1. Use existing site access directly off Richmond Road, upgraded as required

2. Provide access directly opposite Townson Road, with appropriate traffic management works implemented
3. Access site off Hollinsworth Road, and upgrade Richmond Road/Hollinsworth Road intersection as appropriate
4. Upgrade existing site access 600 m north of Townson Road

The relative spacing of these options should be considered. The existing site access is some 190 m north of Hollinsworth Road, with Townson Road being just 50 m north of this existing site access. Thus, the spacing of the two public road intersections is only 240 m, a relatively short distance for a semi-rural road with an 80 km/hr speed limit. The existing right turn bay for the movement from Richmond Road south into Townson Road overlaps the existing site access by about 30 m. Option 1 would require a right turn bay of adequate length, to ensure that right turn queues did not impede southbound traffic. It is highly unlikely that such a right turn bay could be provided into the current access, given the fact that the spacing to Townson Road is some 50 m. For comparison, the right turn bay at Hollinsworth Road has a parallel lane length of 54 m and a taper of about 20 m. This could not be provided at the current site access. The existing right turn bay for the Townson Road intersection is a further complication. Finally, the three intersections would be too close for adequate traffic efficiency and safety. We strongly recommend against Option 1.

Option 2 would see a new four-way junction with Richmond Road and Townson Road. The existing Richmond Road/Townson Road intersection has a sight distance limitation to Richmond Road North, due to the horizontal alignment of Richmond Road. This intersection has been the subject of review in an environmental impact statement by CMPS&F for "Proposed Continuation of Quarrying, Landfilling and Site Rehabilitation at Schofields, Blacktown", (May 1997), prepared for the PGH Brickworks site in Townson Road. Their analysis of the current operation of the Richmond Road/Townson Road intersection found a level of service of D in the morning and C in the afternoon peak hours, primarily due to delays to traffic turning right out of Townson Road, with the situation worsening with any increases in Richmond Road traffic flows. A 12% increase in Richmond Road traffic was predicted to reduce the morning peak level of service to F. This report comments:

"This current "problem" could be ameliorated at minimal cost by the installation of a Seagull configuration at this intersection providing a right-turn acceleration lane on Richmond Road for vehicles emerging from Townson Road. This turning traffic would then only have to give way to southbound traffic on Richmond Road rather than both north and southbound traffic as is the case with the current arrangement."

The addition of a fourth approach to this intersection and the required seagull channelisation for both side approaches would make a priority control intersection very difficult to design, with the additional conflicts in a four-way intersection adding to the design problem. The feasible options would be a roundabout or traffic signals. Given that roundabouts are used on Richmond Road further to the South, in theory this would be an option. It would however delay through traffic all the time. The installation of traffic signals could provide safety for the movements, but again would be introducing delays to Richmond Road through traffic. The installation of traffic signals on a rural or semi-rural road is generally not desirable, although in some locations such as at the major intersection of Richmond Road with Garfield Road, it might be the most feasible option at this location. If signals were to be installed at this Richmond Road/Townson Road intersection, the opportunity should be taken to provide the fourth approach to the subject site, with access through signal control. Such an installation should include auxiliary lanes for access to the site, with a right turn lane and a widening of the Richmond Road approaches.

Option 3, with the Richmond Road/Hollinsworth Road intersection reconstructed, with seagull channelisation, is the third option. Details are further discussed in Section 3.4. This would maintain the through traffic efficiency along Richmond Road, while keeping apart from the Townson Road intersection.

With this option, the critical issue would be the location of the site driveway onto Hollinsworth Road. Environmental considerations should dictate this location. We note the location of existing dwellings. Along Hollinsworth Road there is a dwelling - No.17 - about 150 m from Richmond Road, set back about 30 m from Hollinsworth Road. The next dwelling is about 400 m from Richmond Road, with No.43 being about 50 m from the road, next to a driveway to the Masjid Bait-ut-Huda mosque. The location of the site access road about 100 m west of Richmond Road would keep trucks from passing any existing dwellings, and at the same time would provide an adequate approach to the Richmond Road intersection. However there could still be noise impacts on the nearest dwelling.

We have been instructed that site access off Hollinsworth Road is not considered environmentally acceptable.

Option 4 could be provided at a location where there are few other traffic conflicts, with Richmond Road being relatively straight at this location. There is an existing access to the site at this point, that used to be used for access to a former Council night soil depot to the southwest of the quarry site. This option appears to have the least environmental impact, and with the construction of an appropriate priority-controlled junction, would maintain through traffic efficiency. It is the preferred option.

3.3 Traffic Generation and Distribution

Staff commuter movements will add to daily traffic flows, but with the hours of operation of 6am to 6pm on weekdays, there will not be a great deal of overlap with the weekday peak hours of 7.45-8.45am and 4.45-5.45pm. For initial operations there will be 6-7 staff, so the daily car movements would be up to 12-14 veh/day, if all staff drove. The addition of 5 administration staff would see this increase to 22-24 veh/day.

The major traffic implications of the proposal will result from the heavy vehicle movements, associated with the quarry and with the landfill. As outlined in Section 3.1, the quarry output will be about 300,000 tonnes per annum. The level of extraction would presumably be dependent on the market demand for the material. The landfill operation would begin after three to five years, with an initial landfill of about 120,000 tonnes per annum, increasing to about 360,000 tonnes per annum. The traffic generation that would result from these operations, for weekdays, is set out below.

Quarry

- * Average load in articulated truck: 25 tonnes
- * 300 transport days each year
- * $300,000 \text{ tpa} / 25 \text{ t} / 300 \text{ days} = 40 \text{ trips/day}$
- * 6am-6pm but assume 10 hours transport each day = 4 loads/hour average
- * For peak design hour assume double average loads = 8 loads/hour
- * Total truck movements = twice loads, so 8 IN and 8 OUT in peak design hour

Landfill

- * Average load: 10 tonnes
- * 300 transport days each year
- * 6am-6pm but assume 10 transport hours each day
- * $120,000 \text{ tpa} / 10 \text{ t} / 300 \text{ days} / 10 \text{ hours} = 4 \text{ loads/hour average}$
- * $360,000 \text{ tpa} / 10 \text{ t} / 300 \text{ days} / 10 \text{ hours} = 12 \text{ loads/hour average}$
- * For peak design hour assume double average loads = 8-24 loads/hour
- * Total truck movements = twice loads, so 8-24 IN and 8-24 OUT in peak design hour

The minimum and the maximum numbers of truck movements would depend on the overlap of the ranges of quarry output and landfill input. In summary:

Quarry Output (tonnes/annum)	Landfill Input	Average Hourly Movements		Peak Design Hourly Movements	
		IN	OUT	IN	OUT
300,000	120,000	8	8	16	16
300,000	360,000	16	16	31	31

The absolute worst case scenario is thus for the maximum production of both facilities to be achieved concurrently, with peak design hour flows twice the average flows, with 31 vehicles IN and 31 vehicles OUT in the worst hour, while the average flows on a day with maximum production with both facilities would be 16 IN and 16 OUT. With the 31 movements IN and OUT, based on the current truck types, 87% would be in heavy vehicles and 13% in light vehicles.

In terms of the distribution of the movements, the company estimate that about 75% of the landfill movements would be to/from Richmond Road South, with the quarry movements fairly evenly distributed. The higher numbers of landfill movements would weight the trips to the South. The quarry movements would very much depend on the demand for materials for new subdivisions and roads. Taking these factors into consideration, we have assumed a weighted average of about 70% of total trips to/from Richmond Road South and 30% to/from Richmond Road North.

3.4 External Traffic Impact

Impact on Traffic Efficiency

Option 2: Direct access to Richmond Road/Townson Road

This option would involve the construction of a fourth approach to the Richmond Road/Townson Road intersection. We have assessed the possible intersection operation based on the current intersection flows plus the traffic that would be generated by the proposed operations. In summary, priority control would not provide adequate capacity. A one-lane roundabout also would not provide enough capacity. The alternatives thus would be traffic signals or a two-lane roundabout. The latter would be consistent with the intersection treatment at the nearest main intersection, Richmond Road/Rooty Hill Road. It would delay through traffic at all times. The speed limit in the area is 80 km/hr at present. Signals would be consistent with the treatment at the Richmond Road/Garfield Road intersection. They have a higher maintenance than a roundabout but would not delay through traffic when there is no side street traffic. With the relatively low traffic flows on Townson Road and on the site access, and with the heavy traffic flows on Richmond Road, traffic signals are the preferred option.

There is already a 80 m long right turn bay in Richmond Road South for the right turn into Townson Road. There would need to be a right turn bay for the right turn from Richmond Road North into the site. As with the installation of traffic signals on two lane two-way roads, it would be desirable to widen the Richmond Road approaches to two lanes per approach, with this widening extending for at least 100 m on the approach to the intersection, plus at least 30 m on the departure from the intersection. With this widening, additional provision for left turning traffic would not be needed, given the low left turn flows. The site access would need to have two lanes approaching the intersection, with one lane leaving the intersection. The second approach lane would only be needed for a

short distance. In Townson Road the provision of two approach lanes would be appropriate, at least for a short distance. The new layout of the intersection would need to take into account the horizontal and vertical alignment of Richmond Road to the north of the intersection. The final layout would need to be approved by the RTA. The resulting operation of this intersection has been assessed using the INTANAL program, with the peak design hourly flows added to the current peak hour flows. Table 3.1 presents the results.

TABLE 3.1 INTANAL Analysis of Richmond Road/Townson Road/site access Intersection – 300,000 tpa quarry, 360,000 tpa landfill

Factor	Current Flows, Sign control		Plus Peak Design Flows, 4-way junction, Traffic Signals	
	AM	PM	AM	PM
Level of service	E	C	A	A
Total Delay (veh.hrs/hr)	1.1	0.4	5.1	4.7
Average Delay (secs/veh)	2	1	7	8
Maximum movement Delay (secs/veh)	68	36	70	60

Table 3.1 indicates that traffic signals at this intersection, with the layout suggested, would operate with a high level of service.

Option 3: Access via Hollinsworth Road

With the current low traffic flows in Hollinsworth Road, the additional movement at the site access off Hollinsworth Road would not cause any traffic problems.

The key traffic efficiency impact would be at the Richmond Road/Hollinsworth Road intersection. This has been assessed for the morning and afternoon peak hours. The additional movements for the peak design situation have been doubled in their inputs to the INTANAL model, to better reflect the impact of heavy vehicles. Table 3.2 summarises the results, for the 300,000 tonnes per annum quarry output and 360,000 tonnes per annum landfill input.

**TABLE 3.2 INTANAL Analysis of Richmond Road/Hollinsworth Road
Intersection - 300,000 tpa quarry, 360,000 tpa landfill**

Factor	Current Situation		Plus Peak Design Flows	
	AM	PM	AM	PM
Level of Service	D	E	F	F
Total Delay (veh.hrs/hr)	0.3	0.6	1.7	2.4
Average Delay (secs/veh)	0.5	0.8	2.5	3.5
Delay to Right Turn from Hollinsworth Rd	49	61	82	102

It can be seen that the assumed additional traffic would increase the delays to the right turn movement out of Hollinsworth Road, thus driving the level of service lower. The impact would not be felt by through traffic but would by other traffic leaving Hollinsworth Road. There could be a potential for drivers of heavy vehicles to force their way out onto Richmond Road if their delays became excessive.

We consider that the best treatment for this intersection, should Hollinsworth Road be used for site access, would be to reconstruct it to provide seagull channelisation, to enable a vehicle turning right out of Hollinsworth Road to first cross the northbound traffic and then to accelerate within a median lane to merge with southbound traffic. This option has been reassessed with the INTANAL model, with the results listed in Table 3.3, for the situation with peak output/input at the quarry site.

**TABLE 3.3 INTANAL Analysis of Richmond Road/Hollinsworth Road
Intersection - 300,000 tpa quarry, 360,000 tpa landfill
- Seagull Channelisation -**

Factor	Current flows		Plus Peak Design Flows	
	AM	PM	AM	PM
Level of Service	B	C	B	C
Total Delay (veh.hrs/hr)	0.2	0.4	0.7	1.2
Average Delay (secs/veh)	0.3	0.6	1.0	1.7
Delay to Right Turn from Hollinsworth Rd	21	32	23	35

The construction of the seagull channelisation would result in the worst case scenario with peak design flows having lower delays and a better level of service than the existing situation indicated in Table 3.2. The resulting level of delay and service would be satisfactory, while at the same time the traffic efficiency of the major traffic flows on Richmond Road would be safeguarded. The traffic efficiency implications of the proposal would then be satisfactory.

Note that the INTANAL modelling indicated that the maximum queue length for the right turn into Hollinsworth Road would be one vehicle, with the seagull channelisation. This would not result in any substantial change to the demand for this right turn lane, although the opportunity might be taken to slightly lengthen this right turn lane, with the ultimate constraint being the start of the right turn lane for the Townson Road intersection, which starts about 50 m north of the start of the taper for the Hollinsworth Road right turn lane taper.

Option 4: Access via driveway 600 m north of Townson Road

This is the preferred option. The considerations would be similar to those for Option 3, with the advantages that there would be no other traffic on the side street and there would be no possible interaction with other intersections. The intersection has been analysed with the INTANAL model, with the results presented in Table 3.4, for the situation with peak design flows. Table 3.4 presents results for either a standard T-junction, or a T-junction with seagull channelisation, for current traffic flows along Richmond Road.

**TABLE 3.4 INTANAL Analysis of Richmond Road/site access – Option 4
300,000 tpa quarry, 360,000 tpa landfill**

Factor	T-junction		Seagull Channelisation	
	AM	PM	AM	PM
Level of Service	E	D	B	C
Total Delay (veh.hrs/hr)	0.8	0.8	0.4	0.5
Average Delay (secs/veh)	1.3	1.4	0.6	0.9
Delay to Right Turn Out of site (secs/veh)	58	52	22	29

From considerations of both traffic efficiency and traffic safety, the construction of seagull-channelisation is recommended. This access option would have the benefit of causing the least disruption to through traffic flows and would have the least delays to

traffic leaving the site. There would be some spare capacity for future growth in traffic on Richmond Road. This access option is recommended.

Impact on Amenity/Safety

Option 4: Access north of Townson Road

There are no dwellings in close proximity to this access. The impact on amenity would be minimal. In terms of traffic safety, the construction of an adequate seagull channelisation would provide the safeguards for the access. Figure 3 presents a schematic design. The final design would need to be undertaken, taking into consideration the road reserve boundaries, and submitted to the Roads & Traffic Authority of NSW.

Impact on Road Pavement

At the peak quarry output of 300,000 tonnes per annum and with the peak landfill input of 360,000 tonnes per annum, taking the landfill trucks to be rigid trucks with an average 10 tonnes load, an ESA for such a laden vehicle has been taken as 1.65, while for an unladen vehicle it has been assumed to be 0.25 ESA. For the articulated quarry product trucks, a laden value of 3.0 ESA has been assumed and an unladen value of 0.4 ESA assumed. With these assumptions, in this peak design year the annual loading for the eastbound carriageway of the site access would be 45,000 ESA/annum, while for the westbound carriageway the loading would be 64,200 ESA. The construction of the access road is a matter for the applicant to consider.

Richmond Road, as a State Road, is the responsibility of the Roads & Traffic Authority. As such, it funds on-going maintenance due to wear and tear. For reference, the additional pavement loadings on Richmond Road that would be due to the maximum operation of the site have been calculated, based on the current loadings on Richmond Road, as found in the classification counts that were undertaken for this study, with no allowance for general traffic - including heavy traffic - growth. In summary:

TABLE 3.3 Pavement Loading on Richmond Road due to Quarry/Landfill at Maximum Rates of Production and Input (ESA/annum)

Location	Current		With Quarry/Landfill	
	Northbound	Southbound	Northbound	Southbound
North of Site access	648,000	540,850	661,500(+2%)	560,110(+4%)
South of Site access	648,000	540,850	692,940(+7%)	572,350 (+6%)

4.0 CONCLUSIONS

Proposed Development

1. The proposed development is a landfill and quarry, to be located on the site of a disused quarry. The quarrying activity would extract at a rate of about 300,000 tonnes per annum. The landfill activity would begin after three to five years, with an initial input of 120,000 tonnes per annum, increasing to about 360,000 tonnes per annum.
2. The recommended access to Richmond Road is via an existing driveway to the site located about 600 m north of Townson Road. This access was previously used for trucks hauling night soil to a depot near the quarry site. Seagull channelisation is recommended for this access.

Traffic Generation

3. The worst case scenario with the quarry and landfill operations would be when both are operating at their peak production levels. At this stage the quarry will be generating an average of 40 loads per day, while the landfill will be attracting an average of 120 loads per day. This will result in total two-way movements of 320 movements per day. Averaged over ten operating hours, this will be an average of 32 movements per hour, half IN and half OUT. For assessment purposes, a peak design hour with twice this volume has been used in the intersection analysis. About 70% of the movements are expected to be to/from Richmond Road South, with the balance to Richmond Road North.

External Traffic Impact

4. The main external traffic impact will occur at the intersection of the access road with Richmond Road. This is recommended to be constructed with seagull channelisation, with a schematic design shown on Figure 3. With the layout, there would be minimal delays to through traffic on Richmond Road and acceptable delays to traffic leaving the site. For average design flows the level of service would be B in both AM and PM peak hours while for the peak design flows the level of service would be B in the AM and C in the PM. These levels of service would be acceptable.
5. With the location of the access road, there would be no adverse amenity impacts due to site traffic.
6. The heavy traffic from the site will increase the loading on the road pavements. Richmond Road, as a State Road, is the responsibility of the Roads & Traffic Authority. As such, the RTA funds on-going maintenance due to wear and tear.

The site heavy traffic would increase the loading on the road pavement of Richmond Road south of the site access by 6-7%, with the equivalent figure to the north of the site access being 2-4%.

GUIDE TO INTANAL LEVELS OF SERVICE

Level of Service Criteria for Intersections

Level of Service	Average Delay per Vehicle (secs/veh)	Traffic Signals, Roundabouts	Give Way & Stop Signs
A	less than 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays & spare capacity	Acceptable delays & spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity & accident study required
E	57 to 70	At capacity; at signals, incidents will cause excessive delays; Roundabouts require other control mode	At capacity, requires requires other control mode

GUIDE TO ENVIRONMENTAL CAPACITY

Environmental Capacity Performance Standards on Residential Streets

Road Class	Road Type	Maximum Speed (km/hr)	Maximum Peak Hour Volume (veh/hr)
Local	Access way	25	100
	Street	40	200 environmental goal 300 maximum
Collector	Street	50	300 environmental goal 500 maximum

APPENDIX B

TRAFFIC COUNT DATA

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\019.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 01 Direction : Northbound

1997/10/15 Wednesday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	68	0	6	1	0	0	2	1	3	0	1	0	82	0
01:00	30	0	0	2	0	0	1	0	2	0	0	0	35	0
02:00	31	0	5	1	1	0	0	0	1	0	0	0	39	0
03:00	27	0	7	1	0	0	0	1	4	0	0	0	40	0
04:00	48	0	13	2	1	0	0	3	5	0	0	0	72	1
05:00	190	0	26	2	2	2	2	6	18	0	1	0	249	0
06:00	500	4	56	13	1	2	4	7	24	0	0	0	611	2
07:00	543	6	54	19	3	3	6	2	15	1	0	0	652	1
08:00	600	6	53	17	4	0	6	7	26	0	0	0	719	3
09:00	434	7	57	22	4	2	7	5	16	0	1	0	555	2
10:00	343	6	57	27	4	1	6	8	23	0	1	1	477	6
11:00	380	6	75	27	2	0	3	4	15	0	0	0	512	1
12:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3194	35	409	134	22	10	37	44	152	1	4	1	4043	16

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\132.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 01 Direction : Northbound

1997/10/15 Wednesday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:00	398	6	57	17	4	2	6	5	28	1	0	0	524	9
13:00	428	8	63	36	3	1	4	4	20	1	1	0	569	3
14:00	548	11	74	26	7	2	5	7	26	0	0	0	706	1
15:00	791	7	79	25	4	3	13	6	21	0	0	0	949	2
16:00	959	11	107	12	3	2	13	6	21	0	1	0	1135	0
17:00	1083	6	89	6	1	1	10	6	11	1	1	0	1215	0
18:00	846	8	70	8	1	3	5	2	11	0	0	0	954	0
19:00	496	4	31	4	1	0	1	3	10	0	0	0	550	0
20:00	339	3	23	1	0	1	1	1	7	0	0	0	376	0
21:00	332	4	12	1	1	1	3	3	0	0	0	0	357	0
22:00	215	1	8	2	3	0	1	0	1	0	0	0	231	0
23:00	145	0	10	3	0	1	1	0	1	0	0	0	161	0
Total	6580	69	623	141	28	17	63	43	157	3	3	0	7727	15

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\132.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 01 Direction : Northbound

1997/10/16 Thursday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	76	0	6	0	0	0	1	2	4	1	0	0	90	0
01:00	35	0	2	2	0	0	0	0	1	0	0	0	40	0
02:00	19	0	6	3	1	0	0	0	1	0	1	0	31	0
03:00	30	0	10	3	2	0	2	1	5	0	0	0	53	0
04:00	53	0	9	6	1	0	1	2	4	0	0	0	76	0
05:00	204	3	20	5	4	0	1	3	12	0	0	0	252	1
06:00	495	7	59	19	2	2	6	7	28	0	1	0	626	2
07:00	549	6	58	26	4	4	9	3	12	1	0	0	672	3
08:00	575	4	40	27	3	2	6	8	20	1	1	0	687	1
09:00	415	9	64	27	1	4	6	7	20	0	1	0	554	1
10:00	377	3	76	27	5	2	5	11	20	0	2	0	528	1
11:00	459	10	65	27	7	2	7	5	16	0	2	0	600	1
12:00	467	6	69	23	2	0	7	8	24	0	0	0	606	1
13:00	446	3	69	22	7	3	4	3	20	0	0	0	577	2
14:00	588	7	71	27	5	0	7	5	28	0	1	0	739	3
15:00	783	6	73	28	6	3	10	9	24	0	1	0	943	1
16:00	980	9	103	20	2	6	13	11	23	1	2	0	1170	2
17:00	1002	10	79	17	3	4	8	9	17	0	0	0	1149	0
18:00	805	5	50	10	1	2	10	0	12	0	0	0	895	0
19:00	515	2	30	2	0	1	3	2	4	0	0	0	559	0
20:00	393	3	23	1	0	0	3	4	9	0	1	0	437	0
21:00	386	1	26	2	2	1	0	1	2	0	0	0	421	0
22:00	258	0	14	2	0	0	0	0	3	0	0	0	277	0
23:00	172	1	11	1	0	0	0	0	1	0	0	0	186	0
Total	10082	95	1033	327	58	36	109	101	310	4	13	0	12168	19

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\132.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 01 Direction : Northbound

1997/10/17 Friday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	85	0	7	1	1	1	1	1	2	0	0	0	99	0
01:00	47	1	2	0	0	0	0	0	1	0	0	0	51	0
02:00	30	0	6	1	0	0	0	0	3	0	0	0	40	0
03:00	28	1	7	3	0	0	0	1	5	0	0	0	45	0
04:00	53	1	7	2	1	0	0	3	3	0	0	0	70	0
05:00	209	2	36	2	2	1	5	4	13	0	0	0	274	1
06:00	484	5	55	19	2	1	6	5	10	0	0	0	587	0
07:00	548	9	51	27	3	2	4	5	25	0	0	0	674	0
08:00	603	8	41	20	3	6	6	4	18	1	1	0	711	1
09:00	432	6	66	21	5	4	3	4	21	0	1	0	563	0
10:00	403	10	60	21	7	1	3	7	23	0	0	0	535	1
11:00	444	11	58	25	7	1	7	6	24	0	1	0	584	1
12:00	472	12	72	16	4	6	4	6	20	1	0	0	613	2
13:00	552	12	62	26	8	0	16	4	16	0	1	0	697	4
14:00	646	12	88	18	3	1	8	5	24	1	0	0	806	1
15:00	897	7	100	20	5	1	8	8	23	0	0	0	1069	3
16:00	1048	15	85	19	3	2	9	4	24	0	1	0	1210	0
17:00	1011	14	64	23	1	3	12	5	16	0	0	0	1149	2
18:00	878	7	55	10	1	1	10	5	15	1	0	0	983	0
19:00	598	2	36	6	0	1	2	1	6	0	0	0	652	0
20:00	309	3	31	2	0	3	3	0	5	0	0	0	356	0
21:00	265	1	24	1	0	0	1	2	2	0	0	0	296	0
22:00	251	2	12	0	0	0	1	0	3	0	0	0	269	0
23:00	205	4	9	0	0	1	1	0	2	0	0	0	222	1
Total	10498	145	1034	283	56	36	110	80	304	4	5	0	12555	17

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\132.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 01 Direction : Northbound

1997/10/18 Saturday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	145	0	6	2	0	2	1	0	2	0	0	0	158	0
01:00	67	0	1	0	0	0	0	0	0	0	0	0	68	0
02:00	50	0	2	0	0	0	0	0	2	0	0	0	54	0
03:00	46	1	7	1	1	0	0	1	5	0	0	0	62	0
04:00	76	1	10	0	0	0	0	2	4	0	0	0	93	0
05:00	171	5	19	3	0	0	1	3	9	0	0	0	211	0
06:00	277	10	29	9	0	4	7	5	8	0	1	0	350	1
07:00	341	9	26	13	3	0	4	9	12	0	1	0	418	1
08:00	423	19	39	25	0	0	14	7	12	0	1	0	540	0
09:00	532	18	34	11	2	1	6	4	18	0	0	0	626	0
10:00	563	13	57	10	2	2	6	6	12	0	0	0	671	0
11:00	642	14	52	16	2	3	8	4	19	0	1	0	761	0
12:00	697	12	45	12	3	1	7	2	10	0	0	0	789	0
13:00	661	14	45	13	2	2	8	2	11	0	0	0	758	0
14:00	595	14	44	7	1	0	2	5	12	0	1	0	681	0
15:00	615	12	36	16	0	2	4	5	4	0	0	0	694	0
16:00	649	5	33	5	0	1	4	1	5	0	0	0	703	1
17:00	664	6	31	5	0	0	6	2	2	0	1	0	717	2
18:00	494	5	15	1	0	0	3	0	1	0	0	0	519	1
19:00	350	2	16	2	0	1	2	2	1	0	0	0	376	0
20:00	240	0	7	0	0	0	0	0	1	0	0	0	248	0
21:00	229	1	5	0	0	0	2	0	0	0	0	0	237	0
22:00	247	1	16	0	0	0	4	1	1	0	0	0	270	0
23:00	239	0	12	1	0	0	2	0	1	0	0	0	255	0
Total	9013	162	587	152	16	19	91	61	152	0	6	0	10259	6

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\132.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 01 Direction : Northbound

1997/10/19 Sunday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	162	0	4	0	0	0	0	1	0	0	0	0	167	0
01:00	76	0	1	0	0	0	0	0	0	0	0	0	77	0
02:00	38	0	5	0	0	1	1	0	0	0	0	0	45	0
03:00	36	0	0	0	0	0	0	0	0	0	0	0	36	0
04:00	39	0	7	0	0	0	0	0	2	0	0	0	48	0
05:00	102	0	8	0	0	0	1	1	3	0	1	0	116	1
06:00	165	4	12	1	1	1	6	0	1	0	0	0	191	1
07:00	229	19	17	2	1	3	2	1	0	0	0	0	274	0
08:00	307	8	14	1	0	0	1	0	3	0	1	0	335	1
09:00	554	12	19	2	1	3	3	0	0	0	0	0	594	0
10:00	543	9	18	0	1	7	6	0	1	0	0	0	585	1
11:00	646	13	30	1	0	1	3	0	1	0	0	0	695	2
12:00	634	12	27	5	0	2	9	0	1	0	0	0	690	0
13:00	598	7	18	1	0	2	5	1	3	0	1	0	636	0
14:00	527	12	18	2	0	2	3	0	1	0	0	0	565	0
15:00	559	8	14	2	0	2	3	1	3	0	0	0	592	0
16:00	527	11	21	1	0	0	3	0	0	0	0	0	563	0
17:00	542	9	25	0	0	1	1	1	2	0	0	0	581	0
18:00	418	5	20	0	0	0	3	1	0	0	0	0	447	0
19:00	314	3	10	0	0	1	4	0	3	0	0	0	335	0
20:00	258	0	9	0	0	0	1	0	2	0	0	0	270	0
21:00	194	0	9	0	0	0	0	3	0	0	0	0	206	0
22:00	128	0	6	0	0	0	1	0	1	0	0	0	136	0
23:00	102	0	4	0	0	1	1	2	1	0	0	0	111	0
Total	7698	132	316	18	4	27	57	12	28	0	3	0	8295	6

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\132.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 01 Direction : Northbound

1997/10/20 Monday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	47	0	2	1	0	0	0	0	5	0	0	0	55	0
01:00	17	0	3	1	0	0	0	1	0	0	0	0	22	0
02:00	15	0	3	1	0	0	1	0	0	0	0	0	20	0
03:00	18	0	12	0	1	0	1	0	3	0	0	0	35	1
04:00	44	1	8	0	0	0	1	2	5	0	0	0	61	0
05:00	193	1	24	0	2	2	2	5	7	0	0	0	236	0
06:00	488	6	57	20	3	3	4	2	9	0	1	0	593	0
07:00	546	4	57	22	1	1	6	4	12	0	0	0	653	4
08:00	586	4	50	22	2	2	5	2	16	1	1	0	691	1
09:00	435	8	56	28	2	4	7	4	14	0	1	0	559	0
10:00	396	9	73	27	8	1	4	7	14	0	1	0	540	3
11:00	401	8	70	25	5	4	4	5	23	0	2	0	547	1
12:00	388	3	56	23	5	2	5	6	18	0	0	0	506	1
13:00	416	7	80	17	5	1	7	4	15	0	1	0	553	0
14:00	514	6	80	20	4	0	4	6	24	0	0	0	658	1
15:00	762	10	81	24	3	1	10	6	17	0	0	0	914	1
16:00	940	10	100	17	3	2	8	6	21	0	0	0	1107	0
17:00	1111	10	86	17	2	0	8	3	21	0	0	0	1258	1
18:00	791	9	51	11	3	1	2	1	15	0	1	0	885	0
19:00	421	3	27	3	1	0	4	1	8	0	0	0	468	0
20:00	257	2	26	2	1	0	2	0	4	0	0	0	294	0
21:00	256	2	16	1	0	1	0	1	5	0	0	0	282	0
22:00	155	0	8	3	0	0	1	0	2	0	0	0	169	0
23:00	123	2	7	0	0	1	0	1	2	0	0	0	136	0
Total	9320	105	1033	285	51	26	86	67	260	1	8	0	11242	14

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\132.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 01 Direction : Northbound

1997/10/21 Tuesday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	94	0	6	0	0	0	0	0	0	0	0	0	100	0
01:00	21	0	2	2	0	0	0	0	4	0	0	0	29	0
02:00	20	0	6	0	0	0	0	0	5	0	0	0	31	0
03:00	27	0	2	0	1	0	1	1	2	0	0	0	34	0
04:00	42	0	8	1	2	0	1	3	4	0	0	0	61	0
05:00	200	0	27	3	2	1	3	2	6	1	0	0	245	0
06:00	478	5	55	24	1	0	4	6	13	0	0	0	586	1
07:00	526	7	45	22	3	0	6	5	12	0	0	0	626	2
08:00	600	10	45	30	2	1	3	2	23	0	0	0	716	1
09:00	404	4	60	28	4	1	5	12	20	0	0	0	538	2
10:00	357	1	59	24	6	1	1	8	21	0	0	0	478	0
11:00	390	11	74	29	4	1	6	11	25	1	0	0	552	0
12:00	395	7	65	24	6	2	7	5	24	0	3	0	538	1
13:00	408	8	56	22	5	1	3	5	13	0	0	0	521	2
14:00	545	6	76	21	6	0	6	5	20	0	0	0	685	0
15:00	756	10	112	22	6	1	7	12	23	0	1	0	950	1
16:00	1011	12	96	21	3	1	11	5	16	1	1	0	1178	1
17:00	1029	7	78	17	4	1	6	3	9	1	0	0	1155	3
18:00	821	6	73	6	2	0	5	1	12	0	1	0	927	0
19:00	430	3	35	2	0	0	5	2	7	0	0	0	484	0
20:00	297	5	17	4	1	1	3	0	6	0	0	0	334	0
21:00	297	0	27	0	0	0	0	2	3	0	0	0	329	0
22:00	216	0	9	0	0	0	1	0	1	0	0	0	227	0
23:00	145	0	7	2	0	0	0	0	1	0	0	0	155	0
Total	9509	102	1040	304	58	12	84	90	270	4	6	0	11479	14

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\131.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 02 Direction : Southbound

1997/10/15 Wednesday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	31	1	2	4	0	0	1	1	4	0	0	0	44	0
01:00	13	0	10	2	0	0	0	0	0	1	0	0	26	0
02:00	26	0	11	2	1	0	1	1	1	0	0	0	43	0
03:00	46	0	12	2	0	0	2	0	3	0	0	0	65	0
04:00	127	1	21	4	3	0	3	3	8	0	0	0	170	0
05:00	479	10	60	14	6	2	9	5	33	2	1	0	621	2
06:00	853	13	75	36	3	0	11	7	26	0	0	0	1024	1
07:00	1162	8	48	17	6	4	7	4	21	0	1	0	1278	0
08:00	1013	12	45	20	6	1	8	4	24	1	0	0	1134	6
09:00	598	11	48	17	6	1	12	4	32	0	0	0	729	1
10:00	503	8	46	25	6	0	4	3	15	0	1	0	611	1
11:00	452	3	43	30	4	2	5	6	29	0	2	0	576	1
12:00	475	8	43	16	3	2	4	6	26	0	0	1	584	4
13:00	430	5	39	30	2	1	6	3	25	0	1	0	542	1
14:00	511	8	44	26	3	1	3	3	22	0	2	0	623	1
15:00	638	11	45	23	1	2	7	6	22	0	2	0	757	0
16:00	726	4	43	10	1	0	6	0	8	0	0	0	798	0
17:00	707	8	22	6	0	1	6	1	11	1	0	0	763	0
18:00	580	7	17	2	0	3	3	1	8	0	0	0	621	0
19:00	358	4	15	3	0	1	2	1	5	0	0	0	389	0
20:00	230	1	9	2	0	1	2	1	6	0	0	0	252	1
21:00	241	0	1	3	1	0	0	1	6	0	0	0	253	1
22:00	157	0	3	0	1	0	1	0	2	0	0	0	164	0
23:00	54	1	3	6	1	0	0	1	1	0	0	0	67	0
Total	10410	124	705	300	54	22	103	62	338	5	10	1	12134	20

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\131.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 02 Direction : Southbound

1997/10/16 Thursday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	36	1	2	1	0	0	1	1	3	0	0	0	45	1
01:00	26	0	13	1	0	0	0	2	1	0	0	0	43	0
02:00	25	1	13	2	2	0	1	0	2	0	0	0	46	0
03:00	59	0	13	1	1	0	1	0	3	0	0	0	78	0
04:00	128	0	23	7	3	0	2	2	10	0	0	0	175	1
05:00	460	8	62	19	6	0	4	3	26	1	1	1	591	1
06:00	850	14	68	31	6	0	13	10	23	0	1	0	1016	1
07:00	1126	16	42	38	6	1	14	6	16	0	1	0	1266	0
08:00	1067	5	42	24	5	3	14	4	13	0	1	0	1178	3
09:00	633	13	47	22	2	1	7	4	25	2	1	0	757	1
10:00	468	5	47	32	3	1	7	6	15	0	0	0	584	2
11:00	446	4	43	21	1	2	5	2	28	0	0	0	552	1
12:00	438	5	39	17	9	3	4	7	22	0	0	1	545	0
13:00	509	15	39	31	4	0	4	5	19	0	0	0	626	1
14:00	535	5	52	16	5	3	7	5	26	0	0	0	654	1
15:00	629	3	49	15	3	3	2	1	20	0	0	0	725	0
16:00	781	8	28	8	0	4	10	7	16	0	1	0	863	2
17:00	744	14	22	9	0	2	6	0	5	0	0	0	802	0
18:00	580	8	26	6	0	1	2	4	8	0	1	0	636	1
19:00	378	4	12	1	1	0	3	1	9	0	0	0	409	0
20:00	258	1	3	2	1	1	1	0	3	0	1	0	271	1
21:00	239	0	3	0	0	0	0	4	4	0	0	0	250	0
22:00	169	1	1	0	1	0	0	2	1	0	0	0	175	0
23:00	66	0	1	1	0	0	0	1	6	0	0	0	75	0
Total	10650	131	690	305	59	25	108	77	304	3	8	2	12362	17

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\131.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 02 Direction : Southbound

1997/10/17 Friday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	41	0	3	0	1	0	0	2	3	0	0	0	50	0
01:00	31	0	11	1	3	0	1	3	0	0	0	0	50	0
02:00	27	0	10	4	0	0	1	1	4	0	0	0	47	0
03:00	50	0	12	0	0	0	1	1	4	0	1	0	69	1
04:00	132	2	23	3	3	0	1	1	9	0	0	0	174	1
05:00	473	10	54	21	3	0	5	5	35	1	2	0	609	0
06:00	827	16	73	24	8	2	12	10	20	0	0	0	992	5
07:00	1128	14	52	30	6	2	10	6	26	0	0	0	1274	3
08:00	1043	6	46	23	4	2	10	4	14	0	0	0	1152	1
09:00	665	10	44	27	5	1	4	5	28	0	0	0	789	1
10:00	488	10	39	20	5	1	6	8	32	0	1	0	610	3
11:00	498	9	48	22	4	3	6	4	16	0	0	0	610	2
12:00	521	10	54	17	5	4	8	2	15	0	0	0	636	3
13:00	478	8	53	16	3	4	4	2	25	1	1	0	595	1
14:00	649	13	42	12	5	2	9	2	17	0	0	0	751	0
15:00	707	13	41	16	1	3	10	5	17	0	2	0	815	1
16:00	617	13	24	16	2	2	12	4	6	0	3	0	699	48
17:00	703	10	15	9	2	2	5	1	9	0	0	0	756	1
18:00	532	6	19	3	0	1	3	1	12	0	2	0	579	0
19:00	403	2	15	2	0	0	2	0	6	1	0	0	431	1
20:00	230	6	8	1	1	0	0	1	3	0	0	0	250	2
21:00	233	0	3	2	0	0	0	2	3	0	0	0	243	0
22:00	212	3	2	1	0	0	1	1	3	0	0	0	223	2
23:00	130	0	5	0	0	0	0	0	1	0	0	0	136	0
Total	10818	161	696	270	61	29	111	71	308	3	12	0	12540	76

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\131.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 02 Direction : Southbound

1997/10/18 Saturday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	94	0	4	1	0	0	0	0	1	0	0	0	100	0
01:00	37	0	4	3	0	0	0	0	1	0	0	0	45	0
02:00	36	0	5	2	0	0	0	0	2	0	0	0	45	0
03:00	49	1	6	1	1	0	2	0	2	0	0	0	62	0
04:00	91	0	8	0	1	0	1	1	9	0	0	0	111	1
05:00	284	4	38	7	5	0	2	4	13	1	0	0	358	1
06:00	333	8	26	24	2	0	3	6	12	0	1	0	415	2
07:00	396	13	20	19	1	2	5	2	11	0	0	0	469	0
08:00	527	13	19	14	3	0	6	5	11	0	0	0	598	1
09:00	583	10	20	10	2	0	7	1	12	0	0	0	645	4
10:00	573	23	24	7	0	1	6	3	11	0	1	0	649	2
11:00	582	19	16	9	1	0	8	2	10	0	2	0	649	4
12:00	559	12	9	8	0	1	6	3	14	0	2	0	614	1
13:00	592	14	14	9	1	1	5	3	13	0	0	0	652	1
14:00	560	14	15	6	1	2	9	2	4	0	0	0	613	1
15:00	578	17	14	6	0	1	10	2	2	0	0	0	630	1
16:00	608	20	8	0	2	0	9	1	1	0	0	0	649	4
17:00	687	11	10	1	0	2	10	0	3	0	0	0	724	0
18:00	538	6	15	0	0	0	7	1	2	0	0	0	569	0
19:00	408	2	5	2	0	1	2	0	0	0	0	0	420	0
20:00	263	6	4	1	0	0	0	1	1	0	0	0	276	0
21:00	260	2	5	0	0	0	2	0	3	0	0	0	272	0
22:00	248	3	2	0	0	0	0	0	1	0	0	0	254	0
23:00	186	0	2	0	0	0	1	0	1	0	0	0	190	0
Total	9072	198	293	130	20	11	101	37	140	1	6	0	10009	23

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\131.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 02 Direction : Southbound

1997/10/19 Sunday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	130	1	0	0	0	0	1	0	0	0	0	0	132	0
01:00	60	0	4	0	0	0	0	0	0	0	0	0	64	0
02:00	36	0	1	0	0	0	0	0	0	0	0	0	37	0
03:00	23	0	1	0	0	0	0	1	0	0	0	0	25	0
04:00	39	1	2	0	0	0	0	0	0	0	0	0	42	0
05:00	95	5	6	0	1	0	0	0	4	0	0	0	111	1
06:00	129	5	3	1	0	0	2	3	0	0	0	0	143	0
07:00	216	8	7	3	1	1	1	1	3	0	0	0	241	0
08:00	354	6	8	1	0	0	4	1	0	0	0	0	374	0
09:00	539	12	9	1	0	0	2	0	0	0	0	0	563	1
10:00	549	9	14	2	0	1	4	1	1	0	1	0	582	0
11:00	558	15	4	1	0	1	4	1	3	0	0	0	587	1
12:00	603	11	9	2	0	2	5	0	2	0	0	0	634	1
13:00	556	12	5	0	1	1	4	0	0	0	0	0	579	0
14:00	546	12	5	1	1	0	9	0	2	0	0	0	576	1
15:00	598	10	7	0	0	1	11	1	1	0	0	0	629	1
16:00	717	16	11	1	0	5	9	0	0	0	0	0	759	2
17:00	738	12	16	3	1	3	7	1	5	0	0	0	786	0
18:00	557	18	7	1	0	0	0	0	1	0	0	0	584	2
19:00	398	9	11	2	0	1	5	0	2	0	0	0	428	0
20:00	290	6	2	0	0	0	2	0	3	0	0	0	303	1
21:00	237	3	2	0	0	0	1	1	2	0	0	0	246	0
22:00	165	1	4	0	1	0	3	0	6	0	0	0	180	0
23:00	107	1	5	1	0	0	0	0	1	0	0	0	115	0
Total	8240	173	143	20	6	16	74	11	36	0	1	0	8720	11

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\131.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 02 Direction : Southbound

1997/10/20 Monday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	36	0	5	2	1	0	0	1	1	0	0	0	46	0
01:00	19	0	14	0	0	0	2	0	1	0	0	0	36	0
02:00	20	0	7	1	1	0	1	1	1	0	0	0	32	0
03:00	53	2	9	2	0	0	2	0	3	0	0	0	71	1
04:00	112	0	16	3	1	0	1	2	7	0	0	0	142	0
05:00	439	8	46	20	6	2	7	4	24	0	1	0	557	3
06:00	801	11	63	22	6	3	9	9	26	0	0	0	950	2
07:00	1141	10	53	30	2	1	7	5	15	0	0	0	1264	2
08:00	1037	6	56	24	5	0	15	5	24	0	0	0	1172	0
09:00	598	10	45	23	3	1	5	3	16	0	0	0	704	0
10:00	501	8	42	33	3	2	4	5	16	1	0	0	615	0
11:00	454	10	46	25	6	2	4	3	18	0	0	0	568	2
12:00	456	7	45	11	6	1	6	7	18	0	0	0	557	2
13:00	448	4	41	22	6	2	2	4	17	0	0	0	546	2
14:00	537	6	52	19	5	2	7	3	21	0	1	0	653	0
15:00	617	12	45	13	3	2	6	4	19	0	0	0	721	0
16:00	781	5	40	16	1	0	6	5	11	0	0	0	865	1
17:00	687	10	24	10	1	0	5	1	9	0	0	0	747	0
18:00	413	8	12	4	1	0	2	0	4	0	0	0	444	2
19:00	288	3	19	1	0	0	2	1	8	0	0	0	322	0
20:00	175	0	2	2	0	1	2	0	8	0	0	0	190	0
21:00	147	3	1	2	0	0	1	1	2	0	0	0	157	0
22:00	124	0	2	0	0	0	0	0	6	0	0	0	132	0
23:00	55	0	5	1	0	0	0	2	3	0	0	0	66	0
Total	9939	123	690	286	57	19	96	66	278	1	2	0	11557	17

Traffic Counting Supplies & Service (02)476-6266

HOURLY CLASSIFICATION BY DAY

C:\COUNT\131.RTC

RICHMOND RD

Area : 12 Site : 022 Location : 02 Direction : Southbound

1997/10/21 Tuesday

Class	1	2	3	4	5	6	7	8	9	10	11	12	Total	Error
00:00	33	0	2	1	0	0	0	0	2	0	0	0	38	0
01:00	23	0	3	0	0	0	0	0	2	0	0	0	28	0
02:00	22	0	11	2	0	0	0	2	4	0	0	0	41	0
03:00	46	2	12	2	0	0	2	1	2	0	0	0	67	0
04:00	117	0	14	2	3	0	2	3	8	0	0	0	149	1
05:00	510	11	64	17	10	1	7	7	22	1	1	0	651	2
06:00	873	14	69	24	8	1	14	6	7	0	1	0	1017	5
07:00	1212	11	54	29	2	0	9	2	14	0	1	0	1334	2
08:00	1049	5	41	23	5	0	8	3	10	0	0	0	1144	1
09:00	589	12	32	23	2	1	9	2	23	0	0	0	693	1
10:00	464	4	40	27	5	0	9	8	14	0	0	0	571	0
11:00	411	12	62	32	6	2	5	6	23	0	0	0	559	3
12:00	402	8	51	21	7	2	2	5	21	0	1	0	520	1
13:00	400	7	56	28	2	2	6	1	25	2	1	0	530	1
14:00	513	5	44	21	5	1	1	2	16	2	1	0	611	2
15:00	650	9	44	16	3	3	8	6	18	2	1	0	760	2
16:00	776	5	35	9	4	1	9	2	16	0	0	0	857	0
17:00	679	10	20	4	0	2	9	1	5	1	0	0	731	0
18:00	482	5	22	3	1	0	4	1	3	0	1	0	522	1
19:00	293	1	15	2	1	0	2	0	3	0	1	0	318	0
20:00	191	0	6	3	0	0	3	2	3	0	1	0	209	0
21:00	158	0	2	1	0	0	0	0	4	0	0	0	165	1
22:00	140	1	3	0	0	0	1	2	2	0	0	0	149	1
23:00	62	0	4	0	0	0	1	2	1	0	0	0	70	0
Total	10095	122	706	290	64	16	111	64	248	8	10	0	11734	24

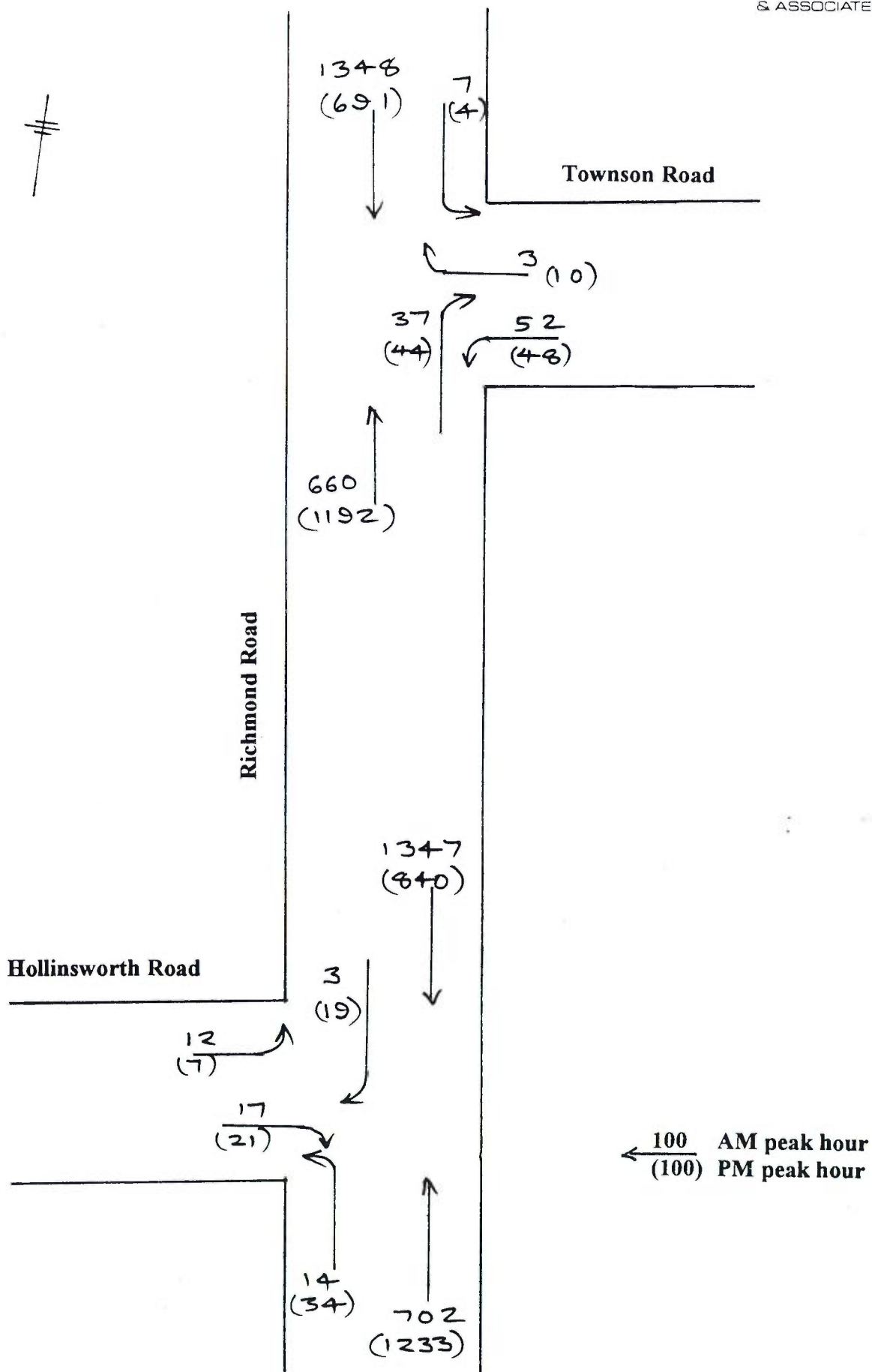
Base Source: CMA 1:25000 Topographic Series: Riverstone

The map displays the Riverstone area with various geographical features and infrastructure. Key locations include Hillview, Yarramoor Lodge, Barning Lodge, Training Tracks, Waste Disposal Depot, Piggery, Caravan Park, and Bidwill Reserve. The proposed depot site is located in a former quarry, with a buffer zone surrounding it. The proposed site access is marked, and the proposed Castlereagh Freeway is shown. The map also indicates Commonwealth Land and various roads and streets, including Clengarr Road, South Street, Clifton Road, and the proposed freeway. The map is divided into sections labeled 1(a), 5(a), and 5(b).

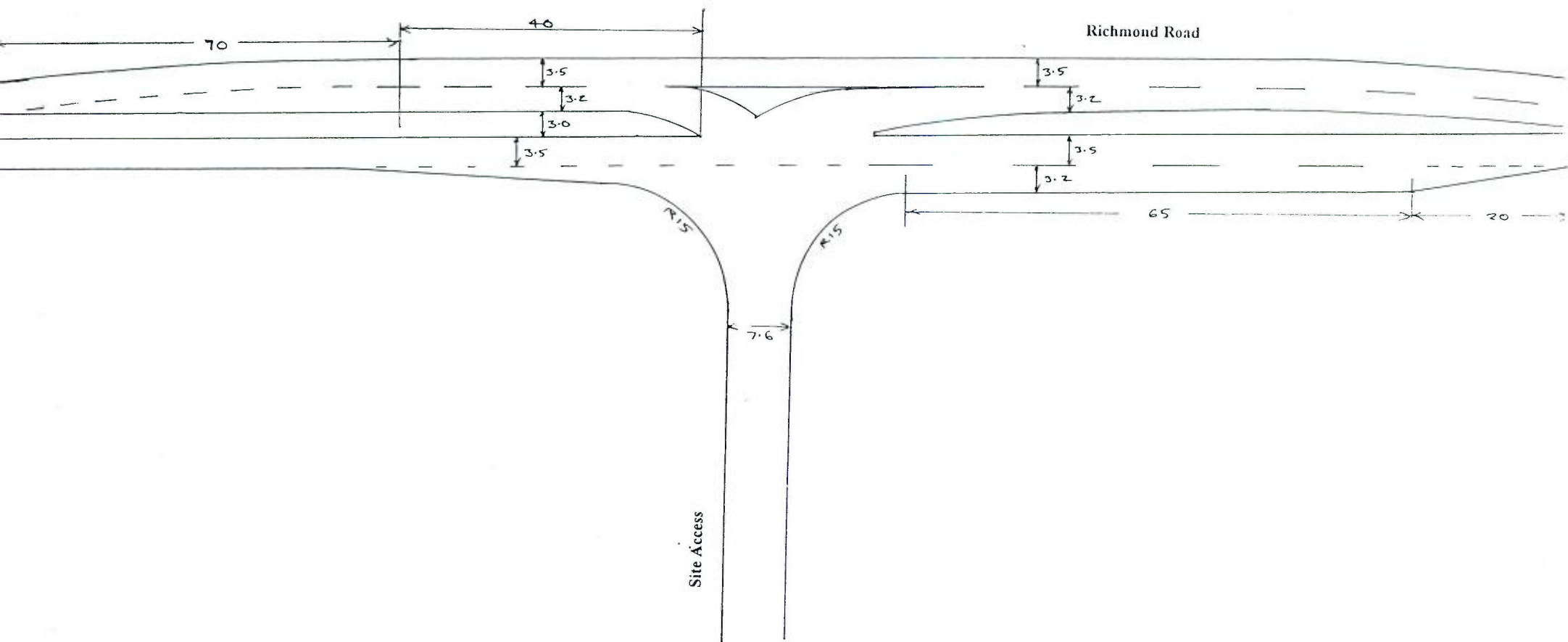
PROPOSED MARSDEN PARK LANDFILL
AND RECYCLING DEPOT

N

ENVIRO-MANAGERS PTY LTD



CURRENT PEAK HOUR TRAFFIC FLOWS FIGURE 2



RECOMMENDED LAYOUT OF RICHMOND ROAD
& SITE ACCESS INTERSECTION