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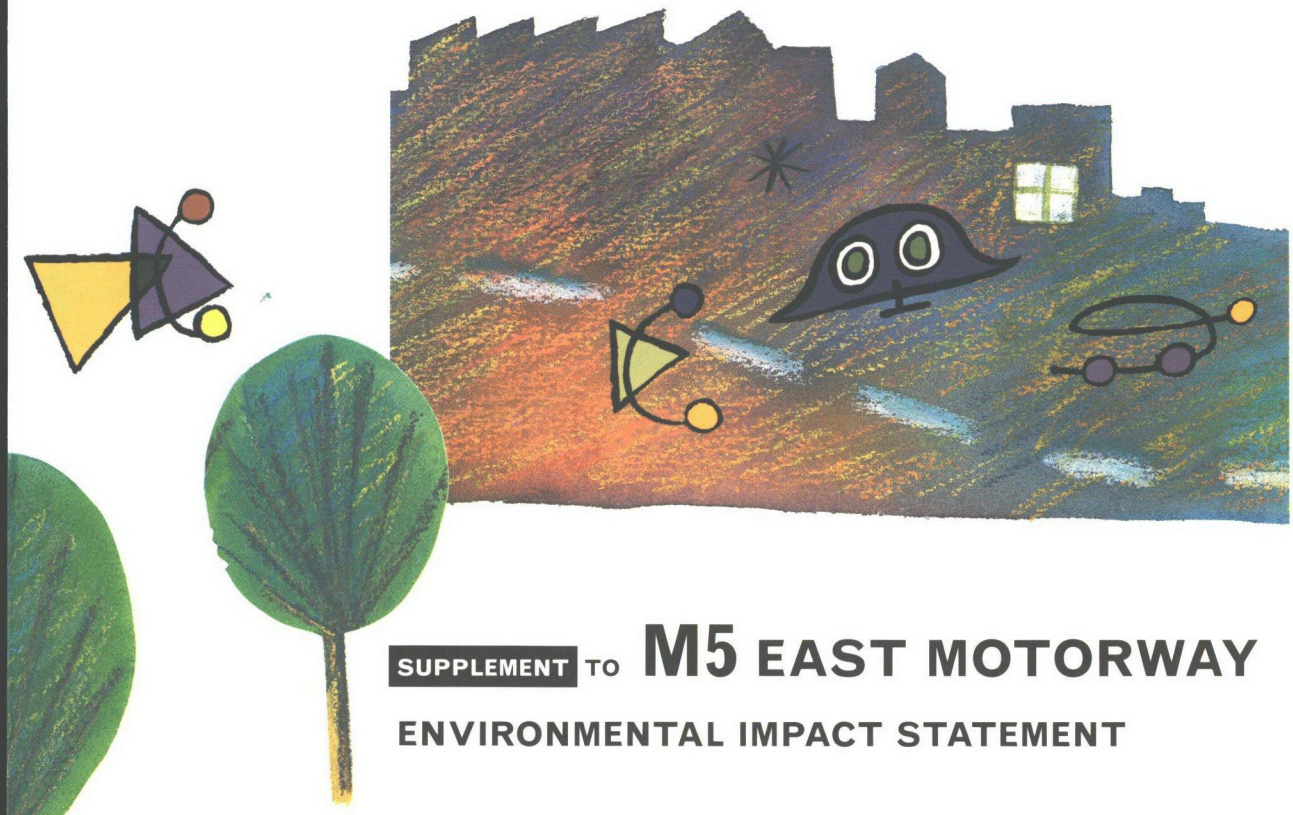

SUPPLEMENT TO M5 EAST MOTORWAY

ENVIRONMENTAL IMPACT STATEMENT

1996

RTA

Better Roads.Safer Roads.
Saving Lives

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Saving Lives

ACKNOWLEDGEMENTS

The study team wishes to thank the individuals, organisations and government bodies who have generously provided their assistance, and members of the public who greatly contributed to the preparation of this environmental impact statement.

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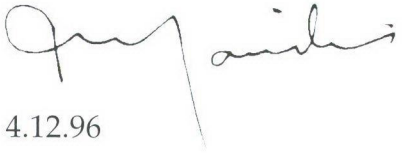
CLAUSE 59 CERTIFICATE

SUPPLEMENT TO M5 EAST MOTORWAY
ENVIRONMENTAL IMPACT STATEMENT 1996

This is to certify that this environmental impact statement has been prepared in accordance with Clauses 57 and 58 of the Environmental Planning and Assessment Regulation, 1980.



4.12.96

Philip Manidis

Director
Manidis Roberts Consultants

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GLOSSARY

1994 M5 East EIS proposal — The preferred option which resulted from the 1994 assessment of environmental impacts of a proposed extension to the existing M5 Motorway. The 1994 M5 East EIS proposal consists of two options:

- The Shorter Tunnel: Option 7e, the preferred alternative from the 1994 M5 East EIS.
- The Extended Tunnel: Option 7l from the 1994 M5 East EIS.

Accident black spot — A location which has had more than 25 reported personal- injury accidents over a three-year period.

Air intake — A small structure housing a fan for the purpose of directing fresh air into a motorway tunnel so as to ventilate it. Air intakes are constructed on the surface above the alignment of the tunnel, and connected to the tunnel by a vertical shaft.

Alignment — A detailed geometric layout, in plan and profile, following a general route.

Areas — For the purposes of the traffic studies, parts of sub-regions used to describe principal origins and destinations of traffic actually using the M5. More traffic is drawn from areas close to the M5, so these areas are smaller and more distinct. The trips which are drawn to the M5 from further away are fewer and their areas of origin, being more generalised, are larger.

Arterial road — A roadway with the primary purpose of carrying medium to long-distance traffic, usually with at-grade intersections and access to adjoining property.

Asphaltic concrete — A dense, continuously graded mixture of coarse and fine aggregates, mineral filler and bitumen usually produced hot in a mixing plant. This material is also known as "bituminous concrete".

At-grade — A road at ground level, not on an embankment or in a cutting.

AUSTROADS — Formerly the National Association of Australian State Road Authorities (NAASRA).

Benzene — A colourless, volatile, inflammable, liquid hydrocarbon obtained chiefly from coal tar.

Capacity — The nominal maximum number of vehicles that can travel along a road in a given time.

Carbon monoxide — A colourless, odourless, poisonous gas which burns with a pale blue flame. It forms when carbon burns with an insufficient supply of air.

Catalytic converter — A device fitted to the exhaust of a motor vehicle which breaks down nitrogen oxides to nitrogen and oxygen.

Commercial vehicle — Any vehicle of 5 tonnes gross weight or more — usually having dual rear wheels and/or twin rear axle.

Container movements — Transport of freight containers from one place to another.

Contractor — The organisation or agency that is responsible for any or all of the design, construction, maintenance or operation of the motorway.

Corridor	The area investigated for this environmental impact statement.
Cumulative impacts	Impacts which, when considered together, lead to a stronger impact than any impact in isolation.
Cut and cover	A method of constructing tunnels whereby the structure is built in an open excavation and subsequently covered with backfill.
Desire lines	Imaginary lines, used in traffic planning, linking an assumed series of origins with an assumed series of destinations; representing the directions in which there is a desire for people and freight to travel.
Direct property impacts	Impacts of construction or operation of the proposed motorway that would result in encroachment upon, or whole or partial destruction of, private properties in the vicinity of the motorway alignment.
Earthworks	All operations involved in loosening, removing, depositing, shaping and compacting soil and rock.
Effects	The potential results, both positive and negative, of a particular option.
Escarpment	A long, cliff-like ridge of rock commonly formed by faulting or fracturing of the earth's crust.
Exhaust stack	A chimney-type structure, built on the surface, for the purpose of extracting vehicle exhaust gases from a motorway tunnel and expelling those gases into the atmosphere at a height above the ground that will ensure that the gases are readily dispersed under all atmospheric conditions. The height of an exhaust stack is dictated by its situation in regard to topography, adjoining land uses and prevailing atmospheric conditions.
Extended tunnel	See 1994 M5 East EIS proposal.
Flood mitigation	Measures taken to control or minimise the effects of flooding.
Geotechnics	The application of scientific methods and engineering principles to the solution of engineering problems involving materials of the earth's crust.
Haul road	A designated road, often temporary, used for moving materials.
Hawkesbury sandstone	A medium-grained yellow quartz sandstone which weathers to sandy soil.
Homogeneous groups	Groups that are the same or very similar.
Hydrocarbons	Compounds containing hydrogen and carbon which are principally derived from petroleum products.
Hydrology	The study of the rainfall and surface water run-off processes.
Impact	See Effects.
Indirect property impacts	A property in close proximity to the motorway, or above the tunnel alignment.
In-situ	In its desired place. Usually referring to the casting of concrete elements in their desired final position.
Interchange	A grade separation of two or more roads with one or more interconnecting carriageways.
Intrusive noise	An environmental noise source that may cause annoyance if clearly audible.
Lead	A heavy, comparably soft, malleable, bluish-grey metal present in petroleum products.

Mangrove	A type of tree found in tropical and sub-tropical areas on salt or brackish (especially estuarine) mudflats. Mangroves are characterised by a strongly developed system of aerial roots.
Methodology	A method for analysis and evaluation of subject matter.
M5 corridor	The area bounded by Canterbury Road, Gardeners Road, O'Riordan Street, General Holmes Drive, President Avenue, Harrow Road, Forest Road and Fairford Road.
Midden deposits	A mound consisting of shells of edible molluscs and other refuse, marking the site of early human habitation.
Mitigative measures	Methods employed to limit the impact of activities which have been identified as being potentially detrimental to the environment.
Morning peak period	The period in the morning during which a maximum traffic flow occurs. In this report, the morning peak period lasts for about two hours. A reciprocal flow of similar magnitude generally occurs in the evening peak period.
Motorway	A high-speed, high capacity roadway with no at-grade intersections and access limited to interchanges.
Motorway embankment	That portion of a motorway located on an earthen structure where the sub-grade level is above the natural surface.
New Jersey barrier	A concrete structure, usually about 0.8 metres high, designed to deflect out of control vehicles back on to the road without overturning.
Nitrogen oxides	Compounds containing oxygen and nitrogen.
NODELAY model	A computer software package used to forecast traffic flows and a range of road network performance criteria (such as travel times).
Northern Variation	Alternative G, described in **Chapter 4**.
Ozone	A form of oxygen (O_3) found in the atmosphere in minute quantities, especially after a thunderstorm.
Particulate matter	Dust and other particles.
Photochemical smog	Regional air pollution, consisting of ozone and other oxidants formed by the interaction of nitrogen oxides, hydrocarbons and sunlight.
Pollutant	Any measured concentration of solid or liquid matter that is not naturally present in the pristine environment.
Pollutant concentrations	In this context, the term refers to emissions from motor vehicles (including carbon monoxide, nitrogen oxides, particulate matter and hydrocarbons) and the resultant concentrations of these in the air.
Portal	The entry/exit area of a tunnel.
Recolonisation	Re-establishment of a species in a habitat after disturbance has occurred.
Regeneration	Re-establishment of a native plant community in an area after a disturbance has occurred.
Road infrastructure	Permanent installations associated with roads, such as roadways, tunnels, bridges, interchanges and traffic signals.
Run-off	That portion of precipitation not immediately absorbed into the soil, thus becomes surface flow. The amount of run-off depends on rainfall intensity and duration, land slope, surface roughness, vegetative cover, and surface soil conditions, including moisture content.

Saltmarsh communities — A wetland that is either in salt water or flooded by the sea.

Sedimentation — Deposition of sediment. The typical use of the term would infer deposition by water. In a soil conservation context, sedimentation is an end point in the erosion process, with transported soil material being deposited in locations such as in a channel, along a fence line, on an area of low slope, or in a gully, creek, river, sediment trap or dam.

Sediment trap — A temporary or permanent structure or a vegetative barrier designed to trap sediment in run-off before it enters stormwater pipes, channels or streams. It is usually designed to control run-off from small catchments only.

Shorter tunnel — See 1994 M5 East EIS proposal.

Southern Variation — Alternative H as described in **Chapter 4**, the preferred alternative (or option) for the motorway which is assessed in this Supplement to the 1994 M5 East EIS.

Sub-arterial road — A road connecting arterial roads to areas of development, and carrying traffic directly from one part of a region to another.

Sub-region (as used in the traffic study) — Used in the traffic analysis for describing origin and destination desire-lines in and across the M5 corridor, comprising:

To the west:

- Menai and areas to the south.
- Bankstown and surrounding suburbs.
- Liverpool and south.
- Suburbs west of Bankstown.

To the east:

- Sydney CBD, South Sydney (excluding the Central Industrial Area) and North Shore.
- South Sydney Central Industrial Area only.
- Eastern suburbs (suburbs east of South Dowling Street/Southern Cross Drive, and north of Maroubra).
- Port Botany and Botany Industrial Area.
- Airport and related industries in Mascot.
- Hurstville and Rockdale local government areas.
- Canterbury local government area.
- Marrickville local government area.

Sydney Basin — An area of relatively low elevation, bounded by the Hornsby and Woronora Plateaux and the Great Dividing Range.

Synchronised green times — Co-ordination of traffic signals to give the main stream of traffic priority over other streams.

SWSOOS — South Western and Southern Ocean Outfall Sewer.

TNL — Leq (24 hour) + 0.1 x NHV where NHV equals the average number of heavy vehicles per hour passing a point between 10 p.m. and 7 a.m. Otherwise stated, TNL is a 24-hour average noise measure weighted for the noise peaks caused by heavy vehicles at night.

Toll plaza	A section on a motorway which incorporates a number of toll booths, administration buildings and staff parking areas.
Toll road	A road where motorists pay a toll for its use.
Traffic calming	The means by which local streets are kept relatively free of through traffic by the implementation of traffic management devices and/or by private vehicle demand management.
Traffic efficiency	Measured by savings (and delays) in travel time.
Transport corridor	The study area, plus the existing portion of the M5 West (King Georges Road to Heathcote Road), plus the South-Western Freeway to the Hume Highway.
Transport infrastructure	Permanent installations including roads, rail, buildings and storage associated with transport (see also Road Infrastructure and Rail Infrastructure).
Transportation reserve	An area of land reserved for future transport needs, usually roads and railways.
Tunnel exhaust stack	See: Exhaust stack.
Urban consolidation	A planning initiative that aims to increase development and population densities in established areas to limit the spatial extent of urban areas.
Variation	The alternative for the motorway being assessed in this Supplement to the 1994 M5 East EIS.
Viaduct	A long bridge consisting of beams with high supporting piers for carrying a road or railway over land or water.
Wetland	A swamp or marsh in which the soil is frequently or permanently saturated with water, or under water.

SPECIALIST WORKING PAPERS FOR THE SUPPLEMENT TO THE 1994 M5 EAST MOTORWAY EIS — CONTAINED IN THREE SEPARATE VOLUMES

VOLUME 1 OF 3

BBC Consulting Planners, 1995a. M5 East motorway: variation from Bexley road to General Holmes Drive: supplementary report on matters relating to zoning. Prepared for Manidis Roberts Consultants on behalf of the Roads and Traffic Authority, Sydney, December, 1995. 1pg.

BBC Consulting Planners, 1995b. M5 East motorway: variation from Bexley road to General Holmes Drive: land use and social impacts. Prepared for Manidis Roberts Consultants on behalf of the Roads and Traffic Authority, Sydney, December, 1995. 14 pgs.

Connell Wagner, 1995a. M5 East motorway - tunnelling supplementary report. Prepared for the Roads and Traffic Authority, Sydney, October 1995. 50 pgs.

Connell Wagner, 1995b M5 East motorway - soils and groundwater report. Prepared for the Roads and Traffic Authority, Sydney, April 1995. 70 pgs.

Ecology Lab, 1995. An assessment of M5 East motorway construction and operational activities on fish and decapods in wetland habitats. Prepared for the Roads and Traffic Authority, Sydney, February 1995. 70 pgs.

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Holmes Air Sciences, 1996. Air Quality Impact Assessment: a Variation to the M5 East Motorway. Prepared for the Roads and Traffic Authority, Sydney, December 1996, approximately 60 pgs.

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Mount King Ecological Surveys, 1995. M5 East motorway - assessment of variation of route between Bexley Road and Cooks River; flora and fauna - supplementary working paper. Prepared for the Roads and Traffic Authority, Sydney, October 1995. 16 pgs.

Osborne, P L, 1995. M5 East Expressway - Wetland habitats - Addendum to reports by P Adcock and P L Osborne. Water Research Laboratory, University of Western Sydney. Prepared for the Roads and Traffic Authority, Richmond, NSW, September 1995. 16 pgs.

Thorp, Wendy, 1995. M5 East motorway: supplementary working paper: European heritage issues. Prepared for the Roads and Traffic Authority, Sydney, December 1995. 8 pgs.

Richard Goodwin, 1996. M5 East Motorway: tunnel exhaust stack designs. Prepared for the Roads and Traffic Authority, Sydney, November 1996. 12 pgs.

Willing & Partners, 1995. Supplementary report to hydrology and hydraulics and water quality study reports. Prepared for the Roads and Traffic Authority, Sydney, October 1995.

VOLUME 2 OF 3

TEC Consulting, McCracken Consulting Services, Acer Wargon Chapman, 1995. M5 Motorway East: transport of dangerous goods. Prepared for Roads and Traffic Authority, Sydney Region, Report No. J485, August 1995.

VOLUME 3 OF 3

TEC Consulting, McCracken Consulting Services, Acer Wargon Chapman, 1995. M5 Motorway East: transport of dangerous goods: technical addendum. Prepared for Roads and Traffic Authority, Sydney Region, August 1995.

GUIDELINES FOR MAKING A PUBLIC SUBMISSION

HOW DOES YOUR SUBMISSION FIT INTO THE EIS PROCESS?

Submissions from members of the public, government agencies and interest groups are invited and sought in response to this supplement to the 1994 M5 East environmental impact statement.

All submissions will be examined and an assessment report will be prepared by the Roads and Traffic Authority. The Roads and Traffic Authority will consider this supplement, the 1994 M5 East environmental impact statement, public submissions on the environmental impact statement and this supplement, and the assessment report. Copies of this supplement, the environmental impact statement, the public submissions and the assessment report will be forwarded to the Department of Urban Affairs & Planning. Construction of the proposed motorway requires the approval of the Minister for Urban Affairs & Planning and the concurrence of the Director-General of National Parks and Wildlife.

Existing comment already received by the RTA on the 1994 M5 East EIS is still current and will be taken into account in the determination process.

WHY WRITE A SUBMISSION?

A submission is a way for you to provide input into the environmental impact assessment process for the proposed motorway. However, it is not recorded as a vote for or against the proposal. It is the substance of the issues raised which is important to the process.

Submissions can provide information, comment on the proposal and findings, or suggest improvements. The report on submissions thus contributes to the decision-making regarding the proposed motorway link.

WHAT SHOULD YOU INCLUDE IN A SUBMISSION?

It is particularly useful if you can indicate:

- Your interest in the proposal.
- Your opinion of the proposal.
- What measures you consider appropriate to improve the proposal.
- Any errors or omissions in the information presented in this supplement.
- Any further factual information you have (and its source).

Your comments may also cover related facts or topics that you believe should be considered.

All submissions will be treated as public documents unless explicitly requested to be otherwise. All written submissions will be acknowledged. While form letters are accepted and examined, they will not be acknowledged. Please indicate if you wish your submission to remain confidential.

WHAT SHOULD YOU KEEP IN MIND?

You will make it easier for your submission to be analysed if you:

- Attempt to list points, so that the issues raised are clear.
- Refer each point to the appropriate sections in this supplement.
- Include your name, address and the date.
- Ensure that your submission is as legible as possible.

SUBMISSIONS SHOULD BE ADDRESSED TO:

Project Manager
M5 East Motorway EIS
NSW Roads and Traffic Authority, Sydney Region
83 Flushcombe Road
BLACKTOWN NSW 2148

DEADLINE FOR SUBMISSIONS: 18 FEBRUARY 1997

CHAPTER 1 INTRODUCTION

1.1 VARIATION TO THE PROPOSED M5 EAST MOTORWAY

1.1.1 BACKGROUND AND NEED TO CONSIDER A VARIATION

In 1994 the Roads and Traffic Authority exhibited an Environmental Impact Statement (1994 M5 East EIS) concerning the proposed M5 East Motorway. In August 1995, in response to comments made in submissions from the community to that EIS, it was announced that the Roads and Traffic Authority would examine alternatives to the 1994 M5 East EIS proposal between Bexley Road and Cooks River. A more direct alternative route was generally indicated in a newsletter 'M5 East Update', circulated in the area. A copy of the newsletter is contained in **Appendix A**.

The need to consider alternatives to the 1994 M5 East EIS proposal between Bexley Road and Cooks River, in addition to the "do nothing" option set out in the 1994 M5 East EIS, arose out of the comments received on the proposal when it was exhibited. There were some 524 submissions and 1675 form letters received in response to the 1994 M5 East EIS. Many of the submissions raised concerns about the visual impact of the proposal to construct an elevated motorway through Turrella as part of the 1994 M5 East EIS proposal, and the impact on residences in Arncliffe. The impacts of the 1994 M5 East EIS proposal on the Wolli Creek valley, and of the redevelopment proposed at North Arncliffe, were also of concern as was the question of tolling. A process of public consultation was undertaken in relation to alternative routes between Bexley Road and Cooks River. During this process, further alternatives were developed. Eight alternatives emerged and one, Alternative H , is similar to the route described in the newsletter. The alternative under consideration in this document is a refinement of Alternative H.

Part 5 of *The Environmental Planning and Assessment Act 1979 ('EPA Act 1979')* sets out the process for assessing this proposed Variation to the 1994 M5 East EIS proposal ("the Variation"), and this supplement has been prepared towards fulfilment of that process.

New Director's requirements were received from the Director of Urban Affairs and Planning by letter of 11 April 1995 regarding the preparation of a supplement to the 1994 M5 East EIS. This supplement has been prepared having regard to those requirements (presented in **Appendix B**). The Roads and Traffic Authority is the 'proponent' of the Variation for the purposes of the Act.

1.1.2 ALTERNATIVES CONSIDERED

In considering alternatives to the 1994 M5 East EIS proposal, aspects for review included:

- the location and length of the tunnel,
- the design of the interchanges at Marsh Street and at General Holmes Drive, and
- whether the motorway would be tolled.

LOCATION AND LENGTH OF TUNNEL, AND DESIGN OF INTERCHANGES

The 1994 M5 East EIS proposal was for a four-lane tolled motorway, extending for about 13.5 kilometers east-west between Fairford Road, Padstow, and General Holmes Drive, Kyeemagh with a three kilometre tunnel, as shown in **Figure 1** ('the shorter tunnel'). This was the preferred proposal. The estimated cost of the 1994 M5 East proposal involving the shorter tunnel was $564 million.

An alternative involving an extended tunnel of 4.3 kilometers was also considered in the 1994 M5 East EIS along the same alignment. This is referred to in the 1994 M5 East EIS as 'the extended tunnel'. This proposal was not preferred. The estimated cost of the 1994 M5 East EIS proposal involving the extended tunnel was $646 million.

The third alternative (the 'direct tunnel') introduced for this Supplement was for a more direct tunnel between Bexley Road and Marsh Street, with a motorway that was not tolled between King Georges Road and General Holmes Drive. In the process the design of the interchanges at Marsh Street and General Holmes Drive were also reviewed. The estimated cost of this alternative is $560 million between Fairford Road, Padstow, and General Holmes Drive at Kyeemagh.

After consideration of the likely impacts, the alignment of the third alternative (the direct tunnel) which includes the duplication of the existing M5 Motorway between Fairford Road and King Georges Road is preferred over both the shorter and longer tunnel alternatives assessed in the 1994 M5 East EIS because the direct tunnel has fewer impacts on the community. This comparison of impacts is more fully presented in **Chapter 9.**

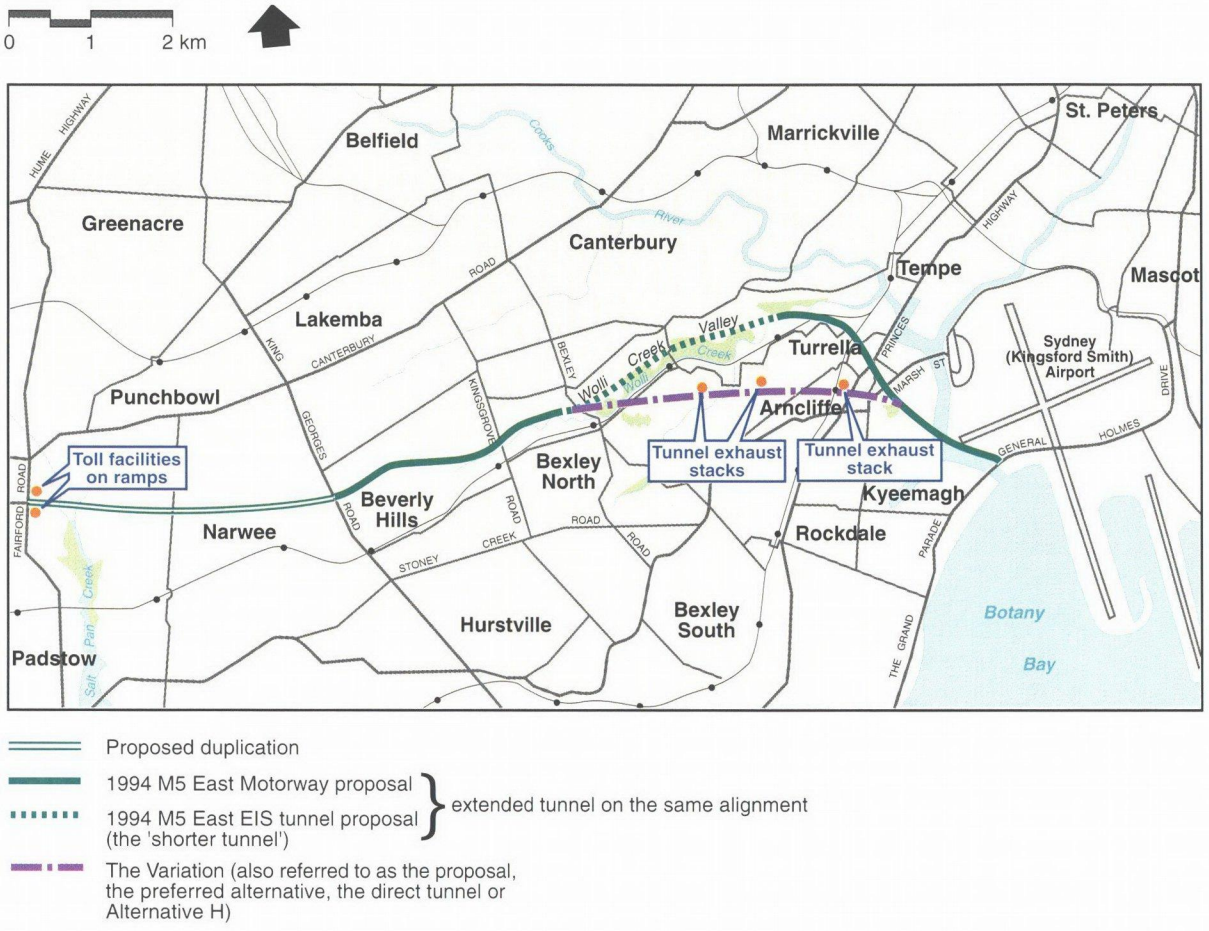


FIGURE 1 —THE 1994 M5 EAST EIS PROPOSAL AND THE VARIATION

Chapter 4 contains a detailed consideration of alternatives. The preferred alignment for the direct tunnel is a refinement on Alternative H. This alternative is preferred on the basis of lower cost and fewer direct land use impacts. It is referred to as "the Variation" and is considered for impacts in this Supplement. **Figure 1** illustrates the alignment of the shorter tunnel and the extended tunnel alternatives assessed in the 1994 M5 East EIS, as well as the Variation assessed in this Supplement.

NO TOLL

Whilst the 1994 EIS proposed a toll road, the Minister for Roads has now announced by news release on 3 November 1996 that the M5 East proposal, if it goes ahead, will not have a toll.

The current proposal is not to toll the motorway between King Georges Road and General Holmes Drive. The proposed mini-toll plazas on the east-facing ramps at Fairford Road would remain as part of the proposal, being within the length of the M5 Motorway which is operated by Interlink Roads Pty Ltd.

The removal of the toll between King Georges Road and General Holmes Drive represents a significant difference between the proposal outlined in the 1994 M5 East EIS and the proposal currently under consideration. The major implications of abandoning the proposed toll plaza at Kingsgrove (see 1994 M5 East EIS) would be:

- The predicted motorway traffic volumes would increase by about one fifth.
- Traffic on parallel roads in the vicinity of the motorway would decrease, as this traffic would divert to the motorway given that the toll would no longer be levied.
- Predictions regarding air quality and noise impacts would change from those made in the 1994 M5 East EIS, and proposed mitigative measures would require review.

The full implications of the proposed abandonment of the toll for the M5 East Motorway, in terms of traffic and transport efficiency, noise, air quality and associated economic, social and environmental impacts, have been investigated and are presented in this Supplement.

1.2 Overview of the Variation

1.2.1 Current proposal compared with the 1994 M5 East EIS proposal

The current proposal (the variation)

The Minister for Roads has announced that the motorway would not be tolled between King Georges Road and General Holmes Drive. That announcement, and comments on the 1994 M5 East EIS, have led to the proposal now described (see **Figures 8** to **23**). The proposal is for:

- Duplication of the existing 2 lanes to provide a 4-lane motorway between Fairford Road and King Georges Road.
- A new 4-lane motorway between King Georges Road and Bexley Road at Bexley North.
- A new direct tunnel from Bexley Road at Bexley North to Marsh Street at Valda Avenue, Arncliffe.
- A new 4-lane road from Marsh Street to General Holmes Drive just north of the Cooks River at Kyeemagh.
- Grade-separated interchanges at Fairford Road, King Georges Road, Bexley Road, Princes Highway, Marsh Street and General Holmes Drive.
- Three tunnel exhaust stacks and three air intakes between Bexley Road and Marsh Street.

Differences From 1994 M5 East EIS Proposal

The differences between the current proposal described in this Supplement and the previous proposal put forward in the 1994 M5 East EIS are:

- There is now no toll on the motorway between King Georges Road at Beverly Hills and General Holmes Drive at Kyeemagh.
- There is no toll plaza as previously proposed near Gareema Circuit, Kingsgrove. This space can now be made available for a Police, EPA and RTA vehicle and driver enforcement/inspection area.
- Each carriageway (outside of the tunnel) would have a cross section with two through lanes each 3.5m wide, a left shoulder 2.5m to 3.5m wide and a right shoulder 1.0m wide, compared with the original cross section which had a 2.5m left shoulder. This would offer improved road safety by providing more space for a disabled vehicle.
- The tunnel is now proposed as a direct tunnel from a portal at Bexley Road, Bexley North to a new portal at Marsh Street, Arncliffe. The tunnel portal at Bexley North is in the same location as previously. However, the previous proposal of the motorway in tunnel below Wolli Creek emerging to run on viaduct through Turrella and North Arncliffe is now not preferred.
- New exit and entry ramps from the Princes Highway to and from the southwest are now proposed about 300m south of where they were previously proposed. At Marsh Street a full diamond interchange is now proposed about 150m south of where the at-grade intersection was previously proposed.
- Exhaust vent stacks for the tunnel are now proposed at Royal Place/Bardwell Road in Bardwell Park, at Hill Street/Duff Street in Arncliffe and at Arncliffe Street/Burrows Street in Arncliffe. Previously there was one proposed at Earlwood car park.
- Three air intakes are now proposed for the tunnel, located adjacent to the exhaust vent stacks at Arncliffe Street/Burrows Street in Arncliffe, at Hill Street/Duff Street in Arncliffe, and adjacent to the Bardwell Valley Golf Course in Bardwell Park adjacent to Bardwell Road.
- Vehicles transporting dangerous goods would not be permitted to travel through the proposed tunnel, because of risk of serious incidents within the confines of the tunnel, but would be permitted onto the other sections of the proposal. Dangerous goods would continue to be restricted from using the Airport Tunnel on General Holmes Drive.
- In place of the previous at-grade intersection with General Holmes Drive, a grade separated off-ramp connecting from the M5 East to the middle lanes of General Holmes Drive northbound, and a grade

separated on-ramp connecting from the left hand lanes of General Holmes Drive southbound to the M5 East southbound are now proposed. This facilitates access for heavy vehicles to and from Port Botany and the surrounding area from the M5 East proposal.

- The changes to the tunnel alignment and portal locations have resulted in the proposed tunnel being 4.0km long compared with the 1994 proposal of 2.9km. The adoption of a more direct tunnel alignment has resulted in a reduction in the overall length of the proposal, from the previous 13.5km to 13.2km.

Major Benefits

Major benefits of the Variation would be:

- Reduced impacts overall by eliminating the viaduct previously proposed between Turrella and North Arncliffe.
- Improved transport benefits by offering a shorter route overall and by having no toll east of King Georges Road.
- Improved road safety by providing for more traffic on the shorter route now proposed.
- Improved operation of the interchanges now proposed at Marsh Street and General Holmes Drive.
- Space provided near Garema Circuit for an enforcement area to be used by Police, EPA and RTA vehicle inspectors.
- Elimination of previous impacts on Wolli Creek at Turrella.

Major Impacts

Major impacts of the Variation would be:

- Three vent stacks would be required, all with residences nearby.
- The tunnel as now proposed would pass below more dwellings than previously.

The proposal would require careful detailed design and mitigation to control the impacts at Marsh Street Wetlands and Eve Street Wetlands.

1.2.2 Cost

The 1994 M5 East EIS proposal was estimated to cost $564 million. The direct tunnel proposal now put forward as the favoured option in this Supplement is estimated to cost $560 million, between Fairford Road at Padstow and General Holmes Drive at Kyeemagh.

The section between Fairford Road at Padstow and King Georges Road at Beverly Hills would be constructed by Interlink Roads Pty Ltd, and

operated as part of the existing M5. The balance of the work, from King Georges Road to General Holmes Drive, would cost $520 million and be constructed by contractors for the RTA and operated as a non-tolled motorway.

1.2.3 Cross section

The cross section of the motorway would be modified from that shown in the 1994 M5 East EIS proposal by providing a breakdown lane 2.5 to 3.5 metres wide to increase safety for motorists, breakdown and emergency service vehicles.

1.3 Construction of the M5 East Motorway

The proposal will not proceed without the approval of the Minister of Urban Affairs and Planning, and the concurrence of the Director-General of National Parks and Wildlife.

Should the decision be made to proceed to construction, it is anticipated that work would commence in late 1997, and that the M5 East Motorway would open in mid 2000.

1.3.2 The 'do nothing' option

As indicated in the 1994 M5 East EIS, improvements to the transport system from Botany / Mascot to the southwest are needed to support the economic, social and environmental wellbeing of the Sydney region and to reduce the loss of urban amenity arising from the intrusion of heavy traffic through areas and on roads not suited to it.

Port Botany has grown rapidly since the construction of its container and bulk liquid facilities in the late 1970s. It is now the dominant Sydney port for containers.

Throughput of containers at Port Botany has grown from 11,000 in 1968-69, to 561,000 in 1992-93, and is projected to reach 918,000 in 2010.

Although about 26% of current container movements are by rail, this is expected to grow to about 35% in 2010. Nonetheless, the large growth in container numbers in future will result in increased container movements on the road system.

The main container route to the southwest is via roads such as Bay Street, Forest Road and Stoney Creek Road. These roads are experiencing heavy congestion and a motorway connecting the southwest to Port Botany would offer significant relief from truck traffic in areas such as Arncliffe, Brighton, Rockdale and Bexley.

Sydney Airport is Australia's major international airport, the hub of the national air transport system, and the focus of aviation operations in New South Wales. It is Australia's international gateway, handling more than half of the nation's international air traffic in 1988 (Kinhill, 1990). It caters for about three times as many international passengers as Melbourne, the next biggest airport.

Sydney Airport catered for 7.5 million passengers in 1975, 14 million passengers in 1988, and by 2010 35 million passengers are expected to pass through Sydney. Freight grew from 154,000 tonnes in 1980 to 360,000 tonnes in 1995, and is expected to reach 690,000 tonnes in 2010. Although some of this growth may by then be using Sydney West Airport, the bulk will use Sydney Airport, ensuring that road traffic serving passengers and freight to and from the airport continues to grow. Even with a possible mode share of 25% to 30% of passengers using the New Southern Railway to access the airport, the doubling of passengers and freight movements in Sydney will more than ensure that road access should be upgraded.

Commensurate with the above growth, commercial vehicle movements are expected to grow by 25% in the Botany / Mascot area.

As Sydney continues to grow, it will be necessary to support the industrial areas along the south western transport corridor, as well as the growing population and employment areas on Sydney's south-western outskirts. Access from the growing areas to the employment areas east of Beverly Hills is essential.

Industrial areas at Liverpool, Moorebank, Padstow, Kingsgrove, Mascot and Botany need to be linked by a high standard road to facilitate their interaction, and to promote the growth of jobs in the south-west.

The continued expansion of suburbs to the west of Liverpool and the emerging development of Sydney West Airport and the National Highway at Liverpool also require connection to Port Botany / Sydney Airport / Mascot / Botany.

The east-west road system linking south-western Sydney and the Port Botany / Sydney Airport / Mascot / Botany economic precinct is inadequate to serve existing needs.

As road traffic grows, and in the absence of significant road improvements, more traffic will tend to use back routes through residential areas. These roads are not designed to carry either heavy vehicles or large volumes of traffic.

The surrounding land uses are also sensitive to the intrusive effects of traffic running through them. The result is that there would be adverse effects for freight transport, residents who live in streets used by heavy vehicles, and the economy of the Sydney region. Sydney's economic development could be constrained, with implications for long-term employment and living standards.

With growing transport pressures in the area, it is becoming more important to relieve the residential suburbs of inner south-western Sydney where increased heavy commercial vehicle and container traffic on local roads is severely reducing living quality. Areas most severely impacted in this area are Rockdale, Bexley, Turrella and Beverly Hills.

In summary, the option of 'do nothing' in the study area would result in the growth of congestion on the road system, as growing volumes of vehicles seek to access Botany / Mascot from the south-west. Further congestion on the main routes would result in increasing spread of peak hours and the more widespread use of 'rat runs' to avoid bottlenecks. There is a need for improvements to the road transport system, from Port Botany / Sydney Airport to the south-west, which is already operating at, or near, capacity.

1.4 Approach to preparing this supplement

The process that was undertaken in preparing this supplement involved the following four parallel activities:

- Consulting with the community.
- Undertaking technical investigations of potential impacts.
- Considering alternatives.
- Developing concept plans for the design of the Variation.

The process undertaken is shown in **Figure 2.**

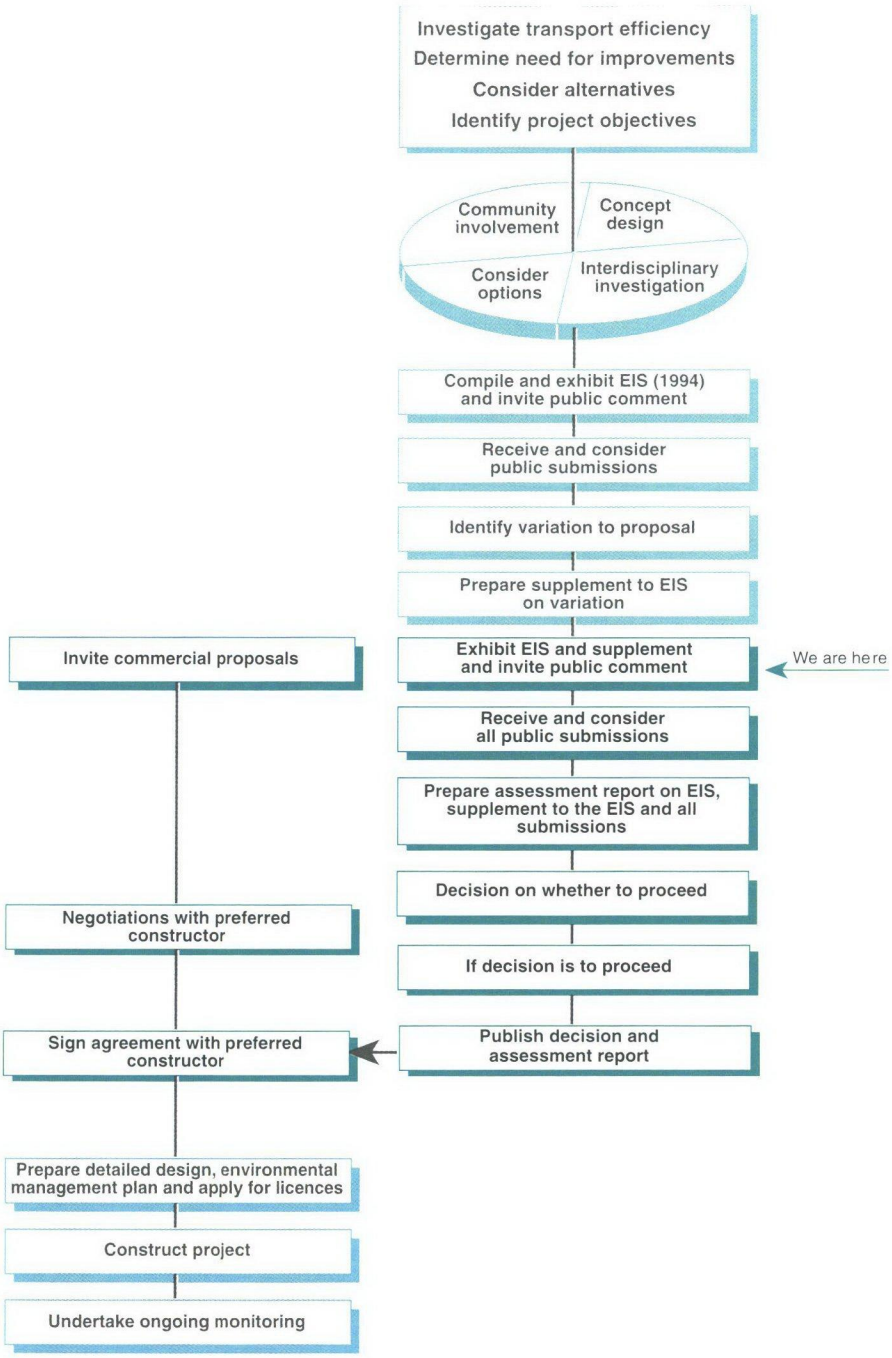


FIGURE 2 — THE PLANNING PROCESS

1.5 STRUCTURE OF THIS SUPPLEMENT

The structure of this supplement broadly follows that of the 1994 M5 East EIS, and subjects are generally discussed in the same order as they were in the 1994 M5 East EIS. This has been done so as to facilitate cross-reference to the 1994 M5 East EIS.

This supplement sets out, in order, the results of the community involvement, development and consideration of alternatives, a detailed description of the Variation and the assessment of its impacts.

In discussing the impacts, the subjects have been grouped into the following categories:

- Assessment of impacts on, and proposed safeguards for transport.
- Assessment of impacts on, and proposed safeguards for the social environment.
- Assessment of impacts on, and proposed safeguards for the natural environment.

This supplement then sets out the assessment of the impacts of the Variation under the following headings:

- Description of the Variation and assessment of its impacts.
- Comparison between the Variation and the 1994 M5 East EIS proposal (both the shorter tunnel and the extended tunnel).

CHAPTER 2 COMMUNITY INVOLVEMENT

Consultations with the community were undertaken in parallel with the development of the concept designs for the alternatives. The goals of the consultation process were to keep the community informed of the alternatives to the proposal and to obtain feedback from the community on them. The objectives were to:

- Inform communities newly affected by the alternatives.
- Inform communities potentially affected by the alternatives.
- Obtain input from the community into the motorway concept design of the alternatives which enabled the variation to be developed.

Consultations involved:

- Formal letters to authorities and affected organisations requesting comments.
- A preliminary newsletter announcing that an alternative to the 1994 M5 East EIS proposal was being investigated, 27,000 copies of which were distributed.
- Meetings with local councils and residents, including members of the non-English speaking community.
- An information hot line.

A total of nine public meetings were held as shown in **Table 1**. Notices of meetings were advertised in local newspapers and distributed to local residents through letter box distribution. In some cases, personal letters were posted to peak community groups, individual residents who were previously involved in the 1994 M5 East EIS, and individual residents who were likely to be directly affected, inviting them to the meetings.

Other meetings which participants attended by invitation were:

- Two Neighbourhood Forum and Community Forum meetings.
- A meeting of residents affected by the Variations, conducted by the Roads and Traffic Authority property acquisition staff, to discuss the possible effect of the Variation on property values and the compensation available.
- A Local Government Forum meeting to brief all relevant Councils.
- A workshop with Sydney Water, Rockdale City Council, Rockdale Wetlands Preservation Society, the Coastal Wetland Society and the Roads and Traffic Authority, conducted to discuss the possible impact of the Variation on Riverine Park (including the wetlands).

TABLE 1 — COMMUNITY CONSULTATION MEETINGS

Date	Topic	Location
Tuesday 3 October 1995	M5 East alternatives	Bardwell Park RSL
Tuesday 3 October 1995	Potential impact on Arncliffe Residents (with Arncliffe Progress Association)	Arncliffe Senior Citizen Centre
Wednesday 4 October 1995	Eastern Air Vent	Bardwell Park RSL
Thursday 5 October 1995	M5 East alternatives	Bardwell Park RSL
Monday 9 October 1995	Western Air Vent	Anglican Church Hall (Bexley North)
Tuesday 10 October 1995	M5 East alternatives Greek Language	Bardwell Park RSL
Thursday 12 October 1995	M5 East alternatives Arabic Language	Arncliffe Senior Citizen Centre
Thursday 26 October 1995	Potential impacts on Eve Street Wetlands	Rockdale Council
Thursday 9 November 1995	M5 East Motorway Northern Variation Southern Variation	St George Rowing Club

- A briefing for Rockdale City Council by an officer from the Roads and Traffic Authority.
- A meeting to discuss issues relating to the Eve Street Wetlands with Rockdale City Council, Coast and Wetlands Society Inc, Rockdale Wetlands Preservation Society, Sydney Water and the Roads and Traffic Authority.

Officers of the relevant Councils, Department of Urban Affairs and Planning, NSW Environment Protection Authority (NSW EPA) and Department of Transport have been kept informed of the community consultations being undertaken and the concerns and issues raised.

Benefits of the consultation process included:

- Providing information to residents.
- Enabling the community to contribute to the development of the concept design of the Variation.
- Obtaining comments that assisted in assessing impacts.

CHAPTER 3 LOCAL CONTEXT

West of Bexley Road the M5 East EIS proposal would traverse the local government areas of Bankstown, Canterbury and Hurstville. East of Bexley Road the Variation would, apart from a short section to the north of Wolli Creek (Canterbury local government area), traverse the Rockdale local government area. The Variation would join General Holmes Drive south of the airport tunnel (see **Figures 8** to **23**).

3.1 THE VARIATION

From Bexley Road to Arncliffe, the Variation would run in tunnel under predominantly residential development, avoiding the Wolli Creek valley. From Firth Street, Arncliffe to the Princes Highway, the Variation would be in cut and cover tunnel through an area of mixed industrial and residential development. At the Princes Highway, west facing ramps, enabling travel to and from the west, would emerge from the motorway in ramp tunnels and join the Princes Highway.

The tunnel for the Variation would require three air exhaust stacks and three air intakes. The air exhaust stacks would be located on the eastern side of the intersection of Royal Place and Bardwell Road, Bardwell Park; on the western side of Hill Street where it intersects with Duff Street, Arncliffe; and at the Arncliffe Street Army Reserve Depot.

The air intakes would be located in open space adjacent to the Bardwell Valley golf course where it meets Bardwell Road, Bardwell Park; on the western side of Hill Street where it intersects with Duff Street, Arncliffe; and at the Arncliffe Street Army Reserve Depot.

3.2 PRINCES HIGHWAY TO GENERAL HOLMES DRIVE

Between the Princes Highway and Marsh Street, the Variation would continue in tunnel under residential properties, emerging at Marsh Street in a grade-separated interchange.

East of Marsh Street the motorway emerges from tunnel and is generally located along the alignment of the South Western and Southern Ocean Outfall Sewer, to join General Holmes Drive in a grade-separated interchange. The interchange would provide for eastbound traffic to enter the median, or middle, lanes of General Holmes Drive. This would facilitate improved access to Foreshore Road for heavy vehicles.

CHAPTER 4 CONSIDERATION OF ALTERNATIVES

This chapter summarises the development and consideration of alternatives to the 1994 M5 East EIS proposal which occurred as part of the preparation of this Supplement.

Consideration of alternatives included not tolling the Motorway, alternatives for the motorway alignment and design between Bexley Road and General Holmes Drive, and alternatives for the tunnel exhaust stacks and air intakes.

Eight alternative alignments for the proposed M5 East Motorway were investigated between Bexley Road and the Cooks River, as shown in **Figure 3**. Some of the alternate alignments had variations in grading, location and intersection design, and some variations in construction methods were considered.

The alignment alternative developed for further assessment in this supplement, referred to as the Variation, is a road with no toll between King Georges Road and General Holmes Drive, generally along the more direct route described in the newsletter attached at **Appendix A**. See **Figures 8** to **23** for details.

4.1 CRITERIA FOR SELECTION OF ROAD ALIGNMENTS

Various criteria were used in developing the alternatives. The three main criteria adopted were:

- The environmental sensitivity of the proposal, including land use impacts, community severance, visual impacts, and physical impact on wetlands.
- The engineering requirements of tunnel design which included ease of construction and geotechnical considerations regarding the requirement to locate the tunnel in sound rock.
- Cost of construction, including the length and cost of tunnelling for the exhaust stacks.

Two types of tunnel construction were adopted, depending upon depth:

- Bored tunnel for the deeper construction and construction in rock.
- Cut and cover tunnel for the shallower sections of tunnel.

The road design aspects of safety and traffic management were major factors in the location of grade-separated interchanges at Princes Highway and Marsh Street.

4.2 DEVELOPMENT, EVALUATION AND REFINEMENT OF TUNNEL ALTERNATIVES

The process of considering alternatives involved developing alternatives and gradually refining the route to arrive at a location that best fulfilled the combination of selection criteria. As the assessment proceeded, the information available on the alternatives became more refined and detailed.

As alternatives were developed they were evaluated against criteria of environmental sensitivity, engineering considerations and cost as described

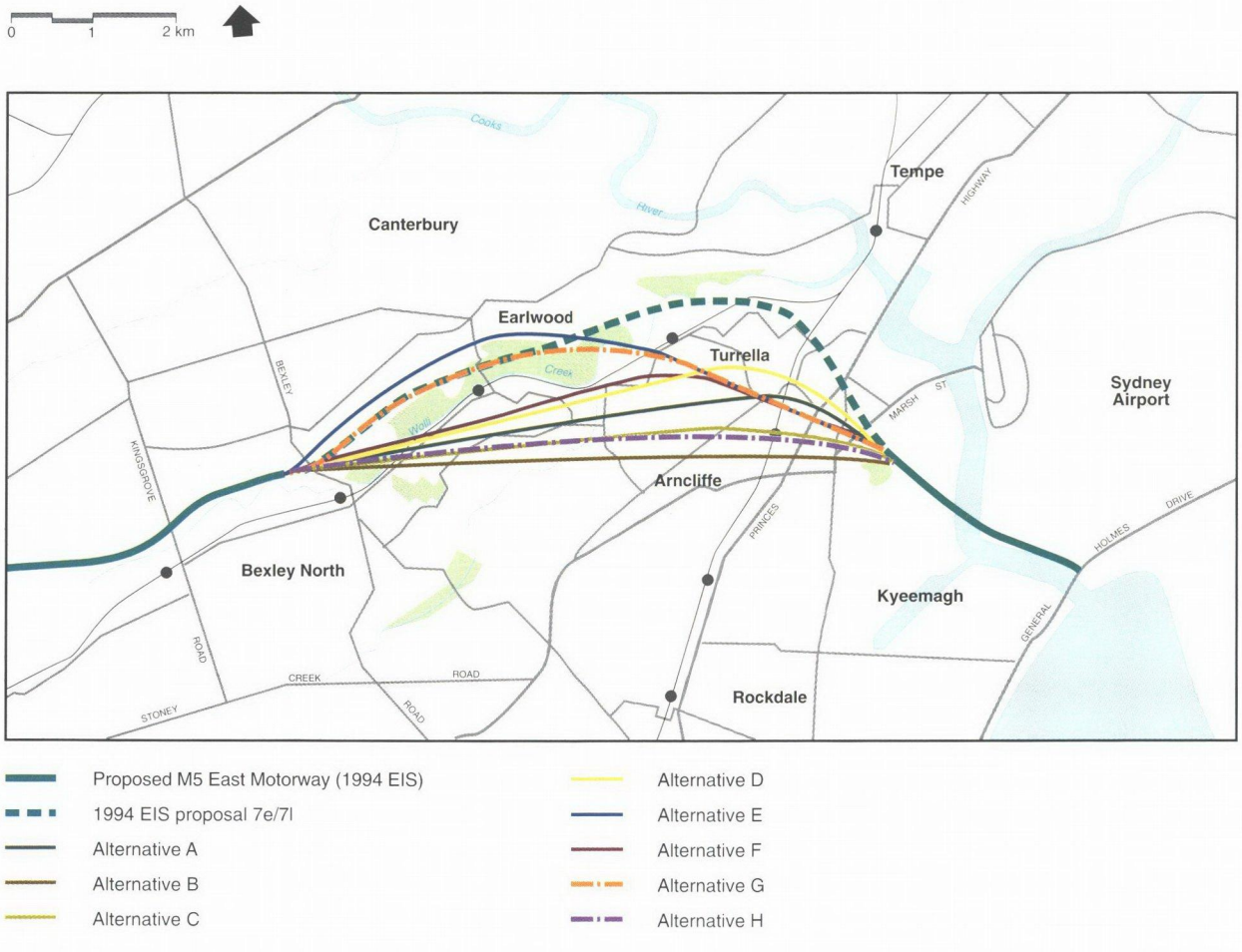


FIGURE 3 — ALTERNATIVES CONSIDERED

below. Poorly performing alternatives were eliminated from further consideration if a better performing option could be identified.

One alternative was identified for detailed assessment of impacts: Alternative H.

The Variation (Alternative H) is a bored tunnel running south of Wolli Creek which is a relatively direct tunnel with the main aim of limiting costs. The cost of the Variation would be approximately $520 million between King Georges Road and General Holmes Drive.

The Variation is described in more detail later in this chapter.

4.2.1 Alternative A – Direct tunnel, with slot at the Princes Highway

Alternative A was the first alignment considered and comprised three sections:

- Bexley Road to Bonar Street which was designed as a bored tunnel.
- Bonar Street to Marsh Street which was developed as a combination of slots (deep open cuttings) and bored tunnel.
- Marsh Street to Cooks River, which was designed as a combination of embankment and bridging.

The location of the first section between Bexley Road and Bonar Street was determined as a bored tunnel. The tunnel was located on an alignment that maximised the depth of cover over the tunnel while meeting preferred interchange locations at the Princes Highway and Marsh Street.

The crossing beneath Wolli Creek was kept as square as possible and the alignment kept relatively straight to minimise the length of bored tunnel.

For the second section it was proposed that the motorway be in deep cutting between Bonar Street and the Princes Highway. This resulted in the need for bridges at three locations as the motorway passed under Firth Street, then the railway line just north of Arncliffe Station and then under Arncliffe Street.

The location of the grade separated interchanges at Princes Highway and Marsh Street was determined by locating a proposed section of bored tunnel under the highest point of a large rock outcrop in Duncan Street.

A half diamond interchange was proposed at the Princes Highway with a west facing entry ramp allowing traffic to travel west on the motorway from the Highway. A west facing exit ramp would allow eastbound motorway traffic to exit at the Princes Highway. No east facing ramps were proposed.

Two possible alignments were considered between Bonar Street and the Princes Highway in an attempt to avoid either a large textile warehouse in

Allen Street or a large block of home units in Ann Street. Between the Princes Highway and Marsh Street the motorway would be in tunnel emerging at a portal to the south of the South Western and Southern Ocean Outfall Sewer (SWSOOS) and east of Marsh Street. A cut and cover section of tunnel would be necessary between West Botany Street and the eastern tunnel portal. A full diamond interchange was proposed at Marsh Street with west facing ramps emerging from cut and cover tunnels. **Figure 17** provides an artist's impression of the Marsh Street Interchange.

In the third section between Marsh Street and the Cooks River, the location of the motorway was determined by its impact on the SWSOOS, and the Marsh Street and Eve Street Wetlands within Riverine Park.

It was considered that this alignment had the following disadvantages:

- Bridges were required at Firth Street and Arncliffe Street to provide access to Arncliffe Station. Street closures at the Princes Highway were also envisaged, creating access difficulties for traffic using the railway underpass at Wollongong Street.
- Community severance, resulting in isolated precincts, particularly for Argyle Street.
- A relatively large land take for the motorway.
- An impact on either a large textile warehouse in Allen Street or a large block of home units in Ann Street.
- A high noise impact on home units located between Ann Street and Allen Street, Arncliffe if they remained.
- The Princes Highway would need to be widened between Kyle/Burrows Streets and West Botany Street to provide dual right turn bays at the entrance to the motorway.
- The geotechnical study indicated that a bored tunnel at the necessary depth was not achievable beneath Bonar Street. Further cut and cover with consequent impacts on surface land uses, would be necessary.

4.2.2 ALTERNATIVE B – WICKHAM STREET STRAIGHT LINE OPTION

Alternative B was developed as a straight line bored tunnel between Bexley Road and the Princes Highway at Wickham Street. It was investigated because it was the more direct tunnel route between these two points and hence possibly the cheapest to construct.

Alternative B was not favoured because further investigation revealed disadvantages in the requirement to locate interchanges at the intersection of Forest Road and the Princes Highway, and at West Botany Street. These interchange locations had a greater land use impact than Alternative A and did not meet the traffic management requirements of the area. The

proximity of the Illawarra Rail Line also presented difficulties in providing linkages to the Princes Highway.

4.2.3 Alternative C – Tunnel located under Bardwell Park / Arncliffe residential area. Princes Highway interchange moved south

Alternative C was the first alternative to consider a full length bored tunnel from Bexley Road to Marsh Street in an attempt to minimise impacts on surface land uses. To improve the alignment and shorten the tunnel, the alignment was moved south at the Princes Highway by approximately 60 metres.

The tunnel required the development of ramps below ground. By diverging and merging traffic underground, it was thought that the land use impact at the Princes Highway would be greatly reduced. Subsequent geotechnical investigations found that further cut and cover would be necessary, with land use impacts on surface land uses.

Access to Arncliffe Station was unaffected by Alternative C and access to Wollongong Road was available using traffic signals on the Princes Highway at Ann Street. However, Alternative C entailed a substantial lateral distance between the tunnel and the proposed exhaust stacks at Earlwood and Turrella.

4.2.4 Alternative D – Tunnel closer to Earlwood and Turrella exhaust stacks. South of Wolli Creek road transportation reserve

Because Alternative C entailed a substantial lateral distance between the tunnel and the proposed exhaust stacks at Earlwood and Turrella, a more northerly route was developed, with the aim of reducing costs resulting from this lateral distance. Alternative D was developed for this purpose.

From Bexley Road the alignment of Alternative D diverges from Alternative A, to be approximately 160 metres to the north and parallel with Alternative A. The tunnel would be continued until the portal east of Marsh Street.

However, avoiding the large textile warehouse in Allen Street or the large block of home units in Ann Street was not achievable with this alignment. The extent of cut and cover tunnel required at this location impacted on either the units or the warehouse or both. The geotechnical investigations subsequently indicated the need for further cut and cover, with a further increase in impacts on surface land uses.

4.2.5 ALTERNATIVE E – TUNNEL LOCATED CLOSE TO EXHAUST STACKS

A serious concern remained about the length of the ventilation tunnels to the ventilation stacks at Earlwood and Turrella.

Alternative E was identified and investigated to determine whether, by moving the bored tunnel closer to the ventilation stacks, construction cost savings could be achieved. However, this alignment proved to have passed beneath a greater number of houses, creating greater indirect land use impacts and costs than Alternative G.

4.2.6 ALTERNATIVE F – TUNNEL SOUTH OF WOLLI CREEK ROAD TRANSPORTATION RESERVE. PRINCES HIGHWAY INTERCHANGE MOVES SOUTH

Alternative F was developed in an attempt to minimise the geotechnical difficulties presented by Alternative D. The tunnel is aligned generally south of Wolli Creek and the interchange at Princes Highway is South of that in Alternative D. Alternative F has greater indirect land use impacts than Alternative G because it passes beneath a greater number of properties.

4.2.7 ALTERNATIVE G – TUNNEL USING WOLLI CREEK ROAD TRANSPORTATION RESERVE WHERE POSSIBLE

A northern option, Alternative G, was identified using where possible the Wolli Creek transportation reserve, running east from Bexley Road. For about two kilometres the alignment follows that of the 1994 M5 East EIS proposal. At Minnamorra Avenue the alignment would divert south to cross Wolli Creek towards the Princes Highway interchange.

The interchange at the Princes Highway would require the construction of ramps below ground. Free flowing ramps would allow west bound traffic to enter the motorway and east bound traffic to exit the motorway. Access from the motorway would only be possible into the north bound lanes of the Princes Highway. **Chapter 5** provides a detailed description of the interchange.

The interchange at Marsh Street would be grade-separated, allowing all movements for east- and west-bound travel on the motorway and for north- and south-bound travel on Marsh Street. **Figure 17** provides an artists impression of the interchange.

The geotechnical study indicated that the necessary depth for a bored tunnel may not be achievable beneath Bonar Street. Further cut and cover, with consequent greater direct impacts on surface land uses, may be necessary and would be determined during detailed design. Allen Street

would become a cul-de-sac at the Princes Highway because of the proximity of the motorway's exit ramp for north-bound travel on the Princes Highway. Access to the Allen Street railway underpass would be by a right turn for south-bound traffic on the Princes Highway at Ann Street, resulting in an increase in traffic in this street.

Alternative G has the least indirect land use impacts.

4.2.8 Alternative H – Direct tunnel, with 3 exhaust stacks, and cut-and-cover at Princes Highway and Marsh Street interchanges

Costs of construction and property impacts associated with the investigation led to further investigations into a more direct tunnel.

This alternative combines the cost advantages of a shorter tunnel with the interchange arrangements of Alternative G at the Princes Highway and Marsh Street. Cut and cover construction would still be required between the Illawarra Railway line and the Princes Highway. However, the geotechnical investigation revealed that sound rock at the necessary depth is located to the west of the railway line.

Due to the length of tunnel involved, Alternative H would require construction of three air exhaust stacks and three air intakes. The stacks would be located above or adjacent to the tunnel alignment itself, and each air exhaust stack would be located adjacent to a tunnel air intake. Tunnel ventilation is discussed in detail in **Section 4.7**, and all exhaust stack and air intake locations considered are illustrated in **Figure 7**.

This alternative would have the least direct property impacts, cost and land acquisition requirements of any alternative. By gently curving the alignment between Shepherd Parade and Bexley Road, the tunnel can be located below Bardwell Valley Golf Course, and so reduce significantly the number of houses below which it passes.

This alternative is the prefered alternative, and is assessed in terms of its impacts in this supplement. For the remainder of this document, it is referred to as the Variation.

4.3 Alternatives for King Georges Road interchange

The proposal provides for the M5 East to bridge over King Georges Road with a full diamond interchange, enabling access to and from the motorway in all directions.

An alternative is that the M5 East pass under King Georges Road. The alternative of an underpass under King Georges Road is not preferred for the following reasons:

- The proposed twin 4km long tunnels east of Bexley Road would produce a substantial amount of excavation material. The embankment formation for the proposal to pass over King Georges Road would recycle approximately 20% of this material resulting in economies of cost relating to the transportation of spoil materials, and of time and effort relevant to construction of the motorway bridge and embankments. There would be commensurate benefits from the reduction of truck movements over long distances and a reduced need for landfill sites.
- The alternative of the motorway passing under the existing King Georges Road would involve significantly higher construction costs related to excavation and the potential for drainage problems, bearing in mind the proximity to Wolli Creek near Tallawalla Street.
- Construction of the proposal would facilitate spoil from the tunnel excavation being used to construct embankments between King Georges Road and Bexley Road, thus removing the need for off-site disposal of this material. The alternative of an underpass at King Georges Road would not only generate a significant volume of additional spoil, but it would also reduce considerably the size and extent of embankments in the vicinity of King Georges Road. Rather than absorb 355,000m^3 (cubic metres) of spoil from the tunnel, the underpass alternative would generate an additional 260,000m^3 of spoil for disposal, a net increase for disposal of 615,000m^3. The underpass alternative would add $14.9 million to the cost of the proposal.
- The construction of the proposal passing over King Georges Road would lead to less disruption to existing King Georges Road traffic during construction, better access for construction vehicles, and minimal impact on public utilities with no impact on major Telecom, Optus, water and gas services compared with the underpass alternative.
- Construction of the underpass alternative under King Georges Road would require relocation of a large high pressure water main along the western side of King Georges Road.
- The construction of the proposal in embankment would increase the height, above ground level, of the source of traffic noise and noise envelope contained by noise barriers, however, both options of an underpass and an overpass would incorporate noise barriers to ensure that the acceptable noise objectives are achieved.
- Construction of the proposal as an overpass would require an embankment near King Georges Road, it would provide opportunities for visual enhancement through landscaping of the batter slopes, and would shield many dwellings from traffic noise from parts of King Georges Road.

4.4 ALTERNATIVES FOR GENERAL HOLMES DRIVE INTERCHANGE

Submissions to the 1994 M5 East EIS expressed concern for the ability of heavy vehicles to undertake weaving manoeuvres to access Foreshore Road for access to and from Port Botany. The RTA therefore investigated options for the motorway's link with General Holmes Drive to facilitate improved access to Foreshore Road. The proposal for the interchange of the M5 East with General Holmes Drive is described in **Chapter 5** and depicted in **Figure 18**.

A bridge would be constructed over the north-bound lanes of General Holmes Drive to allow for east-bound motorway traffic to enter the General Holmes Drive north-bound median (or middle) lanes. This would permit improved access for heavy vehicles turning right into Foreshore Road. South-bound vehicles on General Holmes Drive would access the motorway by entering the left hand lane of General Holmes Drive and proceeding on a bridge over General Holmes Drive to travel west on the motorway.

A separate cyclists / pedestrian underpass would be constructed on the Botany Bay side of the airport tunnel.

4.5 ASSESSMENT OF IMPACTS

Alternative H was developed further by the Roads and Traffic Authority as a motorway concept design and is assessed for impacts in this supplement. The alignment of Alternative H (the Variation) is presented along with those of the 1994 M5 East EIS proposal, involving the shorter tunnel (Option 7e in the M5 East EIS) and the extended tunnel (Option 7l in the M5 East EIS) in **Figure 4**. Alternative H includes the amendment to the interchange at General Holmes Drive, as described above.

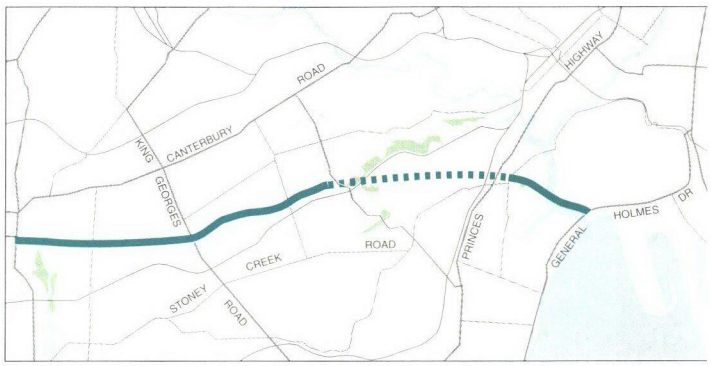
4.6 TUNNEL CROSS SECTION ALTERNATIVES

Two options have been considered for the cross section design of the tunnel for the variation. Each option involves the construction of twin bored tunnels, one for each direction of traffic flow. Each tunnel would carry two lanes of traffic.

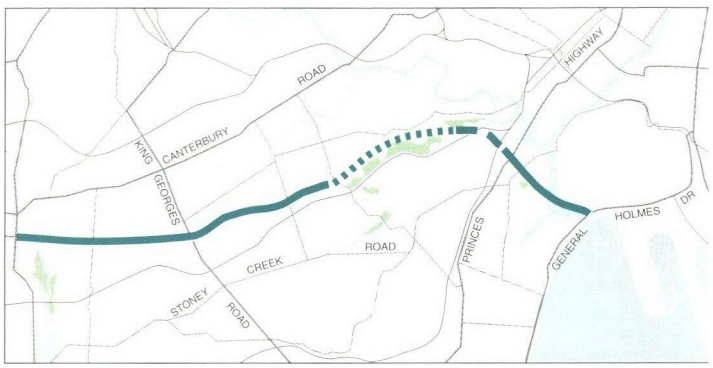
The cross section of each of the options is shown in **Figure 5** and **6**. The preferred option (**Figure 5**) is for each tunnel to accommodate two 3.5 metre-wide lanes, with no shoulder. The other option considered is for each tunnel to accommodate two lanes, each of 3.5 metre width, plus a left hand breakdown lane 2.5 to 3.5 metres wide, and a one-metre wide right hand shoulder.

The preferred option was chosen because it is expected to result in significant cost savings over the alternative, wider tunnels.

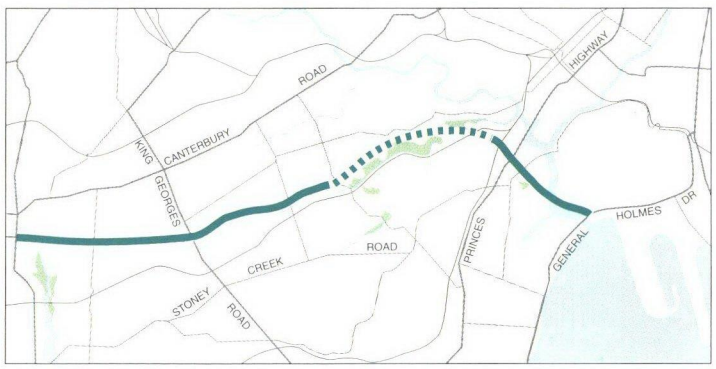
The Variation



1994 M5 East EIS proposal, or shorter tunnel

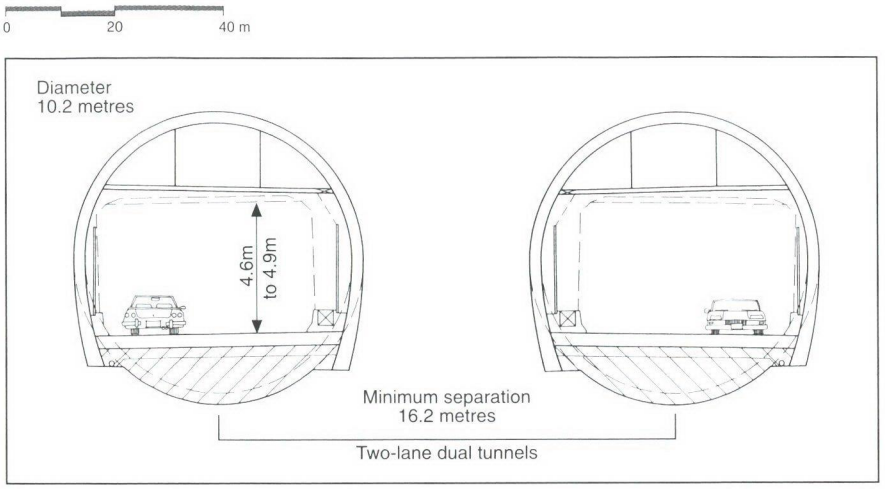


1994 M5 East extended tunnel



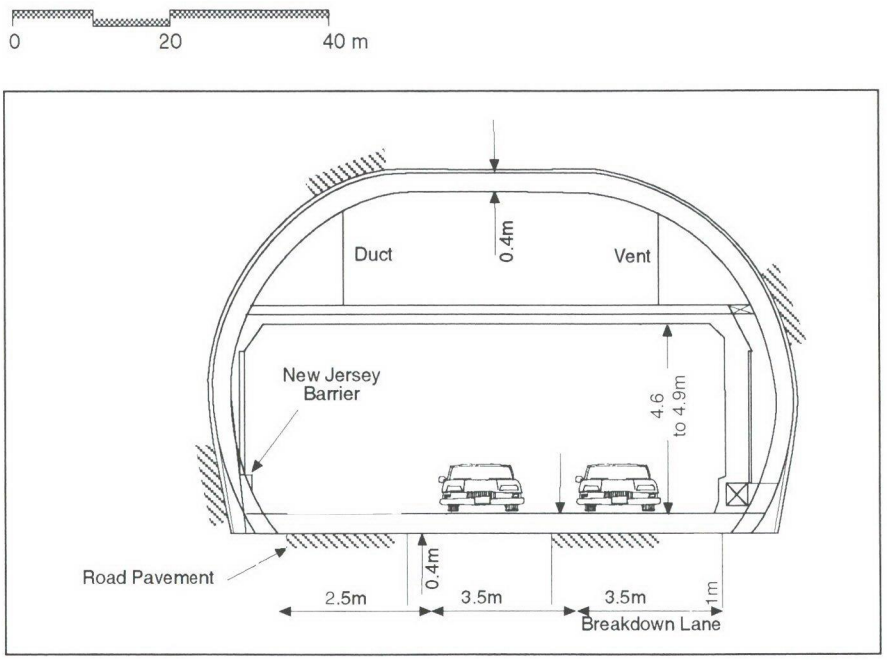
New or upgraded surface road
New road tunnel
New elevated road
Natural vegetation

FIGURE 4 — ALTERNATIVES EVALUATED FOR IMPACTS



Source: Connell Wagner, 1994

FIGURE 5 — PREFERRED TUNNEL CROSS SECTION



Source: RTA, 1996

Note: Only one of the twin tunnels shown

FIGURE 6 — ALTERNATIVE TUNNEL CROSS SECTION

4.7 TUNNEL VENTILATION ALTERNATIVES

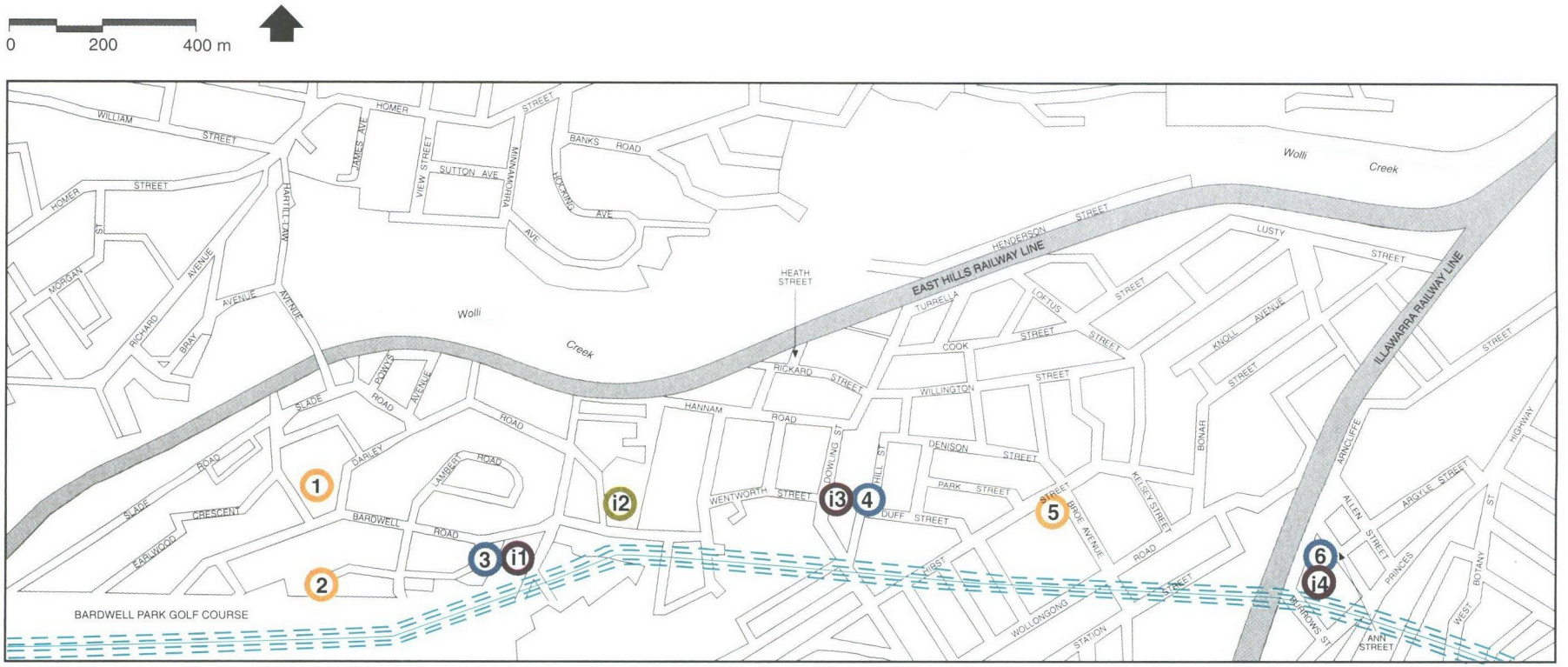
4.7.1 INTRODUCTION

After considering the combined effect of engineering, air quality, land use, visual and community impacts a number of possible alternative exhaust stack and air intake locations were identified. Once the alternative alignment for the motorway had been identified, preferred exhaust stack and air intake locations were also identified. Exhaust stacks at all the locations would be designed to comply with the air emission criteria set by the New South Wales Environment Protection Authority (EPA).

4.7.2 EXHAUST STACK ALTERNATIVES

The 1994 M5 East EIS shorter tunnel contemplated one ventilation exhaust stack located in the vicinity of the Earlwood shopping centre car park (approximately 15 metres high and 12.5 metres in diameter). The 1994 M5 East EIS extended tunnel provided for two exhaust stacks, one located at the Earlwood shopping centre car park and one at the eastern end of Henderson Street, near the mail exchange in Turrella (up to 35 metres high and about 8 metres in diameter).

In considering the tunnel alternatives discussed in **Section 4.2**, it was necessary to investigate options for the ventilation of the tunnel. With regard to the Variation, after considering the combined effect of engineering, air quality, land use, visual and community impacts, a number of possible locations for exhaust stacks were considered for tunnel ventilation. The locations are shown in **Figure 7** (a summary of the relevant factors regarding all possible locations considered for all of the tunnel alternatives is contained in **Appendix C**).



Exhaust stack locations considered

1 Shepherd Park, Bardwell Park (15m high, 10m diameter)
2 Moore Street at Golf Course (20-25m high, 10m diameter)
3 Royal Place at Golf Course (15m high, 9.5m diameter)
4 Duff Street, Arncliffe (15m high, 6.5m diameter)
5 Arncliffe Park, Arncliffe (20-25m high, 9m diameter)
6 Arncliffe Army Reserve depot (15m high, 6.5m diameter)

Air intake locations considered

i1 Royal Place at Golf Course
i2 Coolabah Reserve
i3 Duff Street, Arncliffe
i4 Arncliffe Army Reserve depot

} 10m x 8m, 3m high (nominal)

Exhaust stacks
Preferred exhaust stacks
Air intakes
Preferred air intakes

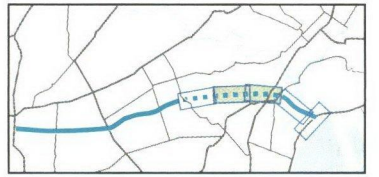


FIGURE 7 — ALTERNATIVE LOCATIONS CONSIDERED FOR AIR EXHAUSTS AND INTAKES

The extension of the tunnel through to Marsh Street as proposed by the Variation requires three exhaust stacks to ventilate it adequately.

In light of the submissions to the 1994 M5 East EIS, and in discussions with the community regarding the preferred locations for the exhaust stacks, it became apparent that there was a community preference for the locations previously identified in the 1994 M5 East EIS. These were at the Earlwood shopping centre car park and at the eastern end of Henderson Street, near the mail exchange in Turrella. The Earlwood location is near a school and while air quality would conform with the air emission criteria set by the EPA this is of concern to some residents. It was found that the proposed duplication of the East Hills Rail Line could affect the Turrella location. A site nearer to Turrella Railway Station was therefore considered more appropriate for this exhaust stack.

With the development of the Variation, three exhaust stacks would need to be located in the Bardwell Park and Arncliffe residential areas.

A potential site in Shepherds Park in Bardwell Park was considered undesirable because of the size of the park and the proximity to Bardwell Park Public School. Another site at the corner of Royal Place and Bardwell Road was identified that would meet the criteria for the location along the tunnel length. This site is:

- Close to the Variation tunnel alignment.
- Relatively exposed.
- On the boundary between residential land and open space.

An exhaust stack on this site would be potentially visually intrusive. However the stack would be located on the private property to be acquired. The site would be landscaped with advanced trees to integrate the stack into the surrounding landscape and architectural treatments would be developed to reduce its visual impacts (see **Section 7.6** on visual impacts for measures to mitigate adverse visual impacts).

In Arncliffe, a site in Arncliffe Park would be suitable but was considered undesirable because of community and heritage values. A site at the corner of Duff Street and Hill Street was identified as a more suitable location. This site is:

- Close to the tunnel.
- Exposed.

The site is in the middle of a residential area. The exhaust stack would also be potentially visually intrusive due to its elevation. Adjacent properties would be acquired for construction purposes and restored by landscaping to integrate the stack into the surrounding landscape, and architectural treatments would be developed to reduce its visual impacts (see **Section 7.6** on visual impacts for measures to mitigate adverse visual impacts).

A location for a third exhaust stack was sought in the Arncliffe area, near the railway line. An Army Reserve Depot in Arncliffe Street between Burrows and Ann Streets was identified as being suitable. The property lies on the tunnel alignment alongside the Illawarra Rail line, and would in any case be affected by the construction of the tunnel. The Army Reserve has vacated the property and the Department of Defence is currently considering options for its disposal.

4.7.3 AIR INTAKE ALTERNATIVES

Alternative sites for possible air intakes were also considered as indicated in **Figure 7**. These intakes are significantly smaller than exhaust stacks and are consequently much less visually intrusive. Alternative locations were identified along the length of the tunnel and considered for the same range of impacts as for the exhaust stacks. Should scrubbers be required to ensure that air quality is within EPA criteria, the installation of appropriate filters would be investigated.

For the Variation, sites in the Bardwell Valley Golf Course, at the intersection of Duff Street and Hill Street, Arncliffe, and at the Arncliffe Street Army Reserve Depot were preferred on the basis of engineering and land use impact criteria.

4.7.4 VENTILATION SYSTEM ALTERNATIVES

Alternative systems for the ventilation of the tunnel are discussed under tunnel ventilation and smoke extraction in **Chapter 5**.

CHAPTER 5 DESCRIPTION OF THE VARIATION

5.1 INTRODUCTION

The 1994 M5 East EIS shorter tunnel proposal provided for twin tunnels from Bexley Road passing generally under the Wolli Creek bushland to emerge at Turrella. A viaduct was proposed from Turrella over the Illawarra Rail line and the Princes Highway, returning to ground level west of Marsh Street. An at-grade intersection with traffic signals was to be provided at the M5 East / Marsh Street Intersection. South of Marsh Street the motorway was to be located on embankment following the South Western and Southern Ocean Outfall Sewer (SWSOOS), which is located between Kogarah Golf Course and Riverine Park, before ending at General Holmes Drive. An alternative involving an extended tunnel along the same alignment was also considered in the 1994 M5 East EIS.

The Variation is an alternative to the section of the 1994 M5 East EIS proposal lying east of Bexley Road. It is illustrated in the following ways: plan and profile, **Figures 8** to **15**; and artist's impressions, **Figures 16** to **23**. The preferred tunnel cross section is illustrated in **Figure 5** in **Chapter 4** of this supplement.

5.2 ROAD CONCEPT DESIGN

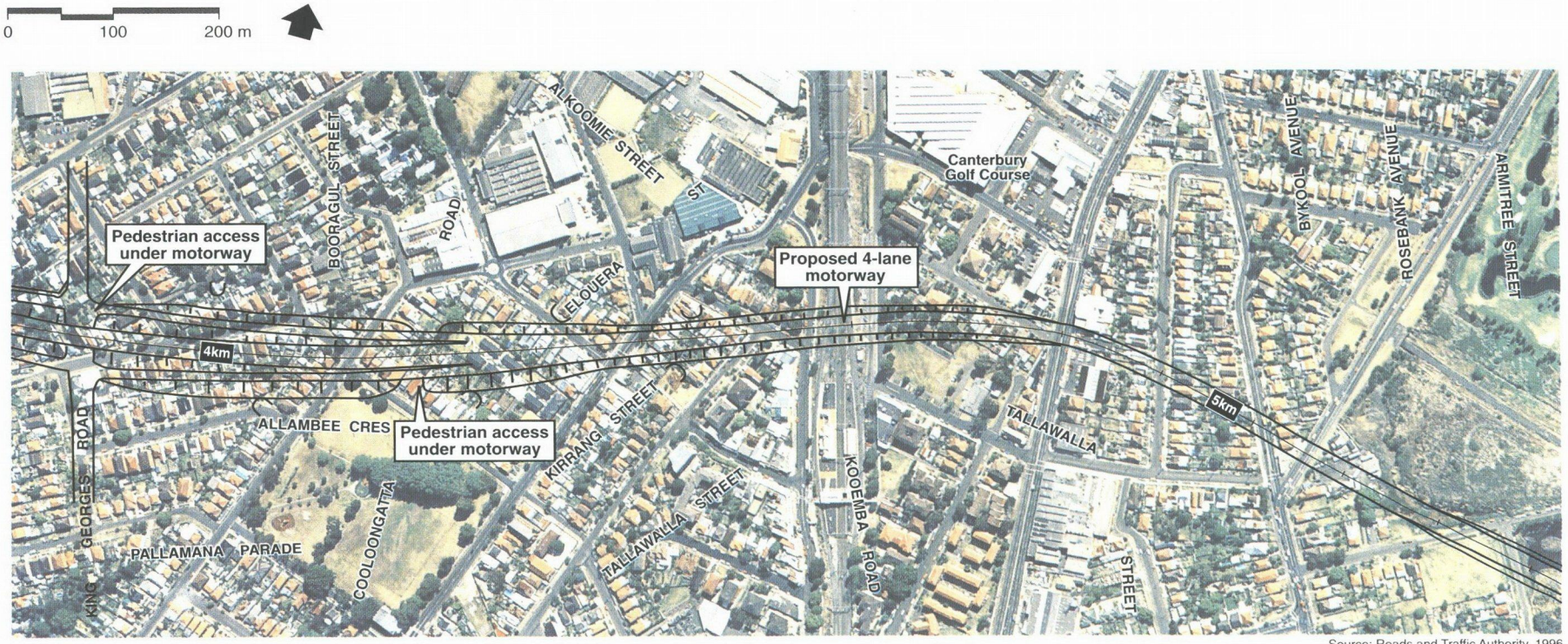
The concept design of the Variation is described below.

5.2.1 HORIZONTAL ALIGNMENT (PLAN)

East of Bexley Road, a more direct tunnel would link Bexley Road and the Princes Highway, with the majority of the tunnel aligned south of Wolli Creek. The tunnel would form a generally direct route between Bexley Road and Duff Street, Arncliffe, before curving slightly and forming another direct route from Arncliffe Park to pass beneath the Princes Highway at Ann Street, Arncliffe.

The Variation would link with and pass Marsh Street to the south of the SWSOOS. To minimise impacts on the Marsh Street and Eve Street Wetlands the motorway would cross the SWSOOS on viaduct, before again crossing the SWSOOS, prior to crossing the Cooks River to link with General Holmes Drive south of Sydney's Kingsford Smith Airport.

The Variation would avoid Turrella completely, and would eliminate the need for a viaduct through Turrella and Arncliffe.



Source: Roads and Traffic Authority, 1996

FIGURE 8 — PLAN AND PROFILE

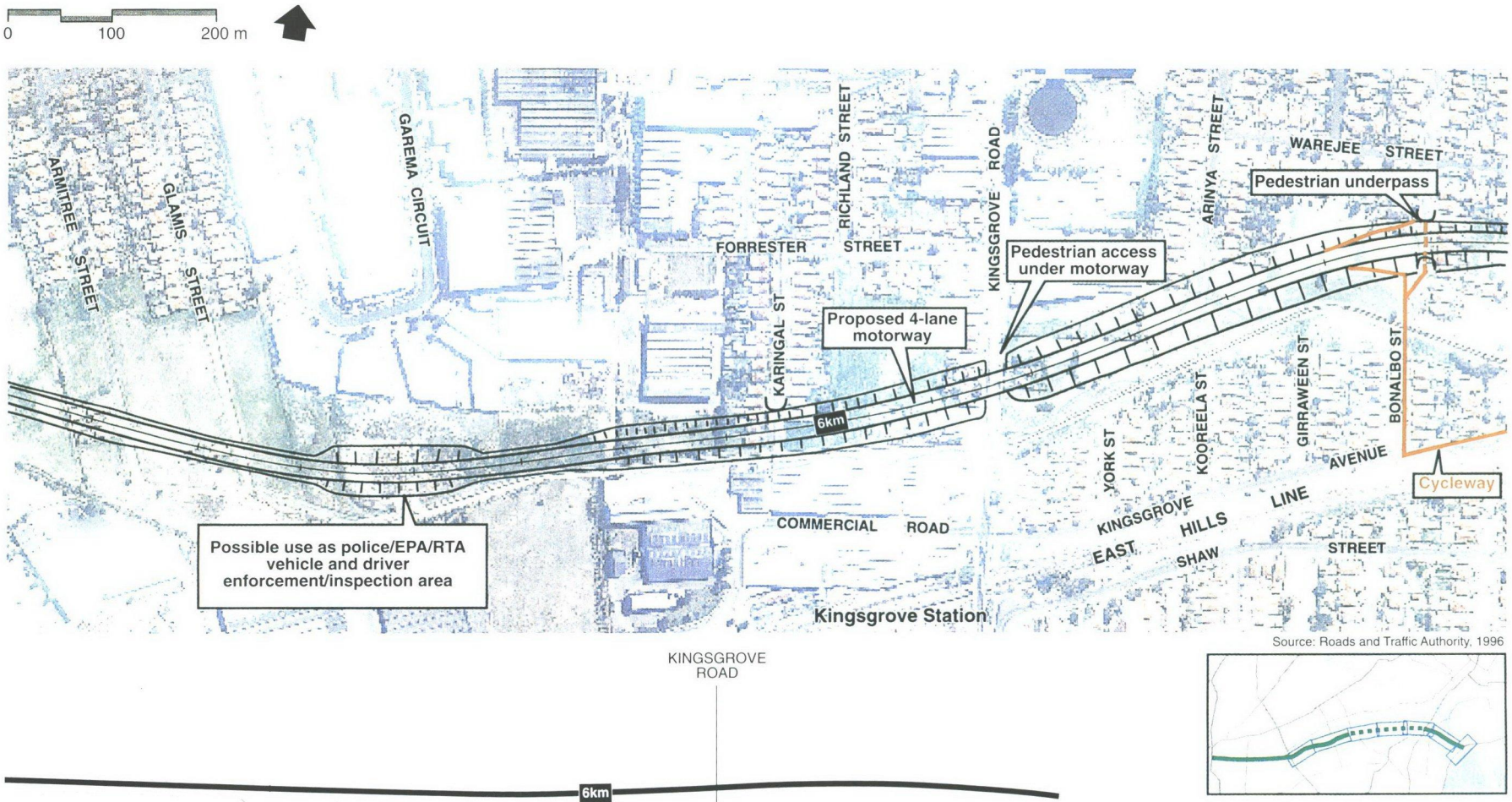
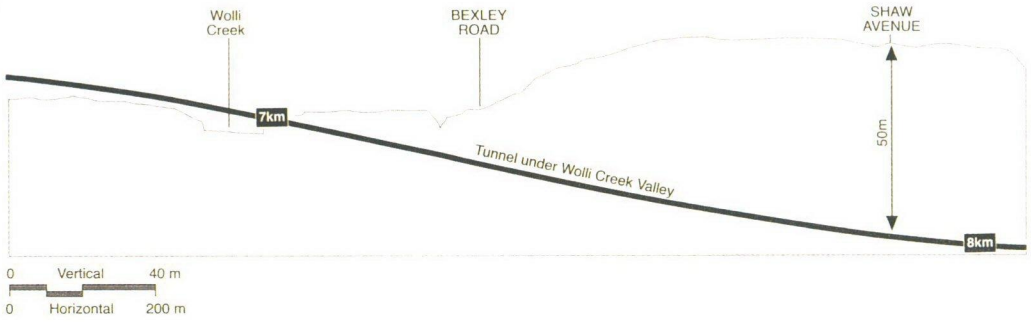
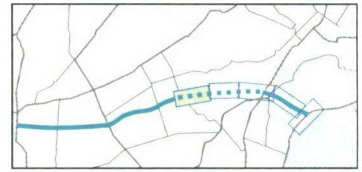


FIGURE 9 — PLAN AND PROFILE

Roads and Traffic Authority, 1996

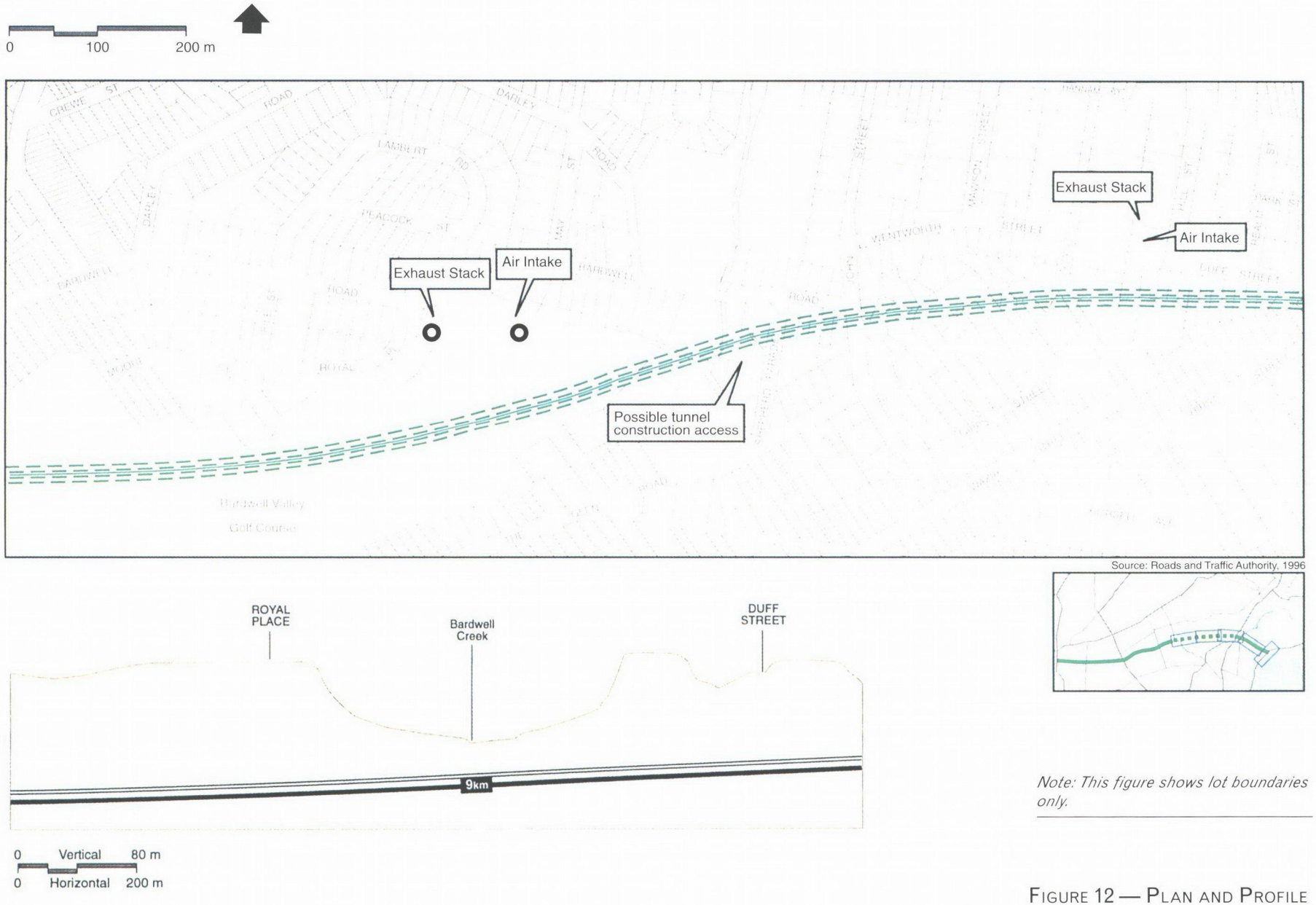




Note: This figure shows lot boundaries only.

FIGURE 10 — PLAN AND PROFILE

FIGURE 11 — PLAN AND PROFILE



Note: This figure shows lot boundaries only.

FIGURE 12 — PLAN AND PROFILE

Note: This figure shows lot boundaries only.

FIGURE 13 — PLAN AND PROFILE

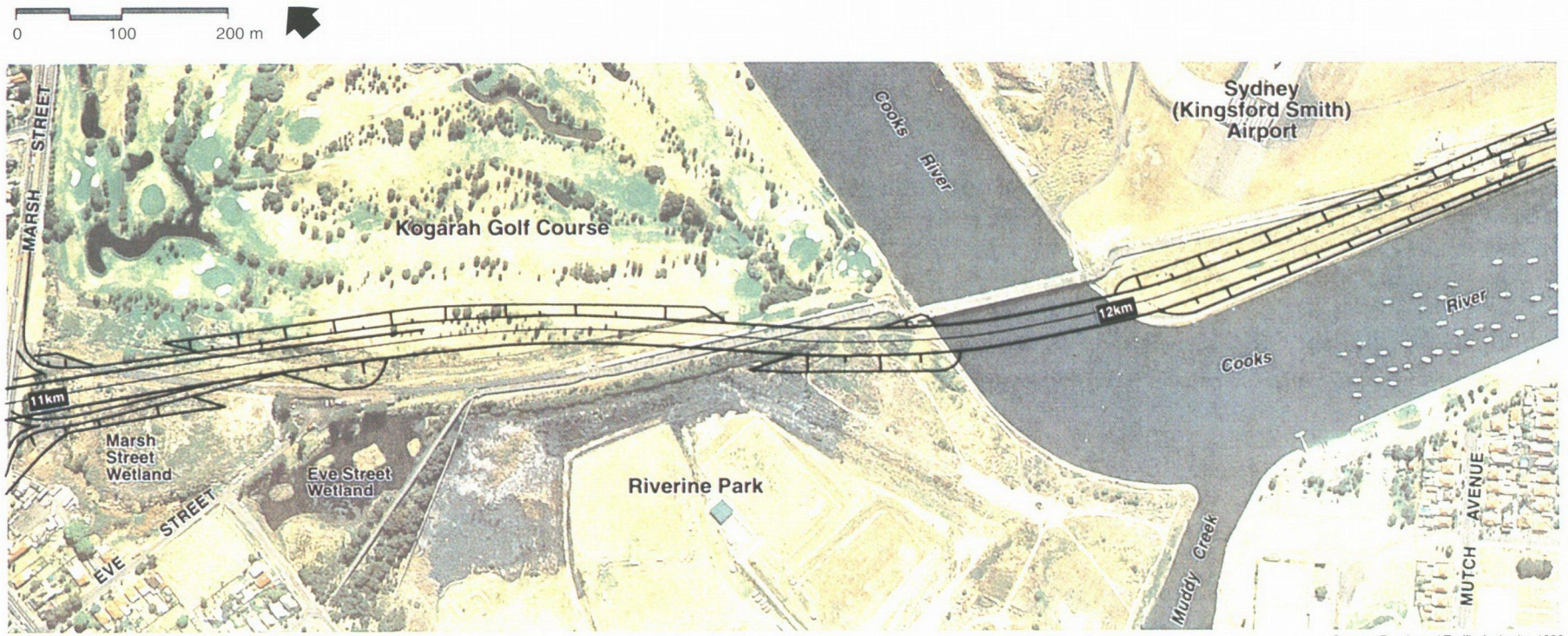
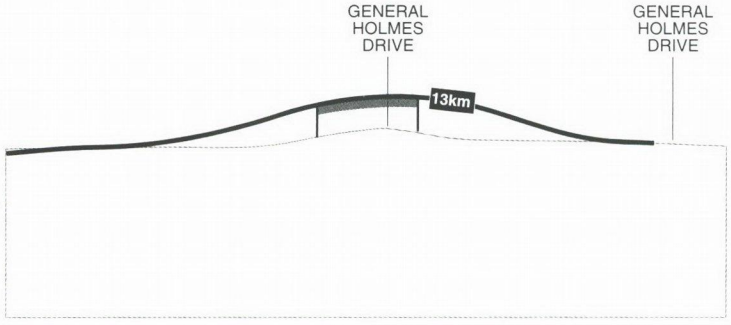


FIGURE 14 — PLAN AND PROFILE

Source: Roads and Traffic Authority, 1996



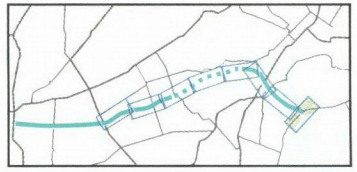


FIGURE 15 — PLAN AND PROFILE

FIGURE 16 — ARTIST'S IMPRESSION: PROPOSED PRINCES HIGHWAY INTERCHANGE

FIGURE 17 — ARTIST'S IMPRESSION: PROPOSED CONFIGURATION, MARSH STREET INTERCHANGE

FIGURE 18 — ARTIST'S IMPRESSION: PROPOSED GENERAL HOLMES DRIVE INTERCHANGE

FIGURE 19—EXISTING SITUATION, ROYAL PLACE, BARDWELL PARK, VENT STACK SITE

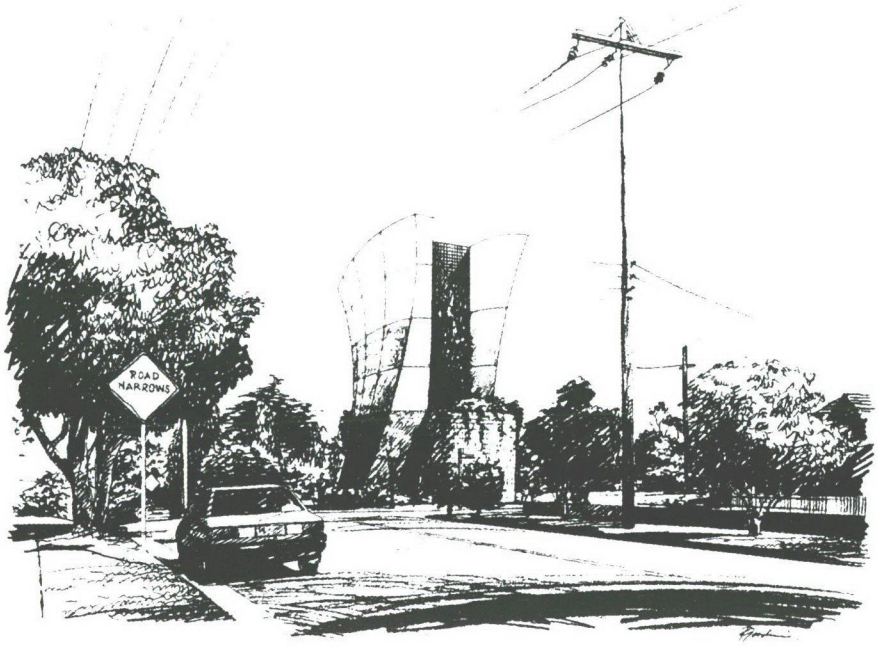


FIGURE 20—ARTIST'S IMPRESSION OF TUNNEL EXHAUST VENT STACK AT ROYAL PLACE

Note: Possible design treatment proposed at Royal Place, Bardwell Park, subject to community input.

FIGURE 21—EXISTING SITUATION, DUFF & HILL STREETS, ARNCLIFFE, VENT STACK SITE

FIGURE 22—ARTIST'S IMPRESSION OF TUNNEL EXHAUST VENT STACK AT DUFF & HILL STREETS, ARNCLIFFE

Note: Possible design treatment proposed at Duff and Hill Streets, Arncliffe, subject to community input.

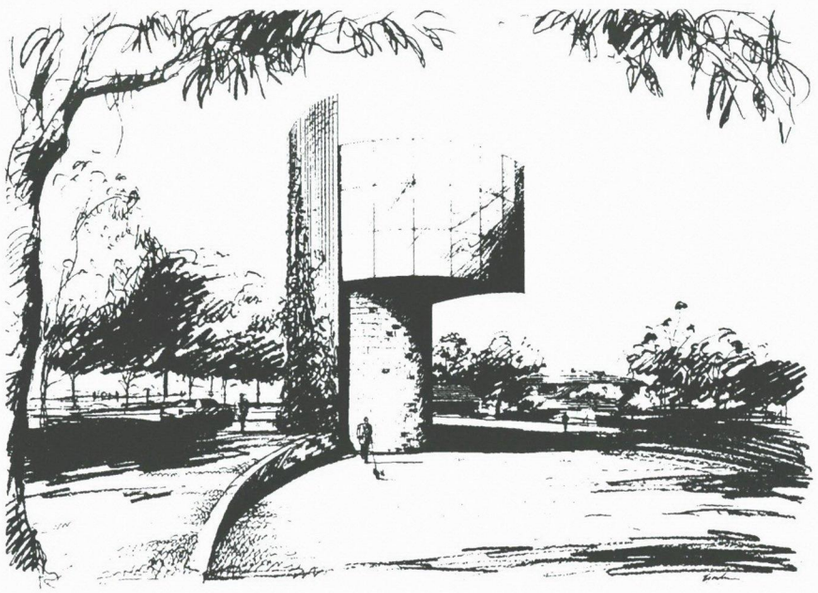


FIGURE 23—ARTIST'S IMPRESSION OF TUNNEL EXHAUST VENT STACK AT ARNCLIFFE STREET

Note: Possible design treatment proposed at Arncliffe and Burrows Streets, Arncliffe, subject to community input.

5.2.2 INTERCHANGES

Details of the proposed interchange arrangements for the Variation would be as follows:

- At Bexley Road there would be on-and-off ramps enabling travel to and from the west on the motorway.
- At the interchange with the Princes Highway the motorway would continue in tunnel under the Princes Highway at Ann Street towards Marsh Street.
- Traffic on the Princes Highway, travelling either north or south would not be able to enter the motorway to travel east. This east bound access would be gained at Marsh Street. Princes Highway traffic would be able to gain access to the motorway to travel west.
- Traffic leaving the M5 at the Princes Highway would only be able to travel north. In order to travel south on the Princes Highway, traffic would have to use the Marsh Street exit.
- There would be a grade-separated interchange at Marsh Street allowing entry and exit in both directions. It would be located between Valda Street and the West Botany Street-Marsh Street intersection, immediately to the south of the SWSOOS. The motorway would remain in tunnel under Marsh Street with the west facing entry and exit ramps being partially constructed in tunnel.
- East of Marsh Street the motorway emerges from tunnel and would be generally located along the alignment of the SWSOOS, to join General Holmes Drive in a grade-separated interchange. The interchange would provide for east bound traffic to enter the median lanes of General Holmes Drive. This would facilitate improved access to Foreshore Road for heavy vehicles.

5.2.3 LONGITUDINAL SECTION (PROFILE)

In longitudinal section, the tunnel would descend gradually from the eastern and western portals, to reach its maximum depth at the approximate half way point.

In the west, the tunnel gradient would be at 5% until the obvert (roof) of the tunnel is able to pass under Wolli Creek or Bardwell Creek. The tunnel would then flatten to generally a 1% downgrade. At the 2 km point (half way) the tunnel gradient would rise at a grade of 1%. In the east, the tunnel gradient would rise at a grade of 5% to meet the west facing ramps at the Princes Highway and Marsh Street.

5.2.4 TUNNEL DESIGN AND CONSTRUCTION

BASIC TUNNEL SECTION

The basic tunnel cross-section is shown in **Figure 5**. This cross-section is similar to that of the Sydney Harbour Tunnel. It is based on:

- Two traffic lanes at 3.5 metres wide for both directions.
- No breakdown lane between Bexley Road and Marsh Street.
- A structure gauge height of 4.6 to 4.9 metres, allowing the passage of double decker buses and trucks. This height would be reviewed in the light of experience with other tunnels, as this would be a very important truck route.
- Provision of fire services.
- An allowance outside the structure gauge for lighting and other services.
- Provision of ventilation ducts, where necessary, above the suspended ceiling.
- Provision of cross connections between parallel tunnel chambers for escape in the case of fire.

Signage and an incident management system would be installed in the tunnel.

The illustrated tunnel section(s) are not based on any specific tunnel excavation equipment. Excavation to achieve the required cross section may be carried out using one or a combination of:

- Tunnel boring machines.
- Roadheaders.
- Mobile miners.
- Machine mounted heavy breakers and ripper dozers.

The final selection of machinery (for example, tunnel boring machine versus roadheader) would be based on factors including:

- Contractor's preference (which includes machine availability and lead time).
- The number of working faces developed, out of a possible maximum of eight faces.
- The destination for tunnel spoil.
- Construction programme requirements.

ALTERNATIVE CONSTRUCTION METHODS FOR THE TUNNEL SECTIONS

A number of alternative tunnel sections would be feasible for constructing the tunnel. One such alternative tunnel section involves a 'double decker' tunnel which would require excavation of the upper portion of the tunnel

by road header, followed by conventional excavation of the remainder of the tunnel using ripper dozers, hydraulic excavators and rock breakers. This alternative could be proposed by the tunnel contractor and would need to meet the design standards and safety and air quality requirements stipulated in this supplement.

The alternative tunnel sections have advantages and disadvantages particularly in terms of costs, duration and interfaces with other activities on the programme, for example, tunnel fitout.

Design and construction of tunnel portals

Urban design advice would be sought in relation to the detailed design of the tunnel portals and surrounds. Construction of the western tunnel portal near Bexley Road would be undertaken as generally described in **Section 12.2.5** of the 1994 M5 East EIS, but would be dependent on the contractor's detailed programme of works.

Construction of the eastern portal to the south of the SWSOOS and east of Marsh Street would be staged to minimise the impact on traffic in West Botany Street and Marsh Street. The first stage would commence with the demolition of properties, construction of temporary fences, soil erosion and sediment control measures and the installation of a dewatering system to keep the excavation dry. Measures associated with the protection and rehabilitation of the Marsh Street and Eve Street Wetlands would also be undertaken in this stage.

Dependent on the contractor's programme of works, a bridge could be built in stages over the motorway along the alignment of Marsh Street. This would require traffic deviations as each stage of the bridge works is completed. Alternatively, the contractor may elect to use the land to the east or west of Marsh Street as a side track to allow the Marsh Street bridge over the motorway to be built within the construction area. The side track could be built as a bridge over the motorway or as a roadway which would be removed when the Marsh Street bridgeworks were completed. Similar options could also exist for the reconstruction of West Botany Street.

Excavation of the cutting and construction of retaining walls, followed by a reinforced concrete cover, would be provided over the motorway between West Botany Street and the tunnel portal to the east of Marsh Street. The east facing ramps and west facing ramps in cut and cover tunnel would be constructed at the same time as the bridge works.

Construction between the Princes Highway and the Illawarra Rail Line would also be dependent on the contractor's construction programme. Staged construction of the Princes Highway bridge over the motorway would be necessary to ensure minimal disruption to existing traffic during construction, and to accommodate the relocation of public utilities.

The Roads and Traffic Authority would require the contractor to provide a detailed construction programme and traffic management plan prior to any work being undertaken. These plans would be made available to the community using the forum of a Community Liaison Group. A Community Liaison Group would be constituted by the RTA by calling for expressions of interest for people from the local community to participate. The Group would meet from time to time to discuss design and construction aspects of the motorway.

5.2.5 TUNNEL VENTILATION AND SMOKE EXTRACTION

BACKGROUND

Ventilation of the road tunnels would be required to ensure that the levels of vehicle exhaust emissions remain within acceptable and safe limits. These limits, known as air quality goals, are set by the NSW EPA. Ventilation is also required to control the spread of smoke in case of a tunnel fire.

The main parameters used in the design of a ventilation system for the tunnel are:

- The worst case scenario for vehicle emissions.
- Air quality goals and the maximum allowable concentration of gases.
- The minimum visibility permitted.
- The amount of traffic in the tunnel under the worst traffic conditions.

The design of the ventilation system would ensure that air quality within the tunnels conforms to the air quality goals set by the NSW EPA. Air quality would be constantly monitored through regularly spaced detectors, which would activate the ventilation control system.

The ventilation concept has been designed for the worst case traffic conditions, which is congested traffic in both directions. This is the most conservative approach, and the final ventilation system may be designed for less onerous conditions. Traffic lights could be installed at the tunnel entry portal, or traffic could be held back elsewhere when traffic in the tunnel becomes stationary due to congestion. An incident management system would operate within the tunnel and on the motorway.

The ventilation system would also provide for smoke extraction in the case of a tunnel fire. Within the longitudinally ventilated segments of the tunnel a smoke extraction duct would be provided with smoke detector activated grilles.

Air would be supplied to the tunnel through both portals, and also from three air intakes. Within the tunnel tubes, where air flow between intake

and exhaust would be in the same direction as traffic flow, longitudinal ventilation using fans only would be applied. Where air flow from intake points to exhaust tunnels opposes traffic flow, a fully or semi transverse ventilation system with ducts is likely to be used.

The three preferred locations for the exhaust vent stacks and air intakes are at Royal Place, Bardwell Park, Duff and Hill Street, Arncliffe, and at the Arncliffe Street Army Reserve Depot, Arncliffe.

ALTERNATIVE VENTILATION SYSTEM

In considering the location of the tunnel exhaust stacks, the major factors are impact on the surrounding environment and cost of the ventilation system. The cost of a ventilation system is largely dependent on the compartment length between outside air supply points, and air extraction points.

The following alternative ventilation systems would be considered and evaluated on the basis of viability and cost:

Longitudinal ventilation

In a longitudinal ventilation system the whole of the required air volume would flow through the tunnel at constant velocity, assisted by jet fans mounted on the tunnel roof. They would blow most efficiently in the same direction as traffic although they may be reversed in emergency situations. A longitudinal system normally allows air supply and exhaust through the portals. The maximum economical length between intake and exhaust in a longitudinal system that meets fixed air quality goals is about 1.2km.

A standard longitudinal ventilation system based on longitudinal ventilation throughout the length of both tubes of the tunnel would require exhaust air to be expelled through the western portal of the west bound tube and the eastern portal of the east bound tube. It is however feasible (although less efficient) for the longitudinal system in the western compartment of the westbound portal and the eastern compartment of the eastbound tube to be based on supply from the portal against the traffic flow, thereby eliminating exhaust through the portals.

Whilst a longitudinal system is, in principle, able to handle smoke in the event of a fire, detailed design may call for separate smoke extraction ducts with grilles activated (opened) locally by smoke detectors.

Transverse ventilation

Transverse ventilation is a fully ducted system with an air supply duct and an air extraction duct along the full length of the tunnel. Supply air grilles would be spaced regularly through the tunnel usually at road level, and exhaust air grilles would connect with the exhaust duct in the roof of the tunnel. Banks of ventilation fans would be connected to both ends of each ventilating section with supply air volume equalling exhaust air volume.

The fans are activated and controlled by air quality monitors along the length of the tunnel, with flow rates varied by changing fan pitch or fan speed as the traffic densities and therefore pollution levels increase.

Semi transverse ventilation

A semi transverse system uses the same supply duct arrangement as the fully transverse system, but the exhaust air travels along the tunnel as in the longitudinal system.

OTHER TUNNEL VENTILATION CONSIDERATIONS

The systems described above may also be combined for various tunnel segments, known as a mixed system.

The tunnel ventilation fans would be located in an underground plant room at the bottom of the tunnel exhaust vent stacks.

LOCATION OF TUNNEL EXHAUST STACKS AND AIR INTAKE VENTS

The locations of the air exhaust stacks for the Variation are described in **Chapter 4**, in the discussion of alternatives.

The exhaust stacks would expel air at a constant velocity of 15 metres per second to ensure dispersal. The dimensions are shown in **Table 2**.

TABLE 2 — DIMENSIONS OF TUNNEL EXHAUST STACKS

Tunnel Exhaust Stacks	Internal diameter	Height
Royal Place / Bardwell Road	9.5m	15m
Duff Street / Hill Street	6.5m	15m
Arncliffe Street Army Reserve Depot	6.5m	15m

Source: Connell Wagner pers. comm. 27.11.1995

ARCHITECTURAL TREATMENT OF TUNNEL EXHAUST STACKS

In order to ensure that the architectural design of the exhaust stacks is compatible with the urban areas in which they are located, advice would be sought from an architect and / or artist with appropriate urban design qualifications. Proposed designs would be discussed with local residents to obtain community input, prior to a decision on the final design.

Examples of the types of architectural treatment which might be applied to the tunnel exhaust stacks are shown in **Figures 20, 22 and 23** (Richard Goodwin Pty Ltd, 1996). The designs would be developed through consultation with the local communities.

5.2.6 DRAINAGE

The tunnel portals would require flood protection barriers in order to satisfy the requirements of a probable maximum flood (PMF) level.

Throughout the length of the tunnel and portal areas, drainage sumps would be required at regular intervals to collect and pump out seepage water.

As specified in the 1994 M5 East EIS, construction of temporary drainage facilities would be carried out at the commencement of site works as part of a comprehensive soil erosion and sediment control plan. This work would be addressed in the environmental management plan. Erosion and sediment control measures would be used where temporary stockpiles of tunnel spoil are necessary. The temporary works would be maintained and modified as the work progresses to ensure that soil erosion is minimised and that the material which does erode is prevented from entering downstream waterways.

5.2.7 LINKS WITH THE PUBLIC TRANSPORT NETWORK

The construction of the New Southern Railway includes the provision of a Railway Station and bus interchange at North Arncliffe. The Variation under consideration in this supplement to the 1994 M5 East EIS substantially reduces the impact on the proposed North Arncliffe Station as it is located well to the south, with the tunnel in close proximity to and under the Arncliffe Railway Station. No interruption to services using the Illawarra Rail line is envisaged. The extended tunnel alternative as described in the 1994 M5 East EIS would likely conflict with the tunnel being constructed as part of the New Southern Railway.

An EIS for the proposed duplication of the East Hills Railway Line was exhibited during 1996 by the State Rail Authority. It is anticipated that a determination regarding that proposal will be made by mid-1997.

5.2.8 BICYCLES

Bicycles would be permitted to use the shoulder of the motorway between Fairford Road and Bobadah Street.

Cyclists would not be permitted to travel in the tunnel. A surface cycle route would be provided from Bobadah Street through the Wolli Creek Valley to link with the Princes Highway on the southern bank of the Cooks River and provide a link to the Ryde to Botany Bay Cycleway. The cycleway would be extended through Cahill Park to Marsh Street which would permit cyclists to rejoin the motorway at the Marsh Street interchange.

Bicycle facilities along General Holmes Drive would be maintained by providing a new cycle/pedestrian tunnel on the Botany Bay side of the existing General Holmes Drive tunnel to serve both directions. In the 1994 M5 East EIS the underpass was proposed to be used by cyclists only.

5.3 Construction

5.3.1 Phasing

As specified in the 1994 M5 East EIS, the construction period for the motorway would be approximately three years. The actual timing would depend on the company to be selected and on the prompt relocation of utility adjustments and availability of resources required to build the project. Development of the road would be carried out through a design, construction, maintenance contract to reach the early completion date. Construction would be carried out as a series of work packages within each of the proposed construction phases.

It is expected that tunnel excavation and the construction of the King Georges Road to Bexley Road sections of the motorway would be conducted simultaneously to save time. Spoil from the tunnel excavations would be used in the motorway embankment, requiring concurrent work on the tunnel excavation and the placement of embankment material.

5.3.2 Hours of construction

The Roads and Traffic Authority would require the contractor to use the best available practical techniques and to restrict the hours during which construction activities are carried out to between 7 am and 6 pm Monday to Friday and 8 am to 1 pm on Saturdays. No work would be permitted on Sundays or public holidays. Where work outside these hours is necessary due to traffic, tunnelling operations, safety requirements or other activities, the approval of the Environment Protection Authority would be sought as to conditions of approval for the work. It is envisaged that a letterbox drop would notify any affected residents of the work. No deliveries of materials, running of plant or equipment or on-site maintenance of plant or equipment would be permitted outside these hours unless approved by the Environment Protection Authority. The background (L_{90}) noise levels during this period would be used to set criteria for construction noise levels.

Tunnel boring work would be permitted at any time once the work was far enough underground to have no noise or vibration effects on residential areas. These effects would be monitored. Spoil would be brought out of the tunnels at the portals and dumped in the approach cutting to avoid noise impacts on nearby residential areas. The small stockpile of material would be transferred to the motorway embankment or other final sites, in accordance with a tunnel spoil waste management plan prepared before construction commences.

5.3.3 CONSTRUCTION TRAFFIC ROUTES

Construction traffic would use Bexley Road, Princes Highway, Marsh Street and General Holmes Drive to access the construction sites. Local streets would be used to obtain access to the tunnel exhaust stack locations. Access to the worksite at the mid-tunnel access off Bardwell Road would be via Slade Road to the section of the proposal west of Bexley Road. The Roads and Traffic Authority would require the contractor to consult with Council and the Community Liaison Groups in the development of a site access and construction traffic management plan as part of an environmental management plan, to be prepared before construction commences.

5.3.4 BALANCE OF EARTHWORKS AND SPOIL DISPOSAL

Approximately 900,000m^3 of material would be excavated from the tunnel between Bexley Road and Marsh Street. Some 600,000m^3 of this material would be placed in the embankment generally between King Georges Road and Bexley Road, with approximately 50,000m^3 required east of Marsh Street. Further sites have been identified between Salt Pan Creek and Belmore Road for the disposal of tunnel spoil.

In this area Canterbury Council proposes enhancement works, involving substantial quantities of fill, to provide an artificial feature south of the motorway near Salt Pan Creek and the rehabilitation of sites near McLaughlin Oval north of the motorway. Other opportunities exist for the disposal of spoil in the Canterbury local government area and other local government areas in the Region. The Roads and Traffic Authority would require the contractor to consult with councils in the area to identify appropriate sites where tunnel spoil could be used to enhance existing areas and the roads to be used for transporting material.

The provision of noise mounds and the rehabilitation of existing open space areas would be considered in the development of a tunnel spoil waste management plan as part of an environmental management plan to be prepared before construction commences.

5.3.5 WASTE MANAGEMENT

As specified in the 1994 M5 East EIS, an environmental management plan would be prepared prior to construction and would address waste management comprehensively. All waste materials found or produced on site would be handled in a responsible manner and in accordance with relevant legislation or codes of practice. Recycling of materials would be undertaken wherever possible.

Except where a sewer is available, site amenities would discharge all sewage to holding tanks for regular removal by tanker. Rubbish skips would be provided at all site compounds and regularly emptied or removed.

5.3.6 On site concrete batching plant

For tunnel construction works and motorway pavement, the manufacture of concrete from a temporary concrete batching plant may be proposed by the contractor on or adjacent to the motorway.

The environmental impact of any proposed plant would be the subject of a separate environmental assessment. In order to assess the impacts the following factors would be considered:

- Transport routes;
- Noise;
- Dust;
- Water quality; and
- Location.

Approval for construction of an on-site concrete batching plant would be required from the EPA and would include conditions relating to working hours, noise attenuation, dust control and water quality control.

The RTA would be required to consult with the community and consider any issues raised, including proposals for measures to mitigate environmental impacts, prior to agreement on any specific proposal.

5.3.7 Tunnel construction

Tunnel construction is likely to take place 6 days per week, 24 hours per day as in previous road tunnels constructed in Sydney.

It is proposed that environmental safeguards for such work would include:

- Restriction on after hours access to the tunnelling site;
- Restriction on noise emitted from the site by imposing conditions such as limiting the noise resulting from the tunnel site at any occupied residences to:
  L_{eq} = 55dBA - 6.00pm to 10.00pm Monday to Saturday
  L_{eq} = 45 dBA - 10.00pm to 7.00 am Sunday to Saturday
- Restricting vibration to ensure that there is not structural damage to structures.
- Restricting vibration at any residence so that it does not create an annoyance from 10.00pm to 7.00am.

5.3.8 TUNNELLING SITE

As shown in **Figure 12**, a mid-tunnel access from the reserve near Bardwell Creek is likely to be required for construction, ventilation or safety to allow the tunnel to be constructed efficiently in the proposed construction period.

In considering whether to approve the additional access the RTA would require the contractor to consult with the community regarding work from the site and propose mitigating measures to address community concerns.

If approval is given to use the site, conditions would be set by the EPA relating to various matters including noise, dust, water quality, lighting, parking, transport routes, damage to access roads, quantity of material hauled to the site and hours of work.

5.3.9 CONCRETE SAWING

If unreinforced concrete pavement is adopted, it is likely some concrete sawing of pavements would occur at night. The RTA would require the contractor to fit noise attenuation to the saw and to notify residents of the nights on which sawing would occur. Detailed conditions would be negotiated with the EPA.

5.3.10 TRANSPORT OF OVERSIZE LOADS

As traffic regulations limit the transport of some heavy or oversized loads to restricted hours at night, some movement of such loads to or from the worksites would occur outside approved work hours. Noise generating activities such as loading and unloading would be restricted to approved work time.

5.3.11 TUNNEL SERVICE CENTRES

A tunnel services area would be required to house:

- Fire service controls
- Lighting controls
- Ventilator controls
- Pump controls
- Traffic monitoring and controls
- Radio re-broadcast
- Telephone services
- Electricity sub-station

The most suitable location is above the cut and cover tunnels between the Princes Highway and the railway at Arncliffe.

The building would require vehicle access and parking for an estimated 6 vehicles. The parking could be constructed below ground level with above ground offices or control facilities.

5.3.12 Dangerous goods

Motorways have a high standard of curvature and grading, and avoid at-grade intersections through the provision of overpasses and underpasses. As a result, motorways generally have a very good road safety record. Further, they tend to offer a high standard of environmental controls through noise amelioration, water treatment and other similar measures. These factors make motorways attractive routes for the transport of the various classes of dangerous goods.

For these reasons, the proposed M5 East Motorway west of Bexley Road and east of Marsh Street would be open for use by vehicles transporting dangerous goods.

The transport of dangerous goods through tunnels has not generally been favoured, especially where reasonably convenient alternative routes are available. Thus the transport of dangerous goods through the Airport tunnel at General Holmes Drive and the Sydney Harbour Tunnel is restricted.

On the basis of specialist investigation into the probability of an incident in or near the proposed tunnel involving a vehicle carrying dangerous goods, and the likely consequences of such an incident in terms of injury to people and property (including vehicles and the tunnel itself) (TEC Consulting et. al, 1995) it is proposed to restrict the use of dangerous goods through the M5 East tunnel. The currently used route from Botany, north around the Airport and then via the Princes Highway and Forest Road to the southwest, would remain the preferred route.

5.4 Funding

It is proposed to invite commercial proposals to design, construct and maintain the project as a non-tolled freeway between King Georges Road at Beverly Hills and General Holmes Drive at Kyeemagh. The duplication of the section operated as a tollway by Interlink Roads between King Georges Road at Beverly Hills and Fairford Road at Padstow would be carried out by Interlink and operated as part of the M5 Motorway between King Georges Road and Moorebank. This would be funded by Interlink and operated by them over the period of the concession deed.

The M5 East Motorway route would be important as a commercial vehicle route servicing Port Botany and Sydney's Kingsford Smith Airport. The decision to operate the road as a non-tolled freeway would act as an

incentive to commercial vehicles to use the motorway, thereby reducing the impact of traffic on surrounding areas.

Subject to a determination to proceed to construction, works could commence in 1997 with an anticipated completion in mid 2000.

5.5 ZONING

A report was prepared by Briggs, Brindle and Chambers (1995), in conjunction with Freehill Hollingdale and Page, to assess matters relating to land use zoning for the Variation. The generalised zoning is presented in **Figure 24**.

The report found that the zoning status of the land on which the Variation is located is the same as the zoning status for the 1994 M5 East EIS proposal. That zoning status is discussed in full in **Chapter 13** of the 1994 M5 East Motorway EIS.

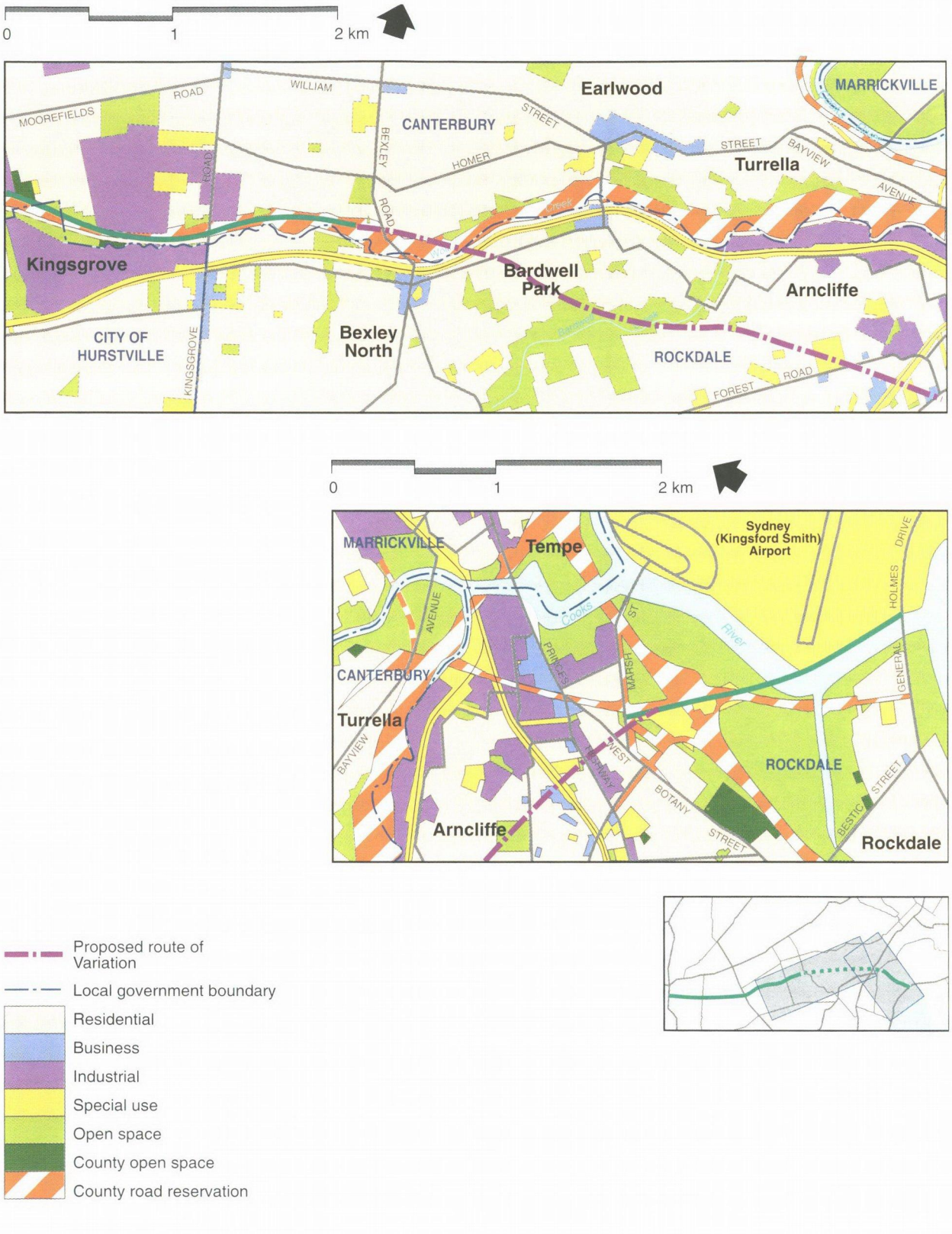


FIGURE 24 — GENERALISED ZONING

CHAPTER 6 IMPACTS ON TRANSPORT AND ROAD SAFETY

6.1 INTRODUCTION

Impacts on traffic and transport were assessed by transport specialists Masson & Wilson and reported in a working paper (Masson & Wilson 1996). The following summary of their working paper deals with road transport and efficiency, and road safety. Roads and Traffic Authority considerations on the transportation of dangerous goods are also presented at the end of the chapter.

When comparing the Variation to the 1994 proposals, the shorter tunnel and extended tunnel alternatives proposed in 1994 can be considered as identical. In traffic terms, they produce identical results and accordingly reference to the 1994 M5 East proposal includes reference to both the shorter tunnel and the extended tunnel alternatives for the purposes of this chapter.

In broad terms, the changes between the 1994 M5 East EIS proposal and the Variation produce travel time savings of about one minute for motorists using the motorway. This represents a five per cent saving of the Variation over the 1994 M5 East EIS proposal on an average trip of 20 minutes. The greatest traffic benefits of the Variation derive from removal of the toll from the proposed M5 East Motorway, resulting in the attraction of about one fifth more traffic onto the motorway and off the adjacent road network.

Significant updating work has been undertaken to the traffic model developed for planning in the 1994 M5 East EIS. It now incorporates data that has since become available with respect to implications of the Casula Link in the M5 Motorway, the addition of an east bound exit ramp at Heathcote Road and ramp tolling on the east facing ramps at Henry Lawson Drive. Other factors of influence that have been included in the traffic model are:

- Tolling of the proposed east facing ramps at Fairford Road.
- Widening of General Holmes Drive to eight lanes between the M5 East Motorway and Foreshore Road.
- Construction of the Eastern Distributor.
- Changing the interchange between the M5 East and General Holmes Drive to include a centre loading ramp onto General Holmes Drive and a southbound ramp from General Holmes Drive.

- A reduced level of traffic calming on Stoney Creek Road than was previously modelled.
- Improved modelling of traffic diversions resulting from the imposition of a toll. This is particularly relevant to M5 West and the introduction of the 'Toll Cashback Scheme'.

Under the 'Toll Cashback Scheme' motorists will be eligible to apply for an account card from the operators of the existing M4 and M5 motorways. The card is to be used to pay tolls at the tollway plazas, and will be associated with a credit account under which private motorists will receive monthly statements of the tolls paid. At the end of each three month period the RTA will rebate the tolls paid to the motorist upon application and presentation of the statements as proof of payment of the tolls. This arrangement is likely to increase the usage of M5 West and subsequently flow onto M5 East if constructed.

Significant changes that occurred to traffic volumes on roads as a result of the changes in the modelling are discussed in detail in the working paper (Masson & Wilson 1996) and summarised below.

6.2 ROAD TRANSPORT AND EFFICIENCY

6.2.1 TRAFFIC FLOWS

Traffic flows on the road network were forecast by the NETANAL model (a new and improved version of NODELAY) using similar procedures adopted in examining the 1994 M5 East EIS proposal. The impacts of the Variation on transport efficiency were analysed with respect to a Base Case or 'do minimal' works case. The Base Case represents the current conditions in 1996. For future years, the 'do minimal' works case represents the network at particular future years, assuming that only minor works are carried out between 1996 and that year.

Table 3 summarises the morning peak hour traffic flow for 1996, 2001 and 2011 for 42 reference roads out of the road network. **Table 4** is provided to show a direct comparison between the 1994 M5 East EIS proposal and the proposed Variation.

Should the M5 East Motorway proceed to construction, the nominal opening date is June 2000. For the purposes of this analysis, the 2001 forecasts are assumed to be the 'on opening' scenarios, given the relatively small difference between the two reference dates.

In general terms M5 East is a highly attractive route expected to carry near capacity traffic volumes during peak periods on opening. Substantial reductions in traffic volumes on numerous other roads across the network result although some arterial roads leading to the M5 East interchanges experience slight increases.

TABLE 3 — FORECAST TOTAL VEHICLE VOLUMES - AM PEAK HOUR MEDIUM DEMAND SCENARIO

Road	Location	1996	2001		2011	
		Base Case	Do Minimal	The Variation	Do Minimal	The Variation
		Volume	Volume	Volume	Volume	Volume
M5	West Of Princes Hwy	0	0	5290	0	5748
Princes Hwy	At Cooks River Bridge	5310	5699	6210	6584	7106
Qantas Drive	East of Link Rd	5162	5494	4920	6324	5838
General Holmes	At Airport Tunnel	7403	7776	9880	9058	11079
Bestic Street	West of Grand Pde	2168	2389	1497	2898	1553
Bay Street	West of Grand Pde	1776	1874	1381	2073	1663
President Ave	West of Grand Pde	292	270	215	407	248
Forest Road	North of Bexley Rd	3193	3440	2357	3886	2863
Stoney Creek Rd	West of Forest Rd	1509	1677	907	1955	1141
Bexley Road	West of Forest Rd	2721	2854	2053	3423	2439
King Georges Rd	North of M5	4861	5091	4836	5509	5646
King Georges Rd	South of M5	5494	5804	4783	6748	5722
Homer Street	East of Bayview Ave	1285	1245	1493	1458	1623
Bayview Street	East of Homer Street	1586	1803	1285	2238	1813
Morgan Street	West of Kingsgrove Rd	541	587	524	681	606
Vanessa Street	West of Kingsgrove Rd	1460	1601	344	2193	778
Moorefields Rd	West of Kingsgrove Rd	3275	3346	2347	3806	2765
Canterbury Rd	West of Kingsgrove Rd	1895	1953	1513	2197	1698
King Street	South of Enmore Rd	1629	1781	1727	2452	2649
Edgeware Road	South of Enmore Rd	999	1047	1126	1228	1292
Sydenham Road	East of Victoria Rd	1731	1854	1811	2064	2071
Marrickville Rd	East of Victoria Rd	1072	1143	1070	1218	1251
Unwins Bridge Rd	South of Railway Pde	2906	3178	2529	3922	3653
Railway Rd	West of Princes Hwy	2525	2627	2474	2727	2763
Enmore Rd	West of King St	4597	4751	4522	5644	5226
Livingstone Rd	North of Addison Rd	1253	1340	1198	1440	1367
Gordon St	North of Canterbury Rd	2374	2410	2312	3212	3128
Slade Rd	West of Hartill-Law Ave	1336	1402	1196	1543	1753
Hartill-Law Ave	North of Slade Rd	2201	2287	2138	2491	2700
William St	West of Bexley Rd	1453	1452	752	1742	957
Fairford Rd	North of M5	3451	3812	3768	4338	4274
Fairford Rd	South of M5	3141	3332	3700	3708	4156
The River Rd	North of M5	1803	1911	1881	2385	2305
The River Rd	South of M5	1852	1974	1936	2392	2344
Foreshore Rd	East of GHD	1961	2079	2479	2374	2815
O'Riordan St	North of Robey St	3448	3745	3840	4286	4579
Coward St	East of Kent St	2241	2421	2152	2883	2701
Coward St	West of O'Riordan St	314	343	272	312	268
Euston Rd	North of Huntley St	1741	1878	1787	2088	2048
McEvoy St	West of Wyndham St	2705	2852	2595	3142	3013
West Botany St	South of Princes Hwy	1932	2240	1962	2503	2375
West Botany St	South of Wickham St	2369	2758	2465	3115	3103

Source: Masson & Wilson 1996

TABLE 4 — FORECAST TOTAL VEHICLE VOLUME CHANGES FROM BASE YEAR 1996 - AM PEAK HOUR MEDIUM DEMAND SCENARIO

Road	Location	1996	2001		2011	
		Base Case	Do Minimal	The Variation	Do Minimal	The Variation
		Volume	Volume	Volume	Volume	Volume
M5	West Of Princes Hwy	0	0	5290	0	5748
Princes Hwy	At Cooks River Bridge	5310	389	900	1274	1796
Qantas Drive	East of Link Rd	5162	332	-242	1162	676
General Holmes	At Airport Tunnel	7403	373	2477	1655	3676
Bestic Street	West of Grand Pde	2168	221	-671	730	-615
Bay Street	West of Grand Pde	1776	98	-395	297	-113
President Ave	West of Grand Pde	292	-22	-77	115	-44
Forest Road	North of Bexley Rd	3193	247	-836	693	-330
Stoney Creek Rd	West of Forest Rd	1509	168	-602	446	-368
Bexley Road	West of Forest Rd	2721	133	-668	702	-282
King Georges Rd	North of M5	4861	230	-25	648	785
King Georges Rd	South of M5	5494	310	-711	1254	228
Homer Street	East of Bayview Ave	1285	-40	208	173	338
Bayview Street	East of Homer Street	1586	217	-301	652	227
Morgan Street	West of Kingsgrove Rd	541	46	-17	140	65
Vanessa Street	West of Kingsgrove Rd	1460	141	-1116	733	-682
Moorefields Rd	West of Kingsgrove Rd	3275	71	-928	531	-510
Canterbury Rd	West of Kingsgrove Rd	1895	58	-382	302	-197
King Street	South of Enmore Rd	1629	152	98	823	1020
Edgeware Road	South of Enmore Rd	999	48	127	229	293
Sydenham Road	East of Victoria Rd	1731	123	80	333	340
Marrickville Rd	East of Victoria Rd	1072	71	-2	146	179
Unwins Bridge Rd	South of Railway Pde	2906	272	-377	1016	747
Railway Rd	West of Princes Hwy	2525	102	-51	202	238
Enmore Rd	West of King St	4597	154	-75	1047	629
Livingstone Rd	North of Addison Rd	1253	87	-55	187	114
Gordon St	North of Canterbury Rd	2374	36	-62	838	754
Slade Rd	West of Hartill-Law Ave	1336	66	-140	207	417
Hartill-Law Ave	North of Slade Rd	2201	86	-63	290	499
William St	West of Bexley Rd	1453	-1	-701	289	-496
Fairford Rd	North of M5	3451	361	317	887	823
Fairford Rd	South of M5	3141	191	559	567	1015
The River Rd	North of M5	1803	108	78	582	502
The River Rd	South of M5	1852	122	84	540	492
Foreshore Rd	East of GHD	1961	118	518	413	854
O'Riordan St	North of Robey St	3448	297	392	838	1131
Coward St	East of Kent St	2241	180	-89	642	460
Coward St	West of O'Riordan St	314	29	-42	-2	-46
Euston Rd	North of Huntley St	1741	137	46	347	307
McEvoy St	West of Wyndham St	2705	147	-110	437	308
West Botany St	South of Princes Hwy	1932	308	30	571	443
West Botany St	South of Wickham St	2369	389	96	746	734

Source: Masson & Wilson 1996

FORECAST TRIP VOLUMES ON M5 EAST

The morning peak hourly volumes and average annual daily traffic volumes (AADTs) expected on the M5 East Motorway in 2001 and 2011 are presented in **Table 5**.

TABLE 5 — TRAFFIC VOLUMES ON M5 EAST - WEST OF PRINCES HIGHWAY

	2001				2011			
	East bound vph	West bound vph	Total vph	vpd	East bound vph	West bound vph	Total vph	vpd
Variation	3,645	1,636	5,290		3,864	1,884	5,748	
Daily Volume				58,200				69,000

Note: vph = vehicles per hour. vpd = vehicles per day.
Source: Masson & Wilson, 1996

According to the table, the average daily volumes to be expected west of Princes Highway (medium scenario) for the Variation are:

- In 2001, a total of 58,200 vehicles per day.
- In 2011, a total of 69,000 vehicles per day.

M5 EAST MOTORWAY PROPOSAL

Upon opening, the Variation with its shorter length and grade separated interchange at Marsh Street, attracts some 5,300 vph during the morning peak hour and 5,750 vph in 2011 west of the Princes Highway interchange. In the peak flow direction the volumes are 3,654 and 3,864 vph respectively, volumes which are approaching the 4,400 vph nominal capacity of the motorway.

Further to the west between King Georges Road and Bexley Road the forecast peak flow exceeds nominal capacity principally due to short distance/local trips joining the motorway at King Georges Road and exiting at Bexley Road. This traffic would be attracted off local routes such as Moorefields Road, Morgan Street and Canterbury Road. Under the 1994 M5 East EIS proposal those traffic flows were lower because the toll plaza was proposed to be located on this section of the motorway.

In broad terms, the M5 East provides the missing link between the termination of the M5 West at King Georges Road and the Botany/South Sydney area. As such it attracts considerable traffic volumes away from:

- Canterbury Road
- Stoney Creek Road/Forest Road
- Moorefields Road/Morgan Street

- Bay Street / Bestic Street

The Variation attracts traffic away from Canterbury Road, thus reducing traffic filtering through streets in Marrickville local government area which is moving to and from Princes Highway, Tempe. Once on the motorway, more traffic would proceed onto General Holmes Drive rather than exiting to use Princes Highway and Qantas Drive. As a consequence forecast volumes would increase on General Holmes Drive north of the M5 East connection.

To a certain extent, the proposed Eastern Distributor is also influencing this traffic pattern.

Canterbury road

Canterbury Road is the nearest parallel arterial route to the north of the proposed M5 East Motorway. It caters for a significant proportion of east-west traffic movements that are either destined for or originate from the South Sydney / Botany area. In the absence of an adequate arterial road connection from Canterbury Road to Princes Highway, Tempe, this traffic currently filters through streets in the Marrickville local government area.

Present congestion levels on Canterbury Road are high, and travel speeds average less than 30km / hour during peak periods. Without any significant upgrading of Canterbury Road or of other roads in the corridor, traffic conditions are forecast to further deteriorate. However increases in traffic volumes would be modest (+300 vph by 2011) owing to the fact that the route is now operating at capacity.

The Variation would produce an initial reduction of 380 vph or 4,000 vehicles per day on the 1996 base flow and would moderate growth to the point that the forecast 2011 traffic volume would still be below the 1996 level.

Stoney Creek road

Along with Canterbury Road, Stoney Creek Road is the second major arterial route through the study corridor. Located to the south of the proposed M5 Motorway, it forms the main current link from the existing M5 West at King Georges Road through to Princes Highway Rockdale.

Forecasts indicate that Stoney Creek Road would be subject to strong growth into the future without M5 East. Between 1996 and 2011, volumes would be expected to grow by about 30%.

Under the Variation proposal significant reductions in traffic flows are forecast. In 2011 the morning peak period is forecast to be 1,140 vph compared to the 1996 level of 2,140 vph. This is equivalent to a reduction of about 10,000 vehicles per day.

Forest road

Previous analysis indicated traffic growth on Forest Road would be limited by capacity constraints at the Bexley Road / Stoney Creek Road / Harrow Road intersections. Growth is constrained to about 700 additional vehicles during the morning peak hour in 2011 should M5 East not proceed.

The Variation would provide long term relief to Forest Road by containing growth to the point where the morning peak hour in 2011 would still be some 330 vph or 3,500 vehicles per day less than the 1996 flow.

Bexley road

Bexley Road crosses the M5 corridor in a generally north-south direction providing an important connecting route between Canterbury Road and Princes Highway. Without the M5 East, Bexley Road is predicted to have strong traffic growth in coming years. By 2011 volumes are expected to be 700 vph above current levels.

The Variation would attract longer distance traffic to the motorway reducing the long term growth on Bexley Road. By 2011 the forecast flows are 2,440 vph which is less than current levels. This is a direct result of the reduced traffic demands on Canterbury Road as discussed previously.

Moorefields road - william street - homer street

Previous traffic working papers to the 1994 M5 East EIS identified this route as one on which adjoining residential areas, schools and local shops currently suffer impacts from relatively high traffic volumes.

Under the Do Minimal scenario, traffic on this route is expected to grow despite attempts by the local council and Roads and Traffic Authority to suppress growth through traffic calming schemes, because other routes are essentially saturated.

The Variation would moderate traffic growth on this route with the western section of this route (Moorefields Road) having forecast 2011 traffic flows less than current levels.

In the eastern section (Homer Street), the traffic growth would eventuate principally as a result of local traffic accessing the Sydenham / Tempe area via Bayview Street and Unwins Bridge Road. This is the result of M5 East freeing up routes through Marrickville, thus allowing easier access from the Earlwood area.

As such, no significant direct relief is forecast under the Variation for this route. However the anticipated reduction to traffic on Canterbury Road and Bexley Road opens up an opportunity to displace traffic from this route through traffic calming works. The reason why traffic calming works have achieved only modest traffic relief in the past is that there was no suitable parallel route with spare capacity onto which traffic could divert.

Spare capacity created on Canterbury Road and Bexley Road by the M5 would now present this opportunity.

PRESIDENT AVENUE - BAY STREET - BESTIC STREET

This group of roads provides two distinct functions in the sub-regional road network:

- An arterial route from Port Botany area and the airport to the west via Harrow Road, Stoney Creek Road and Bexley Road, and
- A north-south arterial cross link which allows traffic to switch between Princes Highway and General Holmes Drive.

Forecasts indicate significant growth would take place on this corridor even if no road improvements were undertaken.

The M5 East would reduce traffic levels on all these roads upon its opening as it directly intercepts the traffic patterns described above. Under the Variation, 2001 forecast traffic volumes on these roads would be down 25% on the 1996 base flows. This relief would be sustained over time, with 2011 traffic forecasts still 18% down in the 1996 flows.

GENERAL HOLMES DRIVE - QANTAS DRIVE - PRINCES HIGHWAY

These three routes convey the major proportion of traffic at the eastern end of the M5 East corridor. Regardless of whether the M5 East Motorway is built, strong traffic growth is expected as the Port Botany, Sydney Airport and South Sydney Central Industrial areas develop.

Table 3 shows traffic growth on all three roads irrespective of the road network improvement options.

Under the M5 East Variation, which includes General Holmes Drive widened to eight lanes, some relief is forecast for Qantas Drive. Instead of an expected flow in 2011 of 6,325 vehicles per hour under the 'Do Minimal' scenario, the motorway is forecast to reduce this to 5,840 vehicles per hour. This is in excess of 60,000 vehicles per day to achieve that flow. Qantas Drive would need to be widened to six lanes, with three lanes in each direction. Certainly under the 'Do Minimal' scenario the widening would need to take place.

General Holmes Drive would experience significant traffic growth as a result of the M5 East focussing traffic towards this route. In 2001 morning peak hour volumes would increase to 9,000 vehicles per hour compared to the 1996 base flow of 7,400 vehicles per hour. This is within the capacity of an eight lane road, however by 2011 flows are forecast to increase to 11,080 vph (8,800 vph in the peak direction) which is at the capacity limit of General Holmes Drive.

The majority of the traffic increase on General Holmes Drive is not associated with the diversion of traffic from Qantas Drive and Princes Highway. Rather it would arise from traffic that has been attracted to the

M5 East Motorway from Canterbury Road and roads through Marrickville, as well as from the Bestic Street / Bay Street / President Avenue routes.

Regardless of whether the M5 East proceeds, consideration would need to be given to improving the capacity of Princes Highway between the M5 interchange and Canal Road. It is likely that four lanes in each direction with tidal flow operating in peak periods would be required some time in the near future. Upgrading Qantas Drive to six lanes may delay this need, but would not eliminate it.

EDGEWARE ROAD - SYDENHAM ROAD - MARRICKVILLE ROAD

This collection of roads provides access from the South Sydney Central Industrial Area, the airport and Port Botany up through Marrickville onto Canterbury Road, Parramatta Road and routes to the west and north-west. These routes are of poor geometric design and are not appropriate for high volumes of traffic and large vehicles. Further, they pass through residential areas. They presently operate at a level close to capacity.

Previous analysis indicated that traffic demands would continue to grow in this area, probably as a result of the capacity constraints on Princes Highway.

The Variation would bring about some minor relief for roads in the Marrickville / Newtown area over the 'Do Minimal' option. However it is unlikely that significant relief would eventuate without a direct arterial link from the Tempe area through to Parramatta Road. Whatever relief is provided by M5 East is taken up by other traffic demands in the sub-region.

6.2.2 COMMERCIAL VEHICLE FLOWS

The commercial vehicle patterns forecast for the M5 East Variation scheme vary significantly from those forecast for the 1994 EIS Proposal. Without the toll, the Variation attracts nearly twice the volume of commercial vehicles to M5 East and brings about a sustained reduction on the environmentally sensitive parallel routes.

As discussed in the second working paper on traffic impacts in the 1994 EIS (Sinclair Knight 1994b), commercial vehicles predominantly move across the study area in a north-west and south-west direction from the Airport, Port Botany, and South Sydney Central Industrial Area. The consequence of these movements is relatively heavy volumes of commercial vehicles on roads such as Bay Street, Brighton-Le-Sands; Harrow Road, Rockdale; Forest Road - Bexley Road, Bexley; Stoney Creek Road, Kingsgrove; Canterbury Road; and many streets through Marrickville and South Sydney local government areas.

The results of the commercial vehicle forecasting for future years are detailed in **Table 6**, which shows total morning peak hour flows for the 42 reference roads in the study area.

In this context some of the results sould be viewed with caution as outlined in previous work (Sinclair Knight 1994b). The commercial vehicle forecasting methods employed are still in developmental stages. However the results viewed in total provide the broad indications in the change of commercial vehicle patterns. Some streets individually may appear to provide anomolous patterns such as the cluster of Bestic Street, President Avenue and Bay Street and the cluster of Eadgware Road, Sydneham, Marickville Road and Livingstone Road, but when grouped together the sum total provides the correct order of magnitude for each cluster.

The M5 East would bring about significant reductions in commercial vehicle use of the Bay Street - Bestic Street - President Avenue routes such that in 2011 commercial vehicle numbers would still be less than 1996 levels.

TABLE 6 — FORECAST COMMERCIAL VEHICLE VOLUMES: AM PEAK HOUR MEDIUM DEMAND SCENARIO

Road	Location	1996	2001		2011	
		Base Case	Do Minimal	The Variation	Do Minimal	The Variation
		Volume	Volume	Volume	Volume	Volume
M5	West Of Princes Hwy	0	0	1150	0	1301
Princes Hwy	At Cooks River Bridge	460	503	851	565	961
Qantas Drive	East of Link Rd	269	291	206	387	241
General Holmes	At Airport Tunnel	937	970	1355	1092	1541
Bestic Street	West of Grand Pde	753	784	232	937	248
Bay Street	West of Grand Pde	163	163	0	140	0
President Ave	West of Grand Pde	4	5	5	5	5
Forest Road	North of Bexley Rd	205	227	143	267	216
Stoney Creek Rd	West of Forest Rd	235	267	83	329	113
Bexley Road	West of Forest Rd	416	440	139	514	189
King Georges Rd	North of M5	510	522	447	612	512
King Georges Rd	South of M5	457	500	221	564	306
Homer Street	East of Bayview Ave	274	245	333	288	379
Bayview Street	East of Homer Street	89	125	54	154	109
Morgan Street	West of Kingsgrove Rd	144	151	157	175	175
Vanessa Street	West of Kingsgrove Rd	187	236	13	227	67
Moorefields Rd	West of Kingsgrove Rd	573	579	129	714	168
Canterbury Rd	West of Kingsgrove Rd	363	396	284	477	295
King Street	South of Enmore Rd	293	395	351	450	520
Edgeware Road	South of Enmore Rd	145	98	197	111	160
Sydenham Road	East of Victoria Rd	77	79	174	93	251
Marrickville Rd	East of Victoria Rd	147	161	69	149	89
Unwins Bridge Rd	South of Railway Pde	222	241	211	309	443
Railway Rd	West of Princes Hwy	195	226	236	216	231
Enmore Rd	West of King St	880	943	832	1078	961
Livingstone Rd	North of Addison Rd	5	5	2	9	10
Gordon St	North of Canterbury Rd	191	124	144	264	202
Slade Rd	West of Hartill-Law Ave	118	113	104	131	170
Hartill-Law Ave	North of Slade Rd	150	151	169	194	223
William St	West of Bexley Rd	349	345	62	425	78
Fairford Rd	North of M5	476	505	500	513	531
Fairford Rd	South of M5	410	433	503	399	521
The River Rd	North of M5	998	1047	1039	1343	1323
The River Rd	South of M5	1093	1147	1139	1458	1438
Foreshore Rd	East of GHD	845	884	1096	977	1240
O'Riordan St	North of Robey St	251	268	267	312	311
Coward St	East of Kent St	193	211	199	276	244
Coward St	West of O'Riordan St	74	72	29	89	32
Euston Rd	North of Huntley St	123	127	121	129	134
McEvoy St	West of Wyndham St	420	436	380	487	440
West Botany St	South of Princes Hwy	208	228	288	260	290
West Botany St	South of Wickham St	210	230	155	267	147

Source: Masson & Wilson 1996

6.2.3 INTERSECTION PERFORMANCE

The performance of an urban road network is greatly dependent on the capacity of its intersections. **Table 7** reports forecast intersection performance based on intersection 'degree of saturation' as outlined in the 1994 M5 East EIS.

TABLE 7 — INTERSECTION PERFORMANCE: LEVEL OF SERVICE

Intersection	1996	2001*	
	Base Case	Do Minimal	The Variation
Canterbury / King Georges	F	F	E
Canterbury / Canarys	C	C	A
Canterbury / Bexley	F	F	B
King Georges / Stoney Creek	B	B	A
Forest / Stoney Creek	B	C	A
Forest / Bexley	F	F	E
Princes / President	F	F	E
Princes / Bay	D	D	A
Princes / Forest	F	F	A
Princes / West Botany	E	E	D
Wickham / West Botany	E	F	B
Princes / Railway	F	E	E
Princes / Canal	F	E	D
Princes / King	D	F	E
Grand / President	E	E	C
Grand / Bay	F	F	C
General Holmes / Bestic	F	F	E
O'Riordan / Robey	C	D	D
O'Riordan / Gardeners	C	C	A
O'Riordan / Bourke	A	B	B
Average	D	E	B

Note: Based on intersection 'Degree of Saturation' criteria

A - Little or no delay *B - Short traffic delays*
C - Average traffic delays *D - Long traffic delays*
E - Very long traffic delays *F - Extreme delay, extra capacity required*

** Nominal opening date for M5 East. More likely to be 1999*

Source: Masson & Wilson, 1996

Intersections in **Table 7** are generally the key intersections in the study area and are generally the more heavily trafficked ones. They are not a representative sample of all intersections and do not reflect the total average performance.

In general there is improved performance between the previously reported 1994 M5 East EIS proposal and the Variation. Considerable improvement can be expected along Forest Road and Stoney Creek Road as well as along Princes Highway through Rockdale. These are currently points of congestion in the road network.

In global terms, the computer analysis reports estimated delays at all intersections throughout the study area by accumulating time delays for each vehicle at all intersections. The result is expressed in 'vehicle delay hours'. **Table 8** reports the relative savings in delays for the Variation.

TABLE 8 — NETWORK VEHICLE DELAYS AM PEAK HOUR

Year	Do Minimal Delay Hours	The Variation Savings	
2001	40,970	1,443	(3.5%)
2011	52,519	1,975	(3.8%)

Source: Masson & Wilson 1996

Total road network delays can be seen to escalate over time with significant savings accumulating in 2011.

6.2.4 IMPACTS ON NETWORK EFFICIENCY

The previous sections have discussed impacts on the various alternatives in terms of volume changes to specific roads and intersections. This section deals with global changes to the road network in relation to travel time benefits and vehicle operating costs.

The modelled road network is bounded by Georges River to the south; Hume Highway to the west; Hume Highway - Parramatta Road and Cleveland Street to the north; and South Dowling Street - Anzac Parade to the east.

TRAVEL TIME BENEFITS

Travel time savings were broadly described above in terms of point to point travel savings in time. However, more specific measures are also provided for:

- Total distance travelled by vehicles on the network (vehicle kilometers travelled).
- Total delays encountered at all intersections by all vehicles (vehicle hours of delay).
- Total travel time measures (vehicle hours of travel).

Table 9 summarises the travel performance measures of each option.

TABLE 9 — FORECAST ROAD NETWORK PERFORMANCE: AM PEAK PERIOD — 2001, 2011

Performance Measure	Total network for 'Do Miminal' Option	The Variation Savings
2001		
Vehicle kilometres travelled	1,505,229	11,872
Vehicle hours of delay	40,970	1,443
Vehicle hours of travel	66,452	2,452
2011		
Vehicle kilometres travelled	1,740,537	13,651
Vehicle hours of delay	52,519	1,975
Vehicle hours of travel	83,355	3,523

Source: Masson & Wilson, 1996

For the Variation, considerable savings are achieved compared to the 'Do Minimal' option. An average of 18.2 minutes delay per vehicle is forecast for the 'Do Minimal' scheme. The M5 East would reduce this delay by 41 seconds, representing a 3.7% reduction.

VEHICLE OPERATING COST BENEFITS

The above section outlines savings in terms of travel time and distance. These savings bring benefits to the community with respect to vehicle operating costs, improved efficiency to transport, commercial time savings and so on. **Table 9** forms the basis for input to estimating the economic benefits. These modelled savings detailed in **Table 9** are for the morning peak hour only but can be projected to describe the savings over the whole day (see Sinclair Knight 1994b).

6.3 ROAD SAFETY

The construction of a new road to motorway standard in an urban network would bring about a reduction in accidents due to the safer operating conditions arising from reduced vehicle conflicts and the absence of intersections.

The Roads and Traffic Authority has recently updated its data on representative accident rates on the urban road network derived from statistics the Road Safety Bureau collects.

These are (as at March 1996):

Local/Sub-arterial Roads — 1.51 accidents per million vehicle kilometres
$62,000 accident cost per million vehicle kilometres

Arterial	1.10 accidents per million vehicle kilometres $45,300 accident cost per million vehicle kilometres
Freeway	0.343 accidents per million vehicle kilometres $14,100 accident cost per million vehicle kilometres

From the modelling analysis the changes in usage of each category of road can be estimated and expanded to annual vehicle kilometres travelled. This is detailed in **Table 10**.

TABLE 10 — NETWORK ANNUAL VEHICLE KILOMETRES TRAVELLED - MILLIONS

	Do Miminal		Variation	
Road Category	**2001**	**2011**	**2001**	**2011**
Tollway / Freeway	310.5	385.0	579.8	699.4
6 Lane Arterials	1,554.5	1,840.6	1,527.7	1,797.7
4 Lane Arterials	1,673.7	2,006.4	1,563.4	1,880.9
Sub-Arterials	1,262.7	1,539.0	1,164.5	1,425.0
Collectors	1,080.6	1,327.1	999.7	1,239.9
Residential	436.1	525.6	433.2	520.9
Total VKT	6,318.2	7,623.6	6,268.4	7,563.8

Note VKT = vehicle kilometers travelled

Source: Masson & Wilson 1996

In **Table 10**, the higher numbers for the first three road categories for the Variation, and the lower numbers for the other road categories, show that the effect of the M5 East Motorway is to attract traffic off the arterial and sub-arterial road system onto a freeway standard road, thus providing a safer form of travel.

Accident savings can be calculated from **Table 10** by application of the March 1996 accident data detailed above. The differences between the Do Minimal option and the Variation are the savings in accident costs. These are detailed in **Table 11**.

TABLE 11 — ANNUAL ACCIDENT EVENT SAVINGS WITH M5 EAST

Year	Reduction in number of accidents	Savings in accident costs
2001	333	$13.7 million
2011	388	$16.0 million

Source: Masson & Wilson 1996

Table 11 indicates that upon opening of the M5 East, at least six serious accidents per week would be avoided on the road network while by 2011, 388 accidents would be avoided per year. This represents a significant $16 million saving to the community in 2011.

6.4 Conclusions

6.4.1 Impacts on transport efficiency

The Variation has been compared to the 'Do Minimal' option with some comparison made to the 1994 EIS Proposal. The Variation is a relatively efficient proposal with forecast volumes during peak periods on opening in 2000 approaching the capacity of the motorway and wide spread reductions of traffic resulting on the rest of the road network. A major proportion of the traffic on the motorway would continue on to General Holmes Drive rather than exiting at Princes Highway. Reductions in the amount of traffic filtering through streets in Marrickville local government area are also forecast.

The commercial vehicle patterns forecast for the Variation would vary significantly from those forecast for the 1994 M5 East EIS proposal. The M5 East would attract a greater proportion of commercial vehicles to use the full length of the motorway, commencing from General Holmes Drive. This would result in significant reductions in commercial vehicular traffic through Rockdale and Bexley.

There would also be improvements in intersection performance over the 'Do Minimal' option and reduced delays can be expected along Forest Road and Stoney Creek Road as well as along the Princes Highway through Rockdale. Overall travel time savings are in the order of 3.7% in 2011.

Overall, the Variation produces greater benefits when compared to the 1994 M5 East EIS proposal. This results from a combination of factors, the most significant being the 'no toll' arrangements.

6.4.2 Impacts on road safety

Significant reductions in traffic accidents are forecast to result from M5 East with the Variation scheme. By 2011 these could represent $16 million per annum in savings to the community by reducing the number of accidents by an estimated 388 per annum.

6.5 ENERGY CONSUMPTION

Energy consumption during construction of the Variation would differ from that of the 1994 M5 East EIS proposal and extended tunnel alternatives. During operations, it was estimated that there would be no significant differences in energy consumption between the respective proposals. The energy requirements of the Variation are discussed below.

6.5.1 DURING CONSTRUCTION

Energy consumption during construction would be related principally to excavation and earth movement (Connell Wagner *pers. comm.* 21/11/1995).

The machinery used for initial heading tunnel excavation (eg. tunnel boring machine, road header, mobile miner or a combination of these) would be electrically powered and consume an amount of electricity in the order of 16 million kilowatt-hours, dependent on rock quality, machine type, and adoption of the double decker alternative which reduces the initial heading excavation significantly.

The machinery used for bulk excavation and filling would possibly include ripper dozers, excavators, scrapers, graders, trucks and compaction equipment. It is estimated that their combined fuel consumption (distillate) would be in the order of 7 million litres.

6.5.2 DURING OPERATIONS

For the Variation there would be a slight reduction in the estimated energy consumed during operations, when compared with the 1994 M5 East EIS proposal and the extended tunnel alternatives (Masson & Wilson *pers. comm.* 2/12/1996).

Annual fuel savings on opening of the M5 East Motorway in 2001 would be 22.4 million litres of fuel when compared with the 'Do Minimal' option. These savings are of a similar order to those estimated for the 1994 M5 East proposal.

In 2011 however, the annual fuel savings of the Variation would be 30.1 million litres, compared with 24 million litres for the 1994 M5 East proposal. Thus the Variation results in greater savings in 2011.

CHAPTER 7 ASSESSMENT OF IMPACTS AND PROPOSED SAFEGUARDS ON THE SOCIAL ENVIRONMENT

7.1 INTRODUCTION

7.1.1 OVERVIEW OF THE CHAPTER

This chapter deals with the potential impacts on the social environment of the Variation. It addresses impacts on noise and air quality, land use, recreation and the visual and social environment.

In the 1994 M5 East EIS, it was found that the major social impacts of the shorter tunnel proposal occurred where the motorway was on viaduct over Turrella and Arncliffe. The extended tunnel alternative reduced those impacts. The Variation to the route considered in this supplement further reduces the impacts on surface land use. However, the number of properties located above the tunnel alignment for the Variation is far greater than for either the 1994 M5 East EIS proposal, or the 1994 M5 East EIS extended tunnel alternatives. (See **Figures 8** to **15** for the Variation.)

The reduced direct impacts of the Variation are due to design proposals that have the tunnel entrance and exit ramps breaking the surface of the ground only in the Arncliffe area, and doing so much closer to the interchanges than in the 1994 M5 East EIS proposal. In addition, in the currently proposed Variation the motorway remains in cut and cover tunnel as it passes under the Illawarra Rail line, the Princes Highway and Marsh Street. For the extended tunnel alternative, the motorway would have been in a combination of cut and cover and open slot in these areas, which would have resulted in greater disruption to existing developments than with the Variation.

The reduced indirect impacts from the Variation are primarily due to the tunnel continuing until Marsh Street. In contrast, the shorter tunnel of the 1994 M5 East EIS emerges in the Wolli Creek valley and is on viaduct over Arncliffe and Turrella, while the 1994 M5 East EIS extended tunnel starts to emerge just west of the Illawarra Rail line at Guess Avenue.

The increased indirect impacts on properties are due to the Variation being aligned not under the Wolli Creek valley, but under developed urban areas comprising some 180 (see **Chapter 7.5**, Social environment) houses, some factories and commercial properties.

7.1.2 STATE GOVERNMENT POLICY CONTEXT

The Roads and Traffic Authority has developed a *State Road Network Strategy* (Roads and Traffic Authority, 1994), in conjunction with the Department of Transport's *Integrated Transport Strategy* (NSW Government, 1995), and the Department of Urban Affairs and Planning's strategy, *Cities for the 21st Century* (Department of Planning, 1995). The three strategies together are being revised and are part of a State Government initiative to better integrate transport and land use planning in New South Wales.

According to the State Road Network Strategy, Sydney's traffic will continue to grow even if integrated demand management is fully implemented, largely as a result of Sydney's continuing growth in population. Integrated demand management includes a range of related measures to influence social behaviour associated with travel demand so as to optimise the use of transport facilities. The strategy concludes that there is a need to upgrade and develop a strategic or primary road network for the metropolitan area largely to serve the needs of commerce and industry. The aims of the Strategy, and the relationship of the proposal to those aims, are to:

- **Support the policies of the Integrated Transport Strategy and Cities For the 21st Century**

  The three main elements of the Integrated Transport Strategy (ITS) are the integration of transport and urban development; the development of an effective, efficient and environmentally responsible transport system; and effective management of the urban environment and transport so that realisation of the land use and transport strategies is an ongoing process.

  The proposed Variation for the M5 East Motorway aims to provide an efficient means of linking transport-intensive land uses such as Port Botany, Sydney's Kingsford Smith Airport and the Sydney West Airport, with key freight, commercial and passenger transport routes to Sydney's west, and intrastate and interstate localities.

  For a transport infrastructure project of this scale, the motorway's environmental impacts would be kept to a minimum and monitored continually, and it would contribute, along with other existing and proposed transport and land use initiatives, to Sydney's overall metropolitan transport network. The relevant policies, actions and priorities of the ITS are shown in **Table 1** of the 1994 M5 East EIS.

- **Support an efficient public transport system and thereby reduce road traffic growth**

  In the study area, the main bus services are feeder services focussed on the heavy rail system. The efficiency of these services would be improved as the proposed M5 East relieves congestion in the area. The M5 East Motorway would also create an opportunity for new trunk bus services. However, other public transport improvements

are contributing to improving accessibility to and from Sydney's west, such as upgrading of the East Hills Rail Line, and the Merrylands Y-Link. The Roads and Traffic Authority and other key government agencies are discussing improvements to be made to bus services in conjunction with the major projects including the Eastern Distributor, the M5 East Motorway and the New Southern Railway. These improvements could include both trunk services and feeder services to stations.

- **Support economic development by facilitating freight movement**

  The M5 East Motorway route corridor is already a major freight corridor, servicing the freight hubs of Port Botany and the Sydney Central Industrial Area. A large proportion of freight to and from these locations will continue to require road transport. The M5 Motorway would contribute to this movement of freight by reducing travel times, road transport efficiency and road safety.

- **Improve access, including that for residents of growth areas outside existing urban areas**

  Major growth areas of metropolitan Sydney tend to be on the western fringe. Along with other key elements of the State Road Network Strategy, existing and proposed, the M5 East Motorway would improve access to growth areas significantly.

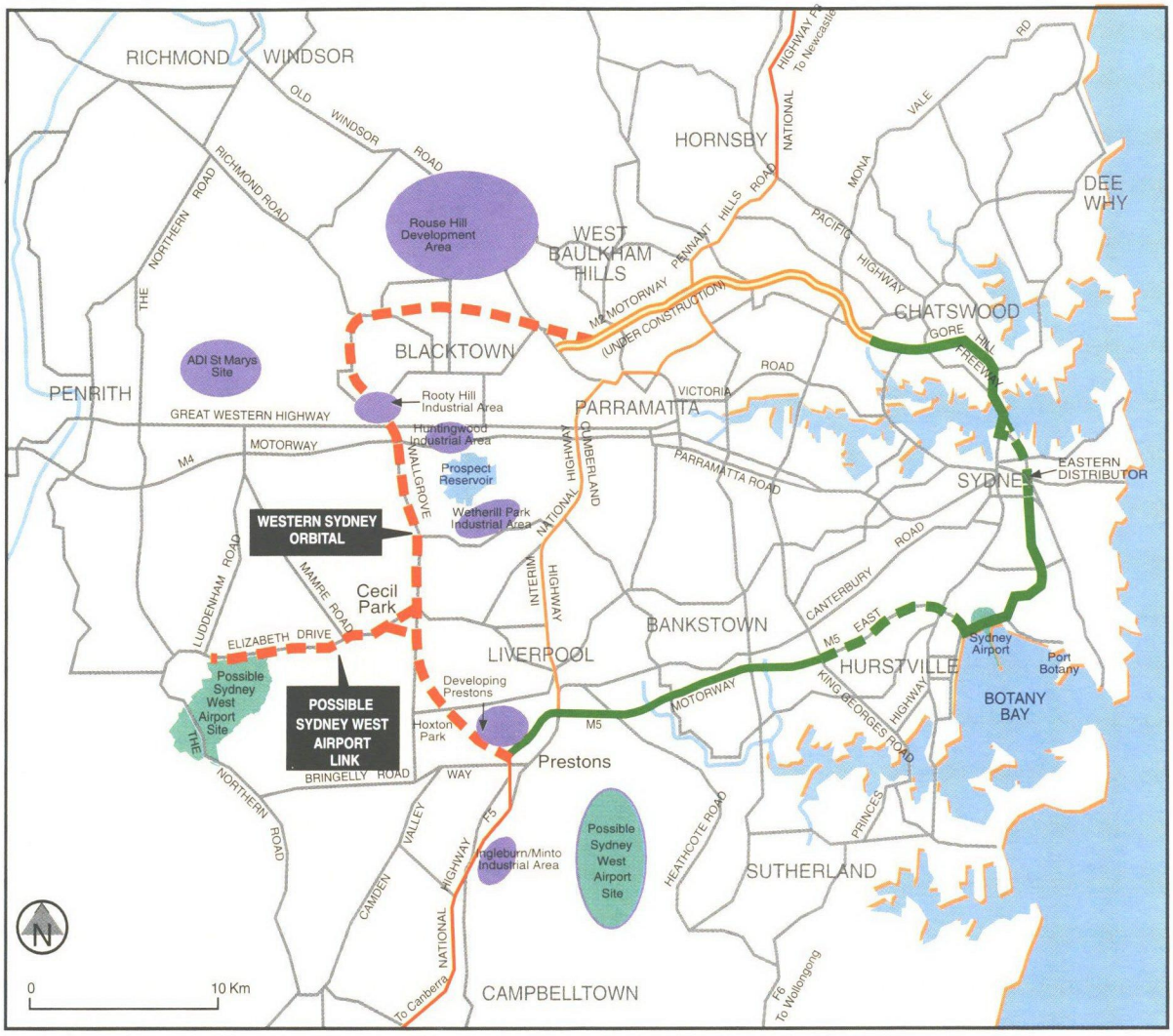
- **Help improve road safety**

  The M5 East Motorway would help to improve road safety by relieving existing main roads in the study area, some of which have very high accident rates. Motorways are known to have a better safety record than arterial roads, and accident frequency is expected to be reduced with the motorway in operation.

- **Help improve living quality in urban areas**

  Without the M5 East Motorway, residents of suburbs within the study area currently put up with high traffic volumes on roads that were not designed to carry them, and the accompanying problems of noise, air pollution and poor road safety. The M5 East Motorway, by removing the volumes of heavy traffic from local and regional roads, would improve the living quality in these areas. It would also reduce travelling times for journeys across and out of the metropolitan area.

  Other key elements of the Integrated Road Network Strategy, existing and proposed, include the Western Sydney Orbital Route, the M2 Motorway, (see **Figure 25**) and Eastern Distributor. When complete, the road network in Sydney will enable easier movement throughout the metropolitan area, catering for freight, commercial and passenger movements. Together with the initiatives proposed under the *Integrated Transport Strategy* and the planning strategy, *Cities for the 21st Century*, transport and land use planning will become better integrated and strategic decisions for future developments will be made within an appropriate framework.



Source: Roads and Traffic Authority

FIGURE 25 — PROPOSED WESTERN SYDNEY ORBITAL AND LINK TO SYDNEY WEST AIRPORT

7.2 NOISE IMPACTS

7.2.1 INTRODUCTION

Noise impacts arising from the proposed motorway were assessed by specialist acoustic consultants Renzo Tonin & Associates. Seven issues were considered in particular: existing ambient noise levels; the extent of treatment required for the control of traffic noise; the noise impact of the proposed motorway upon schools and community facilities; the assessment of noise relating to the construction of the proposed motorway;

the assessment of vibration relating to the construction of the tunnel, and the treatment of noise from the tunnel air intakes and the exhaust stacks.

This impact assessment is based on the M5 East being toll-free. Whilst the effect of the proposal to make the motorway toll-free would be to generally increase traffic volumes, the potential for noise increase would be mitigated by the use of higher noise barriers where this is an issue.

The findings are presented below. The potential impacts are also compared with the impacts arising from the 1994 M5 East EIS proposal and reference is made to the Renzo Tonin & Associates Working Paper for the 1994 EIS (Renzo Tonin & Associates, 1994).

7.2.2 Existing noise environment

Definitions

Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. Noise values measured or referred to in this noise impact assessment include the L_1, L_{10}, L_{90} and Leq levels. The statistical descriptors L_1, L_{10} and L_{90} measure the noise level exceeded for 1%, 10% and 90% of the sample measurement time. The Leq level is the equivalent continuous noise level or the level averaged on an equal energy basis. Measurement sample periods are usually fifteen minutes for general environmental noise, one hour for traffic noise assessment to schools and 24 hours and eight hours for traffic noise assessment to residential premises during the day and night, respectively.

Background noise

Background noise is the term used to describe the noise measured in the absence of the noise under investigation. It is described as the average of the minimum noise levels measured on a sound level meter and is often measured statistically as the noise level exceeded for 90 per cent of a sample time period. This is represented as the L_{90} noise level.

Noise levels are commonly measured in units of A-weighted decibels or dB(A). The "A-weighting" refers to a standardised amplitude versus frequency curve used to "weight" sound measurements to represent the response of the human ear. The human ear is less sensitive to low pitch sound than it is to high pitch sound. Overall A-weighted measurements quantify sound with a single number to represent how people subjectively hear different frequencies at different levels.

Noise monitoring

As part of the 1994 M5 East EIS, ambient noise surveys were conducted at thirty-seven locations along the then proposed M5 route and relevant option (see the Renzo Tonin & Associates 1994 Working Paper). Beyond

this, one additional location was selected for long-term noise monitoring, nominated as Position 38 (immediately east of the Illawarra Rail Line). Furthermore, for the purposes of assessing the potential noise impact from the mechanical plant required by the tunnel ventilation system, short-term ambient noise surveys were conducted during daytime hours in the vicinity of the proposed air intake and exhaust vent locations. Night-time noise levels were extrapolated from similarly structured noise data taken from respective nearby long-term noise monitoring locations. In total, eight new noise survey locations were established for monitoring the existing traffic and background noise levels to determine the expected noise impact from the 1996 proposed motorway. All monitoring locations were selected to present a cross section of the various acoustic environments found along the M5 section proposed to be modified and its proposed extension.

The Renzo Tonin & Associates Working Paper (1994) presents the noise levels measured at each of the original thirty-seven locations, and **Table 59** of the 1994 M5 East EIS presents a noise level summary. **Table 12** below presents the noise levels determined at the eight new locations.

TABLE 12 — EXISTING NOISE CONDITIONS AT SELECTED LOCATIONS

Location No.	Location Address	Leq Noise Level, dB(A) Day: 24 hour	Night: 8 hour	L_{90} Noise Level, dB(A) 7am-10pm	24 hour
38	36 Ann St	56	52	44	42
39	Arncliffe Park	49	55	53	42
40	Henderson St	49	45	41	35
41	Reede St	60	56	58	45
42	Ron Gosling Res	53	49	43	36
43	Coolabah Res	57	53	47	38
44	Slade Rd Res	55	51	50	39
45	Moore St	49	45	43	36

Notes:

1. Leq noise levels are facade corrected [ie a 2.5 dB(A) factor is included] as per RTA and EPA recommendations for traffic noise assessment at facades.

2. L_{90} background noise levels are free field results - used to assess noise impact at property boundaries (eg from construction, tunnel ventilation plant etc).

7.2.3 NOISE ASSESSMENT CRITERIA AND METHOD

The noise assessment criteria and methodology used in the 1994 M5 East EIS were adopted in this study.

As in the 1994 M5 East EIS, noise contours were produced showing the contribution of the proposed motorway for the year 2011. Noise from the motorway combines with that from the major adjoining roads of Fairford Road, Belmore Road, Kingsgrove Road, Bexley Road, Princes Highway, Marsh Street and General Holmes Drive.

In order to demonstrate the effect of the motorway, the 1994 M5 East EIS presented noise contours of the motorway and **Table 61** of the 1994 M5 East EIS presented the change in total noise levels from the 'base case' to 2011 on existing major roads (ie with the M5 East Motorway).

Comments received in submissions to the 1994 M5 East EIS indicated that it would be desirable to show contours of the total noise levels, that is the M5 East Motorway noise plus the noise from adjoining roads. A complete set of noise contours was therefore produced for this supplement showing:

- The predicted Leq (24hour) contribution of noise for the proposed motorway (**Figures 26** to **34**); and
- The predicted Leq (24hour) total noise levels arising from the M5 East Motorway and adjoining roads (**Figures 35** to **42**) for the year 2011, where noise contours differ from those arising from the M5 motorway noise only.

7.2.4 PREDICTED NOISE IMPACTS FROM THE MOTORWAY

Direct noise impacts

The way in which direct noise from the motorway would affect residences, schools and community facilities adjacent to the proposed motorway was assessed and the impact is described below.

Residences

For description purposes, the proposed motorway has been divided into three areas:

1. Fairford Road to King Georges Road
2. King Georges Road to the western portal at Bexley Road
3. Tunnel connection ramps at Princes Highway to General Holmes Drive.

- **Fairford Road to King Georges Road**

  Noise levels at all residences in this area, including multi-level residences, would not exceed the Roads and Traffic Authority noise objectives. The noise contour maps show that the majority of residential areas would be within the normally acceptable range, while a few pockets of residences further from the motorway fall within the clearly acceptable range. The heights and extent of noise barriers in this section of the motorway therefore remain unchanged from those described in the 1994 M5 East EIS.

- **King Georges Road to Bexley Road portal**

  Between King Georges Road and west of the tunnel portal, the proposed four metre noise barriers would ensure that all residential areas close to the proposed motorway are within the normally

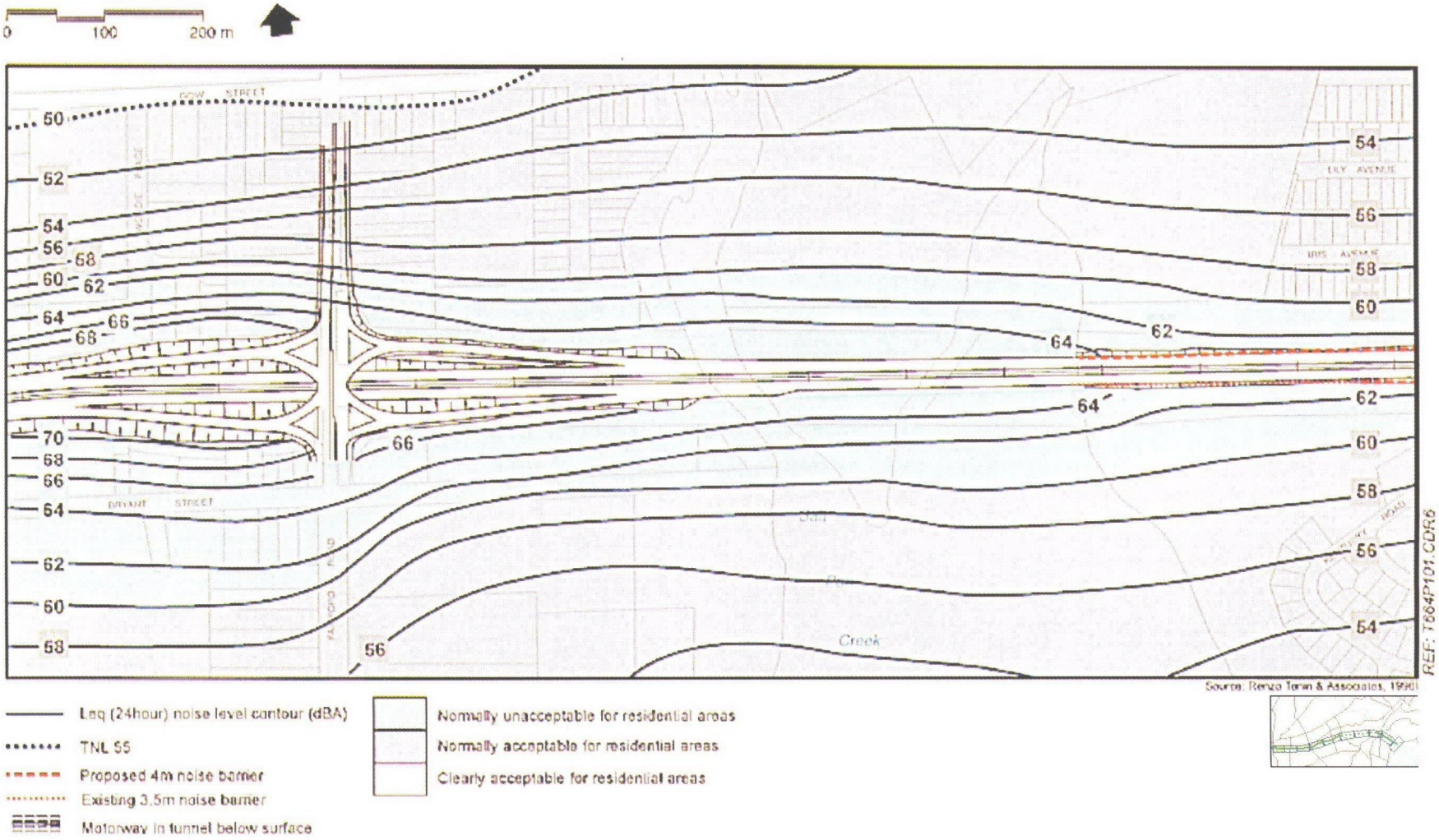


FIGURE 26 — PREDICTED NOISE CONTOURS FROM M5 ONLY

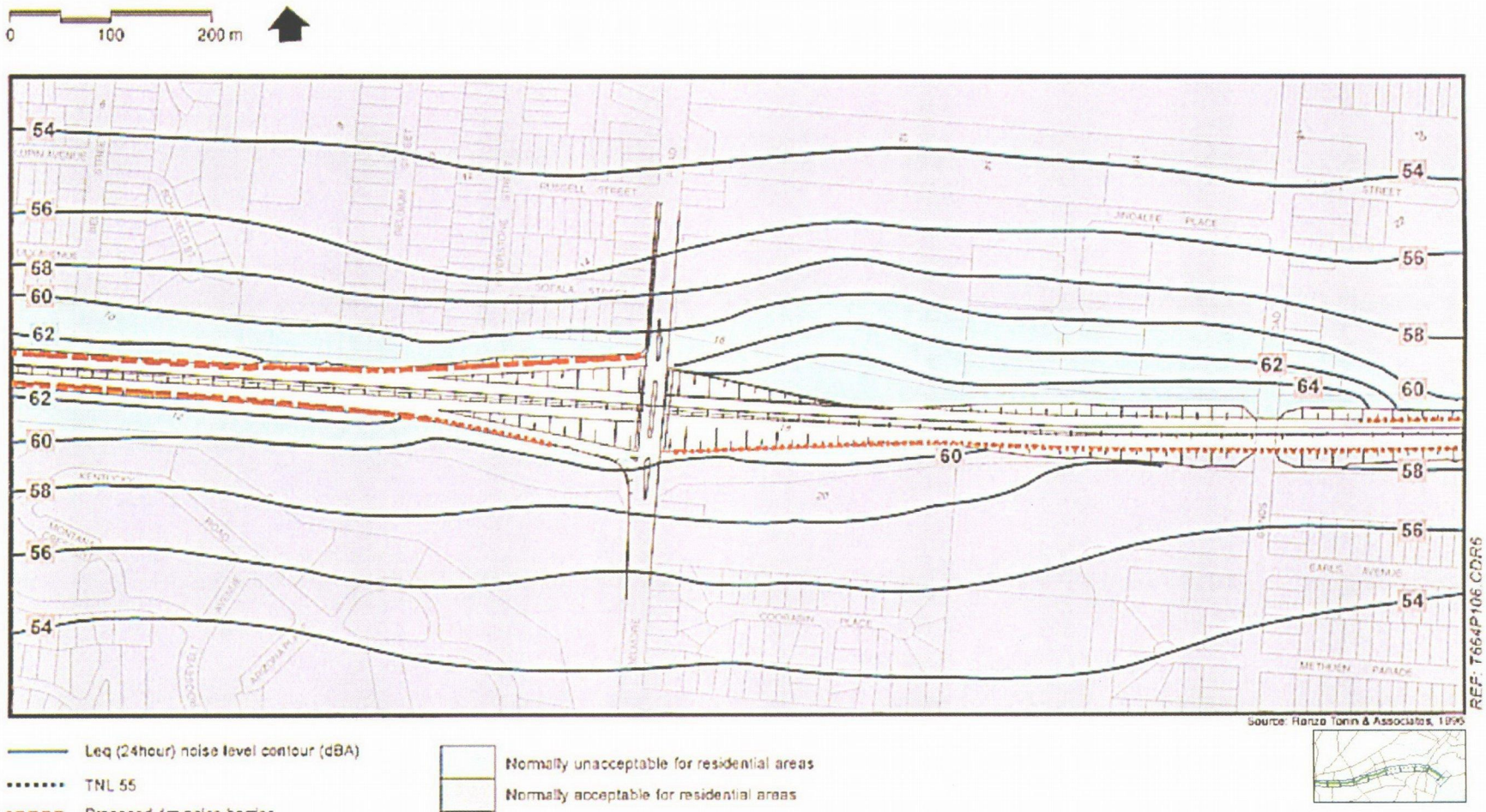


FIGURE 27 — PREDICTED NOISE CONTOURS FROM M5 ONLY

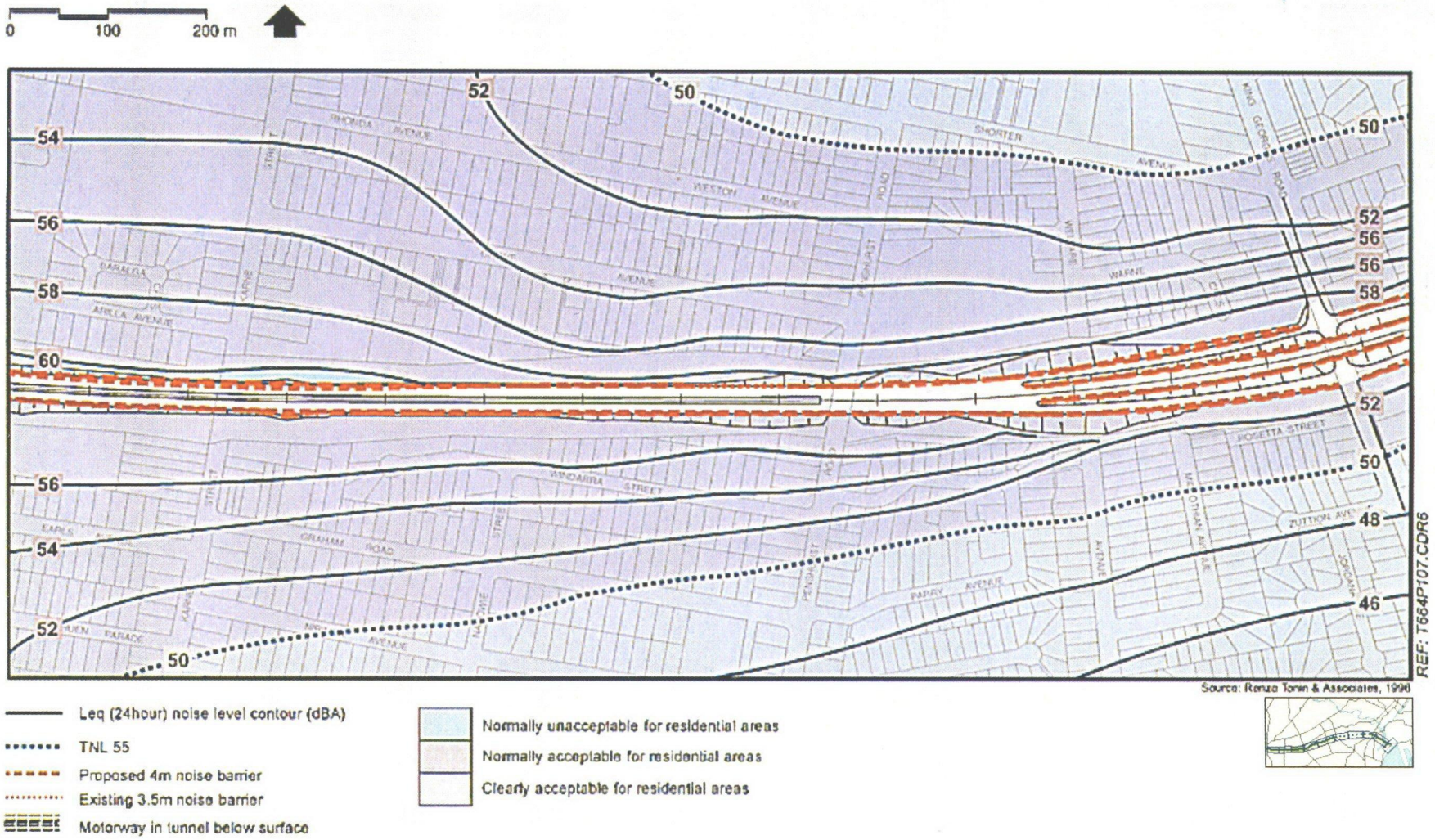


FIGURE 28 — PREDICTED NOISE CONTOURS FROM M5 ONLY

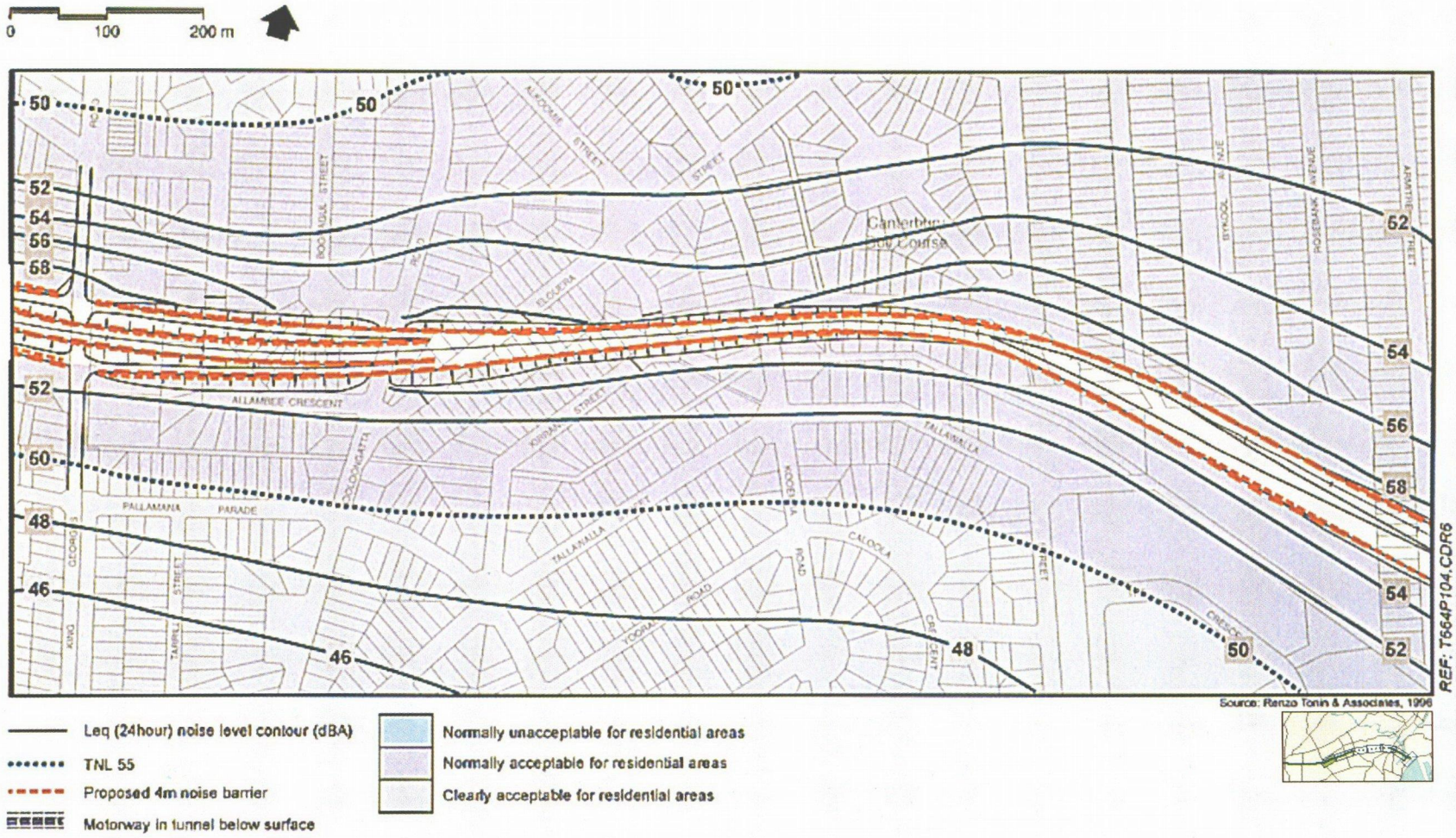


FIGURE 29 — PREDICTED NOISE CONTOURS FROM M5 ONLY

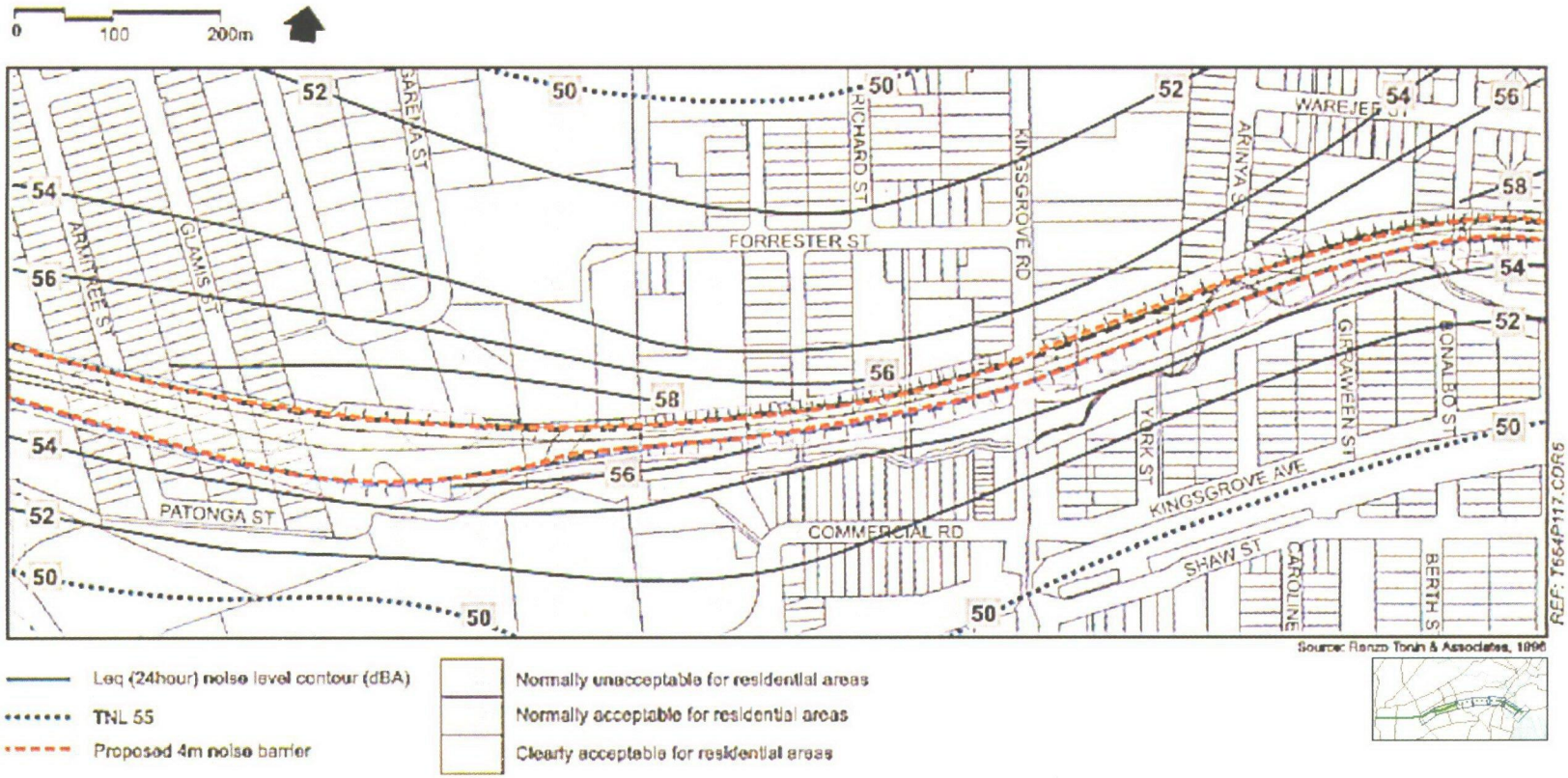


FIGURE 30 — PREDICTED NOISE CONTOURS FROM M5 ONLY

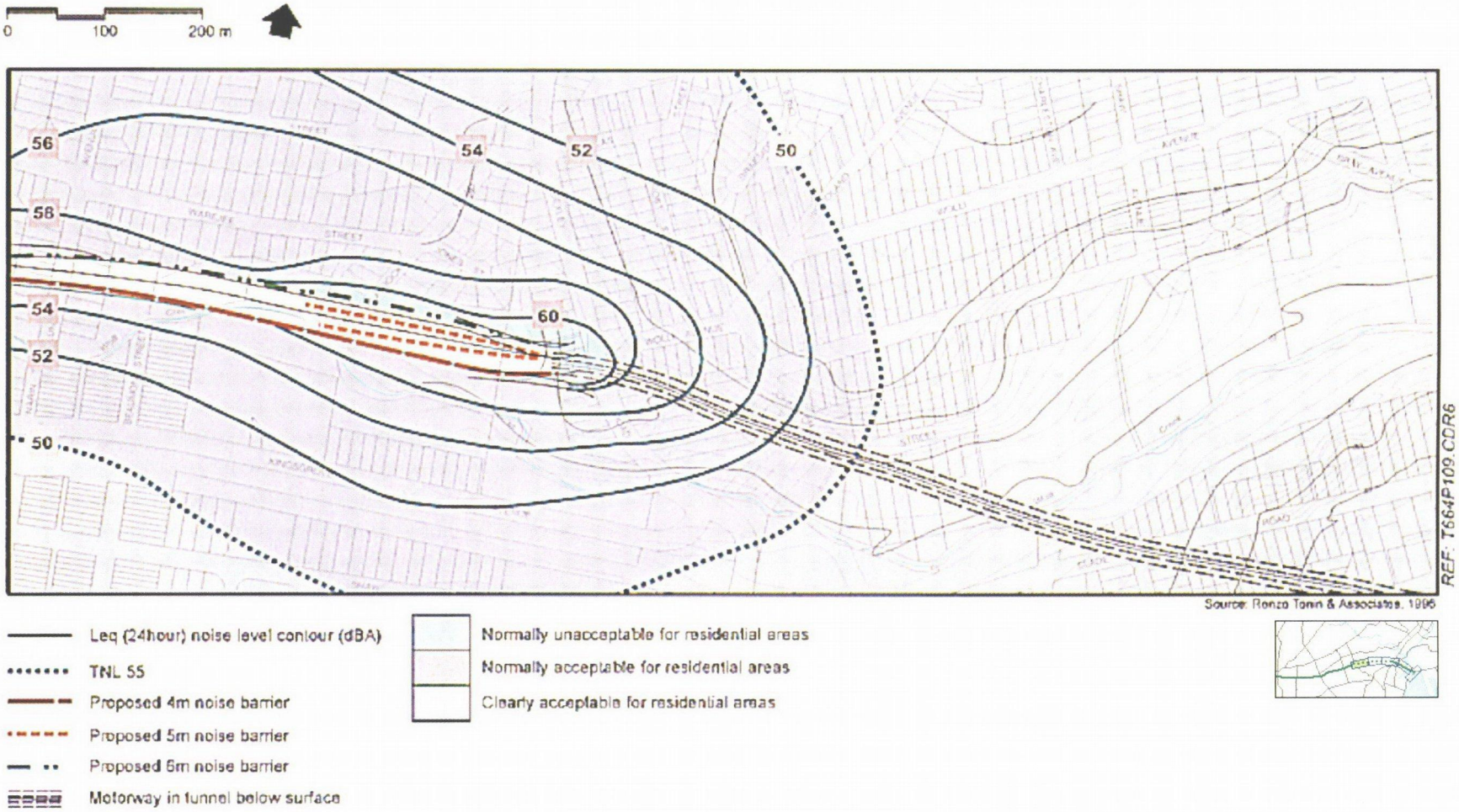


FIGURE 31 — PREDICTED NOISE CONTOURS FROM M5 ONLY

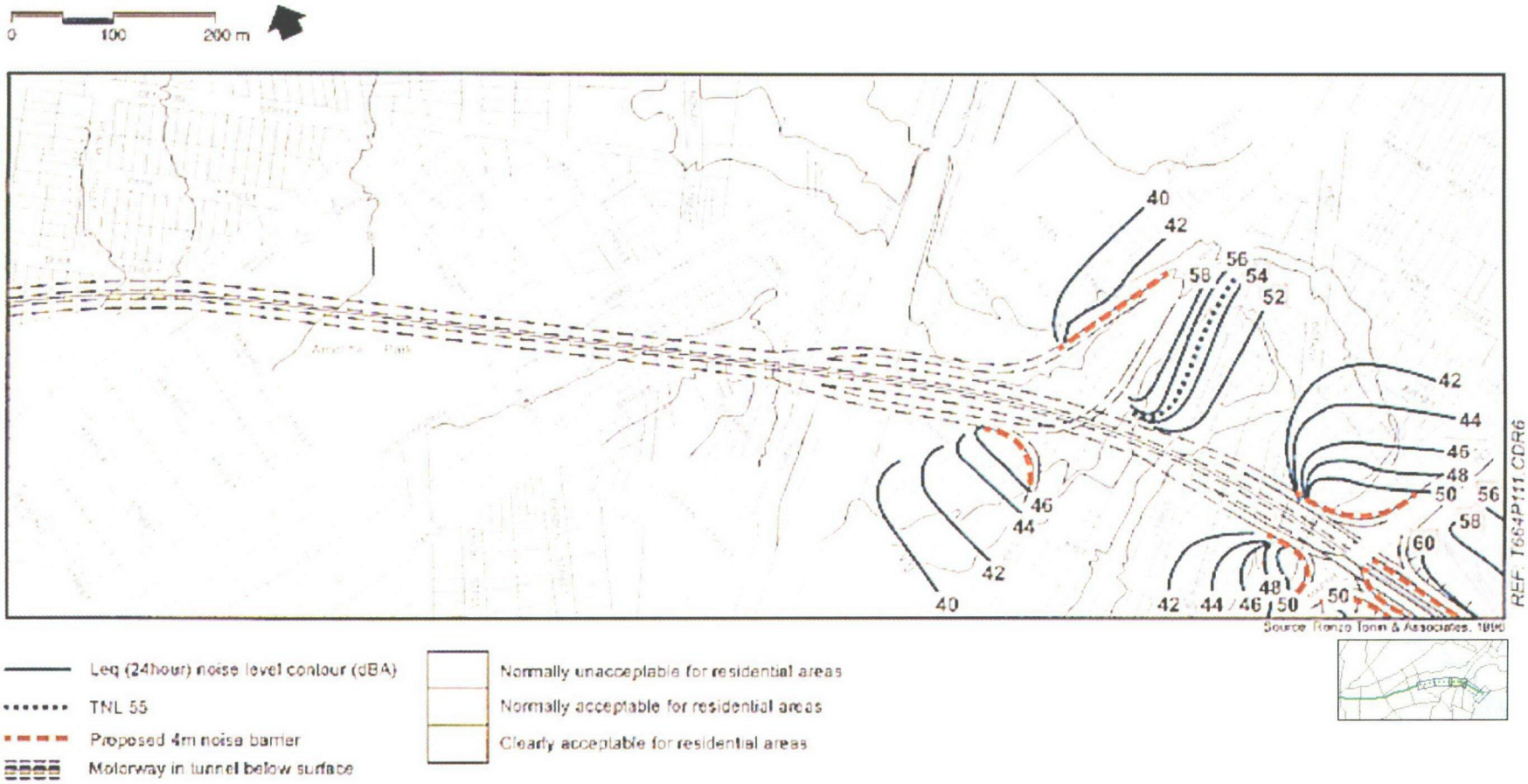


FIGURE 32 — PREDICTED NOISE CONTOURS FROM M5 ONLY

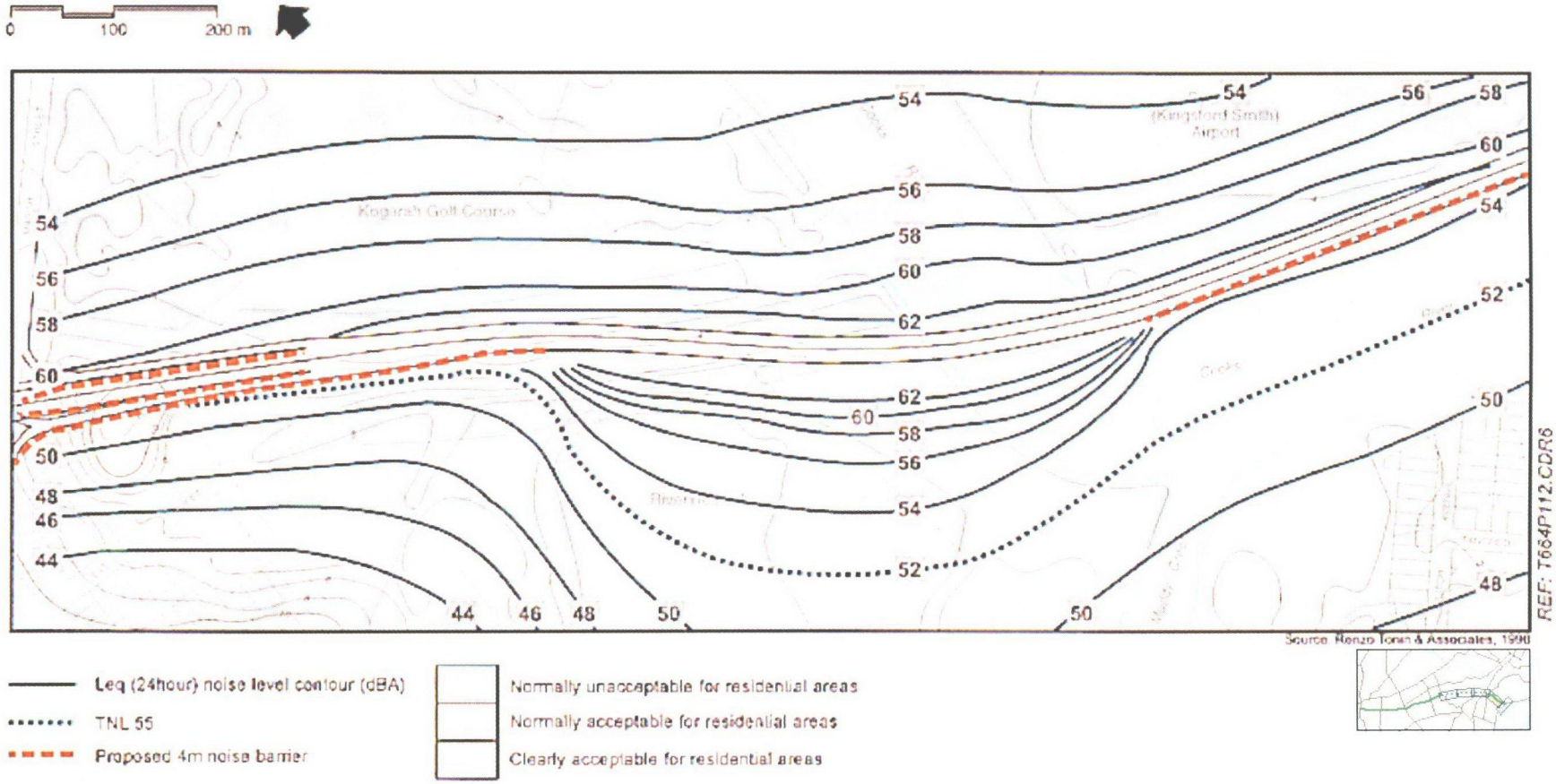


FIGURE 33 — PREDICTED NOISE CONTOURS FROM M5 ONLY

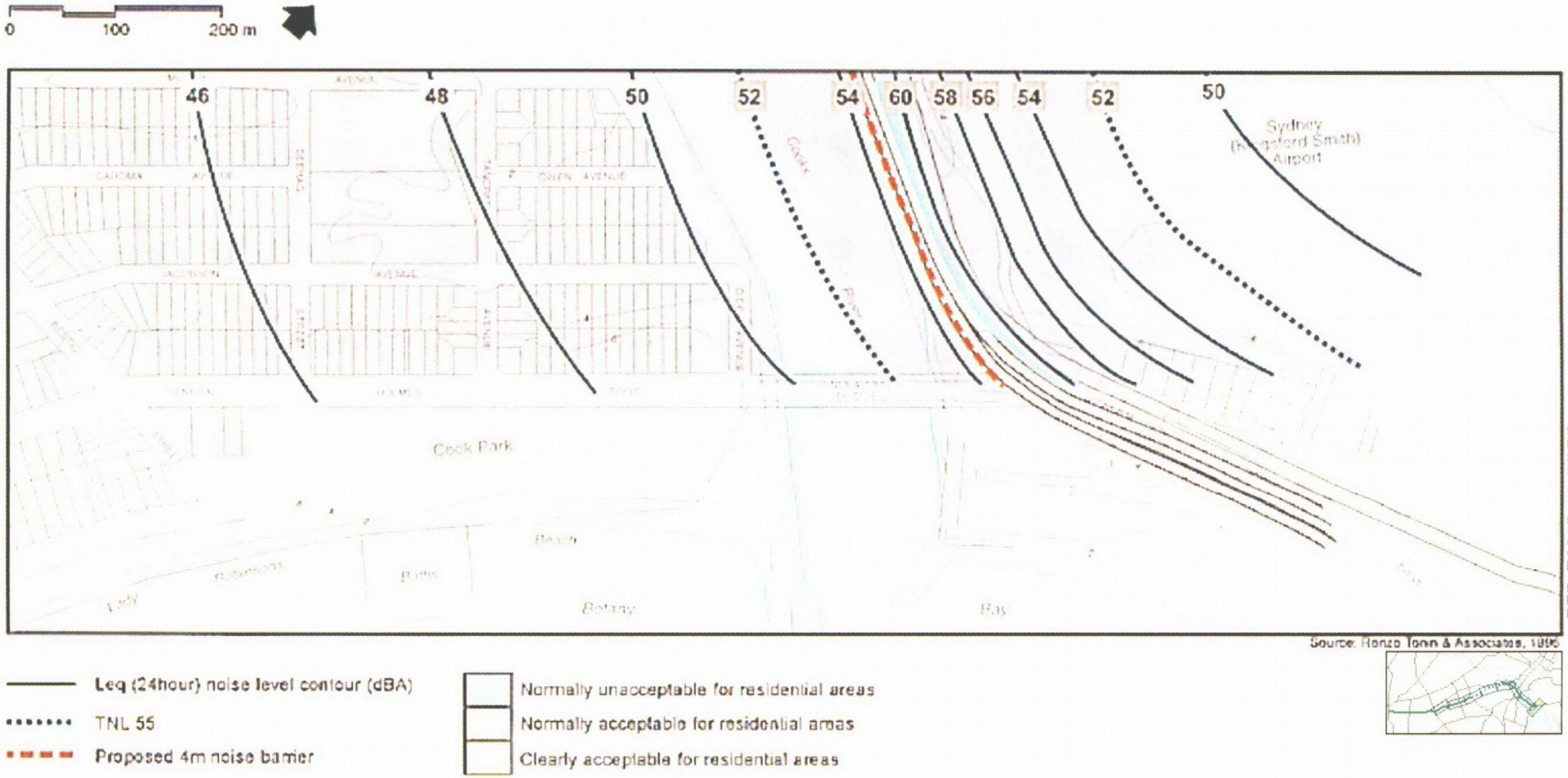


FIGURE 34 — PREDICTED NOISE CONTOURS FROM M5 ONLY

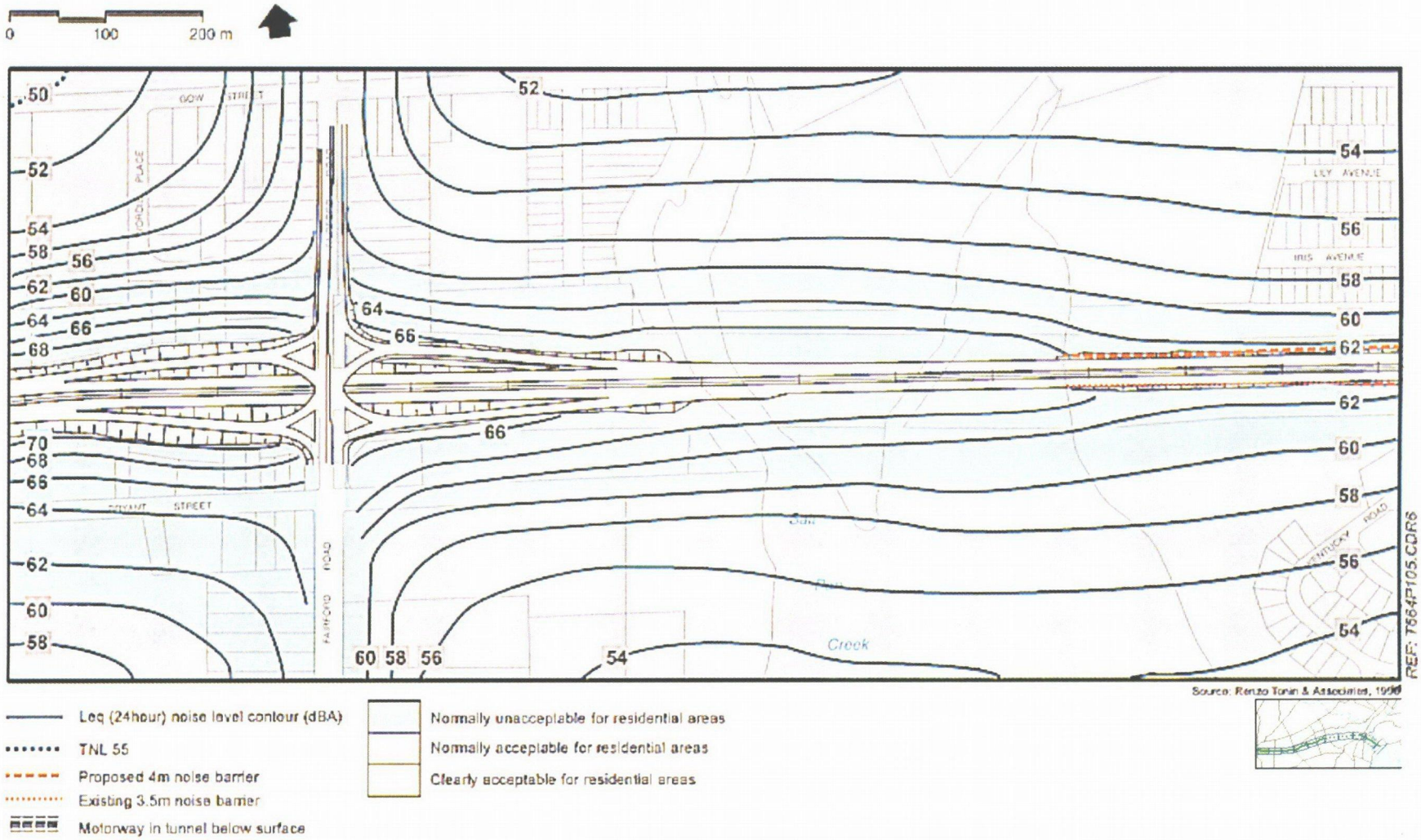


FIGURE 35 — PREDICTED NOISE CONTOURS FROM M5 ONLY

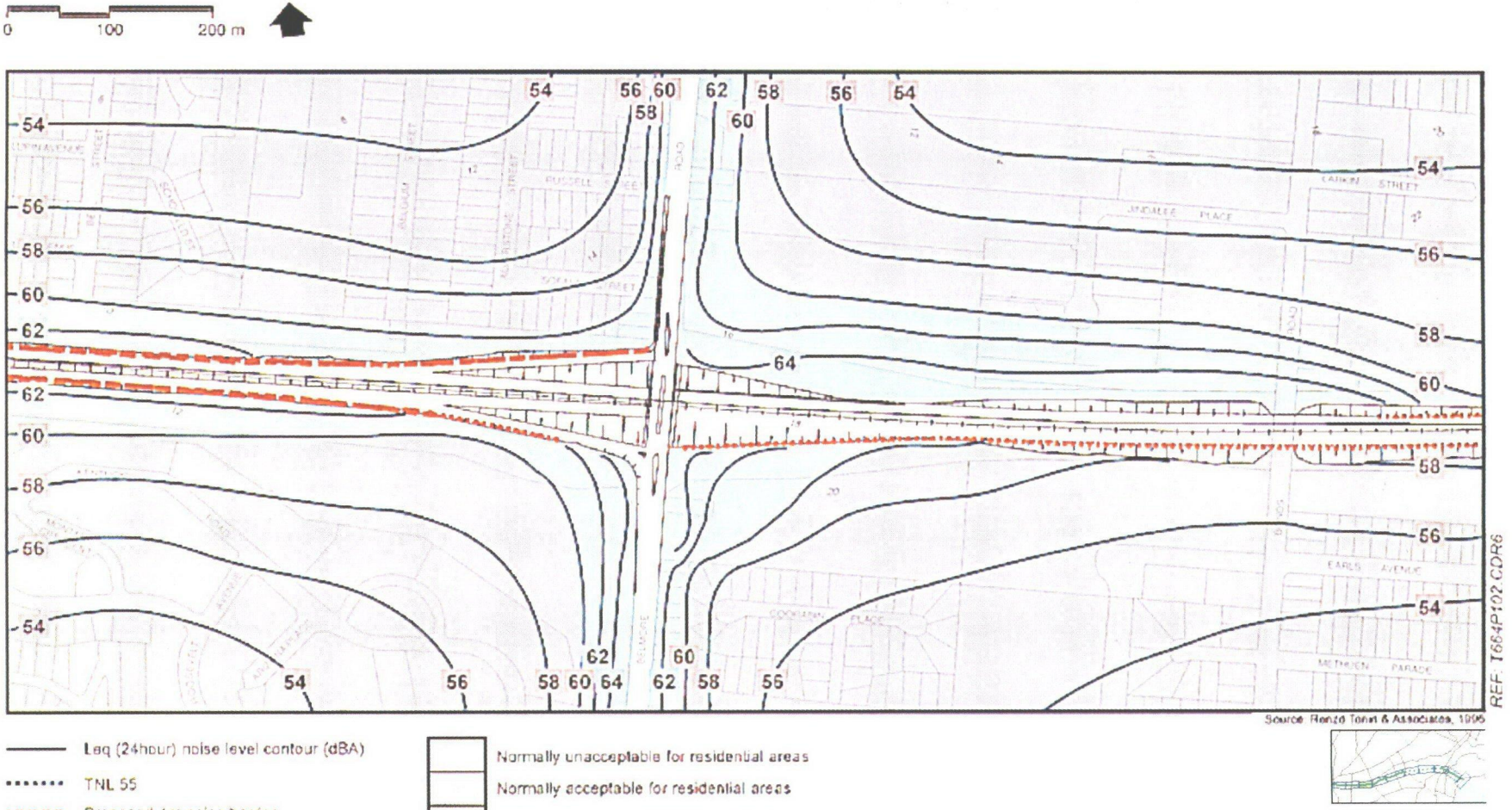


FIGURE 36 — PREDICTED NOISE CONTOURS FROM M5 & ADJOINING ROADS

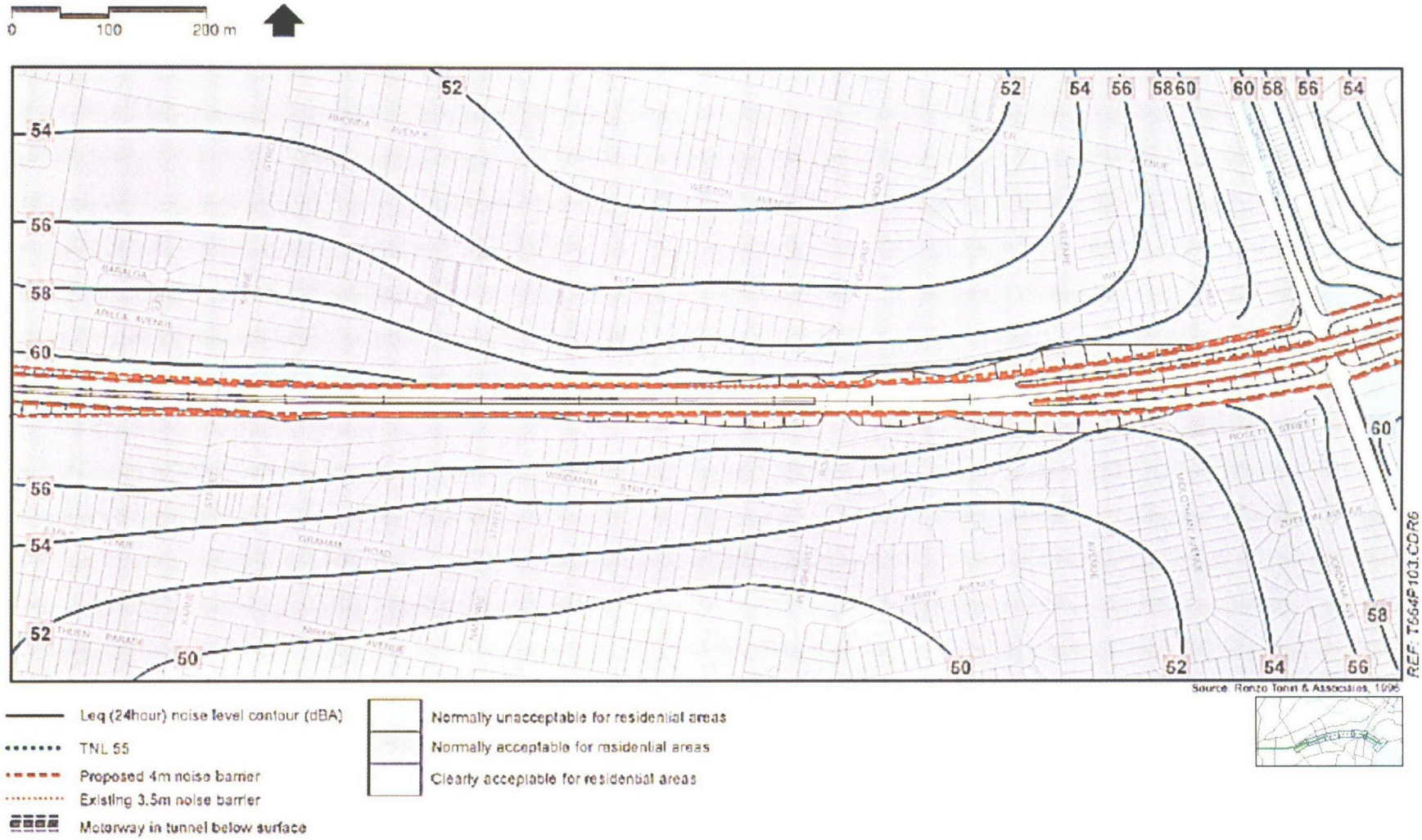


FIGURE 36 — PREDICTED NOISE CONTOURS FROM M5 & ADJOINING ROADS

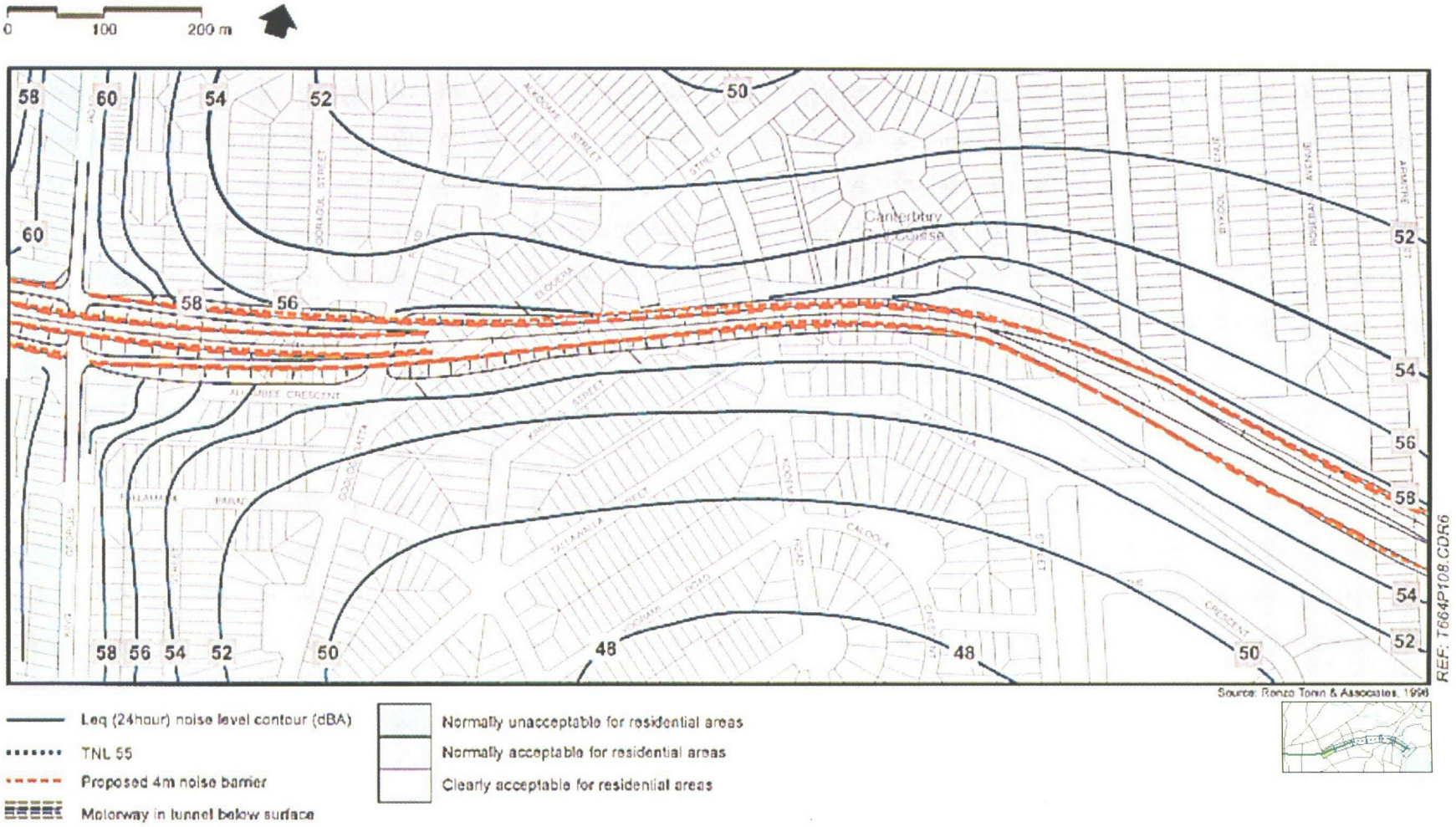


FIGURE 37 — PREDICTED NOISE CONTOURS FROM M5 & ADJOINING ROADS

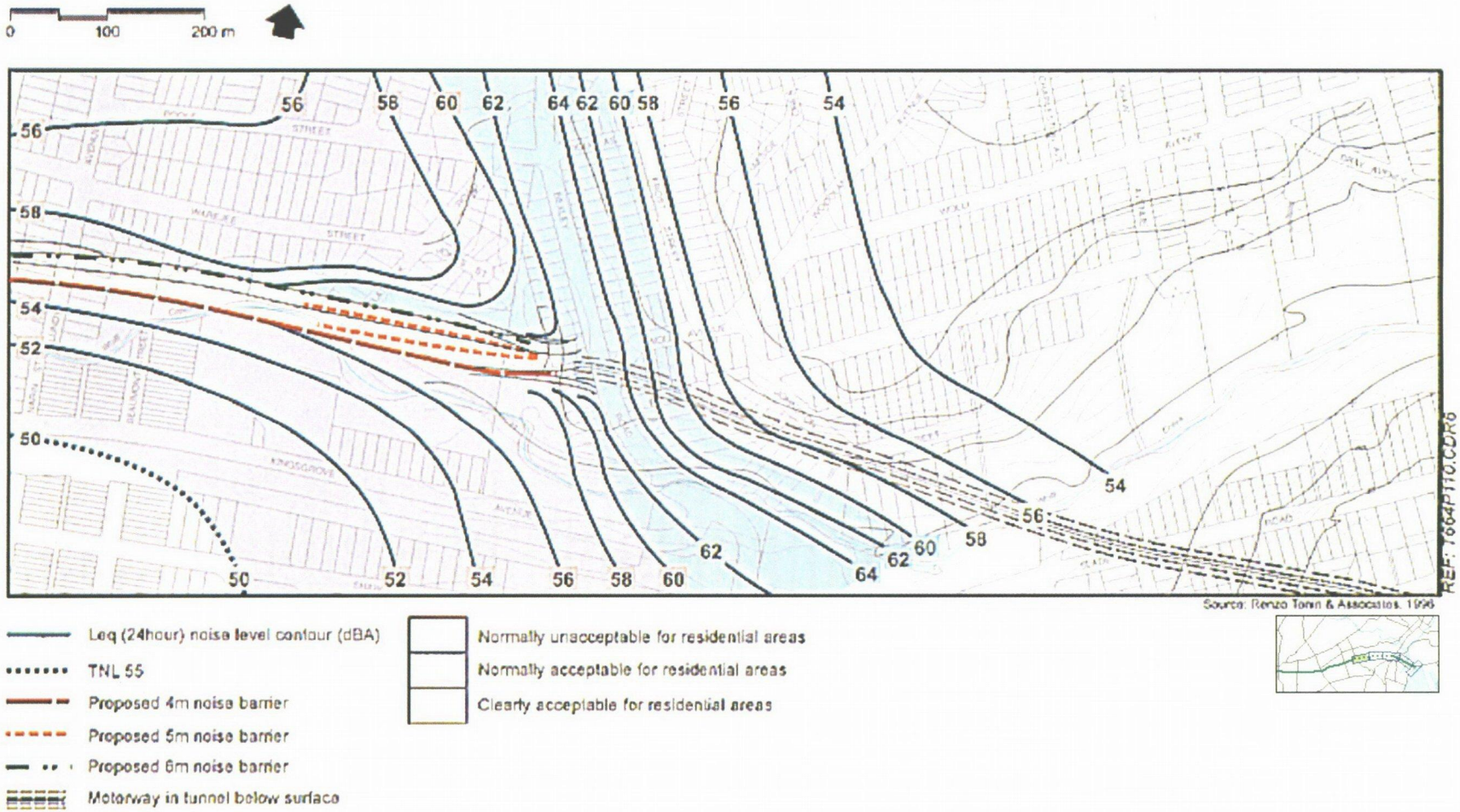


FIGURE 38 — PREDICTED NOISE CONTOURS FROM M5 & ADJOINING ROADS

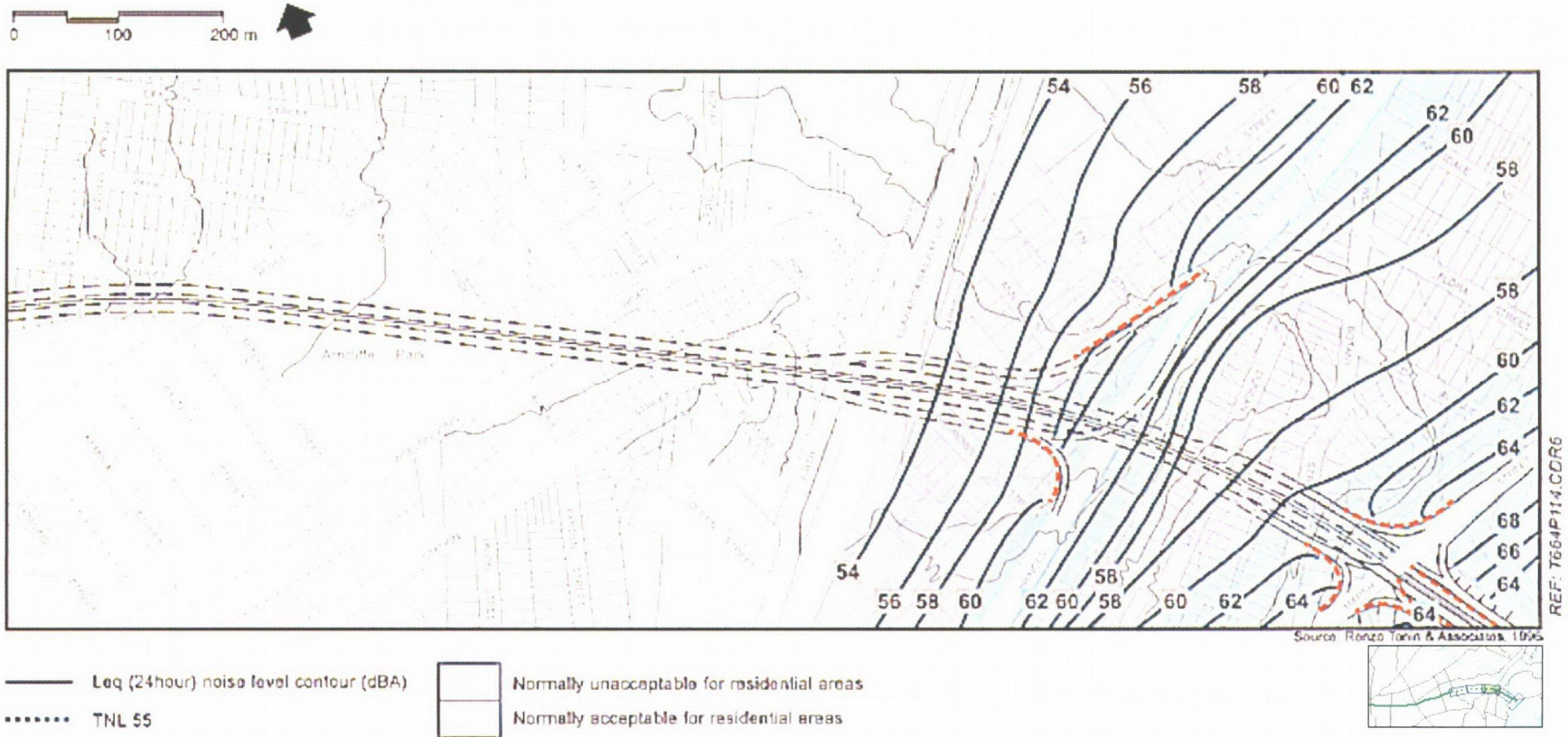


FIGURE 40 — PREDICTED NOISE CONTOURS FROM M5 & ADJOINING ROADS

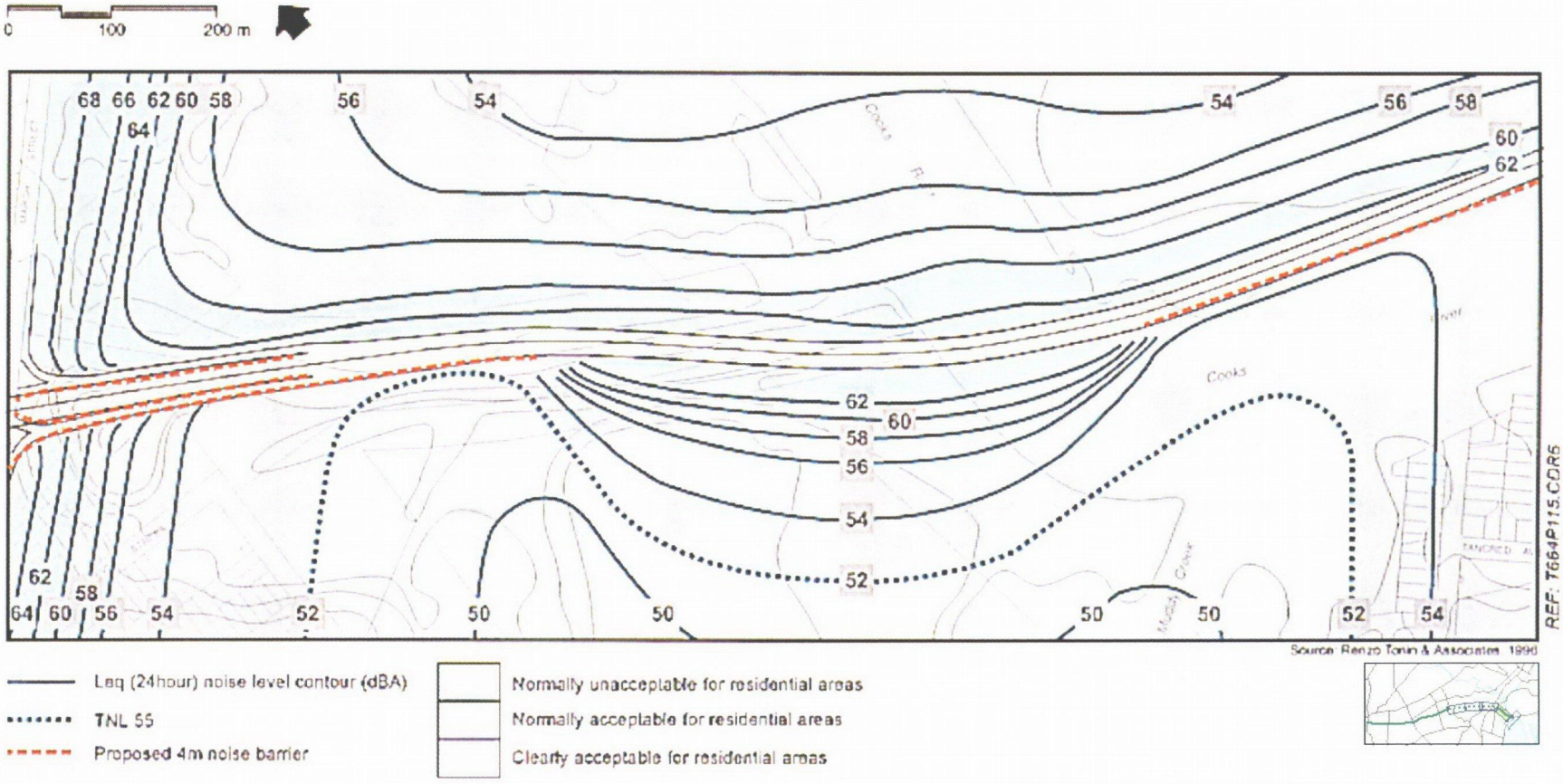


FIGURE 41 — PREDICTED NOISE CONTOURS FROM M5 & ADJOINING ROADS

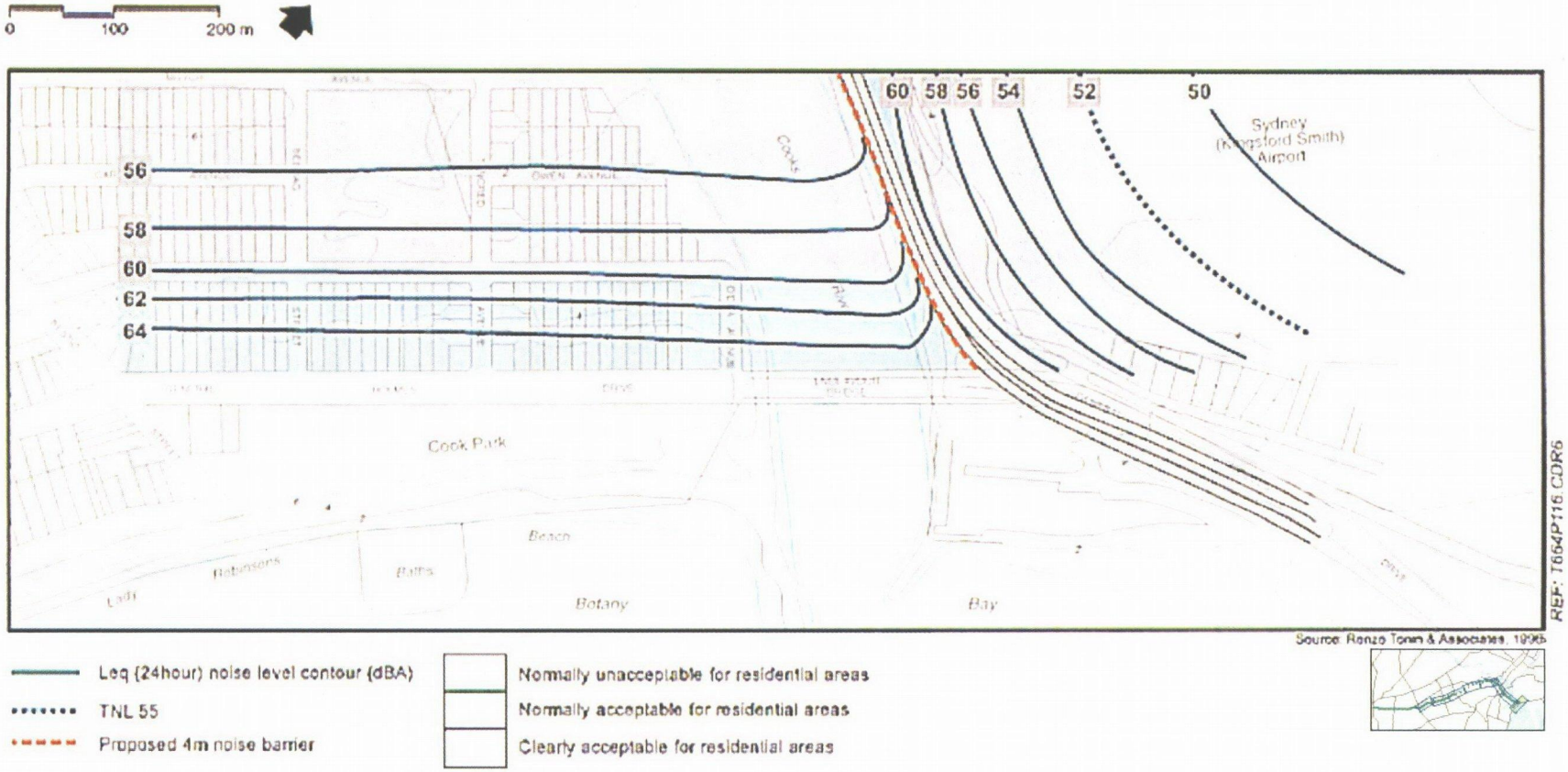


FIGURE 42 — PREDICTED NOISE CONTOURS FROM M5 & ADJOINING ROADS

acceptable noise range. Further from the proposed motorway, a significant portion of residential areas would be within the clearly acceptable noise range. Predicted noise levels would meet the RTA's noise objectives at all residences. The heights and extent of noise barriers in this section of the motorway remain unchanged from those described in the 1994 M5 East EIS, with the exception of extending the length of the western bound noise barrier along the proposed motorway near chainage 5200 to 5300.

At the western portal, the proposed height of barriers would be raised slightly from those described in the 1994 M5 East EIS to ensure all residences close to the tunnel portal would be within the normally acceptable noise range.

- **Princes Highway Ramps to General Holmes Drive**

  Noise levels close to the proposed ramps connecting the tunnel to Princes Highway would be insignificant compared with existing noise from the Princes Highway. A number of multi-storey buildings are located near the ramps. The upper storeys of some of these buildings directly face both the proposed M5 East Motorway tunnel ramps and the Princes Highway. The proposed noise barriers would ensure that vehicle noise from the proposed ramps and tunnel would be within the normally acceptable to clearly acceptable range for residences.

  Two residential zones exist in the Marsh Street to General Holmes Drive section of the route. The residential zone located in the vicinity of Eve Street (Arncliffe) would have normally acceptable noise levels with four metre noise barriers at the ramps and tunnel portal. Noise in this precinct would arise predominantly from the existing traffic network.

  Traffic noise from the proposed motorway to the residences situated in the north-east of Kyeemagh would be adequately shielded by a noise barrier along the westbound side of the motorway on the northern side of Cooks River. The noise environment in this area is significantly affected by existing General Holmes Drive traffic noise.

Schools

In respect of noise from the proposed motorway, the nearest and potentially worst affected schools would be Hannans Road Primary School (Riverwood), Beverly Hills Public School, Kindergarten in Walker Street (Turrella), Arncliffe West Public School and Kyeemagh Public School. The effect of noise attenuation with distance and the use of barriers installed for residential noise control purposes would ensure that vehicle noise from the motorway at all schools would be significantly less than the Leq (1hour) 55

dB(A) acceptable level for schools. Schools not identified above are considered to be unaffected by the proposed motorway.

Community Facilities

Given that community halls and places of worship in the vicinity of the proposed motorway are in all cases located near residential properties, M5 traffic noise to such communal facilities would be controlled to acceptable levels by virtue of the noise control treatment required for the more critical adjacent residences.

Traffic noise from the proposed motorway alterations and extensions potentially affects community urban parklands as identified below. The noise impact from the proposed roadway upon each of the aforementioned facilities was assessed and the degree of impact is described below.

- **Fairford Road to King Georges Road**

  Salt Pan Creek Reserve is partially protected by 4 metre noise barriers, and noise levels in this area are generally less than Leq (24hour) 62 dB(A). Reserve areas without noise barriers are predicted to have noise levels greater than Leq (24hour) 64 dB(A).

  McLaughlin Oval is protected from motorway noise by a barrier and would generally experience noise levels less than Leq (24hour) 58 dB(A). No barriers are proposed for Rotary Park - noise levels are predicted to be slightly higher than Leq (24hour) 64 dB(A).

  Lance Hutchinson Oval and Bland Oval are shielded by noise barriers, and so are predicted to generally experience noise levels less than Leq (24hour) 58 dB(A).

  Bennett Park and John Mountford Reserve are both predicted to generally experience noise levels less than Leq (24hour) 56 dB(A), due to the proposed 4 metre noise barriers along this section of the motorway.

- **King Georges Road to General Holmes Drive**

  Canterbury Golf Course is shielded by a proposed 4 metre barrier along the motorway so that the entire course would experience noise levels significantly less than Leq (24hour) 60 dB(A).

  Beverly Grove Park, Kingsbury Reserve and Kingsgrove Avenue Reserve are also shielded by proposed 4 metre barriers along the motorway. Noise levels are predicted to be significantly less than Leq (24hour) 60 dB(A).

  Kogarah Golf Course, Riverine Park and Barton Park would all experience noise levels less than Leq (24hour) 60 dB(A). Certain pockets of these urban park areas, closest to the motorway and unprotected by noise barriers, are predicted to have noise levels greater than Leq (24hour) 62dB(A).

The Arncliffe and Kyeemagh Bowling Club Greens are predicted to experience noise levels significantly less than Leq (24hour) 60 dB(A).

Indirect noise impacts

Indirect noise impacts are those effects originating from roads other than the motorway, comprised of regional and local effects (see **Section 19.3.2** of the 1994 M5 East EIS). Indirect noise impacts are unchanged from the 1994 M5 East EIS.

Tunnel ventilation plant noise

The criteria and method for assessing the impacts of the tunnel ventilation system are the same as those used in the 1994 M5 East EIS.

As a result of the increased length of the tunnel in this proposal, three exhaust stacks and three air intakes are required. Assessment of the impacts of the selected tunnel exhaust stacks and intake locations are presented below.

The proposed design limits for the fan noise emissions from tunnel exhaust stacks and tunnel air intake vents are shown in **Table 13**. The minimum existing L_{90} background noise levels expected during critical night-time and early morning hours for each location are also presented in the table.

TABLE 13 — DESIGN LIMITS FOR TUNNEL EXHAUST STACKS & AIR INTAKE VENTS

Location	Existing Background Noise Levels L_{90}	EPA Planning Limit dB(A) L_{90}	Adopted Design Criteria dB(A) L_{10}
Arncliffe Street, Army Reserve Depot	32	35	32
Royal Place, Bardwell Park	30	35	34
Duff Street, Arncliffe	32	35	32

EPA noise penalties are applied to the above proposed design limits to account for undesirable characteristics such as tonal noise components, and intermittent or impulsive operation. The presence of any of these characteristics would need to be assessed pending the final selection of the ventilation plant.

7.2.5 'UNDERPASS' OPTION AT KING GEORGES ROAD – PREDICTED NOISE IMPACT

The option of constructing the King Georges Road interchange as an underpass rather than an overpass was considered in detail. In summary, the results reveal that noise emission from the motorway at the interchange

resulting from the underpass option would be greater than for the overpass option.

The reason for this lies partly in the increased noise attenuation which would be afforded by the higher barriers located along the sides of an elevated motorway, and also an increase in noise expected from reflections associated with the underpass option.

To ensure that all residences close to the interchange would be within the normally acceptable range for the underpass option, the eastbound traffic noise barriers would need to be increased in height from 4 metres to 6 metres. Furthermore, the height of the westbound traffic noise barriers would also need to be raised from 4 metres to 4.5 metres.

7.2.6 IMPACT OF CONSTRUCTION NOISE AND VIBRATION

The impact of construction noise and vibration would essentially be unchanged from that identified in the 1994 M5 East EIS, with the exception of the extent of tunnelling work proposed. Reference is also made to **Chapter 8** in the Renzo Tonin & Associates 1994 Working Paper for the 1994 M5 East EIS, where construction noise and vibration impact to residences was assessed. Included below is additional information pertaining to construction noise and vibration impact.

CONSTRUCTION NOISE

Actual construction noise levels would depend on the contractor's construction program, types and duration of operations being undertaken and the location of residences. In the absence of mitigative measures, construction noise levels may exceed the relevant noise objectives when noisy plant operates for long periods near residences. This indicates that mitigative measures would be required in these instances. Construction noise and vibration would be dealt with fully in a Noise Management Plan as part of the Environmental Management Plan, and would be approved by the EPA as part of its approval and licencing process.

Few options are available for controlling noise from this type of construction. Measures described here would be implemented where and when necessary. Residents would be informed that construction is to take place and is likely to generate relatively high noise levels at times. Traffic noise barriers would be built as soon as possible during the construction period to assist in mitigating any potential construction noise impacts. All construction work would be licensed by the EPA, whose approval would be sought prior to construction.

Where it is necessary to complete some construction activities outside of normal construction hours (eg at night, on weekends and on public holidays), the objectives below are applicable. It is possible that

construction activity outside of normal hours may be proposed for an extended period at some locations, and isolated night-time activity may also be proposed at other locations. These hours and places of work would be subject to EPA approval.

More stringent guidelines must be applied to night construction activities due to the greater potential for adverse noise impact. As the Environment Protection Authority does not have specific guidelines published for assessing construction noise impact outside normal construction hours, the guidelines set out here are proposed for assessing the audibility of permanent noise sources (eg industrial noise).

As a result, the following noise objectives may be used to assess the noise impact of construction activity conducted outside normal hours:

- L_{10} noise level should not exceed the L_{90} background noise level by more than 5dB(A) at neighbouring residences.
- L_1 noise level should not exceed the L_{90} background noise level by more than 15dB(A) at neighbouring residences, and where the L_1 objective equates to a noise level less than 65dB(A), then a 65dB(A) noise objective may be adopted between the hours of 10.00 pm and 7.00 am.

VIBRATION RESULTING FROM TUNNEL CONSTRUCTION

Criteria

The effects of ground vibration on buildings resulting from construction may be segregated into the following three categories:

1. Disturbance to building occupants - vibration in which the occupants or users of the building are inconvenienced or possibly disturbed,
2. Effects on building contents - vibration where the building contents may be affected, and
3. Effects on building structures - vibration in which the integrity of the building or structure itself may be prejudiced.

In general, vibration criteria for human disturbance (1, above) are more stringent than vibration criteria for effects on building contents (2) and building structural damage (3). Hence, compliance with the more stringent limits dictated by Category 1, would ensure that compliance is also achieved for the other two categories.

The typical perceptibility of humans to continuous vibration is indicated in **Table 14** below.

TABLE 14 — VIBRATION LEVELS AND HUMAN PERCEPTION

Approximate Vibration Level	Degree Of Perception
0.10 mm/s	Not Felt
0.15 mm/s	Threshold of Perception
0.35 mm/s	Barely Noticeable
1.0 mm/s	Noticeable
2.2 mm/s	Easily Noticeable
6 mm/s	Strongly Noticeable
14 mm/s	Very Strongly Noticeable

Note: These approximate vibration levels (in floors of buildings) are for vibration having a frequency content in the range 8 Hz to 80 Hz.

Although people are able to notice relatively low vibration levels, it is not appropriate to base vibration emission limits on this basis. Section 174 of the Environment Protection Authority's "Environmental Noise Control Manual", Australian Standard AS 2670.2-1990 and British Standard BS 6472:1992 provide guidance on potential disturbance to persons exposed to building vibration in the frequency range produced by most excavation processes.

Section 4.1 of BS 6472 recommends that in the case of excavation and construction projects, higher vibration levels may generally be acceptable because the activities are seen to be of a temporary nature. Very short duration vibration events (eg vibration from blasting), could be permitted to cause somewhat higher levels, depending on vibration frequency content and on the specific susceptibility of particular objects and their location.

To limit vibration induced noise (or structureborne noise as it is called), inside residences during the evening and night, the noise levels recommended in AS 2107-1987 "Acoustics - Recommended Design Sound Levels and Reverberation Times for Building Interiors", may be adhered to. Suitable night-time structureborne noise criteria are therefore 35 dB(A) for bedrooms and 40 dB(A) for general living areas.

Impact

Vibration can be "continuous" or "intermittent". By continuous is meant vibration that is present for long periods of time, for example vibration from vibratory compactors, tunnel boring machines or road headers. Intermittent vibration results from impulsive sources such as rock breaking, piling or blasting. In general, continuous vibration criteria are more stringent than intermittent vibration criteria.

Vibration associated with rock breakers is significantly higher in level than from large road headers, due to the nature of their operation. That is, a road header tends to grind away rock, whereas a rock breaker engages in impulsive activity to break away rock.

The depth of the tunnels is proposed to vary from only a few metres at both the western and eastern portal ends to over 40 metres below ground level. In general, the tunnels would be so deep below the surface of the ground, that vibration from construction would be inconsequential to residences immediately above.

Based on typical ground vibration levels during tunnel construction work, it is predicted that the aforementioned daytime criteria for continuous vibration would be exceeded within the following approximate distances:

- heavy rock breaker within 30 metres
- light rock breaker within 15 metres
- large road header within 10 metres.

Out of the entire tunnel construction operations, vibration is likely to be most noticeable in the vicinity of the western portal (Bexley Road), the Wolli Creek area (Johnston Street and Slade Road), Bardwell Creek area (Bardwell Road and Shepherd Parade) and east of the Illawarra line to the Princes Highway and Marsh Street portals, for the duration of construction activity in the sections of tunnels immediately below.

Structureborne noise on the ground floor of nearby buildings would at times be clearly audible to residents. The actual noise levels and degree of audibility would vary depending on many site specific factors including the type of equipment used, position of tunnelling equipment with respect to each building, intervening ground structure, building design and background noise inside the building.

Prior to work commencing in those areas, residents and occupants would be informed of the hours of work proposed and the likely effects.

Blasting

Blasting is unlikely to be required. However the details below are provided for completeness.

Should blasting be necessary, the blast charge configuration would be selected to ensure that EPA goals are not exceeded.

The recommended goals for blasting are based on EPA guidelines. These state: "Blasting operations should in most cases be confined to the periods Mondays to Saturdays, 9 am to 3 pm. Blasting outside of those times should be approved only where blasting during the preferred times is clearly impracticable, and should then be limited in number. Blasting at night should be avoided unless it is absolutely necessary."

The following **Table 15** shows the limiting blast over-pressure and ground vibration for the control of blasting impact on residential premises.

In addition, any exceedance above a blast over pressure of 115dB (linear) would be limited to not more than 5% of the total number of blasts. On these infrequent occasions a maximum limit of 120 dB (linear) would not be exceeded at any time.

TABLE 15 — LIMITING CRITERIA FOR THE CONTROL OF BLASTING IMPACT AT RESIDENCES

Day	Time Of Blasting	Blast Over Pressure Level, dB(linear)	Ground Vibration, Peak Particle Velocity (mm/sec)
Monday to Saturday	9am-3pm	115	5
Monday to Saturday	6am-9am, 3pm-8pm	105	2
Sunday, Public Holiday	6am-8pm	95	1
Any day	8pm-6am	95	1

Ground vibrations above 5 mm/sec would also be limited to not more than 5% of the total number of blasts. On these infrequent occasions a maximum limit of 10 mm/sec would not be exceeded at any time.

7.2.7 COMPARISON WITH IMPACTS IN THE 1994 M5 EAST EIS

The Variation is a more favourable option than the 1994 M5 East EIS proposal in respect of traffic noise impact, since the latter would include exposed roadway on a viaduct over Arncliffe.

The total noise impact of the Variation was assessed and compared with that for the extended tunnel option. The noise impact of the Variation ranks effectively equal to that of the extended tunnel option for the tunnelled sections, and would affect a lesser number of residences in Arncliffe and Turrella.

7.2.8 MITIGATIVE MEASURES

The Roads and Traffic Authority would ensure that the following mitigative measures are undertaken:

RESIDENCES

From Fairford Road to West of Bexley Road, there would be no change from the 1994 M5 East EIS. Noise barriers of 4 or 5 metres would be constructed as indicated in the 1994 M5 East EIS. Where existing noise barriers are 3.5 metres high, the nearby residences are within the normally acceptable noise range. The cost and difficulty of constructing new walls to a marginally greater height is therefore considered unwarranted.

At the western portal the heights of barriers are proposed to be slightly elevated with respect to those described in the 1994 M5 East EIS to ensure all residences close to the tunnel portal are within the normally acceptable noise range. The increase is from 4 metres to 5 metres on both sides of the motorway, where the barriers are shown to be acoustically absorptive. Also the 5 metre noise barrier along the northern side of the off ramp is proposed to be increased to 6 metres.

The only other change to the proposed noise barriers from the 1994 EIS is between Marsh Street and General Holmes Drive, where a 4 metre noise barrier would be installed along the westbound side of the motorway on the northern side of Cooks River, extending to Endeavour Bridge. This proposed noise barrier is predicted to reduce motorway noise to within the clearly acceptable range for residences on the other side of the river.

Schools and community facilities

No mitigative measures are necessary for schools and community facilities, as in all cases they are located near or amongst residential properties, where by virtue of the noise control treatment required for the more critical adjacent residences, traffic noise from the proposed M5 East motorway would be controlled to acceptable levels.

Tunnel ventilation plant

The Roads and Traffic Authority would ensure that the same mitigative measures as required in 1994 M5 East EIS would be adopted in the detailed design of the Variation. They are:

- Mounting absorptive silencers on the intake and discharge of the air supply and exhaust fans.
- Placing sound rated enclosures around the supply fans located within the tunnel. The other fans would be located in underground plant rooms.
- Using vibration isolation mounts for ventilation fans to reduce vibration from the plant to levels too low to be detectable at residences.
- Selecting any constrictions to the tunnel (for example, mesh on inlets) so as not to create excessive noise generated by the flow of air.

Construction noise

The Roads and Traffic Authority would ensure that the same mitigative measures as required in the 1994 M5 East EIS would be adopted in the construction of the proposed motorway. They are set out in **Appendix I** of the 1994 M5 East EIS. Reiterated below are the main construction noise objectives and mitigative measures, and also included is additional information about construction noise.

The Roads and Traffic Authority would require the contractor to use the best available practical techniques and to restrict the hours during which construction activities are carried out to between 7 am and 6 pm, Monday to Friday and 8 am to 1 pm on Saturdays. No work would be permitted on Sundays or public holidays. Where work outside these hours would be necessary due to traffic and safety requirements, construction program constraints, tunnelling operations or other activities, the approval of the Environment Protection Authority would be sought as to the appropriate conditions for the work.

It is envisaged that a letterbox drop would notify any affected residents of the work. No deliveries of materials, running of plant or equipment or on-site maintenance of plant or equipment would be permitted outside these hours unless approved by the Environment Protection Authority. The background (L_{90}) noise levels during this period would be used to set criteria for construction noise levels.

The EPA specifies conditions on the construction work to ensure that the most appropriate available techniques are used and the proposed equipment meets modern noise emission standards. To assist the EPA in identifying conditions for this project a Noise Management Plan would be prepared and incorporated into the Environmental Management Plan to be agreed to by the EPA before construction proceeds. The following environmental management measures would be taken to minimise temporary noise impacts during construction:

- The contractor(s) would be required to prepare a detailed construction noise assessment showing predicted noise levels at critical locations and the mitigative measures proposed. The construction methods and noise control measures adopted would be the most appropriate available and the proposed equipment would meet relevant standards required by the EPA.
- Construction noise would conform to EPA requirements.
- Community liaison - leaflets and information would be distributed prior to the commencement of construction work informing potentially affected residents of the type, expected noise emissions, times and duration of any construction work. Any community queries, concerns or complaints regarding noise and vibration would also be addressed.
- Silenced equipment - the quietest construction equipment would be selected and where possible residential class mufflers would be used. Noise control kits would be fitted to noisy mobile equipment and shrouds provided around stationary plant. Noise compliance tests for all major equipment used on site would also be undertaken.
- Equipment maintenance and operation - all plant and equipment would be inspected to ensure that it is in ideal running order, regularly maintained and free of defective components to minimise noise emissions.
- Equipment location - noisy plant and equipment would be located as far as possible from noise sensitive areas, optimising attenuation effects from topography, natural and purpose built barriers and materials stockpiles.
- Project planning and erection of barriers - construction would be programmed so that noise barriers or mounding required to control traffic noise would be built as soon as possible. Temporary noise barriers would be erected if necessary.

- Working hours restriction - the hours of operation of particularly noisy equipment would be restricted. Work outside normal hours would only be carried out in special circumstances and after liaison with Councils, the EPA and the local community.
- Construction vehicle movements - construction vehicle movements would be along the main roads surrounding the proposed motorway to access the construction sites wherever possible. Local streets are only to be used when necessary and night-time impact is to be minimised.
- Prior to work commencing in areas where vibration from rock breakers or road headers is likely to be noticed, residents and occupants of the affected buildings would be informed of the hours of work proposed and the likely effects. Where such effects are noticed by residents or occupants, but no notice has been given, people would be invited to communicate their concerns to the RTA through the Environmental Manager for the proposal.

The report would demonstrate the contractor's intention to minimise noise impact wherever practicable. The EPA may monitor noise or request that construction noise be monitored to ensure that levels comply with its guidelines, approvals and licences. The above measures would be incorporated into the environmental management plan, which is to be prepared by the contractor and agreed to by the Environment Protection Authority, before construction proceeds.

VIBRATION RESULTING FROM TUNNEL CONSTRUCTION

To ensure that there would be no adverse vibration impact on residences, vibration monitoring would be carried out at the commencement of construction for all processes likely to produce significant levels of ground vibration. The purpose of the initial measurements would be to establish safe working distances to critical locations for the actual site conditions and actual plant being operated.

Vibration levels would also be monitored during the initial surveys at all critical residences identified as being potentially affected, to ensure that levels comply with the relevant criteria.

To avoid the impacts of structure-borne noise at night, rock breakers would not normally be used at night and road header use would be minimised at night for sections of the tunnels which are close to residences.

The RTA would ask that complaints about structure-borne noise be directed to the Environmental Manager for the proposal, whether they relate to daytime or night time noise.

Blasting

If blasting is proposed to be carried out, blast charge and blast configurations would be selected to ensure that EPA criteria are not exceeded. Prior to the commencement of blasting activity at a site, critically affected locations would be identified and appropriate measures taken to limit overpressure and vibration to acceptable levels. Blasts would be monitored initially at these locations to ensure that predicted overpressure and vibration levels are not exceeded.

7.2.9 Noise mitigation to meet EPA goals

At all locations along the proposal, noise mitigative measures would be installed so that nearby traffic noise levels would meet the RTA's guidelines. However at some locations the traffic noise levels would exceed the EPA's long term goal of TNL 55.

Table 16 below shows that the roadside noise barriers would need to be raised to between 6 and 12 metres (depending on the section of motorway), to meet the EPA's TNL 55 goal (ie within the clearly acceptable zone) for all residences in the section of road analysed.

Barrier heights higher than 6 metres would, in general, be impractical to construct and would obviously have adverse visual impacts incommensurate with the acoustic gains expected.

Where the EPA long term goal cannot practically be met, the RTA would consider measures which may go part of the way towards meeting the EPA long term goal, including:

- Barrier heights moderately higher than the minimum; and
- Use of "quiet" road surfaces such as open graded asphalt road surfacing.

Recognition would be given to community input which showed a desire for noise barriers of a particular height or style.

7.2.10 Conclusion

Overall, the Variation would be acoustically favourable when compared with the 1994 M5 East EIS proposal, as the direct tunnel would act to mitigate motorway noise in the Wolli Creek and Arncliffe areas. Whilst the effect of the proposal to make the motorway toll-free would be to generally increase traffic volumes, the potential for noise increase would be mitigated by the use of higher noise barriers where this effect is an issue.

Although some residences would be affected by the noise arising from the proposed M5 East motorway, the noise impacts would be effectively

TABLE 16 — BARRIER HEIGHT ANALYSIS TO ACHIEVE EPA'S TNL 55

Approx. Chainage	Location Description	Proposed Roadside Noise Barrier Height	Barrier Height Required To Meet EPA's TNL 55
11300**	North side of motorway, at Iris Avenue residences	4 metres	12 metres
9900**	South side of motorway, at Earls Avenue residences	3.5 metres*	8 metres
4600	South side of motorway, at cnr. Tallawalla Street and Kooemba Avenue	4 metres	6 metres
5400	North side of motorway, at Glamis Street residences	4 metres	7 metres
6600	North side of motorway, at Bobadah Street residences	4 metres	9 metres
6800	South side of motorway, at Beaumont Street residences	4 metres	7 metres

* *Existing barrier height* ** *Chainage references according to the original M5 West EIS*

controlled and reduced to 'normally acceptable' levels by installing 4 metre and in some cases up to 6 metre high roadside noise barriers as indicated. Noise barriers can be constructed of earth mounds and/or solid fencing. Acoustically absorptive barriers would be erected along the motorway at both the western and eastern portals to the tunnel.

All noise emissions relating to the tunnel ventilation system would be controlled to acceptable levels as required by NSW EPA criteria.

Construction noise and vibration would be controlled in terms of the NSW EPA criteria. Measures would also be taken to eliminate noise at the source. Noise and vibration control measures would be incorporated into the environmental management plan, which would be prepared before construction proceeds.

Vibration levels would also be monitored during the initial surveys at all critical residences identified as being potentially affected, to ensure that levels comply with the relevant criteria.

To avoid the impacts of structure-borne noise at night, rock breakers would not normally be used at night and road header use would be minimised at night for sections of the tunnels which are close to residences. Complaints about structure-borne noise would be directed to the Environmental Manager for the proposal.

7.3 AIR QUALITY IMPACT ASSESSMENT

A specialist report on the air quality impacts of the Variation has been prepared by Holmes Air Sciences (1996) and is summarised below. The report examined the air quality impacts of the surface road and the relative merits from an air quality perspective of a number of potential locations of tunnel exhaust stacks. Dispersion modelling was carried out to determine the ground level concentrations of all the primary motor vehicle emissions. The predicted levels were compared with the relevant air quality goals, taking into account likely background concentrations. The height of the stacks was adjusted so that the predicted ground level concentrations were well within air quality goals. In addition a regional assessment was undertaken to determine the impact of the proposed motorway on total vehicle emissions into the Sydney airshed.

7.3.1 AIR QUALITY GOALS

The NSW EPA notes air quality goals for nitrogen dioxide, carbon monoxide, ozone, sulphur dioxide, lead and particulate matter determined by the World Health Organisation (WHO), the United States Environmental Protection Agency (US EPA) and the National Health and Medical Research Council of Australia (NHMRC). Air quality goals for hydrocarbons have been used previously, but these have been discarded because they are not specific for reactive species which are the important elements in the formation of photochemical smog.

It should be noted that since the 1994 M5 East EIS was produced the NSW EPA has discarded its goal for acid gases. It should also be noted that the NHMRC has recently determined new ozone goals of 0.10 ppm (1-hour) and 0.08 ppm (4 hour). New goals for sulphur dioxide have also been determined.

Table 17 summarises the air quality goals currently noted in NSW.

TABLE 17 — NEW SOUTH WALES AIR QUALITY GOALS

Pollutants	Standard	Agency
Total suspended particulate matter (TSP)	90 µg/m³ (annual mean)	NHMRC
Particulate matter < 10 µm (PM_{10})	50 µg/m³ (annual mean) 150 µg/m³ (24-hour maximum)	US EPA US EPA
Lead	1.5 µg/m³ (90 day average)	NHMRC
Carbon monoxide	87 ppm or 108 mg/m³ (15-minute maximum) 25 ppm or 31 mg/m³ (1-hour maximum) 9 ppm or 11 mg/m³ (8-hour maximum)	WHO WHO NHMRC
Nitrogen dioxide	0.16 ppm or 328 µg/m³ (1-hour maximum) 0.05 ppm or 103 µg/m³ (annual mean)	NHMRC US EPA
Ozone	0.10 ppm or 214 µg/m³ (1-hour maximum) 0.08 ppm or 170 µg/m³ (4-hour maximum)	NHMRC NHMRC
Sulphur dioxide	25 pphm or 700 µg/m³ (10-minute maximum) 20 pphm or 570 µg/m³ (1-hour maximum) 2 pphm or 60 µg/m³ (annual mean)	NHMRC NHMRC NHMRC
Suspended matter	40 µg/m³ (annual mean)	WHO

Note: All concentration units have been converted at 0°C

mg/m³ = milligrams per cubic metre

µg/m³ = micrograms per cubic metre

ppm = parts per million

pphm = parts per hundred million

Source: Holmes Air Sciences 1996

7.3.2 LOCATION OF EXHAUST VENT STACKS AND AIR INTAKES

The increased length of the tunnel creates a requirement for three tunnel exhaust stacks. A total of seven options were considered, that included modelling for a range of stack heights (from 10 to 40 metres) at each location. Details of this modelling are presented in the specialist report.

Ideally the stacks should be located on high ground. This results in the expelled air being better dispersed by the stronger winds experienced at greater elevation compared to the relatively calm conditions which could prevail in a valley. Locating the stack in a valley means that it must be substantially taller than if it were located on a ridge, to achieve the same air quality through dispersion.

Air intakes do not have air quality impacts. However pollutant levels in the intake air will in part determine the ventilation rate required to keep carbon monoxide levels within the tunnel at acceptable levels. It therefore is preferable, although not essential, to locate air intake vents in areas where the air is relatively unpolluted (for example parks).

7.3.3 ASSUMED MODELLING CONDITIONS

This section discusses the assumptions used in the modelling. It covers the surface road emissions, and the tunnel vent stacks. It also discusses the approach used in determining the regional emissions into the Sydney airshed.

SURFACE ROAD

Surface road emissions have been calculated with new traffic data generated to take account of the removal of the toll. As in the 1994 EIS, the Caline4 dispersion model has been used to determine roadside impacts. However new emissions based on the emission inventory prepared for the Metropolitan Air Quality Study recently carried out in Sydney have been used instead of those based on the US EPA database which were used in the EIS. These emission rates have also been used for the tunnel vent stack assessment.

TUNNEL VENT STACKS

Concentrations of carbon monoxide within the proposed tunnel would be controlled by ventilation. The NSW EPA requires that for a 15 minute period the carbon monoxide concentration will not exceed 87 parts per million (108 milligrams per cubic metre) in the tunnel. The ventilation system for the tunnel would be designed so that this concentration would not be exceeded. Air quality would be constantly monitored electronically to ensure that it meets NSW EPA standards. Instantaneous sampling would be carried out at given locations in the tunnel to monitor air quality in the tunnel and enable the Tunnel Control Centre to maintain clean air conditions in the tunnel using electronically controlled automatic systems (with manual override available).

The EPA was consulted on the approach to be adopted in assessing the impact of the tunnel air vent stacks. Account was taken of the findings of the Metropolitan Air Quality Study (MAQS) undertaken by the EPA, and as discussed above, vehicle emission rates determined by MAQS were incorporated into the air quality assessment for the vent stacks emissions. Details of the calculations are presented in the specialist air quality report (Holmes Air Sciences, 1996).

Detailed modelling was undertaken for three air exhaust stacks with the following configurations: at Arncliffe Street Army Reserve Depot (15 metres high), at Royal Place/Bardwell Road, Bardwell Park (15 metres high) and Duff Street, Arncliffe (15 metres high).

REGIONAL IMPACTS

In addition to impacts close to the road, an assessment of the regional impacts of the M5 East Motorway has been undertaken. This comprises an estimate of the total vehicle emissions into the Sydney airshed, with and without the M5 East Motorway built.

7.3.4 PREDICTED ROADSIDE IMPACTS

CARBON MONOXIDE

It can be seen from **Table 18** that the highest predicted 1-hour carbon monoxide concentration 10 metres from the road in 2001 is 6.6 milligrams per cubic metre (mg/m^3) between King Georges Road and Bexley Road. This is well below the EPA's 1-hour goal of 31 mg/m^3 and levels at residences 30 metres away are even lower. Levels at kerbside are also predicted to be below the 1-hour goal.

Despite higher traffic volumes, levels are predicted to be lower in 2011 at 10 metres from the motorway, with a maximum 1-hour concentration estimated to be 5.3 mg/m^3 (17% of the goal) between King Georges Road and Bexley Road. This is because a higher proportion of the vehicle fleet will be equipped with catalytic converters in 2011 than in 2001 and as a result, the fleet will have a lower average emission rate of carbon monoxide. The highest kerbside concentration is predicted to be 10.9 mg/m^3 along the same section, which is also below the goal.

NITROGEN DIOXIDE

Estimating nitrogen dioxide concentrations is more complicated than estimating carbon monoxide concentrations. Nitrogen oxides are initially emitted as a mixture of nitric oxide and other oxides of nitrogen (NO_x), which may then be oxidised to nitrogen dioxide (NO_2). At the point of emission the mixture is generally about 5% nitrogen dioxide by mass. At 10 metres from the road the nitrogen oxides would be unlikely to contain more than 20% (by mass) nitrogen dioxide and recent monitoring studies in process for the RTA indicate that the proportion is more likely to be about 10%.

The maximum 1-hour nitrogen dioxide concentration at 10 metres from the roadway (the nearest residence to the motorway would be approximately 35 metres from the kerb, in Kirrang Street, Beverly Hills) is predicted to be 458 micrograms per cubic metre ($\mu g/m^3$) in 2001 and 472 $\mu g/m^3$ in 2011, between King Georges Road and Bexley Road. These are both above the air quality goal for nitrogen dioxide. The method used for estimating NO_x is conservative and likely to give an over-estimate. However it should be noted that these predictions do not take into account fully the benefits of three-way catalytic converters which are fitted to all new passenger vehicles in Australia and which substantially reduce NO_x emissions. Nor do they take account of controls on diesel vehicles which are currently being introduced in Australia. Heavy duty diesel vehicles are a major source of NO_x.

Levels at 30 m and 50 m from the kerb are predicted to remain below the 1-hour goal of 328 $\mu g/m^3$, but they do come close to the goal with predictions of 300 $\mu g/m^3$ in 2001 and 310 $\mu g/m^3$ in 2011, between King Georges Road and Bexley Road.

TABLE 18 — PREDICTED INCREASE IN 1-HOUR AVERAGE GROUND-LEVEL CONCENTRATIONS OF VEHICLE EMISSIONS AT VARIOUS DISTANCES FROM THE ROADWAY EDGE, 2001 AND 2011

Roadway Section	Distance from the edge (m)	Carbon Monoxide (mg/m³)	Nitrogen Oxides (µg/m³)	Nitrogenn Dioxide* (µg/m³)	Hydrocarbons (mg/m³)	Particulate Matter (µg/m³)	Lead (µg/m³)
2001							
Fairford Rd to	0	11.3	4133	413	1.14	200	2.9
Penshurst Rd	10	5.6	2153	431	0.58	107	1.4
	30	3.7	1415	283	0.38	71	0.9
	50	2.9	1144	229	0.30	58	0.7
Penshurst Rd to	0	9.8	3825	383	1.01	380	2.5
King Georges Rd	10	5.0	2005	401	0.53	192	1.3
	30	3.3	1328	266	0.35	125	0.8
	50	2.6	1070	214	0.28	100	0.7
King Georges Rd to	0	13.9	4416	442	1.50	358	3.0
Bexley Rd	10	6.6	2288	458	0.72	174	1.4
	30	4.2	1501	300	0.47	113	0.9
	50	3.4	1205	241	0.37	90	0.7
Marsh St to	0	7.6	3493	349	0.85	190	1.8
General Holmes Dr	10	3.9	1894	379	0.45	105	0.9
	30	2.6	1255	251	0.30	70	0.6
	50	2.0	1099	202	0.24	56	0.5
2011							
Fairford Rd to	0	10.7	4022	402	1.07	317	#
Penshurst Rd	10	5.2	2091	418	0.54	154	#
	30	3.4	1378	276	0.35	100	#
	50	2.7	1107	221	0.28	79	#
Penshurst Rd to	0	9.2	4121	412	0.98	213	#
King Georges Rd	10	4.6	2153	431	0.51	114	#
	30	3.0	1415	283	0.33	76	#
	50	2.4	1144	229	0.26	61	#
King Georges Rd to	0	10.9	4563	456	1.15	382	#
Bexley Rd	10	5.3	2362	472	0.58	185	#
	30	3.4	1550	310	0.38	120	#
	50	2.7	1242	248	0.30	96	#
Marsh St to	0	7.5	4047	405	0.89	231	#
General Holmes Dr	10	3.9	2153	431	0.47	125	#
	30	2.5	1427	285	0.31	84	#
	50	2.0	1144	229	0.24	67	#

** Assumed to be 20% by weight of total nitrogren oxides (except at kerbside where NO_2 is assumed to be 10% by weight of total nitrogen oxides)*

 # Lead not modelled in 2011

Source: Holmes Air Sciences, 1996

PARTICULATE MATTER AND LEAD

The predicted levels of PM_{10} (particles smaller than 10 micrometres in diameter) are for 1-hour averaging periods, while the air quality goal refers to a 24-hour period. Comparing these is therefore a conservative approach (that is, an over-prediction) as the maximum predicted 1-hour average will always be higher than the predicted 24-hour average.

The highest predicted increase in PM_{10} at 10 metres from the road in 2001 is 192 $\mu g/m^3$, and 185 $\mu g/m^3$ in 2011. These levels are both above the EPA 24-hour goal of 150 $\mu g/m^3$, but it should be emphasised that these are 1-hour predictions and will not persist over a 24-hour period. Concentrations at 30 metres and 50 metres from the kerb are all predicted to be below the 24-hour PM_{10} goal for both 2001 and 2011. Concentrations over a year would be substantially less and concentrations at sites further removed from the road would again be reduced. Similarly the NHMRC 90 $\mu g/m^3$ (annual average) total suspended particulates (TSP) goal is unlikely to be exceeded.

Lead impacts have also been assessed for 2001 only. It should be noted that the lead goal applies to a 90-day average, and the predicted level is for a "worst-case" 1-hour period. Predictions would therefore be greater than the 90-day average. The maximum predicted lead level for the motorway in 2001 is 3.0 $\mu g/m^3$ at the kerb, 1.4 $\mu g/m^3$ 10 metres from the kerb, 0.9 $\mu g/m^3$ at 30 metres and 0.7 $\mu g/m^3$ at 50 metres. Kerbside values are above the 90-day average of 1.5 $\mu g/m^3$, but this is a short term prediction and is therefore likely to remain below long term goals since "worst-case" conditions are very unlikely to prevail for any significant period of time. Residences further than 10 metres from the kerb are predicted to experience lead levels below the 90-day air quality goal. The predicted lead impacts take into account the increasing use of unleaded fuel.

HYDROCARBONS

From **Table 18** the predicted maximum 1-hour increase in total hydrocarbons is of the order of 0.72 mg/m^3 at 10 metres from the existing roadway. Assuming a 5% benzene composition in the exhaust the benzene concentration at 10 metres from the roadway edge would be approximately 0.036 mg/m^3 or 36 $\mu g/m^3$ (1-hour average), under unfavourable dispersion and with peak traffic flows. This is only 36% of the Victorian EPA design 3-minute goal, which as noted before specifically excludes petrol, but is above the proposed UK goal of 16 $\mu g/m^3$ (the UK goal however is an annual average, and these figures would not exceed this goal). Concentrations of total hydrocarbons are of course substantially lower at the locations of residences 30 metres from the road, 0.47 mg/m^3 (24 $\mu g/m^3$ benzene), and 50 metres from the road, 0.37 mg/m^3 (19 $\mu g/m^3$ benzene). It is nevertheless recognised that there may be no safe limit for benzene, but the risk to a particular individual over a lifetime is small, and on a population and individual basis could be offset by lower risks through safer roads, although to an undetermined extent.

7.3.5 PREDICTED TUNNEL IMPACTS

Predicted maximum increases in the one hour carbon monoxide concentrations resulting from emissions from the proposed tunnel exhaust vent stacks, using worst case conditions, are shown in **Figures 43** to **45**.

Note: The one-hour goal for carbon monoxide is 31 mg/m^3

Source: Holmes Air Sciences, 1996

Predicted increase in concentration of carbon monoxide (mg/m^3)

Proposed tunnel

FIGURE 43 — AIR QUALITY: ROYAL PLACE EXHAUST STACK

Note: The one-hour goal for carbon monoxide is 31 mg/m^3

Source: Holmes Air Sciences, 1996

Predicted increase in concentration of carbon monoxide (mg/m^3)

Proposed tunnel

FIGURE 44 — AIR QUALITY: DUFF STREETE EXHAUST STACK

Note: The one-hour standard for carbon monoxide is 31 mg/m^3

Source: Air Sciences, 1996

Predicted increase in concentration of carbon monoxide (mg/m^3)

Proposed tunnel

FIGURE 45 — AIR QUALITY: ARNCLIFFE STREET EXHAUST STACK

These figures show the predicted increase, in milligrams per cubic metre, in one hour carbon monoxide concentrations at a grid of receptors in the vicinity of the vent, over and above ambient levels. The predicted concentrations are well below the respective air quality goals.

In general, when the terrain around the stack is reasonably flat, the highest ground-level concentrations close to the stack occur to the south-east and north-east under strong wind conditions (approximately 13 metres per second) where the plume is brought to the ground close to the stack. However the predicted maximum values are well below the respective air quality standards. Under these reasonably good dispersion conditions, that is strong winds and neutral atmospheric stability, background concentrations of carbon monoxide and other roadway emissions would be very low. Local terrain can also influence the pattern of dispersion from the exhaust stacks. Maximum one hour levels are predicted to occur on the high ground under stable conditions when dispersion is poor.

Even under poor dispersion conditions, the plume would be sufficiently diluted so as not to exceed air quality standards. **Tables 19** to **21** show the predicted ground level concentrations for emissions from the air tunnel exhaust vent stacks for 2001 and 2011, for the Variation. All predicted levels (including background levels) are below the relevant air quality goals.

TABLE 19 — PREDICTED GROUND LEVEL# CONCENTRATIONS DUE TO EMISSIONS FROM PROPOSED ARNCLIFFE STREET ARMY RESERVE DEPOT EXHAUST STACK, 2001## AND 2011

Pollutants	Carbon monoxide	Nitrogen oxides (A)	Nitrogen dioxide	Hydro-carbons (B)	PM_{10}	Lead
	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)
Maximum predicted ground level concentrations						
2001	**1 hour**	**1 hour**	**1 hour**	**3 mins**	**24 hour**	**90 day**
Increase	0.38	297	60	0.07	3.3	0.004
'Background'	6.9+		63++		54+	1.1**
Total	**7.3**		**123**		**57.3**	**1.104**
2001	**8 hour**				**Annual**	
Increase	0.32				0.12	
'Background'	4.5+				22*	
Total	**7.3**				**22.1**	
2011	**1 hour**	**1 hour**	**1 hour**	**3 mins**	**24 hour**	**90 day**
Increase	0.38	343	69	0.08	4.0	-
'Background'	6.9+		63++		54+	1.1**
Total	**7.3**		**132**		**59.0**	**1.1**
2011	**8 hour**				**Annual**	
Increase	0.32				0.14	
'Background'	4.5+				22*	
Total	**4.8**				**22.1**	
Air quality standard noted by Environment Protection Authority						
	31 (1 hour)		328 (1-hour)		150 (24-hour)	1.5 (90-day)
	11 (8 hour)				50 (annual)	

\# *Ground level concentrations: in all cases the increase due to the M5 East Motorway has been estimated; where possible the background levels have been added to provided total predicted concentrations.*

\## *1996 is the nominal opening date for the M5 East Motorway; more likely to be 1999.*

'Background' is the maximum measured ground level concentration. The following sources for this background data are:

\+ *Maximum measured along the route in this study (Environsciences 1994).*

** *Measured by the Environment Protection Authority in 1992 at Earlwood (Environment Protection Authority 1992).*

++ *Measured in a monitoring study for the Casula Link (Stephenson 1992).*

(A) Nitrogen oxide levels are only predicted so as to estimate Nitrogen Dioxide levels.

(B) Hydrocarbon levels are only predicted so as to estimate benzene levels and effects on photochemical smog.

mg/m^3 = milligrams per cubic metre

$\mu g/m^3$ = micrograms per cubic metre

Source: Holmes Air Sciences, 1996

TABLE 20— PREDICTED GROUND LEVEL# CONCENTRATIONS DUE TO EMISSIONS FROM PROPOSED ROYAL PLACE EXHAUST STACK, 2001## AND 2011

Pollutants	Carbon monoxide (mg/m³)	Nitrogen oxides (A) (µg/m³)	Nitrogen dioxide (µg/m³)	Hydro-carbons (B) (mg/m³)	PM_{10} (µg/m³)	Lead (µg/m³)
Maximum predicted ground level concentrations						
2001	**1 hour**	**1 hour**	**1 hour**	**3 mins**	**24 hour**	**90 day**
Increase	0.88	693	138	0.14	4.5	0.005
'Background'	6.9+		63++		54+	1.1**
Total	**7.8**		**201**		**58.5**	**1.105**
2001	**8 hour**				**Annual**	
Increase	0.31				0.20	
'Background'	4.5+				22*	
Total	**4.8**				**22.2**	
2011	**1 hour**	**1 hour**	**1 hour**	**3 mins**	**24 hour**	**90 day**
Increase	0.88	800	160	0.17	5.1	-
'Background'	6.9+		63++		54+	1.1**
Total	**7.8**		**223**		**59.1**	**1.1**
2011	**8 hour**				**Annual**	
Increase	0.31				0.23	
'Background'	4.5+				22*	
Total	**4.8**				**22.2**	
Air quality standard noted by Environment Protection Authority						
	31 (1 hour)		328 (1-hour)		150 (24-hour)	1.5 (90-day)
	11 (8 hour)				50 (annual)	

Ground level concentrations: in all cases the increase due to the M5 East Motorway has been estimated; where possible the background levels have been added to provided total predicted concentrations.

1996 is the nominal opening date for the M5 East Motorway; more likely to be 1999.

'Background' is the maximum measured ground level concentration. The following sources for this background data are:

\+ *Maximum measured along the route in this study (Environsciences 1994).*

** *Measured by the Environment Protection Authority in 1992 at Earlwood (Environment Protection Authority 1992).*

++ *Measured in a monitoring study for the Casula Link (Stephenson 1992).*

(A) Nitrogen oxide levels are only predicted so as to estimate Nitrogen Dioxide levels.

(B) Hydrocarbon levels are only predicted so as to estimate benzene levels and effects on photochemical smog.

mg/m^3 = milligrams per cubic metre

$\mu g/m^3$ = micrograms per cubic metre

Source: Holmes Air Sciences, 1996

TABLE 21 — PREDICTED GROUND LEVEL# CONCENTRATIONS DUE TO EMISSIONS FROM PROPOSED DUFF STREET EXHAUST STACK, 2001## AND 2011

Pollutants	Carbon monoxide (mg/m^3)	Nitrogen oxides (A) ($\mu g/m^3$)	Nitrogen dioxide ($\mu g/m^3$)	Hydro-carbons (B) (mg/m^3)	PM_{10} ($\mu g/m^3$)	Lead ($\mu g/m^3$)
Maximum predicted ground level concentrations						
1996	**1 hour**	**1 hour**	**1 hour**	**3 mins**	**24 hour**	**90 day**
Increase	1.08	850	170	0.12	3.1	0.004
'Background'	6.9+		63++		54+	1.1**
Total	**8.0**		**233**		**57.1**	**1.104**
1996	**8 hour**				**Annual**	
Increase	0.40				0.16	
'Background'	4.5+				22*	
Total	**4.9**				**22.2**	
2011	**1 hour**	**1 hour**	**1 hour**	**3 mins**	**24 hour**	**90 day**
Increase	0.98	980	196	0.14	3.7	-
'Background'	6.9+		63++		54+	1.1**
Total	**8.0**		**253**		**57.7**	**1.1**
2011	**8 hour**				**Annual**	
Increase	0.40				0.30	
'Background'	4.5+				22*	
Total	**4.9**				**22.3**	
Air quality standard noted by Environment Protection Authority						
	31 (1 hour)		328 (1-hour)		150 (24-hour)	1.5 (90-day)
	11 (8 hour)				50 (annual)	

Ground level concentrations: in all cases the increase due to the M5 East Motorway has been estimated; where possible the background levels have been added to provided total predicted concentrations.

1996 is the nominal opening date for the M5 East Motorway; more likely to be 1999.

'Background' is the maximum measured ground level concentration. The following sources for this background data are:

\+ *Maximum measured along the route in this study (Envirosciences 1994).*

** *Measured by the Environment Protection Authority in 1992 at Earlwood (Environment Protection Authority 1992).*

++ *Measured in a monitoring study for the Casula Link (Stephenson 1992).*

(A) Nitrogen oxide levels are only predicted so as to estimate Nitrogen Dioxide levels.

(B) Hydrocarbon levels are only predicted so as to estimate benzene levels and effects on photochemical smog.

mg/m^3 = milligrams per cubic metre

$\mu g/m^3$ = micrograms per cubic metre

Source: Holmes Air Sciences, 1996

7.3.6 REGIONAL IMPACTS

Estimates of emissions in 2001 from vehicles using the Sydney road network with and without the M5 East constructed are presented in **Table 22**. In most instances there is a small reduction in emissions with the M5 East built. This is due in part to the reduced vehicle kilometres travelled (VKT) with the motorway built and also due to somewhat lower emission rates for freeway travel mode for most pollutants. The exception is nitrogen oxides which are emitted at a higher rate per vehicle under freeway travel conditions compared to arterial travel mode. However the percentage increase for the case with the M5 East built is small, in fact less than 0.5%.

TABLE— 22 TOTAL MOTOR VEHICLE EMISSIONS FROM THE SYDNEY NETWORK IN 2001 WITH AND WITHOUT THE M5 EAST ('000 TONNES)

Emission	Carbon Monixide	Nitrogen Oxides	Hydrocarbons	Particulate Matter	Carbon Dioxide
With M5 East	586.49	78.16	73.69	5.59	11421.22
Without M5 East	594.30	77.79	74.78	5.72	11493.65

Source: Holmes Air Sciences, 1996

7.3.7 COMPARISON OF IMPACTS WITH IMPACTS IN THE 1994 M5 EAST EIS

SURFACE ROAD

The increased traffic on the motorway resulting from the removal of the toll is predicted to result in increased concentrations of roadway pollutants over those estimated in the 1994 EIS. In addition the traffic modelling predicts that a higher proportion of heavy duty vehicles would be using the road compared to the 1994 EIS estimate. These vehicles are major emitters of nitrogen oxides and particulate matter, and are being targeted for emission control strategies by the EPA and the RTA.

TUNNEL VENT STACKS

The design of the tunnel air exhaust stacks has been specified to ensure that the emissions do not result in exceedances of air quality criteria. Comparing the predicted ground level concentrations for the exhaust stack configurations indicates that the results for the Variation are very similar to the predictions made in the 1994 M5 East EIS.

In terms of air quality, construction impacts of the Variation would be similar to the EIS, and would consist of dust generated during excavations and construction, and fumes generated by construction machinery.

It is not possible to accurately quantify the potential air quality impacts of construction. This is because there are so many variable factors involved, such as atmospheric conditions which would influence dust generation, the area of bare earth that would be exposed, and the time taken to re-establish cover on exposed areas. However the impacts on air quality from construction of the motorway in tunnel would be considerably less than if the motorway were being constructed on the surface, as the works would be largely confined to under the ground. Therefore, excavations would not be exposed to wind and dust generation would be controlled.

Impacts on air quality resulting from construction of exhaust stacks and air intakes would be very similar for the Variation and for the 1994 M5 East EIS shorter tunnel and extended tunnel options, the only difference being that the Variation has a greater number of stack/intake construction sites. Therefore, mitigative measures for the Variation would generally be the same as those described for the 1994 M5 East EIS shorter tunnel and extended tunnel options (see **Section 7.3.8** below). The potential additional impacts on air quality from construction of the extra exhaust stack(s) and air intake(s), when compared with the EIS shorter tunnel and extended tunnel options, would be more than offset by the air quality gains that would be made by constructing the motorway underground.

REGIONAL IMPACTS

Regional impacts were not assessed in the 1994 M5 East EIS. However the assessment carried out for the Variation indicates that for most pollutants, there would be a small decrease in emissions with the motorway built. The exception is nitrogen oxides, where the higher speed on the motorway would lead to marginally increased emissions.

7.3.8 MITIGATIVE MEASURES

The mitigative measures would be the same as the undertakings set out in the 1994 M5 East EIS, as set out below.

DURING CONSTRUCTION

Prior to commencement of construction the Roads and Traffic Authority would require the contractor to develop, implement and review procedures for air pollution control during demolitions and construction works, consistent with the Roads and Traffic Authority's Plan for reducing vehicle emissions (including dust and asbestos suppression techniques) to the NSW EPA's satisfaction.

The following techniques would be among those adopted:

- All haul roads and unsealed access roads, and all areas of excavation, construction or other disturbance, would be watered regularly or as required to suppress dust.
- Wheel-washes would be provided (where appropriate) for all vehicles leaving any construction zone.
- All vehicles loaded with soil or spoil would have their loads covered by tarpaulins or otherwise as appropriate to suppress dust.
- All excavated or otherwise disturbed areas would be landscaped and revegetated as soon as practicable after excavation or disturbance.
- The Roads and Traffic Authority would require the contractor to comply with, and to ensure compliance by subcontractors with, the techniques adopted.

DURING OPERATIONS

The Roads and Traffic Authority would require the contractor to ensure that the tunnel ventilation system is designed for worst-case traffic conditions, and to ensure that air quality within the tunnel meets NSW EPA goals.

Surface road emissions have the potential to cause exceedances of nitrogen dioxide air quality goals close to the roadway edge. These impacts can only be mitigated by emission controls. To this end, the RTA has developed a detailed strategy (although not specific to this project) to reduce vehicle emissions through a series of programs which include:

- Tighter controls of emissions from individual vehicles, particularly heavy duty diesel trucks which have been identified as a major source of nitrogen oxides and fine particulate matter emissions into the Sydney airshed;
- Working with the EPA to implement the State's Motor Vehicle Maintenance Program for lowering emissions, and on the introduction of vehicle emissions testing; and
- Enhancing the State's vehicle emissions enforcement resources

7.3.9 CONCLUSIONS

The predicted increase in traffic, particularly heavy duty diesel vehicles, on the M5 East Motorway with the toll removed is likely to result in slightly higher vehicle emissions on the motorway and hence higher roadside concentrations compared to those predicted in the 1994 M5 East EIS. It should be noted, however, that these emissions would occur anyway without the M5 East but instead would be concentrated on the M5 East rather than dispersed throughout the road network. In fact for most pollutants, the overall airshed emissions would be reduced, due in part to the shorter travel distance which the motorway would provide. Roadside

impacts can be mitigated most effectively by tighter emission controls on vehicles and this is being done at a Federal level through ACVEN (Advisory Committee on Vehicle Emissions and Noise) which develops vehicle emission and noise related Australian Design Rules for motor vehicles.

The air quality modelling carried out for the exhaust stacks resulted in predictions of ground level concentrations of pollutants that were very similar to those results obtained for the corresponding modelling carried out for the 1994 M5 East EIS.

The results of the modelling, as shown in **Tables 19** to **21**, show that the ground level concentrations of pollutants from the exhaust stacks would be well below the goals set by the EPA for those pollutants. This demonstrates a clear advantage of tunnels over surface roads from an air quality perspective in that while emissions are not altered, they can be collected and their dispersion controlled though appropriate location of tunnel air exhaust stacks and appropriate ventilation conditions.

7.4 LAND USE

Land use impacts of the Variation were assessed in a report by Briggs, Brindle and Chambers Consulting Planners (1995). That report is summarised below. The impacts of theVariation are compared with the impacts arising from the 1994 M5 East EIS proposal (the shorter tunnel) and the extended tunnel alternative.

The Variation would travel through some residential areas, industrial land uses, vacant land, park land and the perimeter of Sydney (Kingsford Smith) Airport (see **Figures 8** to **15**.). As a general comment, the extended length of tunnel in the Variation would mean that fewer properties would be directly affected (see definition below) by the Variation than would be the case under either the shorter tunnel or the extended tunnel. However, the Variation would result in a greater number of properties being indirectly affected (see definition below).

The Variation would be constructed in bored tunnel until the Princes Highway. Exit ramps would be constructed in cut and cover tunnel from the motorway to the highway. From West Botany Street to Marsh Street, the Variation would be constructed in cut and cover tunnel. As a result of the construction of cut and cover tunnel, there would be land use impacts around the exit ramps and from West Botany Street through to Marsh Street. The Variation emerges fully from tunnel immediately east of Marsh Street.

The Variation requires three tunnel exhaust stacks and three air intakes. Several locations were considered for these structures. The preferred locations are discussed below, but all locations would result in land use impacts. An area of nominally 350 square metres would be required for each air exhaust structure and 100 square metres for the air intake structure.

7.4.1. Direct and indirect impacts

In this supplement, a property is said to be 'directly' affected if the property would need to be either totally or partially acquired by the Roads and Traffic Authority for the construction of the motorway.

A property is said to be 'indirectly affected' if the motorway passes under the property in bored tunnel or is in close proximity to a property.

7.4.2 Impacts on residential land uses

Impacts on residential land uses include direct impacts (property acquisition) and indirect impacts (where the tunnel passes under property).

Direct impacts (property acquisition)

Properties which would be directly affected by the Variation are illustrated in **Figures 46-53** below. Forty-two dwellings would be directly affected. In addition to properties previously acquired by the Roads and Traffic Authority, residential properties in the following streets would also be wholly acquired:

- Ann Street
- Eden Street
- Princes Highway
- West Botany Street
- Marsh Street

In addition, three residential properties would be affected by the location of the air intakes and air exhaust stacks. The preferred locations for these are as follows.

- Royal Place, Bardwell Park
- Hill and Duff Streets, Arncliffe

Two residential properties and one vacant lot on Marsh Street would be affected by partial acquisition.

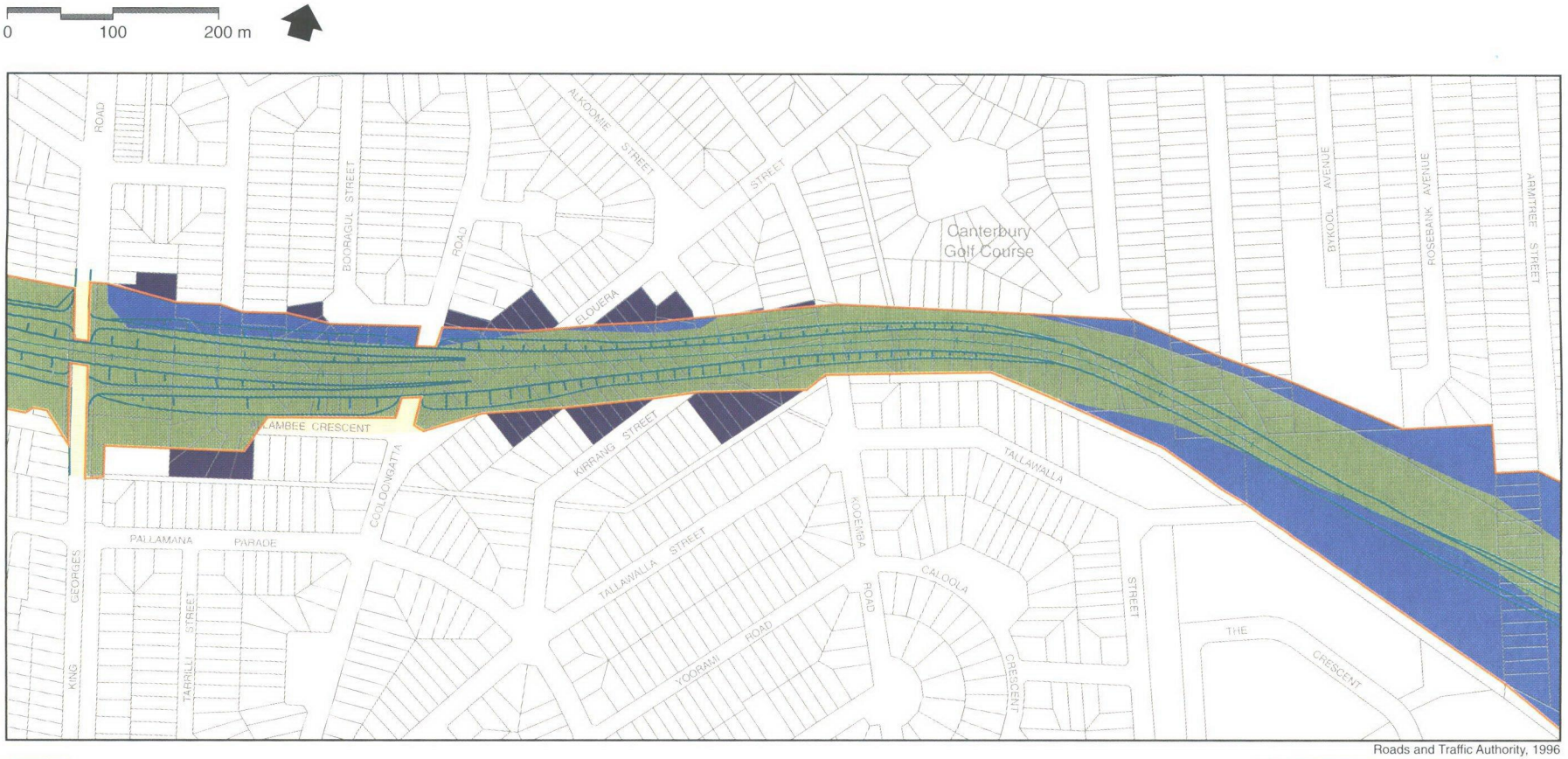
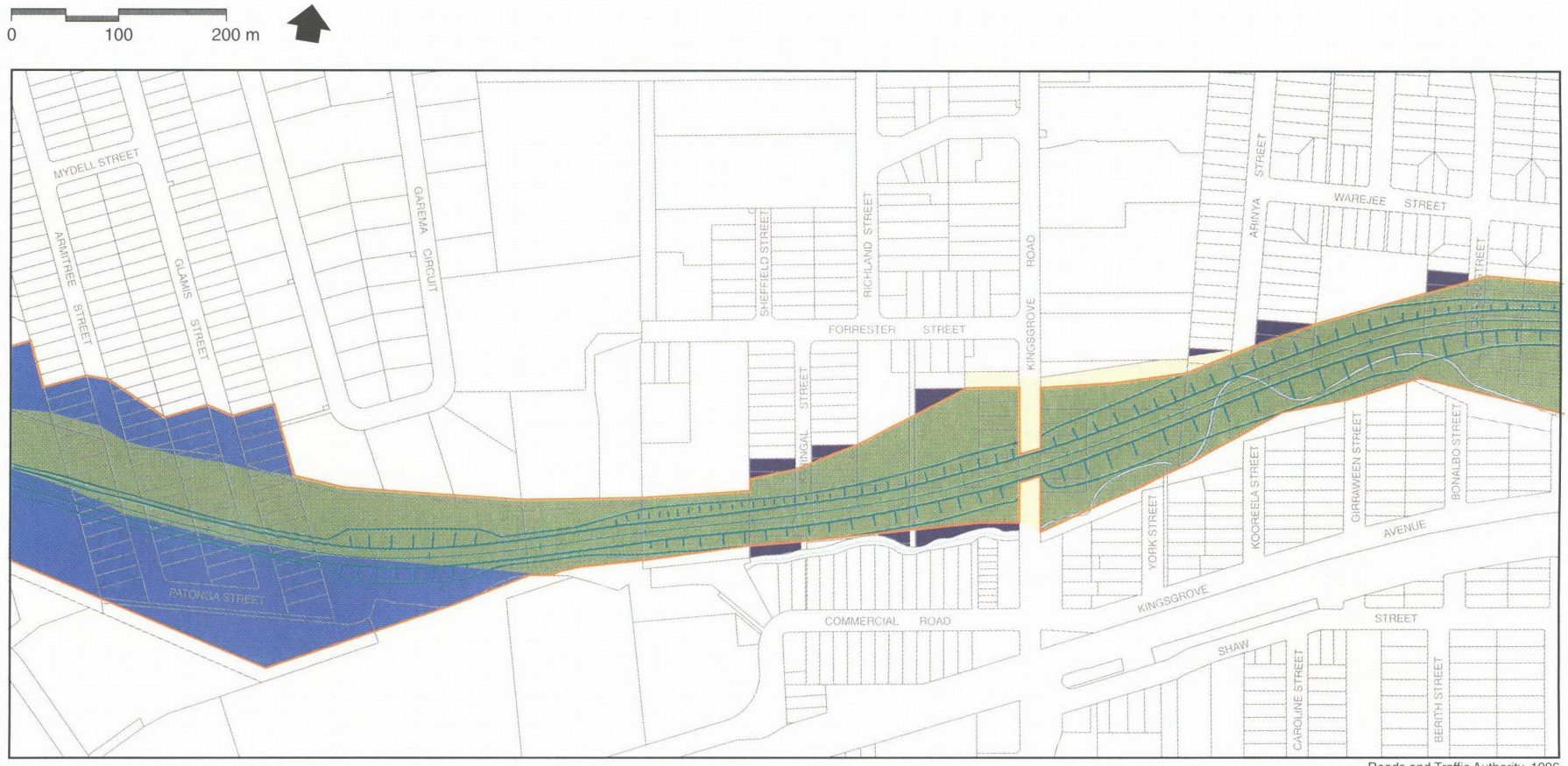


FIGURE 46 — LAND REQUIRED FOR THE PROPOSED MOTORWAY



Land previously identified for road purposes and required for the proposal

Land previously identified for road purposes and not required for the proposal

Additional land required for the proposal

Land where full acquisition is proposed*

Boundary of proposed M5 East Motorway

* These residences have the potential to be rezoned and redeveloped in conjunction with council planning.

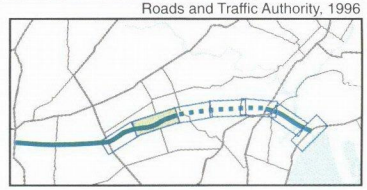


FIGURE 47— LAND REQUIRED FOR THE PROPOSED MOTORWAY

Land previously identified for road purposes and required for the proposal

Land previously identified for road purposes and not required for the proposal

Additional land required for the proposal

Land where full acquisition is proposed*

Boundary of proposed M5 East Motorway

Motorway in tunnel below surface
- stratum aquisition only
- no compensation

* These residences have the potential to be rezoned and redeveloped in conjunction with council planning.

FIGURE 48 — LAND REQUIRED FOR THE PROPOSED MOTORWAY

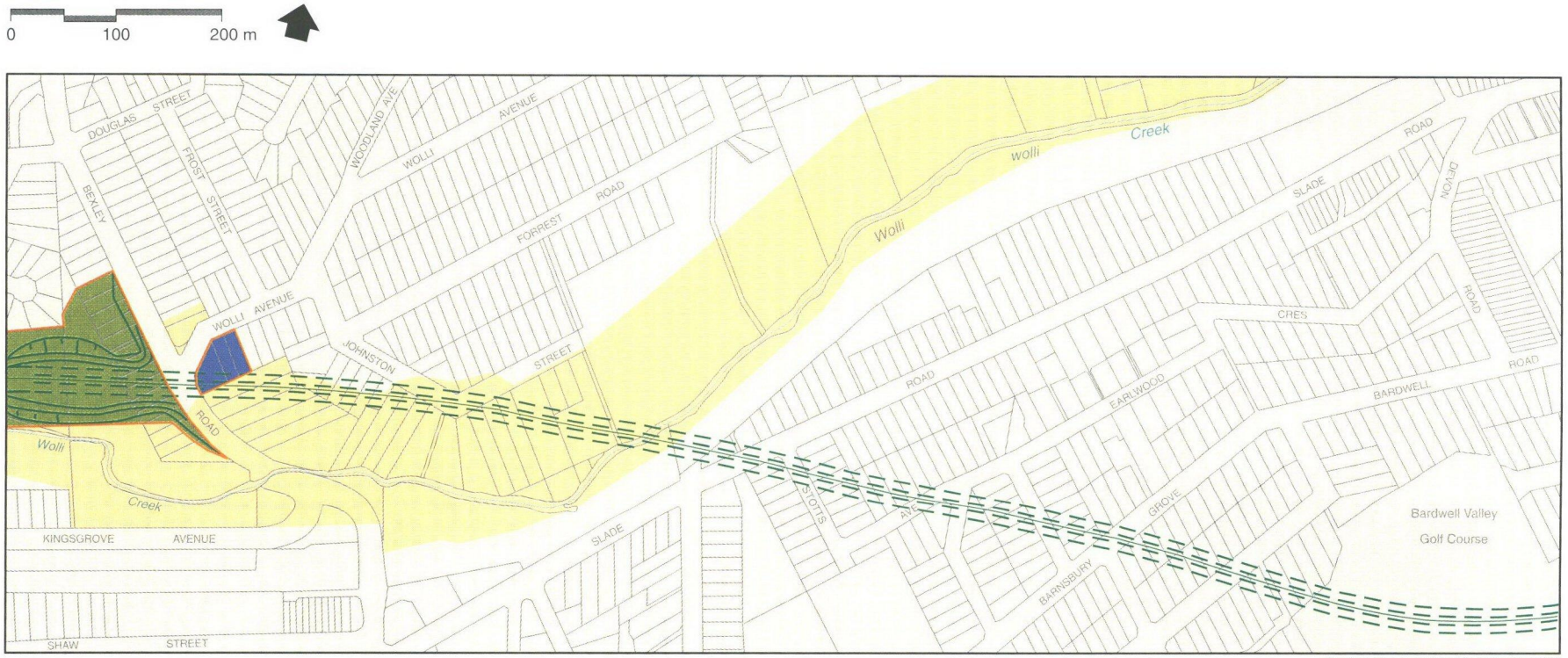
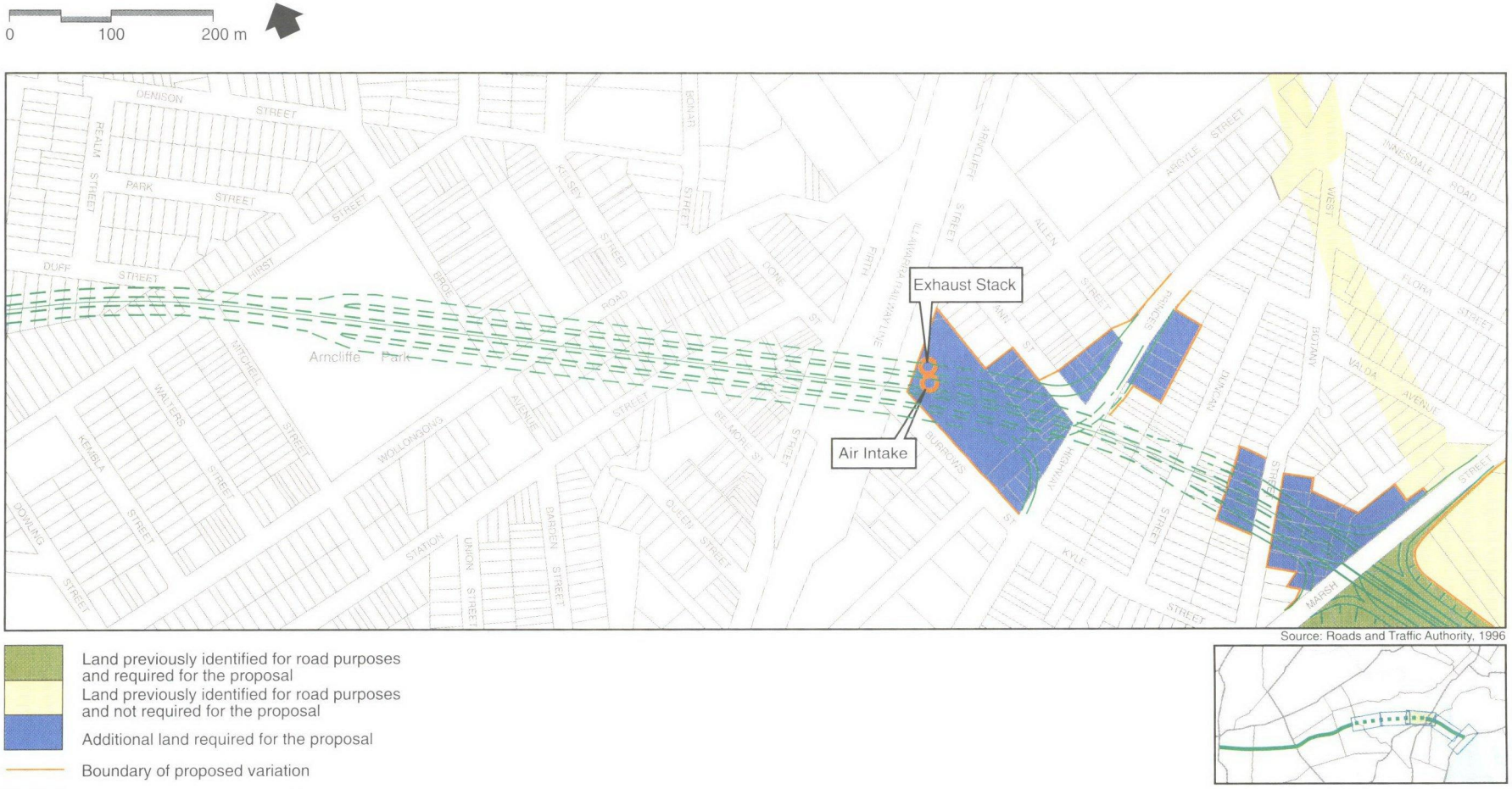


FIGURE 49— LAND REQUIRED FOR THE PROPOSED MOTORWAY

Source: Roads and Traffic Authority, 1996

FIGURE 50 — LAND REQUIRED FOR THE PROPOSED MOTORWAY



Source: Roads and Traffic Authority, 1996

FIGURE 51— LAND REQUIRED FOR THE PROPOSED MOTORWAY

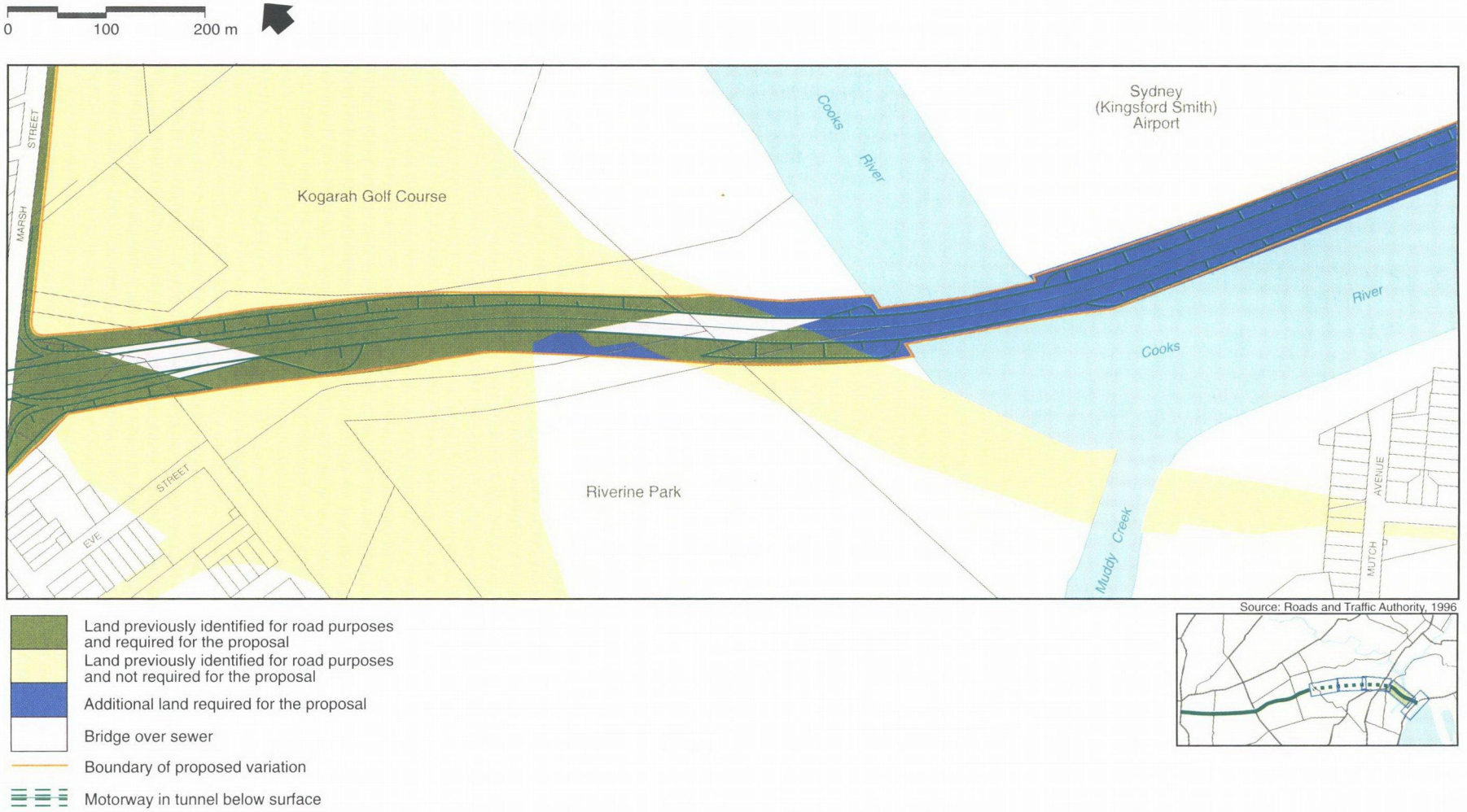


FIGURE 52 — LAND REQUIRED FOR THE PROPOSED MOTORWAY

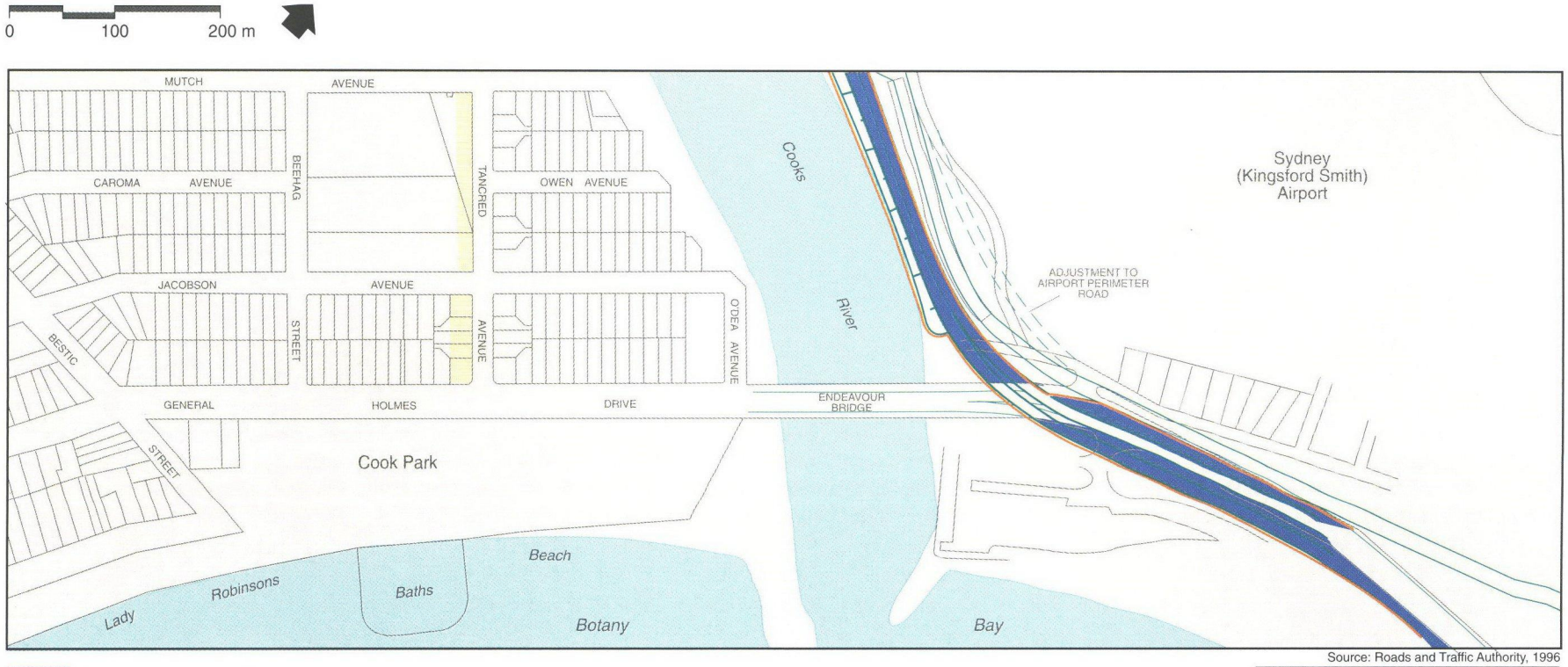


FIGURE 53— LAND REQUIRED FOR THE PROPOSED MOTORWAY

INDIRECT IMPACTS (TUNNEL BELOW PROPERTIES)

Residential land uses in communities from Bexley North to Arncliffe would be indirectly affected by the Variation passing underneath properties in tunnel. Except where the motorway was approaching the surface and emerging from tunnel, the motorway would have a minimum depth of 20 to 80 metres from the top of the tunnel to ground surface level. The motorway would pass underneath approximately 178 residential properties and three blocks of flats.

The Variation would allow redevelopment to occur over areas where the motorway would be constructed in cut and cover tunnel. These areas of land would be around Allen and Ann Streets, Arncliffe and around Marsh and West Botany Streets, Arncliffe. This redevelopment would go some way towards ameliorating the land use impacts of the motorway.

7.4.3 IMPACTS ON COMMERCIAL LAND USES

DIRECT IMPACTS (PROPERTY ACQUISITION)

There are nine commercial properties which would be directly affected by the Variation. Properties which would be directly affected by the Variation are illustrated in **Figures 46-53.**

INDIRECT IMPACTS (TUNNEL UNDER PROPERTIES)

Approximately four commercial properties at Arncliffe would be affected.

7.4.4 IMPACT ON OPEN SPACE

Impacts of the Variation on open space are likely to be limited to:

- **Near Royal Place, Bardwell Park** - an air intake would be located on the edge of the Bardwell Valley Golf Couse, at the bottom of the escarpment and adjacent to Bardwell Road.
- **Arncliffe Street, Arncliffe** - an air intake and an exhaust stack would be located on property currently owned by the Department of Defence.
- **Marsh Street** - a small linear park adjacent to Marsh Street would be affected, as the southern most part of the park would be required for the proposal. A small park containing play equipment at the southern end of Valda Avenue would be retained.
- **Kogarah Golf Course** - the rough on the fairway of one hole of the golf course would be affected by road widening along Marsh Street, which is a marginal effect.
- **Riverine Park** - the northern part of this park would be affected, adjacent to the South West and Southern Ocean Outfall Sewer.

Although the motorway would be almost wholly located within the road reservation, part of this land is zoned open space.

- **Eve Street Wetlands** - the eastern end of the drainage channel to the Cooks River.

The Variation would cause the loss of approximately 17,750m^2 of open space.

Further acquisition of vacant land and parkland would be required to allow the widening of Marsh Street in the vicinity of its intersection with the proposed motorway and access ramps.

7.4.5 IMPACT ON COMMUNITY AND GOVERNMENT FACILITIES

The following community and government facilities would be directly affected by the Variation:

- **Land between Ann Street and Burrows Street, Arncliffe** - the Arncliffe Street Army Reserve Depot. This land would be used for the construction of some exit ramps as well as an air exhaust stack and an air intake .
- **Burrows Street and the Princes Highway** - a small church on the corner of these streets.

7.4.6 ADJACENT LAND USES

Adjacent land uses for the M5 East EIS proposal are discussed in **Section 23.1** of the 1994 M5 East EIS. The 1994 M5 East EIS proposal and the Variation would generate similar impacts on adjacent land uses. However, the extent of the impacts of the Variation would be less than those for the EIS shorter tunnel proposal.

Adjacent land uses include:

- Residential development at north Arncliffe.
- Industrial and commercial development along the Princes Highway.
- Community facilities at Burrows Street.
- Recreation facilities, such as Kogarah Golf Club and Riverine Park.

Adjacent residential development would be particularly susceptible to the following impacts:

- Community severance.
- Noise.
- Reductions in air quality.
- Visual impact.
- Altered local traffic patterns.

The extent of the direct impact of the Variation would generally be less than the 1994 M5 East EIS shorter tunnel or extended tunnel options, due to the shorter length of the motorway above ground.

7.4.7 Mitigative measures

The Variation provides for a longer bored tunnel and also reduces the area where the motorway would be constructed in cut and cover tunnel. These features would reduce the visual impact of the motorway, compared to either the shorter tunnel or the extended tunnel options, and would provide greater opportunities to redevelop affected locations and reduce noise emissions.

In addition, the design of the motorway would be influenced by the need to reduce the amount of land acquired, and also the need to reduce the number of residences and businesses directly affected by the proposed motorway. In achieving these aims, the Roads and Traffic Authority would require the contractor to:

- Appoint an urban designer to ensure that the visual impact of the air exhaust stacks and air intakes is minimised.
- Rehabilitate any open space disrupted during the construction of the motorway.
- Develop an environmental management plan, in conjunction with the detailed design of the motorway, to detail the manner in which surplus land above the tunnel would be rehabilitated after construction.

In addition, the Roads and Traffic Authority would:

- Conduct a condition audit of the properties over the tunnel prior to construction commencing. A copy of such an audit would be given to the respective owners of properties as a record of the property condition prior to construction commencing.
- Implement the Roads and Traffic Authority's Property Acquisition Policy (described below) for affected properties.

7.4.8 RTA Property Acquisition Policy

Special Acquisition

Once properties which are wholly or partly required for road construction were eligible for acquisition. The special acquisition policy, as stated in Appendix F of the 1994 M5 East EIS, and as aplied to the M5 East Motorway, has been withdrawn from the M5 East project.

RTA PROPERTY ACQUISITION POLICY

The Roads and Traffic Authority has developed a policy statement relating to land acquisition. This policy states that owners of property required by the Roads and Traffic Authority in connection with roads works are generally made aware of the proposals either through inquiries when purchasing properties or from the proposal being shown on a local planning scheme. New proposals are made public as soon as possible after a final decision has been reached.

The Roads and Traffic Authority endeavours to purchase land by negotiation in much the same way as a private property transaction. The offer of compensation is assessed in accordance with the Land Acquisition (Just Terms Compensation) Act 1991. A valuer representing the Roads and Traffic Authority values the property to enable the Authority to submit a formal offer for the owner's consideration. If an owner engages a registered valuer and a solicitor, the Authority reimburses reasonable fees. Every effort is then made to negotiate an agreement.

Upon commencement of the acquisition program, the Roads and Traffic Authority would contact the owners of all directly affected properties by letter which would include details relating to the acquisition process and the basis upon which the Roads and Traffic Authority would reimburse valuation and legal costs.

It is recommended to property owners that they do not make any commitment to a replacement property until after contracts are exchanged with the Roads and Traffic Authority for their existing property.

In relation to the acquisition of whole properties, compensation is assessed according to the market value of the property as if it were unaffected by the road proposals. In addition to the market value, account is also taken of special value, disturbance and solatium (compensation for non-financial disadvantages resulting from relocation of principal place of residence as a result of acquisition). An advance payment for the purpose of paying a deposit on a replacement property is considered if requested.

If agreement cannot be reached, the land may be compulsorily acquired. This process also incorporates a means for resolving disputes about the amount of compensation payable.

In the case of partial acquisition, the amount of compensation is usually represented by the difference in valuations of the whole property carried out on the same date on a "before and after road works" basis.

In many cases, residents fear partial acquisition, where they are left in close proximity to a proposed road, rather than whole acquisition, which many people feel at least allows the owners to relocate and "start again". If a residential property is partially affected at surface, the Roads and Traffic Authority would acquire the whole property if preferred by the owner.

Compensation is assessed according to market value of the property as if it were unaffected by the proposal.

If part of the M5 East Motorway is constructed in tunnel, the Roads and Traffic Authority would need to acquire a stratum of land below the surface of the properties below which the tunnel runs. Acquisition of a stratum below the surface does not attract compensation under Section 62 of the Land Acquisition (Just Terms Compensation) Act 1991 and is not considered to be partial acquisition as described above.

Acquisition associated with rock anchors

The constructionof the portals and the driven tunnel in rock would require the placement of rock anchors to ensure stability of rock around the tunnel. The anchors will be of variable length above or beside the tunnel.

The RTA would acquire the stratum required for the tunnel and for the rock anchors. If the acquisition of the stratum has a demonstrated detrimental impact on the use of a property on the surface, compensation would be considered.

If not, acquisition of the stratum below the surface does not attract compensation under Section 62 of the Land Acquisition (Just Terms Compensation) Act, 1991.

Formal notice would be given to all property owners where the RTA proposed to acquire a stratum, once details fo the design have been settled.

Dislocation, uncertainty, hardship

A major road proposal is inevitably associated with dislocation, even where the proposal has generally been known for a very long period of time, as with the proposed M5 East Motorway.

The dislocation of existing owners or non-Roads and Traffic Authority tenants would be more significant where the displacement was unexpected. Whilst the procedures adopted by the Roads and Traffic Authority as outlined above would minimise this effect, the impact would be felt by a small number of residents.

Uncertainty is also a feature of road proposals. This uncertainty is currently greatest due to the lack of a final decision. This impact is inevitable, partly as a result of the open consultation practices adopted today. However, this outcome is considered by the Roads and Traffic Authority to be preferable, despite the period of uncertainty, compared to more closed decision-making practices.

The procedures adopted by the Roads and Traffic Authority are designed to mitigate as far as possible hardship arising from the proposal to develop the proposed M5 East Motorway. During the period of uncertainty, it is possible that some hardship may occur due to the inability to sell properties required by the Roads and Traffic Authority. If hardship exists,

there is provision for the Roads and Traffic Authority to acquire the property as if it were unaffected by the road proposal. However, the other items of compensation need not apply to hardship acquisitions.

7.4.9 COMPARISON OF VARIATION AND EIS PROPOSAL

A comparison of the land use impacts of the Variation, the shorter tunnel and the extended tunnel options is presented in **Table 23** below. All figures are estimates and would be likely to alter in small details at the detailed design stage of the motorway.

TABLE 23 — COMPARISON OF LAND USE IMPACTS OF THE VARIATION, THE SHORTER TUNNEL AND THE EXTENDED TUNNEL ALTERNATIVES

Land use	Variation	1994 M5 East EIS proposal East of Bexley Road	
		Shorter tunnel	Extended tunnel
Residential			
- directly affected, either wholly or partially	42 dwellings	56 dwellings and 1 vacant lot	56 dwelliings
- indirectly affected	178 dwellings	87 dwellings	87 dwellings
Air exhaust stack	3, each requiring nominally 350m², 2 on residential land, 1 on Commonwealth land	1, requiring nominally 350m² land zoned open space	2, each requiring nominally 350m² of open space, 1 in space, 1 in commercial land
Air intake	3, each requiring 100m²; 1 residential, 1 open space, 1 on Commonwealth land	N/Known	N/Known
Commercial			
- directly affected, either wholly or partially	9	27 properties	24 properties
- indirectly affected	4	N/Applicable	N/Available
Open space	17,750m² affected. Minor impacts on land used, but not zoned, as open space at Kogarah Golf Course	10,350m² affected*	10,350m² affected*
Community facilities			
- directly affected, either wholly or partially	2	None	None

'Variation' = current 1996 proposal for more direct tunnel
'Shorter tunnel' = preferred option (7e) in the 1994 M5 East EIS
'Extended tunnel' = Option 7l in the 1994 M5 East EIS
** Areas re-estimated. Were 1,400m² in the 1994 M5 East EIS.*

7.4.10 Conclusion

The Variation would have lesser impacts on residential and commercial land uses and community facilities than would either the shorter tunnel or the extended tunnel alternatives in the 1994 EIS.

7.5 Social environment

The impacts of the Variation on the social environment were assessed in a report by Briggs, Brindle and Chambers (1995), summarised below. The impacts of the Variation are also compared with the impacts arising from the shorter tunnel and the extended tunnel alternatives, as identified in the 1994 M5 East Motorway EIS.

7.5.1. Severance and instability

The Variation would have a small impact on community severance and instability. This would be the result of some of the air intakes and air exhaust structures being located in residential areas.

In the West Botany / Marsh Streets areas, local road access would not be significantly affected, as existing access would be largely retained.

7.5.2 Local access patterns

Vehicular

The Variation would pass underneath the Princes Highway, West Botany Street and Marsh Street. Consequently, most local access roads would be retained. Allen Street would remain open at the Princes Highway.

Eden Street cul-de-sac would be closed to vehicles at Burrows Street. Marsh Street slip road would be closed at the motorway. Access to Valda Avenue and Marsh Street slip road would be from West Botany Street.

During construction of the exit ramps, there may be some temporary road closures in the vicinity of the Illawarra Rail line and the Princes Highway, and between West Botany Street and Marsh Street.

Pedestrian

At Arncliffe, existing pedestrian access would be retained. On the western side of the Princes Highway, north of Ann Street, pedestrian access would be relocated from the existing footpath to a footpath built to the west of the east-bound exit ramp. A similar arrangement would be necessary for Burrows Street to accommodate the west bound entry ramp.

East of Marsh Street, the proposed motorway would generally follow the location of the South Western and Southern Ocean Outfall Sewer (SWSOOS), and other existing barriers to pedestrian movement. At the

intersection with General Holmes Drive, the proposed motorway would be on embankment and viaduct. Pedestrians on General Holmes Drive would be directed to use the pedestrian/cyclist underpass, which would be constructed along the Botany Bay side of the airport tunnel. In the 1994 M5 East EIS the underpass was proposed to be used by cyclists only.

Pedestrian access may be disrupted during construction. At all times, pedestrian access to Arncliffe Railway Station would be maintained.

7.5.3 Residential amenity and character

The location of the Variation within tunnel, rather than on viaduct, would minimise the impact of the Variation on residential amenity and character. As the Variation would generally be below street level, more effective acoustic screening and landscape treatments could be implemented than would be the case for either the shorter tunnel or the extended tunnel alternatives.

The tunnel exhaust stacks and air intakes could potentially have an adverse impact on the residential character and amenity of the area in Bardwell Park and Arncliffe, due to their size.

7.5.4 Wider changes to traffic patterns

The impacts of the Variation on wider changes to traffic patterns would be no different to those of either the shorter tunnel or the extended tunnel options.

7.5.5 Displacement and property affectation

The Variation would directly affect fewer properties than either the shorter tunnel or extended alternatives. This would enable displacement and dislocation to be minimised. Property acquisition is discussed in more detail in **Section 7.4** above.

7.5.6 Construction impacts

Construction sites for the Variation would alter from those proposed for the shorter tunnel and the extended tunnel alternatives. Impacts would include:

- Floodlighting for night work.
- Removal of trees and possibly some levelling of sites.
- Recreational use of some open space would cease for between 12 to 24 months.
- Noise, dust, and traffic.

Where proposed construction sites are located near residential areas, particular care would need to be taken to minimise adverse impacts.

Construction sites for the air intakes and exhaust stacks would be located adjacent to these structures. Some residences will require acquisition and demolition.

Construction activity may also result in disruption to road access arrangements. Where roads are closed, it is anticipated that pedestrian access would be maintained.

7.5.7 MITIGATIVE MEASURES

Mitigation measures remain the same for the Variation as for the shorter tunnel and the extended tunnel alternatives. These are discussed at **Section 23.7** of the 1994 M5 East EIS. In addition the Roads and Traffic Authority would ensure that:

- Vehicular access would be maintained wherever possible.
- Land acquisition would take place in terms of the Roads and Traffic Authority's land acquisition policy as set out in **Section 7.4** above.
- Pedestrian access would be maintained during construction. The Roads and Traffic Authority would require the contractor to prepare a pedestrian management plan as part of an environmental management plan. Details would be made available to the Community Liaison Group. The Roads and Traffic Authority would convene the Community Liaison Group by inviting the community to participate. The Group would meet from time to time to discuss design and construction aspects of the motorway.

7.5.8 COMPARISON OF VARIATION AND THE PREVIOUS ALTERNATIVES

The impacts on the social environment of the Variation are compared to those of the shorter tunnel and extended tunnel alternatives in **Table 24** below.

TABLE 24 — OVERVIEW OF IMPACTS OF THE VARIATION, THE SHORTER TUNNEL AND THE EXTENDED TUNNEL ALTERNATIVES

Land use	Variation	1994 M 5 East EIS proposal	
		Shorter tunnel	Extended tunnel
Severance and instability	Least impact	Greatest impacts	Fewer impacts than the shorter tunnel
Access			
- vehicular	Fewer impacts than either of the tunnel alternatives	Greatest impacts	Similar to the shorter tunnel
- pedestrian	Fewer impacts than either of the tunnel alternatives	Greatest impacts	Fewer impacts than the shorter tunnel
Residential amenity and character	Least impact	Greatest impacts	Fewer impacts than the shorter tunnel
Wider changes to traffic patterns	Local traffic patterns improved	Local traffic patterns	Local traffic patterns improved
Displacement and property affectation	Least impact	Greatest impacts	Fewer impacts than the shorter tunnel
Construction	Least impact	Greatest impacts	More widespread, indirect impacts than the shorter tunnel

Note: Variation - current 1996 proposal for a more direct tunnel
Shorter tunnel - the preferred option (7e), 1994 M5 East EIS
Extended tunnel - option 7l from 1994 M5 East EIS

7.5.9 CONCLUSION

The Variation would have the least impact of all of the alternatives considered.

7.6 VISUAL ASSESSMENT

7.6.1 INTRODUCTION

The following section is a comparative assessment of the visual impacts of the Variation. A detailed visual assessment of the Variation has been prepared by Manidis Roberts Consultants (1995), and is available as a separate document. A summary of the findings follows.

The visual assessment includes the Variation, the proposed tunnel exhaust vent stacks and air intake locations, and the noise walls which would be constructed where appropriate (**see Section 7.2**). The assessment aims to quantify and evaluate the potential visual impacts of the Variation, in comparison with the visual impacts that were assessed for the 1994 M5 East EIS shorter tunnel and extended tunnel alternatives.

METHOD OF ASSESSMENT

The method of assessment of potential visual impacts of the proposed Variation is the same as the method used for the visual assessment in the 1994 M5 East EIS. It involves:

- Dividing the proposal into units for assessment.
- Determining their visual catchment.
- Assessing the landscape's capability to absorb change.
- Assessing the likely impacts within each unit.

EXISTING CONDITIONS

Existing visual conditions along the proposed motorway route are described in the 1994 M5 East EIS. No change of significance has occurred since that document was prepared.

7.6.2 VISUAL IMPACTS OF THE VARIATION

BEXLEY ROAD TO MARSH STREET

Compared with the 1994 M5 East EIS option and the extended tunnel option, the Variation would have significantly less visual impact in this section of the route, due to the fact that the motorway would be in tunnel for the whole of this length. The most significant change would be in the area of Arncliffe and Turrella, where the 1994 M5 East EIS shorter tunnel alternative would be on a large, highly visible viaduct between Wolli Creek and Marsh Street. The extended tunnel alternative would be less visible in this area than the 1994 M5 East EIS alternative, but more visible than the Variation due to the sections of open slot.

PRINCES HIGHWAY INTERCHANGE

The only visible elements of the Variation through this section would be the on and off ramps at the Princes Highway, and the portal and the ramps at the Marsh Street interchange. The Princes Highway interchange would consist of three curved ramps; two on ramps and one off ramp. The on ramps would cater for the north and south bound lanes of the Princes Highway, and the off ramp for traffic exiting the motorway to travel north along the Princes Highway. The ramps would be visible only between the cut-and-cover portals and the surface. The motorway itself would not be visible.

The visual impact of the ramps would be minimal, as their 'visual catchment' would be small, and the landscape in this locality is highly altered and capable of absorbing the change that would result from the ramps' construction.

Construction of the cut-and-cover ramp sections at the Princes Highway interchange would necessitate the demolition of a number of buildings in

this locality. This would contribute to the visual impact, but in this highly built-up area of Arncliffe, the visual impact of reducing the number of structures would be considered positive. It would, however cause a significant negative social impact (see **Section 7.5**) due to the number of residents who would be displaced. The long term visual impacts will depend on how the residual land is used or developed in the future, assessment of which is outside the scope of this report.

Marsh Street interchange

At Marsh Street interchange a full diamond interchange would be constructed, with the motorway passing beneath Marsh Street. On the western side of Marsh Street, the motorway ramps would emerge from two cut-and-cover portals midway between West Botany Street and Marsh Street. The motorway itself would remain in cut-and-cover and emerge from a portal on the eastern side of Marsh Street.

The design of the Marsh Street interchange for the Variation would have a greater visual impact than the 1994 M5 East EIS shorter tunnel and extended tunnel alternatives. Under these previous proposals, the Marsh Street interchange would have been a signalised at-grade intersection, with the motorway descending from the viaduct (shorter tunnel alternative) or ascending from a tunnel portal (extended tunnel alternative) some 250 metres west of the interchange. With the Variation, the motorway would emerge from tunnel, with the ramps and their respective portals visible on the western side of Marsh Street where numerous residential properties would be demolished and extensive earthworks carried out.

The visual impact of the Marsh Street interchange for the Variation would be high within the local visual catchment. Marsh Street would be widened to six lanes plus turning lanes, and when the interchange is complete, the combined visual impact of the portals, the earthworks and the interchange itself would be significant for the residents of the properties that are to remain. The visual catchment for the interchange would include the Marsh Street residences that would overlook the site from the elevated ground adjacent to the ramp portal locations. Their existing outlook takes in the small park between the Marsh Street slip road and Marsh Street, the Kogarah Golf Course and Riverine Park across to the airport. Much of the small park adjoining the Marsh Street slip road would be lost to the construction of the interchange.

The interchange would result in a significant overall change to the landscape at this locality. Although the Variation has an overall lesser visual impact than the 1994 M5 East EIS shorter tunnel or extended tunnel alternatives, the Marsh Street interchange, as designed for the Variation, would have a greater visual impact than the corresponding at-grade intersection as proposed in the 1994 M5 East EIS.

Marsh Street to General Holmes Drive

Between Marsh Street and General Holmes Drive, the alignment and configuration of the Variation is very similar to the 1994 M5 East EIS shorter tunnel alternative (and the extended tunnel alternative, which is identical to the shorter tunnel alternative between Marsh Street and General Holmes Drive). The three main differences are that the alignment through the Riverine Park area is slightly changed, the General Holmes Drive interchange has been re-designed, and new 4 metre high noise barriers would be erected along the westbound carriageway of the motorway, on the northern bank of the Cooks River extending to the Endeavour Bridge.

The visual impact of the Variation east of Marsh Street is similar to that described in the 1994 M5 East EIS. The visual impact of the General Holmes Drive interchange for the Variation would be considerably greater, due to the construction of the proposed flyovers which would alter the visual landscape significantly when compared to the underpass proposed for the 1994 M5 East EIS alternative.

The visual impact of noise barriers is discussed in **Section 7.6.5** below.

At General Holmes Drive, the flyovers associated with the proposed interchange would widen the visual catchment such that the interchange would be visible to those residents of Kyeemagh who look out over the Cooks River, and recreational and other users of the river. However the nearest residences are approximately 250 metres from the location of the flyovers, and this distance would help to minimise the visual impact. The maximum height of the flyovers would be seven metres (height of the road surface above General Holmes Drive), plus approximately one metre for kerb safety barriers. Street lighting may also be provided and this would potentially be visually intrusive at night time. However, the airport is heavily lit at night, and it is not considered that street lighting would increase the overall spillover of light from all sources.

When all factors are taken into account, the visual impact of the proposed General Holmes Drive interchange for the Variation would be low, due to its distance from visually sensitive locations, and the existing visual environment which is dominated by Sydney Airport when viewed from any point on the southern or western side of the Cooks River.

7.6.3 Visual impacts of the tunnel exhaust stacks

Because of the extra tunnel length compared with the 1994 M5 East EIS shorter tunnel or extended tunnel alternatives, the Variation would require three tunnel exhaust stacks to be constructed at regular intervals along the tunnel's length. A number of possible tunnel exhaust stack locations were investigated initially, and three preferred locations were arrived at based

on a range of criteria including cost, proximity to the proposed motorway alignment, engineering considerations, likely air quality impacts, suitability of surrounding land uses and visual aspects. The selection and assessment of tunnel exhaust stack locations is described more fully in **Section 4.2**.

The alternative tunnel exhaust stack locations, and the preferred locations for the Variation, are shown in **Figure 7** in **Chapter 4**. As shown in the illustration, the preferred locations follow closely the alignment of the Variation. The preferred tunnel exhaust stack locations for the Variation are:

- The corner of Royal Place and Bardwell Road, Bardwell Park.
- The corner of Duff Street and Hill Street, Arncliffe.
- The Arncliffe Street Army Reserve Depot, Arncliffe Street.

The following is an assessment of the visual impacts of the preferred locations.

The tunnel exhaust stacks (and air intakes; see below) would be the only visible elements of the tunnel section of the Variation. Each of the preferred locations has different requirements in terms of the dimensions of the exhaust stacks. Each location is discussed below.

Preferred locations

Royal Place, Bardwell Park

Royal Place skirts the escarpment on the northern edge of the Bardwell Creek Valley, and the Bardwell Valley Golf Club. Above the escarpment, the land forms a plateau dominated by residential development. A tunnel exhaust stack at this location would be 15 metres high with an external diameter of 10 metres, and would be located near the corner of Bardwell Road and Royal Place where the land begins to fall away into the valley. The landscape on the edge of the escarpment is heavily wooded, screening the valley against the line of dwellings atop the ridge.

A tunnel exhaust stack at this location would be partly hidden by trees, but would still be highly visible especially when viewed from the residences in Bardwell Road. Trees would help to minimise the visual impact when viewed from in the valley or from its southern side.

Duff Street, Arncliffe

Duff Street climbs to the top of a high knoll above Arncliffe. The tunnel exhaust stack would be located at the top of Duff Street where it meets Hill Street, on the western side of the knoll, and would be 15 metres in height and 9 metres in external diameter.

Land use at this location is residential, and the stack would be visible from the residential area surrounding the lower end of Bardwell Creek, and to a

lesser extent the residences on the northern side of Wolli Creek in Minnamorra Avenue. The stack location would be partly hidden by the existing tree cover, but the top of the stack would be widely visible from the west and the north.

Arncliffe Street Army Reserve depot

A tunnel exhaust stack at this location would have dimensions of 15 metres high, by 9 metres in external diameter. In construction terms this location is ideal, being directly above the tunnel, close to its shallowest point. However in visual terms, the stack would be located in a residential/commercial area and although topography at this location means that the visual catchment is quite small, local land uses make for a relatively low visual absorption capability, and therefore a high visual impact on the immediate surrounding area.

However, it may be possible to incorporate this exhaust stack within a services structure or other commercial building, thereby minimising its visual impact.

The tunnel exhaust stack proposed for this location would incorporate, as part of the same structure, an air intake which would give the stack a larger footprint. However the air intake would only need to be some three metres high, and would not contribute to the overall visual impact of the structure.

7.6.4 VISUAL IMPACT OF THE TUNNEL AIR INTAKES

The length of tunnel associated with the Variation dictates a requirement for three air intakes, located at similar intervals along the tunnel's length as the exhaust stacks. The process of selecting air intake locations was similar to that for the exhaust stacks. A number of locations were considered (see **Figure 7**), and through preliminary assessment based on a range of criteria, three preferred locations for the Variation have been chosen. The preferred locations are:

- Royal Place, Bardwell Park – adjacent to the Golf Course.
- Duff Street, Arncliffe.
- Arncliffe Street Army Reserve depot.

Air intakes would be constructed in two ways. Where possible, they would be incorporated into the exhaust stack structures. Otherwise, they would be free standing structures approximately three metres high, ten metres long and eight metres wide. The height requirement is primarily to discourage vandalism, and the surface area requirement is to allow sufficient volumes of fresh air to be drawn into the tunnel. The preferred locations are described below.

AIR INTAKES

Royal Place, Bardwell Park
The air intake would be located adjacent to the Bardwell Valley Golf Course which is well screened by bushland.

Duff Street, Arncliffe
This location is the same as that described above for the tunnel exhaust stack for the Southern Variation. The air intake would be constructed adjacent to the proposed tunnel exhaust stack, at the edge of the golf course and surrounded by trees. The cumulative visual impact of the exhaust stack would not be significantly increased by the inclusion of the air intake.

Arncliffe Street Army Reserve depot
At this location, the air intake would be incorporated into the same structure as the proposed tunnel exhaust stack, and the cumulative visual impact of the exhaust stack would not be significantly increased by the inclusion of the air intake.

AIR INTAKES – GENERAL VISUAL ASSESSMENT
Visually, the impact of the air intakes would be minor. Their size would be such that they would be relatively easy to camouflage, or to build into the landscape. The visual catchments for the air intake structures would be small, and the capability of each site to absorb the structures is adequate.

7.6.5 VISUAL IMPACT OF NOISE WALLS

The Variation would significantly reduce the requirement for construction of noise walls beside the motorway. Compared with the 1994 M5 East EIS shorter tunnel and extended tunnel options, the Variation would require very little noise reduction treatment east of Bexley Road, as the motorway would be underground for most of the route and few noise-sensitive land uses would be exposed to motorway noise. Between Fairford Road and the Bexley Road interchange, noise walls would be constructed as described in the 1994 M5 East EIS.

Noise walls would be required however in four locations, at the Bexley Road, Princes Highway and Marsh Street interchanges, as shown in **Figures 39, 40** and **41,** and along the northern bank of the Cooks River extending to the Endeavour Bridge, as shown in **Figure 42**. At the Bexley Road interchange, barriers on the northern side of the off-ramp to Bexley Road would be raised from 5 to 6 metres in height, while on the motorway itself, barriers approaching the western tunnel portal would be raised in height from 4 to 5 metres. At the Princes Highway, noise walls would be constructed for the west bound on-ramp and the north bound off-ramp, above the ramp portals as shown in the figure. These would be designed primarily to protect nearby residential properties against noise from

motorway traffic. At the Marsh Street ramps, noise walls would be located as shown in the figure, to minimise noise for adjacent residences.

Between Marsh Street and General Holmes Drive, 4 metre high barriers would be erected along the edge of the westbound lane of the motorway, on the northern side of the Cooks River, from where it crosses the river alongside the South Western and Southern Ocean Outfall Sewer (SWSOOS), to the Endeavour Bridge.

Except as otherwise stated, noise walls would be approximately four metres in height above the road surface at all locations. At the Bexley Road interchange the visual impact of the noise walls would be moderate, and would be absorbed into the greater overall visual impact of the new interchange and tunnel portal structures. At the Princes Highway, the visual impact would be low, as the length of the walls would be minimal, the visual catchment small and the absorptive capability high. At Marsh Street, the walls would be highly visible for the residences immediately to the north, but otherwise impacts would be minimal.

Along the northern bank of the Cooks River, visual impact would be low, as the visual catchment is low and absorptive capability is high. Also, the expanse of the adjacent airport would help to absorb the visual impact of the noise barriers.

7.6.6 MITIGATIVE MEASURES

Mitigative measures for reducing or minimising visual impacts resulting from the construction of the Variation would be the same as those detailed in the 1994 M5 East EIS. In addition, measures are also proposed for the tunnel exhaust stacks.

MITIGATIVE MEASURES SET OUT IN THE 1994 EIS

Mitigative measures set out in **Appendix I** of the 1994 EIS are as follows and are specifically related to the 1994 M5 East EIS shorter tunnel and extended tunnel alternatives. Impacts on Wolli Creek and its valley are substantially reduced for the Variation. In the case of the Riverine Wetlands, the Roads and Traffic Authority would establish a Riverine Park Plan of Management Committee to assess and determine the appropriate uses for the Park, as detailed in **Chapter 8**.

General

The Roads and Traffic Authority would require the contractor to ensure that:

- The visual impact of the motorway is reduced by:
  - — reinforcing and extending the landscape objectives of the existing M5 Motorway, in particular use of indigenous species in a woodland type configuration; and

— ensuring that the earthworks design, fencing treatment and landscape structure are integrated with adjacent existing land uses.

- Wherever possible, adjoining land uses are considered in conjunction with the design of embankments with a view to enhancing and reinforcing their landscape and open space potential.

In particular:

- The following measures are taken to reduce the visual impact of the motorway:
  - — fast growing species of plants are used in landscape treatment;
  - — mangrove mudflats and the creek environment are rehabilitated after construction is completed;
  - — a clean up campaign is implemented;
  - — the stormwater drainage system is screened;
  - — landscape treatment of the embankments is to include native species;
  - — climbing species of plants are to be incorporated into the landscape treatment of the noise walls where appropriate.

Security and linkage

The Roads and Traffic Authority would require the contractor to ensure that, when designing landscaping treatments, the following safety issues are considered:

- Pedestrian areas are well designed, welcoming, well lit and well maintained.
- 'Dead-end' and blocked off streets are linked with new roads, lanes, and/or safely designed pedestrian and cyclist routes.
- Any proposed pedestrian and cyclist routes are linked into existing networks and form part of a pedestrian and cyclist strategy for the area.

Planting structure

The Roads and Traffic Authority would require the contractor to ensure that the predominant landscape structure is a continuation of the indigenous eucalyptus woodland parkway theme established on the M5 Motorway and Wolli Bushland. The landscape design would ensure that woodland planting generally occupies the embankments on either side of the motorway. In specific areas, this theme may be modified as follows:

- Re-establishing specific vegetation and ecological communities (such as mangrove or salt marsh) in areas such as Wolli Creek and the Cooks River flood plains.

- Undertaking special plantings at significant locations, such as major intersections, underpasses and visit termination points.

Species selection

The Roads and Traffic Authority would require the contractor to ensure that:

- Indigenous endemic species of vegetation are selected (where possible) to create a natural appearance, increase habitat, reinstate cleared indigenous vegetation, and reinforce local character. The five existing vegetation types identified by Mount King Ecological Survey (1994) would form the basis of species selection.
- Some non-indigenous species are also to be planted at particular locations including:
  - — possible signature trees;
  - — lawn varieties and other non-indigenous species in places where the embankments form part of existing recreational space.

Implementation of landscaping program

The Roads and Traffic Authority would require the contractor to ensure that:

- Landscaping work is carried out in accordance with detailed plans and specifications prepared by a qualified landscape architect experienced in large scale rehabilitation projects prior to construction;
- A quality assistance plan for landscape construction and regular monitoring after construction and planting is implemented.

During construction

The Roads and Traffic Authority would require the contractor to ensure that:

- A construction corridor is established on site within precise lines.
- The extent of clearing trees and vegetation within the motorway boundary is limited to the minimum required for construction.
- Construction works are carried out as far as possible within the corridor.

MITIGATIVE MEASURES FOR THE TUNNEL EXHAUST STACKS

The visual impacts resulting from the construction of the tunnel exhaust stacks would be a significant visual feature of the proposed Variation. It would not be possible to completely disguise or camouflage the stacks. However, they could be designed and the surface treated so as to help them fit into the visual landscape.

The following mitigative measures were not set out in the 1994 M5 East EIS.

The Roads and Traffic Authority would require the contractor:

- To appoint an urban designer to ensure that the visible portions of the tunnel exhaust stacks and intake vents are designed and screened in response to their urban context.
- To consider measures such as painting the stacks a suitable colour, and use of trees and shrubs, to further reduce the visual impact of the exhaust vent stacks.

The Roads and Traffic Authority would also consider the possibility of fully enclosing the tunnel exhaust stacks and air intakes within a purpose-built structure to mitigate the visual impact. This would apply particularly in the case of the Arncliffe Army Reserve Depot site.

7.6.7 Conclusions

The Variation's potential to affect the visual quality of the area east of Bexley Road would be significantly less than the shorter or extended tunnel alternatives that were given detailed consideration in the 1994 M5 East EIS, for the sole reason that the longer tunnel associated with the Variation would put most of the motorway underground and out of sight. This is considered to be a significant positive impact in visual terms, compared with 1994 M5 East EIS proposal.

The 1994 M5 East EIS shorter tunnel alternative would have resulted in the construction of a motorway viaduct through Turrella and Arncliffe, between Wolli Creek and West Botany Street. As discussed in **Chapter 24** of the 1994 M5 East EIS, the visual impact of the viaduct would have altered the landscape of Arncliffe substantially.

The 1994 M5 East extended tunnel alternative partially addressed the visual impacts, and was a significant improvement over the shorter tunnel alternative. However the extended tunnel alternative would have required substantial acquisition, for demolition, of properties and would have left sections of open slot which would still have had a greater impact than the Variation.

The Variation would effectively resolve this issue of visual intrusion in Arncliffe such that the motorway would be mostly invisible.

At the few locations where the Variation is above ground and configured differently to the 1994 M5 East EIS shorter tunnel and extended tunnel alternatives, impacts would be caused by the ramps, the Marsh Street interchange structure, the General Holmes Drive interchange and the noise walls. For the length of the Variation east of Marsh Street, visual impacts

would not differ significantly from those described in the 1994 M5 East EIS except for the General Holmes Drive interchange.

The major difference in visual impact between the Variation and the shorter tunnel and extended tunnel alternatives is that there would be three tunnel exhaust stacks instead of one (shorter tunnel alternative) or two (extended tunnel alternative). Their visual impact, though not great, would be magnified because in most cases they would have a large visual catchment area and would be visible from a considerable distance, in residential areas. Specifically, the Royal Place and Duff Street exhaust stacks would be visible at residences up to one kilometre away.

However, the proposed architectural treatment of the exhaust stacks, shown in the artist's impressions in **Figures 19** to **23** would reduce the level of visual impact.

Noise walls would be a visual feature of the Variation, but there would be significantly less requirement for noise walls than for the 1994 M5 East EIS or extended tunnel alternatives, and therefore less visual impact as a result.

7.7 Recreation

Recreation impacts of the Variation were assessed by Manidis Roberts Consultants. The results of this assessment are presented below. The impacts of the Variation are compared with the impacts associated with the shorter tunnel and extended tunnel alternatives as identified in the 1994 M5 East EIS.

As the Variation would mostly be underground, impacts on recreation would be small. There would be some impacts on recreation from the tunnel exhaust stacks and the air intakes.

7.7.1 Existing Recreation Opportunities

From Arncliffe to Kyeemagh, the existing recreation opportunities include several areas of open space, bushland and wetlands varying in size. These are used for both structured and unstructured recreation, and include public sports fields, picnic areas, boating and fishing facilities, and informal recreation areas as well as one golf course.

Impacts on existing recreation opportunities

Bardwell Park

A tunnel exhaust stack would be located on Bardwell Road, at the corner of Royal Place. Some residential properties would be affected, as would open space at the top of the escarpment overlooking the Bardwell Valley Golf Course. The golf course itself would not be affected, however, an intake vent would be located in land adjoining the golf course, between Royal

Place and May Street. This open space is quite steep and well-vegetated. It is mainly used for passive recreation such as walking the dog and jogging. The air intake and exhaust stack structures would have an impact on these recreation activities as well as a small impact on the recreational amenity of the golf course.

Arncliffe

A tunnel exhaust stack and air intake would be constructed in open space behind residential properties at Hill and Duff Streets. There are no formal recreation opportunities available in this open space, and it is enjoyed mainly by residents in the immediate vicinity. The structures may have a small impact on the passive recreation activities undertaken by local residents.

Exit ramps from the motorway to the Princes Highway would be constructed at Arncliffe. These would be constructed in cut-and-cover tunnel from the Illawarra rail line to the Princes Highway. A small local park with some play equipment is situated on the corner of Allen and Arncliffe Streets. There would be some impacts on this park during the construction of the motorway, as noise, dust and changes in air quality would affect the recreation opportunities available within this park. Once the motorway was constructed, the park would continue to operate as before. The park is located at a busy intersection and near the railway line, and impacts from the motorway would be combined with these existing impacts.

The Variation would emerge from tunnel at Marsh Street, Arncliffe. A small local park situated between Marsh Street and the Marsh Street slip road would be affected by the construction of exit ramps. This park is an area of open space, and has no play facilities or other features. Impact on recreation opportunities would be minor.

Marsh Street, Arncliffe to General Holmes Drive, Kyeemagh

The impacts of the Variation on recreation in this section would be slightly different to the impacts on recreation of the shorter tunnel or extended tunnel alternatives. These impacts are discussed at **Section 27.2** of the 1994 M5 East EIS.

The impact of the Variation on the Kogarah Golf Course would be marginally greater than under the shorter tunnel or extended tunnel alternatives. This is because the shorter tunnel and extended tunnel alternatives both included an at grade intersection with traffic signals at Marsh Street. With the grade separated intersection now proposed the development of the east facing ramps requires an additional encroachment onto the Golf Course. The Variation would cross to the north side of the SWSOOS in the vicinity of the golf course, affecting the rough alongside

one fairway. Details of golf course land that would be acquired by the motorway are contained in **Section 7.4**.

7.7.2 Impacts on future recreation opportunities

In addition to the impacts on existing recreation opportunities, the Variation would impact on plans by Rockdale Council to upgrade its recreation facilities in the Riverine Park area.

Where the Variation runs south of Marsh Street, it would impact on Rockdale Council's proposed plan for upgrading the recreation experience in Riverine Park. Council envisages an area of informal recreation running between the Barton Park sports fields and the SWSOOS, linking the Eve Street Wetlands with Muddy Creek. The plan is part of Rockdale's Wetlands Corridor Plan of Management that continues south to Ramsgate. The design was prepared on the assumption that none of the land would be required for main road purposes.

7.7.3 Mitigative measures

The Roads and Traffic Authority would compensate for any net loss of formal sports facilities. These measures would include assisting local councils with funding to:

- Provide landscaping to reduce the visual impact of the tunnel exhaust stacks in Bardwell Park and Arncliffe;
- Provide landscaping to reduce the visual impact of the motorway at Arncliffe where exit ramps to the Princes Highway are constructed in cut and cover tunnel;
- Provide noise barriers to reduce the noise impact of the motorway at Allen and Ann Streets, Arncliffe and at Marsh Street, Arncliffe; and
- Consult with Bicycle New South Wales concerning the design of, and access to, the motorway for cyclists, and the design of, and access to, a dedicated cycleway as an alternative to the proposed tunnel. Surfaces, road shoulder width and design of grates placed in gutters are to be suitable for cyclists.

To mitigate the impact of the Variation on the proposed upgrading of open space planned by Rockdale Council, the Roads and Traffic Authority would engage specialist consultants to prepare a plan of management for Riverine Park. The following organisations would be consulted during the preparation of the plan: National Parks and Wildlife Service, Department of Land and Water Conservation, Sydney Water, Rockdale City Council, Rockdale Wetlands Preservation Society, the Coastal Wetlands Preservation Society, Bicycle NSW, relevant sporting groups and the Roads and Traffic Authority. It would be intended that the park cater for passive and active recreation and provide an enhanced wetland habitat. The Roads and

Traffic Authority would also establish a consultative committee, inviting representation from the above organisations.

7.7.4 Comparison of Variation and EIS Proposal

Impacts of the Variation from the east of Bardwell Park are compared below with those identified for the shorter tunnel and extended tunnel alternatives. The impacts of the latter two are discussed in full in **Chapter 27** of the1994 M5 East EIS.

From Bardwell Park to Kyeemagh, the impacts of the Variation on recreation would be less than that of either the shorter tunnel or extended tunnel alternatives. The Variation would affect fewer recreation facilities than either of the other two alternatives. Where the Variation would affect recreation facilities, the impact would be generally related to the effects of changes in noise and air quality on the recreation experience. Kogarah Golf Course would lose approximately 1,350m^2 of land zoned open space and 7,500m^2 of land zoned County Road Reservation. The Variation would cause the loss of this open space, unless a decision was taken to replace it.

7.7.5 Conclusion

The Variation has the smallest impact on recreation of all the alternatives surveyed.

7.8 Aboriginal archaeology

Aboriginal archaeology was assessed in a report prepared by Haglund and Associates (1995), which is summarised below. The Variation is considered, and the impacts of the Variation are compared to the impacts which would arise from the shorter tunnel and extended tunnel alternatives, and which are identified in the 1994 M5 East EIS.

7.8.1 Description of the resource

The Variation

Proposed road alignment

A full description of the alignment proposed for the Variation is discussed in **Chapter 5** of this supplement to the 1994 M5 East EIS (see **Figures 8-15**.).

Where the motorway would be in tunnel, no definite Aboriginal archaeological sites were identified along the alignment of the Variation. The tunnel would run underneath Bardwell Creek and areas of possible high level alluvium, well beneath the surface.

The general area of the Riverine Park wetlands has been substantially disturbed but the actual wetlands may be a relic of pre-European landscape; they were left undeveloped because of the unsuitability of the land for farming or crop growing, according to Callaghan (1990). Haglund (1995) considers that such a landscape could retain evidence of past Aboriginal land use. This would be relevant if, and only to the extent that, the location is disturbed during construction of the Marsh Street interchange or the motorway itself.

Tunnel exhaust stacks – preferred locations

Three air exhaust stacks are proposed for the Variation. An assessment of the Aboriginal archaeological potential of the preferred locations is presented below. The three locations are at Royal Place, Bardwell Park, the intersection of Hill and Duff Streets, Arncliffe, and at Arncliffe Street, Arncliffe.

The Royal Place, Bardwell Park site is located on high alluvium which could contain the lenses of Aboriginal archaeological material. Depending on the precise location of the stack, the surface may need detailed inspection, possibly in connection with some surface clearing. The site would have low or minimal archaeological potential.

The Hill and Duff Streets site is located above and to the south of the Wolli Creek valley escarpment. It is situated in a residential area, on solid sandstone foundations, and it is unlikely that any Aboriginal archaeological material would exist at this site.

The Arncliffe Street site would have minimal archaeological potential. The site's setting and history of development would indicate that any Aboriginal archaeological material that may have existed would have already been lost.

Air intakes – preferred locations

Three air intakes are proposed for the Variation. The Aboriginal archaeological potential of the preferred locations is assessed below. The three locations are the same as for the tunnel exhaust stacks discussed above: near Royal Place at Bardwell Park, Duff Street Arncliffe and Arncliffe Street, Arncliffe.

Only the Royal Place location would be likely to have any Aboriginal archaeological material. As the air intake would be located near to the tunnel exhaust stack, the implications for Aboriginal archaeology on this air intake site would be the same as those for the exhaust stack, discussed above.

7.8.2 Assessment of impacts

The construction and use of the proposed Variation would be unlikely to have any impact on the Aboriginal archaeological resource. The potential

impacts of the Variation would be limited to possible disturbance of patches of sub-surface archaeological deposits where tunnel exhaust vent stacks or road supports cut through the sediments. However, the probability of this appears extremely low. In particular:

- The construction of tunnel exhaust stacks and air intakes at the above proposed locations, and use of access routes to these would be unlikely to cause damage to potential Aboriginal sites.
- Tunnel construction would not involve blasting which could cause cracking or collapse of cliff faces with rock shelters.
- Road construction in or near the Riverine Park wetlands would be unlikely to have an adverse impact on a potential Aboriginal archaeological resource.

The Variation is unlikely to adversely affect the known and unknown Aboriginal heritage of the area.

7.8.3 Mitigative measures

The following mitigative measures are suggested:

- The presence of archaeological deposits in areas of alluvium should be monitored through examination of the relevant portions of the excavation during construction.
- The Roads and Traffic Authority would require the contractor to engage a consultant archaeologist to monitor earthworks at sensitive areas, such as at the Riverine Park Wetlands.
- The Roads and Traffic Authority would consult with the Metropolitan Local Aboriginal Land Council and request their participation and monitoring during the construction of the motorway.
- Where air intakes or exhaust stacks are to be constructed close to or on cliff faces adjoining the Bardwell Valley Golf Course, clearing and inspection of adjoining cliff faces is recommended.

7.8.4 Comparison

The impacts of the shorter tunnel and extended tunnel options are discussed in full in the 1994 M5 East EIS. The comments below are drawn from that discussion.

The archaeological impacts of the shorter tunnel relate primarily to possible impacts on Wolli Creek. A possible shell midden would require further testing to establish its significance, and other sites are not in danger of disturbance. The overall impacts of the shorter tunnel are therefore minimal.

In the case of the extended tunnel option, the possibility of even these likely impacts occurring is removed.

The shorter tunnel would be likely to have the greatest impact, then the extended tunnel would have a lesser impact. The Variation would have the least impact.

7.8.5 Conclusion

The Variation would be less likely to adversely affect both the known and unknown Aboriginal archaeology of the area than either the shorter tunnel option or the extended tunnel option.

7.9 European heritage

Impacts of the proposed Variation on European heritage were assessed in a working paper by Wendy Thorp (1995). That report is summarised below. The impacts of the Variation are also compared with the impacts predicted to arise from the shorter tunnel and extended tunnel alternatives, as identified in the 1994 M5 East EIS.

7.9.1 Description of the resource

The Variation would involve three tunnel exhaust stacks and three air intakes. These would be situated in areas of Bardwell Park and Arncliffe.

Bardwell Park
This area was first subdivided for residential use in the late nineteenth century, and was then consolidated significantly in the years post-World War II. The East Hills railway was opened in 1931.

Arncliffe
The Arncliffe area was subdivided during the later years of the nineteenth century. Land in the vicinity includes land that was alienated during the nineteenth century and principally developed during the later nineteenth century and first half of the twentieth century.

7.9.2 Assessment of impacts

The Variation directly affects far fewer properties than either the shorter tunnel or extended tunnel alternatives, because of the longer tunnel and the fact that there would be less disturbance of the ground surface along the route.

No heritage items or properties would be affected by the road alignment of the Variation. A stone cottage in West Botany Street, listed in the Schedule

attached to the Rockdale Draft LEP, may be affected by the Marsh Street interchange and road widening around the interchange.

At the site of the former Rockdale Sewage Farm near Marsh Street, there is a stand of pine trees lining a driveway to the current Council depot that has heritage value and is listed in the Schedule attached to the Rockdale Draft LEP. This stand is not likely to be affected by the Variation.

In relation to the air intakes and/or tunnel exhaust stacks, none of the preferred locations have been identified by this or earlier studies to be of European heritage significance. Therefore, there are no potential impacts on European heritage value. No associated mitigative measures are therefore required.

7.9.3 Mitigative measures

- All authorisations and consents required under the National Parks and Wildlife Act 1974, or the Heritage Act 1977, would be in place prior to any works commencing.
- A suitably qualified person would be appointed to prepare a report to verify the heritage conclusions drawn in the 1994 M5 East EIS and this Supplementary EIS. A plan of management would be required for any identified sites of significance.

A development application would need to be submitted to Rockdale Council before the demolition of heritage items.

7.9.4 Comparison of the Variation with the 1994 M5 East EIS alternatives

A comparison of the impacts of the Variation with the shorter tunnel and extended tunnel alternatives is presented below. The impacts of the latter two have been drawn from the 1994 M5 East EIS.

The shorter tunnel and extended tunnel alternatives would have possible visual impacts on Tempe House and the viaduct for the South Western and Southern Ocean Outfall Sewer (SWSOOS) at Turrella. Neither of these sites, or any other heritage listed sites in Arncliffe or Turrella, would be impacted by the Variation.

The Variation would not have any impact on the above items. However, it would be in relatively close proximity to the line of pine trees between Marsh Street and Eve Street, and the stone cottage on West Botany Street, which are listed in the Schedule of heritage items attached to the Rockdale Draft LEP.

The Variation would have fewer impacts on European heritage than either the shorter tunnel or extended tunnel alternatives.

7.9.5 Conclusion

The impacts of the Variation on known items of European heritage significance would be significantly less than those arising from either the shorter tunnel or extended tunnel alternatives.

7.10 Economic evaluation

A detailed economic evaluation was undertaken by Applied Economics (1994) for the M5 East EIS proposal. That evaluation has been updated, using the same method, for the Variation in regard to road user benefits and costs, and the results are set out below (Applied Economics *pers comm* 28.11.1996 reproduced in **Appendix D**).

7.10.1 Cost-benefit analysis

Costs and benefits used

The cost benefit analysis involved valuing the costs and road user benefits of the Variation and comparing the results against those for the 1994 M5 East EIS proposal.

The quantified costs identified for the Variation are summarised in **Table 25** below.

Table 25 — Summary of quantified costs for the Variation, $million, 1996 prices

Year	Land acquisition costs	Construction costs	Maintenance costs
1997	19	80	
1998	56	155	
1999		155	
2000		95	4
2001			4
2002			4
2003			4
Costs for all following years			4

Source: Roads and Traffic Authority 1996

RESULTS OF THE COST BENEFIT ANALYSIS

A summary of the results of the cost-benefit analysis is presented in **Table 26** below, with the detailed tables presented in **Appendix D**.

TABLE 26 — SUMMARY OF RESULTS OF COST BENEFIT ANALYSIS AT 7% DISCOUNT RATE

Benefits and costs	Variation	1994 M5 East EIS Proposal
User benefits	$1,185m*	$1,011m
Costs	$514m*	$569m
Net benefit	$671m*	$441m
Benefit-cost ratio	2.4	1.8

**Discounted to present value in 1996*
Source: Applied Economics pers comm. *28 November 1996.*

At a discount rate of 7%, the net present value is positive at $671 million for the Variation and $441 million for the M5 East EIS proposal, so the proposed motorway is economically viable in either case.

It can be seen from **Table 26** that the Variation compares with the 1994 M5 East EIS proposal in the following ways:

- User benefits for the Variation exceed those of the 1994 M5 East EIS proposal by a small margin, $174 million.
- Costs for the Variation are lower than for the M5 East EIS proposal. The net present value of user benefits for the Variation therefore exceed those of the 1994 M5 East EIS proposal.
- The benefit-cost ratio (ratio of user benefits to costs) for the Variation is slightly better than for the 1994 M5 East EIS proposal.

7.10.2 SENSITIVITY ANALYSIS

The sensitivity of the cost-benefit calculation for the Variation was tested at 7% discount rate for conservative construction costs (assumed to be increased by 20%) and travel time savings (assumed to be decreased by 20%). The motorway still remains viable with these changes in assumptions, having a net present value of $388 million.

The sensitivity of the cost-benefit results to the alternative discount rates of 10% and 4% was also tested. Due to the high upfront costs and long life of the project, the size of the net benefits is sensitive to the choice of discount rate. The results are presented in **Table 27** below.

TABLE 27 — SENSITIVITY TO CHANGES IN DISCOUNT RATES

Discount rate	Variation Net benefit (1996 dollars)	1994 M5 East EIS Proposal (1994 dollars)
4%	$1,229m	$987m
7%	$671m	$441m
10%	$348m	$987m

Source: Applied Economics pers comm. *28 November 1996*

CHAPTER 8 ASSESSMENT OF IMPACTS AND PROPOSED SAFEGUARDS ON THE NATURAL ENVIRONMENT

8.1 INTRODUCTION

This chapter deals with the potential impacts of the Variation on the natural environment.

In the 1994 M5 East EIS, the impacts on hydrology, water quality, flora and fauna were principally in the Wolli Creek area. The Variation considered in this Supplement reduce those impacts. Where there are differences they are dealt with below.

The 1994 M5 East EIS found that both the shorter tunnel and the extended tunnel presented in that EIS would impact on wetlands in the west at Salt Pan Creek. In the east the shorter tunnel would impact on the wetlands of Wolli Creek. The impacts at Salt Pan Creek are as dealt with in the 1994 M5 East EIS. With the Variation presented in this Supplement, the wetlands of Wolli Creek would no longer be under threat, but the Variation would impact on the Eve Street and Marsh Street Wetlands adjacent to Riverine Park.

8.2 HYDROLOGY AND WATER QUALITY

8.2.1 INTRODUCTION

A specialist study on hydrological and water quality impacts was prepared by Willing & Partners (1995) and the results are summarised below.

The notable features with respect to hydrology, hydraulics and water quality in the study area are Wolli Creek, Riverine Park Wetlands, Coolabah Reserve and Cooks River. The existing situation is the same as that described in the 1994 M5 East EIS.

The impacts of the Variation from construction and operations are discussed below and compared with those assessed for the 1994 M5 East EIS shorter tunnel and extended tunnel alternatives.

8.2.2 THE IMPACTS OF THE VARIATION

The assessment of impacts was undertaken on a section by section basis as follows:

BEXLEY ROAD TO MARSH STREET

Generally speaking, there would be no impact on the local drainage and flood regime from the Variation alignment. The motorway no longer lies within the Wolli Creek floodplain and it runs sufficiently deep to pass safely under both Wolli Creek and Bardwell Creek. The Variation would necessitate permanent alterations to both local and trunk drainage infrastructure as the tunnel approaches the surface. In particular, the section between the Illawarra Railway and the Princes Highway is likely to interfere with a major underground trunk drainage system.

MARSH STREET TO COOKS RIVER

The construction phase would pose substantial water quality problems with respect to the Riverine Park wetlands. The location of the motorway to the north of the South Western and Southern Ocean Outfall Sewer (SWSOOS) would reduce the impact on the Eve Street Wetlands.

The eastern portal of the Variation would be located east of Marsh Street and south of the SWSOOS. The construction of the tunnel is not expected to have any long term adverse impact on flooding or water quality, with either the boring or 'cut and cover' tunnelling methods used.

COOKS RIVER TO GENERAL HOLMES DRIVE

The impacts on this section would be the same as identified in the 1994 M5 East EIS, since they follow an almost identical alignment.

8.2.3 ACID SULFATE SOILS

An investigation of the possibility of acid sulfate soils occurring along the alignment of the 1994 M5 East EIS proposal was undertaken by Connell Wagner and Pells Sullivan Meynink Pty Ltd and reported in April 1995. The assessment of impacts for the route of the Variation was undertaken by extrapolating from that information.

Potential for acid sulfate generation was determined by measuring the difference between total potential acidity (TPA) and total actual acidity (TAA). Where this is greater than 0.12 moles per kilogram for clayey soils, or 0.03 moles per kilogram for sandy soils, it is concluded that the soils have the potential to generate acidic drainage.

For the driven tunnel through Hawkesbury sandstone, acid drainage would not be expected as sulfide minerals are not present.

Where the tunnel from the 1994 M5 East EIS shorter tunnel alternative would have emerged at Turrella, acid sulfate was expected to be generated when soils were exposed to the atmosphere. For the Variation, no deep sampling has been carried out at the locations of the various cut-and-cover and slot sections. However, from the deep sampling previously carried out at Turrella, and the shallow sampling carried out in the vicinity of Marsh Street, it is concluded that similar potential may be expected.

8.2.4 Comparison of impacts

The impacts of the proposed Variation and those identified in the 1994 M5 East EIS are set out below.

In the Wolli Creek Valley at Turrella, the Variation would avoid the adverse impacts with respect to both flooding and water quality that would occur with the 1994 M5 East EIS shorter tunnel alternative. The extended tunnel would also avoid adverse impacts on existing flood behaviour in Wolli Creek at Turrella, although these benefits would be likely to be partly negated by an increased risk of flooding in the tunnel due to runoff from the road surface where the route runs within slot (open cut).

In the vicinity of the Riverine Park wetlands, the Variation would pose a higher risk to the water quality of wetlands than the shorter tunnel and extended tunnel options, as they would pass closer to the Marsh Street wetland, and more importantly the Eve Street wetland, thus increasing the risk of water quality problems.

The Variation, as well as the shorter tunnel and extended tunnel, would be expected to have similar problems with the management of acid-sulphate soils, but these problems would be avoided in the Wolli Creek valley for the Variation. However, at the locations of the proposed tunnel exhaust stacks and air intakes, any impacts would be localised, and therefore more easily managed.

8.2.5 Mitigative measures

Should the Variation proceed, the following mitigative measures would be undertaken:

General mitigative measures

The following mitigative measures are the same as those proposed in the 1994 M5 East EIS. The Roads and Traffic Authority would require the contractor to:

- Construct floodwalls or levees, especially around the tunnel portals.
- Investigate existing drainage systems and construct modifications where there is a potential increase in stormwater runoff.

Additional general mitigative measures that would be undertaken are:

- An acid sulfate soil management plan as part of the environmental management plan would be prepared by the contractor, for approval by the NSW EPA, to include:
  - — Provision for further sampling and analysis of soils during the early stages of construction.
  - — Plans of management of soil stockpiles and for treatment and discharges of acidic leachate.
  - — A focussed monitoring program for water quality in both surface and groundwater.
  - — Contingency procedures, to be implemented in case of failure of the proposed management plan.
- Where acid sulfate soils are encountered, the Roads and Traffic Authority would require the contractor to manage them in accordance with accepted practice as documented in the NSW EPA guidelines 'Assessing and Managing Acid-sulphate Soils.'

Fairford Road to Bexley Road

The mitigative measures to be undertaken between Fairford Road and Bexley Road would be the same as those for the 1994 M5 East EIS proposal.

Bexley Road to Marsh Street

At the isolated worksites above the tunnel in this section, the Roads and Traffic Authority would require the contractor to undertake the following mitigative measures:

- Construct a temporary levee to minimise flooding risk during construction.
- Construct air intakes above flood levels.
- Establish a water quality monitoring station to monitor the water quality of the effluent from the motorway.
- Undertake construction in a historically low water flow period in order to minimise the risks associated with flooding and water quality during construction.
- Where 'cut and cover' tunnelling is used, to provide low level bunding, pumps and sedimentation basins to collect and treat polluted water prior to discharging into the drainage system.

Marsh Street to General Holmes Drive

The Roads and Traffic Authority would require the contractor to undertake the following mitigative measures between Marsh Street and Cooks River:

- Direct all motorway drainage to sedimentation basins in accordance with the Riverine Park Plan of Management.

- Provide carefully installed and maintained geotextile sediment fences between the work sites and the wetlands together with an absorbent bund behind the geotextile fence.
- Establish a water quality monitoring station and regime to check the effectiveness of the water quality control measures established for both the construction and initial operation phases. Monitoring specifications are as follows:
  - — Typical monitoring would include tests for turbidity, hydrocarbons, heavy metals, litter, conductivity, temperature and pH.
  - — Monitoring frequencies: once every two months in the first year of operations; quarterly for the second and third operational years if the monitoring results from the first year are stable. Monitoring after the third operational year would be subject to review.
  - — Monitoring during the construction phase should be far more frequent. Testing should be at least weekly whilst construction is occurring in areas which drain directly to the wetlands.
- Construct floodwalls to a height of RL 4.00 metres AHD or levees at the eastern tunnel portal to protect against the extreme flood. They would be incorporated into sound walls where appropriate.
- Construct streamlined motorway viaduct piers to minimise any disturbance to flood flows.
- Construct a vertical face to the river embankment wall, cantilevering the proposed motorway over the river bank or relocating the SWSOOS, as an alternative to filling within the Cooks River.

8.2.6 Conclusions

Notwithstanding the concern for the integrity of the Riverine Park wetlands, the Variation is considered likely to present fewer problems overall with respect to water quality, drainage and flooding compared to the shorter tunnel and extended tunnel. This is because the motorway would be in tunnel for a greater portion of its length and would avoid direct impacts on Wolli Creek with less opportunity for polluted runoff to enter waterways or wetlands.

8.3 FLORA AND FAUNA

8.3.1 INTRODUCTION

Between Bexley Road and Marsh Street, the potential disturbance of flora and fauna would be limited to those areas which would be disturbed by the motorway's construction and operation. Specifically, these areas would be the Bexley Road portal location, the Princes Highway interchange location (the Arncliffe Street Army Reserve Depot), the Marsh Street interchange and portal location, and the tunnel exhaust/air intake sites.

Locations where tunnel exhaust stacks and/or air intakes are proposed and where flora and fauna disturbance would occur, include:

- Royal Place adjacent to Bardwell Road (exhaust stack)
- Royal Place adjacent to Bardwell Valley Golf Club (air intake)
- Corner of Duff Street and Hill Street, Arncliffe (exhaust stack and air intake)
- Arncliffe Street Army Reserve Depot (exhaust stack and air intake)

East of Marsh Street, the Variation would differ slightly from the alignment of the 1994 M5 East EIS proposal in that it would encroach on the northern side on the Marsh Street wetland, and follow closely the alignment of the SWSOOS. In terms of flora and fauna, these would be the only likely areas of impact.

8.3.2 STUDY APPROACH

Since the release of the 1994 M5 East EIS, additional flora and fauna studies and surveys were carried out by Mount King Ecological Surveys (1995) and by Lesryk Environmental Consultants (1996). A more recent survey for the Marsh Street and Eve Street wetlands was carried out by Lesryk Environmental Consultants (1996). A report by P L Osborne (1995) provided additional information with regard to wetland habitats as identified by Adcock and Osborne (1994). These and other environmental studies haves been carried out to assess the conservation status of flora and fauna and the likely impacts of the proposal.

A meeting was held on 19 October 1995 at Rockdale City Council Chambers to discuss issues concerning the wetlands near Eve Street, Arncliffe with regard to the proposed new M5 East tunnel alignment. These issues included the impact on migratory birds using the wetlands.

In addition, an investigation was also undertaken by the Ecology Lab (1995) of fish and decapods in the Cooks River, in response to comments received on the 1994 M5 East EIS. The river has been canalised and in this area the river bottom is mainly mud. All species of fish caught in the

sampling are common species. The blue swimmer crab and penaeid prawns caught are also common species and commercially harvested.

8.3.3 THE EXISTING SITUATION

A number of possible sites for tunnel exhaust stacks and air intake vents were considered along the length of the proposed tunnel. Each site is described and assessed in detail in the M5 East - Supplementary Flora and Fauna Assessment (Mount King Ecological Surveys, 1995).

All sites studied for the tunnel exhaust stacks and air intakes have been modified or disturbed, and none could be described as being in a natural state. The existing situation with regard to flora and fauna at each of these locations of the proposal is described below.

ROYAL PLACE, BARDWELL PARK (TUNNEL EXHAUST STACK)

This site is currently occupied by three residential dwellings, and there is no undisturbed native bushland within the site. However the site is close to an area of ridgeline vegetation associated with Bardwell Valley and classified in the Bardwell Valley Management Plan as 'bushland, virtually free of exotic plants' and recommended as a bushland area worthy of conservation in that plan. This site is also adjacent to the Bardwell Valley Bushland and the Bardwell Valley Golf Course.

DUFF STREET AND HILL STREET, ARNCLIFFE (TUNNEL EXHAUST STACK AND AIR INTAKE)

This site is currently occupied by residential dwellings, and there is no undisturbed native bushland within the site. However, the air intake could potentially be located within a small area of native vegetation comprising several rainforest and sandstone species. Although weeds are present, the site could be classified as urban bushland.

The M5 East - Supplementary Flora and Fauna Assessment (Mount King Ecological Surveys, 1995) noted that if the air intake vent was located within the bushland along the ridgeline near Duff Street, it could result in the loss of native vegetation and wildlife habitat. The possible generation of noise and vibration could affect native fauna using the area.

ARNCLIFFE STREET ARMY RESERVE DEPOT (TUNNEL EXHAUST STACK AND AIR INTAKE)

This site, near the corner of Ann Street and Arncliffe Street, is also highly modified, being used by the Army as a depot and parade ground, with some housing for defence personnel. It is surrounded by residential and commercial land uses, and is adjacent to the Illawarra Rail Line. No original native flora exists, and fauna would be limited to those bird species which have adapted to this type of urban environment.

8.3.4 IMPACT ASSESSMENT

OVERVIEW OF IMPACTS

The proposal would not alter the impacts as described and assessed in detail in the M5 East - Supplementary Flora and Fauna Assessment (Mount King Ecological Surveys, 1995) and in the 1994 M5 East EIS. The impacts are as follows:

Between Bexley Road and Marsh Street there would no longer be an impact on Wolli Creek.

At the Marsh Street and Eve Street wetlands, there would be some impact due to the motorway alignment shifting to the south of the SWSOOS. Of particular concern are potential impacts upon the Marsh Street wetland where the endangered Green and Golden Bell Frog (*Litoria aurea*) is found. These impacts would be similar to those described in the 'Construction phase' impacts on wetlands in the 1994 M5 East EIS.

From Marsh Street to General Holmes Drive there are no changes to the 1994 M5 East EIS. Environmental management of impacts in regard to the Cooks River and tidal channels that link Eve Street Saltwater wetland to the river would need to be maintained.

AIR INTAKE AND EXHAUST STACK LOCATIONS

The preferred location of the Royal Place air intake at the Bardwell Valley Golf Course comprises potentially significant ridgeline bushland. There is potential for disturbance of the bushland during construction of the air intake, and noise and vibration which would have a disturbing impact on fauna. Similarly, the site at the corner of Duff Street and Hill Street, Arncliffe comprises potentially significant bushland which could be considered as having high habitat value. An exhaust stack/air intake at this location may affect fauna movement patterns along the ridgelines, through noise and vibration, as well as resulting in a loss of habitat having a restricted distribution in south-western Sydney. The Arncliffe Street Army Reserve Depot has a limited habitat value due to the source of food that birds may obtain from the tree blossoms.

WETLANDS

The proposal would take the motorway closer to the Marsh Street and Eve Street wetlands within Riverine Park, both of which have value as remnants of the extensive mudflat, saltmarsh and mangrove flats which previously existed in this area. The Eve Street wetland habitat type is limited within the Sydney region and is used by several migratory bird species. The Green and Golden Bell Frog (a species of endangered fauna) is a known inhabitant of the Marsh Street wetlands, an area which supports a variety of exotic and native plants and provides a relatively dense vegetation cover for native fauna. Any loss of this cover, from the Eve Street or Marsh Street areas, may affect local faunal biodiversity.

According to the specialist report on wetlands (Osborne, 1995), the proposal and its construction would have a substantial impact on the Eve Street and Marsh Street wetland areas. However, mitigative measures have been identified (see below) which would ensure the long term survival of these wetlands. Both these areas have State significance (presence of endangered species in NSW) and the Eve Street wetland has international significance due to the presence of migratory waders listed in the JAMBA (Japan-Australia Migratory Birds Agreement) and CAMBA (China-Australia Migratory Birds Agreement) international conventions.

Cooks River

The impact on habitat of fish and decapods of the construction and operation of the proposal is likely to be negligible (Ecology Lab, 1995).

8.3.5 Mitigative measures

The mitigative measures are largely based on the proposed management plans and rehabilitation of the Marsh Street wetlands prior to the commencement of any works associated with the proposal. Also, the choice of locations for the air intakes and exhaust stacks, and treatment of the sites during and after construction would provide the required safeguards. Specific mitigation measures relating to flora and fauna impacts of construction and operation of the motorway and air intake and exhaust facilities are presented below.

Mitigative measures presented in the 1994 EIS

The following mitigative measures were proposed in the 1994 M5 East EIS which would still apply for the proposed new tunnel alignment. The Roads and Traffic Authority would require the contractor to implement the following strategies to enhance or restore the motorway route as a continuous flora and fauna corridor:

- Plant trees and shrubs on the outside of noise barriers in the eastern and western sections of the route.
- Plant low to medium shrubs and ground cover inside the noise barriers where possible and within median strips between the two roadways.
- Provide broken rocks at selected locations to roadside slopes or embankments, with soil and low-growing plants between the interstices of the rocks.
- Link the corridor established along the M5 resulting from plantings inside and outside the road boundaries with bushland within the Wolli Creek valley, to provide an unbroken corridor between the Georges and Cooks rivers.
- Stabilise cleared areas and revegetate these.
- Establish a seed bank of local native species prior to construction, in order to replant the motorway with local plant species.

- Replace exotic plant species (gradually).
- Through specialist consultants, prepare a Plan of Management for the Riverine Park with the aim of establishing an enhanced wetland.
- Establish a consultative committee inviting representation from NPWS, Rockdale Council, Sydney Water, Department of Land and Water Conservation, Rockdale Wetlands Preservation Society, the Coastal Wetlands Society, Bicycle NSW and relevant sporting groups.

8.4 WETLANDS

8.4.1 INTRODUCTION

Osborne (1995) undertook an assessment of potential impacts on wetland habitats along the proposed motorway route as an addendum to Adcock and Osborne's 1994 reports. A summary of that report is presented below.

This section assesses the ecological impacts and benefits to wetland habitats that would accrue as a result of the proposed changes.

8.4.2 IMPACT ASSESSMENT

MOTORWAY CONSTRUCTION

The major impact of the 1994 M5 East EIS proposal on the wetlands resulted from the construction of a cut and cover section of the motorway under Wolli Creek just downstream of the weir at Turrella. Selection of the Variation would remove any threat to these wetlands from motorway construction and operation.

The wetlands potentially affected by the proposal are those adjacent to Riverine Park and the Eve Street (salt and freshwater) and Marsh Street wetlands (collectively referred to as the Riverine Park wetlands). The wetlands are shown in **Figure 54**.

Construction of the proposal would have two major impacts on the Marsh Street and Eve Street wetlands: a direct reduction in the wetland habitat area; and an impact on the hydrology of the Eve Street wetland.

Within drainage channels, wetlands have aesthetic value as well as benefiting water quality by providing filtration for suspended solids and reducing Biochemical Oxygen Demand (BOD). The Eve Street wetland is connected to the channel system and probably plays a role in enhancing water quality. Furthermore, this wetland is of major regional significance owing to its aesthetic, scientific and heritage values.

The second major concern is run-off during construction. Run-off has the potential to cause damage to sites downstream of the activity through increased levels of turbidity. High levels of turbidity affect the clarity of the receiving waters and can, if sustained for long periods, affect the

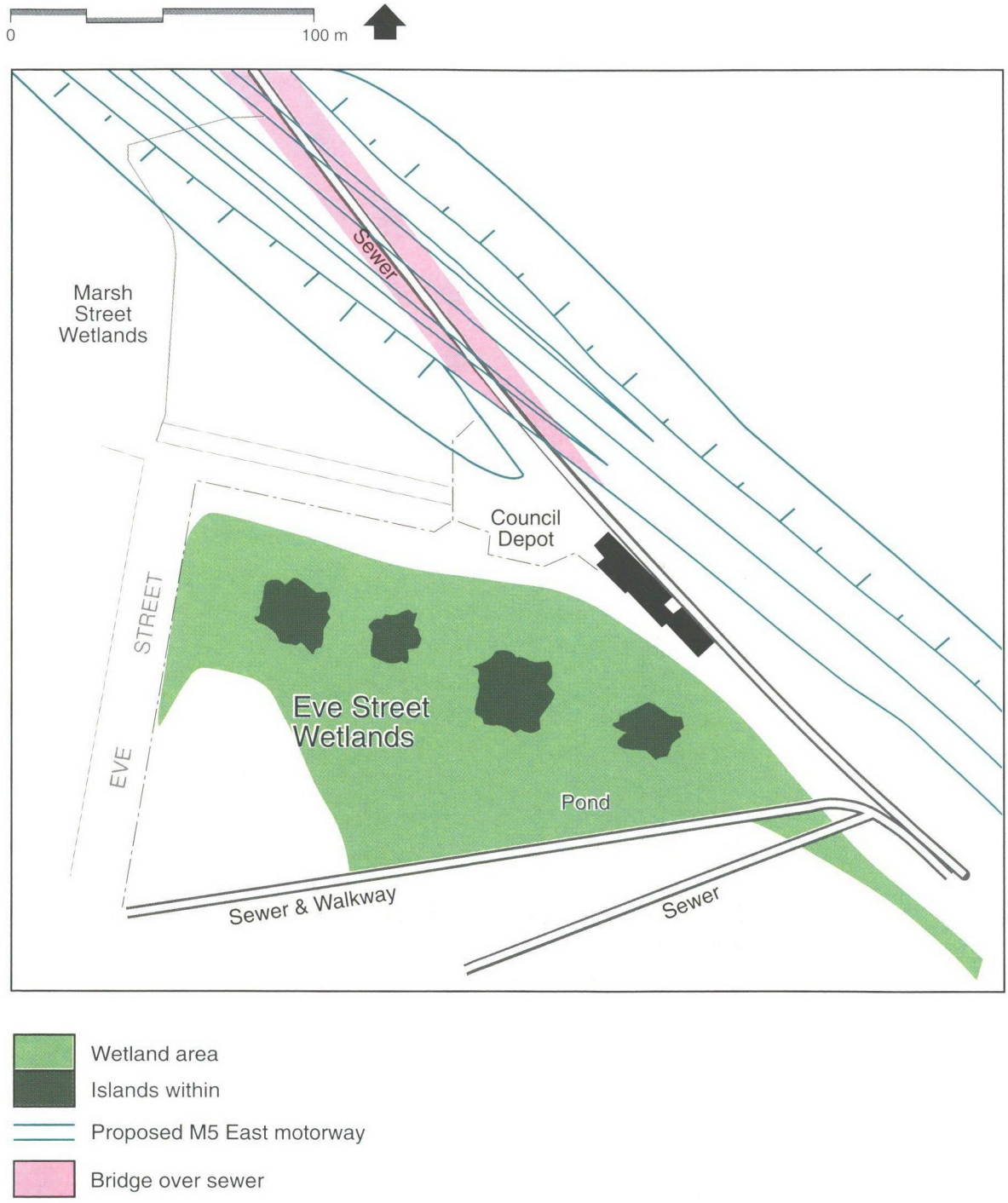


FIGURE 54 — EVE STREET AND MARSH STREET WETLANDS

photosynthetic capacity of submerged plants. Emergent species are more tolerant of turbid water but can be susceptible to contaminants in the run-off.

The Marsh Street and Eve Street wetlands have the potential to be threatened by run-off from the site during construction. Sensitive motorway design would reduce the impact of the structure on waders and other waterfowl that utilise this habitat. Both sites would require protection from sediments and pollutants throughout construction activity and during motorway operation.

MOTORWAY OPERATION

The major impact on the wetlands from motorway operation would be run-off. A four lane motorway, as a catchment area, would accumulate pollutants associated with vehicles, including oil, grease, rubber, brake pad dust and particulate exhaust material. Drainage from this area would be concentrated into disposal points and could escape into natural water courses.

8.4.3 MITIGATIVE MEASURES

The Roads and Traffic Authority would:

- Through specialist consultants, develop an appropriate plan of management for the affected area. The Marsh Street and the Eve Street (freshwater) wetlands would be enhanced and possibly linked to adjoining Council land to extend the wetlands and form a more viable wetland area. Options for extending the Eve Street (salt water) wetlands towards the Cooks River and Muddy Creek would be considered and a preferred strategy implemented.
- Establish a Riverine Park Management Committee, and request representation from NPWS, Rockdale Council, Sydney Water, Department of Land and Water Conservation, Rockdale Wetlands Preservation Society, the Coastal Wetlands Society, Bicycle NSW and relevant sporting groups. The Roads and Traffic Authority would provide funds to support the Committee. Committee actions would be linked to the recommendations contained within the Species Impact Statement, the plan of management and the requirements of the National Parks and Wildlife Service.
- Require the contractor to develop a wetland rehabilitation plan prior to construction. Implementation of the plan, prior to construction, in the Marsh Street and Eve Street (fresh water) wetlands, would mitigate construction impacts. Issues which would be addressed include management of Green and Golden Bell Frog populations during rehabilitation and construction, control of sediment loads, litter and garbage.

- Ensure that the necessary mitigation works to protect the wetlands would be undertaken as one of the first stages of construction, and before any motorway construction takes place in the wetlands area. This would ensure that suitable wetland habitat is maintained throughout the construction period.
- Require the design of the proposal to have as low a profile in the vicinity of the Marsh Street and Eve Street wetlands as possible. Such a profile would have less impact on birds approaching the wetland as their line of sight would be less restricted.
- Require the contractor to ensure that an effective runoff monitoring program is implemented during and after construction.
- Require the contractor to ensure that the tidal channel linking the Eve Street (salt water) wetlands with the Cooks River, remains open throughout the construction period.

8.4.4 MONITORING AND AUDITING

The Roads and Traffic Authority would ensure that monitoring and auditing is carried out as follows:

- During construction environmental scientists would monitor run-off. A sampling program would be designed providing details of sampling sites, sampling frequency, and water quality measurements.
- The effectiveness of pollution control measures would be assessed following the opening of the motorway and a monitoring program would be designed to carry out this program.

8.4.5 CONCLUSION

This proposal would remove the impact of the 1994 M5 East EIS proposal on the wetlands of Wolli Creek. There would be less impact on the Eve Street wetland area than for the 1994 M5 East EIS proposal, as the motorway would be aligned over the SWSOOS However, the Marsh Street wetland would be affected to a greater degree than it would have been under the 1994 M5 East EIS proposal. This area of wetland is already significantly degraded and of little conservation value other than the occurrence of the Green and Golden Bell Frog in isolated areas. However, there is significant scope for its rehabilitation within the proposal.

8.5 THE NEED FOR A SPECIES IMPACT STATEMENT

The 1994 M5 East EIS contained a Fauna Impact Statement (FIS). Mount King Ecological Surveys has subsequently completed a supplement to that FIS to provide more comprehensive environmental evaluation.

Since the M5 East EIS (1994) and Mount King Ecological Surveys (1995), legislation in regard to endangered species has been encompassed within the Threatened Species Conservation Act, 1995. Endangered flora and fauna contained within Schedules to the Act require a Species Impact Statement (SIS) to be prepared if the proposal is likely to cause a significant adverse impact. This is in regard to requirements set down by the Director-General of the National Parks and Wildlife Service.

Guidelines for assessment of the significance of the likely effect of a proposal upon the environment and endangered flora and fauna have been set out in Section 5A of the Environmental Planning and Assessment Act 1979. By applying the 'eight point test' and taking into account the flora, fauna and wetland surveys undertaken for the proposed M5 East motorway it is possible to assess the need for a SIS. Taking all points into consideration it was concluded that there is a need for a SIS in regard to the Marsh Street wetland and the Green and Golden Bell Frog. The requirements of the Director-General of the National Parks and Wildlife Service were sought (**Appendix E**) and Gunninah Environmental Consultants was engaged to prepare a SIS (see **Appendix F**).

The SIS is attached in **Appendix F** as part of this Supplement.

The decision to prepare a SIS was taken following assessment of ecological surveys carried out by Lesryk Environmental Consultants (1996) and supplements to the FIS prepared for the 1994 M5 East EIS by Mount King Ecological Surveys (1995).

The key findings of the Mount King Ecological Surveys report (1995) are as follows:

The Variation would result in less impacts on flora and fauna than the 1994 M5 East EIS proposal because the only places where the proposal would disturb the surface would be at the locations of tunnel exhaust stacks and the air intakes, and the tunnel portals and cut-and-cover sections. Although there are potential impacts on flora and fauna at the Royal Place and Duff Street exhaust stack/air intake locations, they occupy a small area and mitigation of the potential impacts is achievable.

8.5.1 Fauna applicable to the Threatened Species Conservation Act

The motorway's construction in the areas adjacent to the Marsh Street and Eve Street wetlands would result in significant impacts on the habitat of the Green and Golden Bell Frog, a species of endangered fauna.

As part of the environmental assessment and to assist the preparation of the plan of management for Riverine Park, the Roads and Traffic Authority would appoint a consultant to undertake a further assessment of the Green and Golden Bell Frog habitat within the Marsh Street wetland. The consultant would prepare a Plan of Management for the Green and Golden Bell Frog and, if necessary, would consider alternative sites for relocation of the species. The Roads and Traffic Authority would also appoint a consultant to undertake a study of bird habitat and flightpaths within the Riverine Park habitat area, to determine impacts associated with the proposal.

The following amelioration measures, and those outlined in the SIS, should be implemented to preserve the habitat of the Green and Golden Bell Frog in the Marsh Street and Eve Street wetland areas:

- Development of sites of preferred habitat on land close to the present frog site, and capture and transfer of frogs to such sites. Such a process is currently under way for the same frog species at Homebush Bay, although it is too early to measure the success of the exercise, which has an inherent element of risk attached. A plan of management for the Green and Golden Bell Frog would be developed by a suitably qualified biologist.
- The proposed motorway exit on the eastern side of Marsh Street, which would pass through the Marsh Street wetland site, could be designed to incorporate a viaduct which would allow retention of the frog habitat. This would be a matter for consideration in the development of the plan of management for the Green and Golden Bell Frog.
- A habitat corridor for the frogs exists between the Marsh Street wetland, across the SWSOOS and into the Kogarah Golf Course. If the motorway proceeds, there would be a need for an underpass to be provided to preserve this corridor. Ideally, a tunnel of approximately one metre diameter associated with a small water course would be built in to the motorway embankment.
- Gross pollutant traps would be installed to trap sediments, and artificial wetlands would be constructed to treat runoff from the motorway.
- Wetlands affected by construction of the motorway would be revegetated. Revegetation and management of the wetland would

be determined during the preparation of the Riverine Park Plan of Management.

The key findings and general mitigation measures included in the Gunninah Environmental SIS report, 1996 (see **Appendix F**) are as follows:

- Application of 'best practice' throughout the construction phase of the proposal.
- Application of environmentally sound construction methods for all construction operations (involving minimal vegetation removal, sediment and water controls, avoidance of unnecessary damage to trees or native vegetation), to optimise the retention of resources in the vicinity and to avoid the discharge of sediment or contaminants into ponds on the site or into surrounding lands.
- Use of hay-bale filters, silt screens, sediment traps and macrophyte wetlands (as appropriate) to retain sediment and contaminants or nutrients from all discharge areas.
- Implementation of standard contaminant control measures (such as the protection of exposed surfaces, bunding of potential contaminant sites, proper waste management protocols etc) to limit the potential for adverse impacts.
- Minimal clearing of any native vegetation on the site, wherever possible.
- Careful management and disposal of all waste materials generated during construction activities on the subject site, to prevent contamination of natural or newly created habitats on the site, in particular of the Eve Street wetland and its adjoining vegetation communities.
- Appropriate location and management of areas where oils, fuels, chemicals or other liquid contaminants are stored during construction, to avoid accidental spillages.
- Adequate provision for the collection and removal of human and construction waste materials during the construction program, with bins and appropriate ablution facilities. This approach would avoid further degradation or contamination of the limited areas of native vegetation on the subject site and areas of vegetation in the vicinity.
- Establishment of a weed management program and bush regeneration program over the site to prevent the spread of existing weeds, to reduce the potential for introduction of additional weed species, and to control noxious species which are present.
- Use of appropriate measures to control the discharge of sediment into retained or newly created ponds. Exposed surfaces and construction areas would need to be carefully managed to avoid significant discharge of sediment and sand into ponds and water

bodies which could reduce water quality and potentially render the ponds unsuitable for native fauna species.

- A detailed management and monitoring protocol as part of the environmental management plan for the Eve Street and Marsh Street wetlands, and for the native fauna which use them.

The key findings of the Gunninah Environmental SIS report (1996) in regard to mitigation measures for the Green and Golden Bell Frog, are as follows:

It is recommended that a management plan for the Marsh Street and Eve Street wetlands and the Green and Golden Bell Frog be prepared prior to the commencement of construction activities at this locality. It is particularly important for the Green and Golden Bell Frog that management of the on-site population be initiated well prior to construction, and that the establishment of a captive breeding population, to ensure the survival of this population, be implemented well before construction activities commence.

The Management Plan should include:

- Measures to ensure that the road works would not discharge contaminants or sediment into the Eve Street wetland.
- A detailed rehabilitation program for the Marsh Street wetland area, involving removal of the substantial amounts of rubble and waste which currently occupy the site, vegetation re-establishment, landscaping to provide resources and features for the Green and Golden Bell Frog and other fauna, and a detailed staged approach to ensure that the Green and Golden Bell Frog would be able to either survive in situ during the operations, or would be removed for its protection and reintroduced following the rehabilitation program.
- A captive breeding colony of Green and Golden Bell Frogs from the Marsh Street wetland would be established, to ensure their survival and to provide offspring for re-introduction once rehabilitation works have been completed.
- Design of stormwater discharge from the completed road and an upgrading of the existing stormwater discharge into the Marsh Street wetland to ensure better water quality. The Marsh Street wetland currently appears to exist primarily as a result of stormwater discharge.
- Installation of culverts under the M5 East Motorway to enable the Green and Golden Bell Frog to retain access to lands adjacent to the Kogarah Golf Course. Culverts would be of moderate size (up to 2m in diameter), and would include some moisture and some cover at the entrance if possible.

8.5.2 Flora applicable to the Threatened Species Conservation Act

The ecological assessment of the Marsh Street and Eve Street wetlands, (Lesryk Environmental Consultants, 1996) included a vegetation survey. One threatened species, *Deyeuxia appressa*, was recorded by Blick (1990) in a baseline vegetation survey in the Eve Street wetland site prior to wetland reconstruction but has not been recorded since. A subsequent survey of both Marsh Street and Eve Street wetlands failed to locate the species. It is therefore presumed to be extinct on that site and an SIS is not required for that species.

CHAPTER 9 CUMULATIVE IMPACT ASSESSMENT

Cumulative impact is required to be assessed. The assessment presented in this chapter addresses the cumulative impact of:

- All factors identified in this assessment of impacts and proposed safeguards.
- The proposed motorway with other transportation projects.

9.1 CUMULATIVE IMPACTS OF ALL FACTORS

The cumulative impact of all factors is shown in a planning balance sheet in **Table 28**. The planning balance sheet provides a short description of the impact of all factors, both positive and negative.

The major negative impacts of the proposed Variation would include effects on individual properties, noise impacts, air quality impacts, impacts on the Marsh Street and Eve Street wetlands, and the visual impact of three large tunnel exhaust vent stacks that would be required.

The major positive impacts include completion of a strategic link in the road network to support regional economic growth, improved road safety, a reduction in traffic on local roads and an increase in travel time savings.

Related to the positive impacts would be the fact that the transport, economic, traffic and road safety improvements would be achieved with a section of road that is largely invisible, as it would be underground between Bexley North and Arncliffe. This in itself helps to minimise many of the impacts and eliminate other potential impacts.

TABLE 28 — PLANNING BALANCE SHEET OF CUMULATIVE IMPACTS OF THE PROPOSED VARIATION TO THE M5 EAST MOTORWAY, BEXLEY ROAD TO GENERAL HOLMES DRIVE

Evaluation criteria and factor	Impact assessment
Transport efficiency	
Travel time and cost saving	• Variation services the freight and commuter requirements of Port Botany, Sydney Airport and the adjacent Central Industrial Area. • Provides a strategic east-west link between south-west suburbs, and the airport, Port Botany and Central Industrial Area. • Forms the 'missing link' in the existing Southern section of the Sydney Orbital Route, which will eventually encircle Sydney and provide access to the future Sydney West Airport. • Provides a strategic link between Sydney Airport and the future Sydney West Airport. • Reduces travel time and operating costs of individual commercial and passenger vehicles. • Reduces congestion including heavy vehicles on other roads such as Canterbury Road, Stoney Creek Road, Moorefields Road, William Street, Homer Street, President Avenue, Bay Street and Bestic Street. • Provides a commuter cycleway. • The M5 East would attract a greater proportion of commercial vehicles to use the full length of the motorway. This would result in significant reductions in commercial vehicular traffic through Rockdale and Bexley. • Overall greater benefits compared with the 1994 M5 East EIS proposal.
Road Safety	
Savings in costs of accidents	• Considerably fewer road accidents because of better traffic flow and less traffic conflict points. • Reduced risk to pedestrians and cyclists on local streets because of traffic diverted to new motorway.
Risk from materials transportation	• Lower risk as proposed motorway is safer than existing roads, although when weighed up, the risk associated with allowing dangerous goods into the longer tunnel is considered to be too great to permit it.
Social Environment	
Effects on land use	• Acquisition of 45 residential properties (43+ 2) and 1 vacant lot. • Acquisition of 9 commercial/industrial properties. • Reduced congestion on local streets of adjacent suburbs. Land values are likely to rise.

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Evaluation criteria and factor	Impact assessment
Effects on land use, community severance, etc.	• Some severance impact in Arncliffe. • All major access routes across the motorway would remain open. Two local roads would be closed. • The tunnel section of motorway would have a minor severance impact. • Arterial and other roads in nearby suburbs would have reduced congestion.
Indirect effects on land use	• Tunnel would pass beneath 178 dwellings. • Tunnel would pass beneath 4 commercial/industrial properties.
Open space impacts	• No impact on Wolli Creek Open space. • Loss of 17,750m^2 ha of land zoned and/or used for open space, including part of Kogarah Golf Course.
Visual assessment	• Visual impact of tunnel exhaust vent stacks at Bardwell Park and 2 locations in Arncliffe. • Minor visual impact of tunnel ramps and portals, and grade separated interchange at General Holmes Drive.
Recreation effect	• Some loss of recreation areas in Riverine Park, Arncliffe, and a narrow strip of Kogarah Golf Course.
Natural Environment	
Net air quality effect	• Minimal impact on local air quality.
Net noise effect	• Reduced noise impact on many roads now carrying major traffic which would divert to the new motorway. Some noise impacts associated with tunnel ramps and portal areas. • No residences exposed to noise in excess of RTA interim noise level objectives.
Impact on flora and fauna	• Most flora and fauna not affected due to the tunnel. Minor impact on the Marsh Street Wetlands and Riverine Park.
Impact on heritage sites	• No physical impact on European heritage or Aboriginal archaeological sites.
Sedimentation and water quality impacts	• Water quality within Wolli Creek would not be affected.
Effects on flooding patterns	• Minimal impact on flood levels.
Energy consumption	• Considerable fuel savings.
Impacts on utilities and services	• Not a major effect.
Economic efficiency	
Net present value	• At 7% discount rate, net present value would be $671 million

9.2 COMPARISON WITH THE 1994 M5 EAST EIS ALTERNATIVE

This section presents a comparison between the cumulative impacts of the Variation and the cumulative impacts of the shorter tunnel and extended tunnel alternatives, as presented in the 1994 M5 East EIS.

Although the Variation would have some negative impacts on property, noise, air quality, flora and fauna, and some elements would have a negative visual impact when compared with the shorter tunnel and the extended tunnel, the Variation has significantly less overall impact than either the shorter or extended tunnel. The following **Table 29** illustrates the overall comparisons.

TABLE 29 — COMPARISON OF CUMULATIVE IMPACTS

Impact on	Variation (direct tunnel)	1994 M5 East EIS proposal (shorter tunnel)	Extended tunnel
Residential (direct impacts)	45	57 dwellings directly affected.	57 dwellings directly affected.
Residential (indirect impacts)	178	Tunnel would pass beneath 87 residential dwellings.	Tunnel would pass beneath 87 residential dwellings.
Commercial properties (direct impacts)	9	27 properties directly affected.	24 properties directly affected.
Commercial properties (indirect impacts)	4	N/A	N/A
Economic efficiency	NPV $671 at 7% discount rate	NPV $441 million million	N/A (less than shorter tunnel)
Open space	17,750m² ha of land zoned and/or used as open space, including part of Kogarah Golf Course	10,350 m² affected*.	10,350 m² affected*.
Severance and instability	Fewer locations subjected to severance.	Greatest impacts.	Fewer impacts than 1994 M5 East EIS proposal, greater impact than Variation.
Local access	Fewer impacts on vehicular or pedestrian access within or across motorway corridor.	Greatest impacts to pedestrian and vehicle access.	Marginally fewer impacts than 1994 M5 East EIS proposal.
Residential amenity and character	Fewer impacts than either 1994 M5 East EIS proposal or extended tunnel.	Greatest impacts.	Fewer impacts than 1994 M5 East EIS proposal; greater impacts than Variation.
Visual	Less overall impact than 1994 M5 East EIS proposal or extended tunnel, although significant visual impacts caused by tunnel exhaust stacks.	Greatest overall visual impact.	Less impact than 1994 M5 East EIS proposal, greater impact than Variation.
Air quality	Minimal impact on local air quality. Air quality is a metropolitan issue, not confined to this proposal.	Minimal impact on local air quality. Air quality is a metropolitan issue, not confined to this proposal.	Minimal impact on local air quality. Air quality is a metropolitan issue, not confined to this proposal.
Noise	Less overall impact than 1994 M5 East EIS proposal, similar overall impact to extended tunnel.	Greatest overall noise impact.	Similar impacts to Variation.

continued/...

TABLE 29 (CONT.)

Impact on	Variation (direct tunnel)	1994 M5 East EIS proposal (shorter tunnel)	Extended tunnel
Recreation	Some loss of recreation areas in Arncliffe, but no loss between Arncliffe and Bexley Road.	Greatest overall impact on recreation.	Fewer impacts than 1994 M5 East EIS proposal, greater impact than Variation.
Flora and fauna	Less impact than 1994 M5 East EIS proposal, greater impact than extended tunnel, due to proximity of motorway to Riverine Park wetlands.	Greatest overall impact on flora and fauna.	Fewer impacts than either 1994 M5 East EIS proposal or Variation.
Heritage and archaeology	No impacts.	No impacts.	No impacts.
Sedimentation and water quality	No impacts, Bexley Road to Marsh Street, potential significant impacts on Riverine Park wetlands.	Few impacts than Variation, greater impact than extended tunnel.	Fewer impacts than either 1994 M5 East EIS proposal or Variation.

** Areas re-estimated. Were 1,400m² in the 1994 M5 East EIS.*

9.3 CUMULATIVE IMPACT WITH OTHER TRANSPORTATION PROJECTS

The impacts of this Variation in combination with other projects are taken into account in the transportation study (Sinclair Knight 1994, Masson & Wilson 1996) which predicted the traffic volumes on which assessment of other impacts is based. Other road projects likely to occur in 1996, 2001 and 2011 were included in the Base Case for the traffic modelling that predicted demand and need. Thus the conclusions from the transportation and economic evaluations were conservatively low in their estimates of the need for additional road space. Also, the high trip demand estimates were used to assess impacts of noise and air quality, making their assessment of likely impacts conservatively high. The M5 East Motorway complements the new Southern Railway and proposed duplication of the East Hills Railway Line.

PROPOSED EASTERN DISTRIBUTOR

An EIS for the proposed Eastern Distributor has been on public exhibition between 15 November 1996 and 16 December 1996. The Eastern Distributor proposal is to develop a motorway standard road with limited access between the Cahill Expressway, Woolloomooloo and Epsom Road, Zetland, and improvements to Southern Cross Drive and the intersection of Mill Pond Road with Botany Road and General Holmes Drive. As part of the proposal, Crown Street would be converted from one-way traffic to two-way traffic and Bourke Street would be closed, north of Oxford Street. All northbound vehicles using the main tunnel from Moore Park Road, Anzac Parade or South Dowling Street would be tolled, except public buses.

Subject to approval to proceed with the Eastern Distributor, construction would take approximately 36 months and would be open to traffic in mid 2000.

The Eastern Distributor would address a wide range of needs for the metropolitan planning of Sydney, namely:

- Assisting in realising the objectives of the Sydney orbital road concept;
- Assisting economic growth because of improvements to access to and from important markets, industrial centres, business activities and cultural and recreational facilities;
- Providing opportunities for improvement to public transport and also providing an improved level of service for access to Sydney (Kingsford Smith) Airport; and
- Providing support for major redevelopment proposals in the eastern and south-eastern areas of Sydney through improved accessibility and removal of uncertainty about a major urban infrastructure project.

Construction of the proposal would result in a range of adverse environmental impacts which would vary both in terms of their extent and period of duration. The most significant impacts would be noise increases, visual impacts and increased delays for traffic. A range of measures would be introduced to minimise those impacts.

The major adverse impacts of the operation of the proposal include an increase in the concentrations of air pollutants (although still within accepted goals), property acquisition, areas of community severance including inconvenience to pedestrians and a range of visual impacts on important civic and historical urban spaces.

A range of environmental benefits would result from the proposal including significant improvements to the amenity of residential areas in East Sydney, Darlinghurst and Surry Hills.

The EIS for the Eastern Distributor predicts (using a worst-case scenario) significant increases in the volumes of traffic through that corridor. The predicted traffic volumes for the M5 East Motorway (see **Chapter 6** of this Supplement) have taken into account the proportion of Eastern Distributor traffic which would continue onto the M5 East. It is predicted that the M5 East would carry significantly higher volumes of traffic, if the Eastern Distributor is constructed, than predicted in the 1994 M5 East EIS.

New Southern Railway

The New Southern Railway is an underground passenger railway linking Central Station to the domestic and international terminals at Sydney (Kingsford Smith) Airport and the East Hills Line. Stations are to be

constructed at Green Square, Mascot, Airport domestic and international terminals, and Wolli Creek connecting with the existing station at Turrella. The New Southern Railway is a expected to commence operation in the year 2000 and is anticipated to attract up to 65,000 passenger trips per day by 2013 (Kinhill, 1994).

The Department of Urban Affairs and Planning has prepared an urban planning strategy for the area influenced by the New Southern Railway to guide redevelopment and land use change over the next 30 years (Department of Planning, 1994). The strategy envisages up to 13,000 new dwellings at Waterloo/Zetland leading to an additional population in this area of approximately 30,000 persons. It is also envisaged that an additional 15,100 jobs could be created in airport related zones around Sydney (Kingsford Smith) Airport, in additional to the predicted 20,000 jobs to be created at the airport itself. A further 800 jobs could be created at Waterloo/Zetland due to the new railway stations. The planning strategy suggests that major road proposals, such as the Southern Arterial (extension of the paired one-way roads south of Henderson Road, Alexandria), M5 East Motorway and the Bourke Street link, would need to be implemented to satisfy the transport task associated with the projected population and employment increases.

9.4 CUMULATIVE IMPACT WITH OTHER DEVELOPMENTS

Patterns of land use on the southern and south-eastern fringe of the city (primarily in the local government areas of South Sydney and Botany) are undergoing a natural process of change, as the traditional industrial land uses give way to higher residential densities and more intensive airport-related land uses. These areas would benefit from the construction of the M5 East Motorway, through improved accessibility to Sydney's west and south-west. It is considered that the combined effects of the M5 East, the Eastern Distributor, the New Southern Railway and the East Hills rail duplication, would be to accelerate this process of change.

CHAPTER 10 MITIGATIVE MEASURES AND MONITORING

Mitigative measures and monitoring requirements are specified in this chapter and in **Appendix I** of the 1994 M5 East EIS. An environmental management plan would be prepared to apply to the pre-construction, construction and operations phases of the motorway, and agreed to by the NSW EPA before construction proceeds. An Environmental Manager would be appointed, for the duration of construction, to oversee the environmental quality of the construction process. The Roads and Traffic Authority would convene a Community Liaison Group by inviting the community to participate. This group would meet from time to time to discuss design and construction aspects of the motorway. **Table 86** in the 1994 M5 East EIS outlines activities that would be included in an environmental management plan. The following sections outline the requirements and undertakings that would be made, should the motorway proceed to construction.

10.1 MITIGATIVE MEASURES FOR NOISE IMPACTS

The Roads and Traffic Authority would ensure that the following mitigative measures are undertaken.

10.1.1 RESIDENCES

From Fairford Road to west of Bexley Road, there is no change from the 1994 M5 East EIS. Noise barriers of 4 or 5 metres would be constructed as indicated in the 1994 M5 East EIS.

Where existing noise barriers between Fairford Road and King Georges Road are 3.5 metres high, the nearby residences are within the normally acceptable noise range. The cost and difficulty of constructing new walls to a marginally greater height is therefore considered unwarranted.

At the western portal at Bexley Road the heights of barriers are proposed to be slightly raised from those described in the 1994 M5 East EIS to ensure that all residences close to the tunnel portal are within the normally acceptable noise range. The increase is from 4 metres to 5 metres on both sides of the motorway, where the barriers are acoustically absorptive. Also the 5 metre noise barrier along the northern side of the off ramp is proposed to be increased to 6 metres.

In this area, the height of noise barriers required to meet the EPA's TNL55 criteria is generally well in excess of 6 metres, a height which would be impractical to build and which may intrude unacceptably on the visual amenity of the area. Recognition would be given to community input which showed a desire for noise barriers of a particular height or style.

The only other change to the proposed noise barriers from the 1994 EIS is between Marsh Street to General Holmes Drive, where a 4 metre noise barrier would be installed along the westbound side of the motorway on the northern side of Cooks River, extending to Endeavour Bridge.

10.1.2 Schools and community facilities

No mitigative measures are necessary for schools and community facilities, as in all cases they are located near or amongst residential tenancies, where by virtue of the noise control treatment required for the more critical adjacent residential tenancies, expected M5 traffic noise would be controlled to acceptable levels.

10.1.3 Tunnel ventilation plant

The Roads and Traffic Authority would ensure that the same mitigative measures as required in 1994 M5 East EIS would be adopted in the detailed design of the Variation. They are:

- Mounting absorptive silencers on the intake and discharge of the air supply and exhaust fans.
- Placing sound rated enclosures around the supply fans located within the tunnel. The other fans would be located in underground plant rooms.
- Using vibration isolation mounts for ventilation fans to reduce vibration from the plant to levels too low to be detectable at residences.
- Selecting any constrictions to the tunnel (for example, mesh on inlets) so as not to create excessive noise generated by the flow of air.

10.1.4 Construction noise

The Roads and Traffic Authority would ensure that the same mitigative measures as required in the 1994 M5 East EIS would be adopted in the construction of the proposed motorway. They are set out in **Appendix I** of the 1994 M5 East EIS. Reiterated below are the main construction noise objectives and mitigative measures, as well as additional information pertaining to construction noise.

The Roads and Traffic Authority would require the contractor to use the best available practical techniques and to restrict the hours during which construction activities are carried out to between 7 am and 6 pm, Monday to Friday and 8 am to 1 pm on Saturdays. No work would be permitted on Sundays or public holidays.

Where work outside these hours is necessary due to traffic and safety requirements, construction program constraints, tunnelling operations or other activities, the approval of the Environment Protection Authority would be sought as to the appropriate conditions for the work.

It is envisaged that a letterbox drop would notify any affected residents of the work. No deliveries of materials, running of plant or equipment or on-site maintenance of plant or equipment would be permitted outside these hours unless approved by the Environment Protection Authority. The background (L_{90}) noise levels during this period would be used to set criteria for construction noise levels.

It is difficult to control noise from construction sites due to the variations in the duration, type of noise generated and also the location of residences. The EPA specifies conditions on the construction work to ensure that the most appropriate available techniques are used and the proposed equipment meets modern noise emission standards. The following environmental management measures would be taken to minimise temporary noise impacts during construction:

- The contractor(s) would prepare a detailed construction noise assessment showing predicted noise levels at critical locations and the mitigative measures proposed. The construction methods and noise control measures would be the most appropriate available and the proposed equipment would meet relevant standards.
- Construction noise would conform to EPA requirements.
- Community liaison: leaflets and information would be distributed prior to the commencement of construction work informing potentially affected residents of the type, expected noise emissions, times and duration of any construction work. Any community queries, concerns or complaints regarding noise and vibration would also be addressed.
- Silenced equipment: the quietest construction equipment would be selected and where possible residential class mufflers would be used. Noise control kits would be fitted to noisy mobile equipment and shrouds provided around stationary plant. Noise compliance tests for all major equipment used on site would also be undertaken.
- Equipment maintenance and operation - all plant and equipment would be inspected to ensure that it is in ideal running order, regularly maintained and free of defective components to minimise noise emissions.

- Equipment location - noisy plant and equipment would be located as far as possible from noise sensitive areas, optimising attenuation effects from topography, natural and purpose built barriers and materials stockpiles.
- Project planning and erection of barriers - construction would be programmed so that noise barriers or mounding required to control traffic noise are built as soon as possible. Temporary noise barriers would be erected if necessary.
- The hours of operation of particularly noisy equipment would be restricted. Work outside normal hours would only be carried out in special circumstances and after liaison with Councils, the EPA and the local community.
- Construction vehicle movements - construction vehicle movements would use the main roads surrounding the proposed motorway to access the construction sites wherever possible. Local streets are only to be used when necessary and night-time impact is to be minimised.
- Prior to work commencing in areas where vibration from rock breakers or road headers is likely to be noticed, residents and occupants of the affected buildings would be informed of the hours of work proposed and the likely effects. Where such effects are noticed by residents or occupants, but no notice has been given, people would be invited to communicate their concerns to the RTA through the Environmental Manager for the proposal.

The report would demonstrate the contractor's intention to minimise noise impact wherever practicable. The EPA may monitor noise or request that construction noise be monitored to ensure that levels comply with its guidelines, approvals and licences. The above measures would be incorporated into the environmental management plan, which is to be prepared by the contractor, and agreed to by the Environment Protection Authority, before construction proceeds.

10.1.5 VIBRATION RESULTING FROM TUNNEL CONSTRUCTION

To ensure that there is no adverse vibration impact on residences, vibration monitoring would be carried out at the commencement of construction for all processes likely to produce significant levels of ground vibration. The purpose of the initial measurements is to establish safe working distances to critical locations for the actual site conditions and actual plant being operated.

Vibration levels would also be monitored during the initial surveys at all critical residences identified as being potentially affected, to ensure that levels comply with the relevant criteria.

To avoid the impacts of structure-borne noise at night, rock breakers would not normally be used at night and road header use would be minimised at night for sections of the tunnels which are close to residences. The RTA would ask that complaints about daytime or night-time structure-borne noise be directed to the Environmental Manager.

10.1.6 Blasting

If blasting is to be carried out, blast charge and blast configuration would be selected to ensure that EPA criteria are not exceeded. Prior to the commencement of blasting activity at a site, critically affected locations would be identified and appropriate measures taken to limit overpressure and vibration to acceptable levels. Blasts would be monitored initially at these locations to ensure that predicted overpressure and vibration levels are not exceeded.

10.2 Mitigative measures for air quality impacts

The mitigative measures would be the same as the undertakings set out in the 1994 M5 East EIS, as set out below.

10.2.1 During construction

Prior to the commencement of construction the Roads and Traffic Authority would require the contractor to develop, implement and review dust suppression techniques to the NSW EPA's satisfaction.

The following techniques would be among those adopted.

- All haul roads and unsealed access roads, and all areas of excavation, construction or other disturbance, are watered regularly or otherwise as appropriate to suppress dust.
- Wheel-washes are provided (where appropriate) for all vehicles leaving any construction zone.
- All vehicles loaded with soil or spoil would have their loads covered by tarpaulins or otherwise as appropriate to suppress dust.
- All excavated or otherwise disturbed areas are landscaped and revegetated as soon as practicable after excavation or disturbance.

The Roads and Traffic Authority would require the contractor to comply with, and to ensure compliance by subcontractors with, the techniques adopted.

10.2.2 During operations

The Roads and Traffic Authority would require the contractor to ensure that the tunnel ventilation system is designed for worst-case traffic

conditions, and to ensure that air quality within the tunnel meets NSW EPA standards.

Procedures would be implemented to monitor the dispersal of air pollutants at tunnel portals, ramp portals and exhaust stacks. Emissions of carbon monoxide, oxides of nitrogen, hydrocarbons, particulate matter, lead, sulphur compounds and benzene would be continuously monitored.

To this end, the RTA has developed a detailed strategy (although not specific to this project) to reduce vehicle emissions through a series of programs which include:

- Tighter controls of emissions from individual vehicles, particularly heavy duty diesel trucks which have been identified as a major source of nitrogen oxides and fine particulate matter emissions into the Sydney airshed;
- Working with the EPA to implement the State's Motor Vehicle Maintenance Program for lowering emissions, and on the introduction of vehicle emissions testing; and
- Enhancing the State's vehicle emissions enforcement resources.

10.3 MITIGATIVE MEASURES FOR LAND USE IMPACTS

The Variation provides for a longer bored tunnel and also reduces the area where the motorway would be constructed in cut and cover tunnel. These features would reduce the visual impact of the motorway, compared to either the shorter tunnel or the extended tunnel alternatives in the 1994 M5 East EIS, and would provide greater opportunities to redevelop affected locations and reduce noise emissions.

In addition, the design of the motorway would be influenced by the need to reduce the amount of land acquired, and also the need to reduce the number of residences and businesses directly affected by the proposed motorway. In achieving these aims, the Roads and Traffic Authority would require the contractor to:

- Rehabilitate any open space disrupted during the construction of the motorway.
- Develop an environmental management plan, in conjunction with the detailed design of the motorway, which would include details of the manner in which surplus land would be rehabilitated after construction.

In addition, the Roads and Traffic Authority would:

- Conduct a condition audit of the properties over the tunnel prior to construction commencing. A copy of such an audit would be given to the respective owners of properties as a record of the property condition prior to construction commencing.

- Implement the Roads and Traffic Authority's Property Acquisition Policy (described in **Chapter 7.4**) for affected properties.

10.4 MITIGATIVE MEASURES FOR SOCIAL IMPACTS

Mitigation measures remain the same for the Variation as for the shorter tunnel and the extended tunnel alternatives in the 1994 M5 East EIS. These are discussed at **Section 23.7** of the 1994 M5 East EIS. In addition the Roads and Traffic Authority would ensure that:

- Vehicular access would be maintained wherever possible.
- Land acquisition would take place in terms of the Roads and Traffic Authority's land acquisition policy as set out in **Section 7.4** above. This includes paying market value for the purchase, plus legal expenses and also a sum for the inconvenience of moving.
- Pedestrian access would be maintained during construction. The Roads and Traffic Authority would require the contractor to prepare a pedestrian management plan as part of an environmental management plan. Details would be made available to the Community Liaison Group.

10.5 MITIGATIVE MEASURES FOR VISUAL IMPACTS

MITIGATIVE MEASURES FOR CONSTRUCTION

Mitigative measures for reducing or minimising visual impacts resulting from the construction of the proposed variation would be the same as those detailed in the 1994 M5 East EIS. In addition, measures are also proposed for the tunnel exhaust stacks and the portal areas.

MITIGATIVE MEASURES FOR THE TUNNEL EXHAUST STACKS

The 1994 M5 East EIS does not discuss measures to mitigate the visual impacts resulting from the construction of the tunnel exhaust stacks, which would be a significant visual feature of the proposed variation. It would not be possible to completely disguise or camouflage the stacks, however they would be designed and treated so as to help them fit into the visual landscape.

The Roads and Traffic Authority would require the contractor:

- To appoint an urban designer to ensure that the visible portions of the tunnel exhaust vent stacks and air intake vents are designed and screened in response to their urban context.
- To consider measures such as selecting an aesthetic architectural design, choosing suitable building materials, painting the stacks a

suitable colour, and planting trees and shrubs around their bases, to further reduce the visual impact of the exhaust vent stacks.

- To consult with the local community in the development of appropriate architectural design of the exhaust vent stacks.

The Roads and Traffic would also consider the possibility of fully enclosing one or more of the tunnel exhaust vent stacks and air intake vents within a purpose built structure to mitigate the visual impact. This would apply particularly in the case of the site at the Arncliffe Street Army Reserve Depot.

10.6 MITIGATIVE MEASURES FOR IMPACTS ON RECREATION

The Roads and Traffic Authority would compensate for any net loss of formal sports facilities by assisting local councils with funding to:

- Provide landscaping, an aesthetic architectural design, and suitable building materials and colours to reduce the visual impact of the air intakes and exhaust stacks in accordance with the recommendations from the appointed urban designer.
- Provide landscaping to reduce the visual impact of the motorway at Arncliffe where exit and entrance ramps between the motorway and the Princes Highway are constructed in cut and cover tunnel.
- Provide noise barriers to reduce the noise impact of the motorway at Allen and Ann Streets, Arncliffe and at Marsh Street, Arncliffe.
- Consult with Bicycle NSW concerning the design of and access to the motorway for cyclists, and the design of and access to a dedicated cycleway as an alternative to the proposed tunnel. Surfaces, road shoulder width and design of grates placed in gutters are to be suitable for cyclists.
- Provide assistance to the affected councils in rezoning the Wolli Creek Valley from 'corridor for future road' to 'open space'.

To mitigate the impact of the Variation on the proposed upgrading of open space planned by Rockdale Council, the Roads and Traffic Authority would engage specialist consultants to prepare a plan of management for Riverine Park. The following organisations would be consulted during the preparation of the plan: National Parks and Wildlife Service, Department of Land and Water Conservation, Sydney Water, Roads and Traffic Authority, Rockdale Council, Rockdale Wetlands Preservation Society, the Coastal Wetlands Preservation Society, Bicycle NSW and relevant sporting groups. Subject to the views of the controlling local authorities, it would be intended that the park cater for passive and active recreation, and provide an enhanced wetland habitat. The Roads and Traffic Authority would also establish a consultative committee, inviting representation from the above organisations.

10.7 MITIGATIVE MEASURES FOR HERITAGE, ARCHAEOLOGY

10.7.1 MEASURES FOR ARCHAEOLOGICAL IMPACTS

The presence of aboriginal archaeological deposits in the areas of alluvium which would be directly affected by motorway construction would be investigated through monitoring of the excavations as they take place.

The Roads and Traffic Authority would require the contractor to engage a consultant archaeologist to monitor earthworks at sensitive areas, such as the Riverine Park wetlands.

The Roads and Traffic Authority would also consult with the Metropolitan Local Aboriginal Land Council and request their participation and monitoring during the construction of the motorway.

Where air intakes or exhaust stacks are to be constructed close to or on cliff faces adjoining the Bardwell Valley Golf Course, clearing and inspection of adjoining cliff faces is recommended.

10.7.2 MEASURES FOR EUROPEAN HERITAGE IMPACTS

All authorisations and consents required under the National Parks and Wildlife Act 1974, or the Heritage Act 1977, would be in place prior to any works commencing.

10.8 MITIGATIVE MEASURES FOR IMPACTS ON HYDROLOGY AND WATER QUALITY

As specified in the 1994 M5 East EIS, construction of temporary drainage facilities would be carried out at the commencement of site works as part of a comprehensive soil erosion and sediment control plan. This work would be addressed in the environmental management plan. Erosion and sediment control measures would be used where temporary stockpiles of tunnel spoil are necessary. The temporary works would be maintained and modified as the work progresses to ensure that soil erosion is minimised and that the material that does erode is prevented from entering downstream waterways.

Should the proposed Variation proceed, the following mitigative measures would be undertaken:

GENERAL MITIGATIVE MEASURES

The following mitigative measures are the same as those proposed in the 1994 M5 East EIS. The Roads and Traffic Authority would require the contractor to:

- Construct flood walls or levees, especially around the tunnel portals.
- Investigate existing drainage systems and construct modifications where there is a potential increase in stormwater runoff.

Additional general mitigative measures that would be undertaken are:

- An acid sulfate soil management plan would be prepared by the contractor, for approval by the Environment Protection Authority, to include:
  - — Provision for further sampling and analysis of soils during the early stages of construction.
  - — Plans of management of soil stockpiles and for treatment of discharges of acidic leachate.
  - — A focussed monitoring program for water quality in both surface and ground water.
  - — Contingency procedures, to be implemented in case of failure of the proposed management plan.
- Where acid sulfate soils are encountered, the Roads and Traffic Authority would require the contractor to manage them in accordance with accepted practice as documented in the EPA guidelines 'Assessing and Managing Acid-sulfate Soils.'

Bexley Road to Marsh Street

At the isolated work sites above the tunnel, the Roads and Traffic Authority would require the contractor to undertake the following mitigative measures between Bexley Road and Marsh Street:

- Construct a temporary levee to minimise flooding risk during construction.
- Construct air intakes above flood levels.
- Establish a water quality monitoring station to monitor the water quality of the effluent from the motorway.
- Undertake construction in a historically low water flow period in order to minimise the risks associated with flooding and water quality during construction.
- Where 'cut and cover' tunnelling is used, to provide low level bunding, pumps and sedimentation basins to collect and treat polluted water prior to discharging into the drainage system.

Marsh Street to General Holmes Drive

The Roads and Traffic Authority would require the contractor to undertake the following mitigative measures between Marsh Street and Cooks River:

- Direct all motorway drainage to sedimentation basins in accordance with the Riverine Park Plan of Management.

- Provide carefully installed and maintained geotextile sediment fences between the work sites and the wetlands together with an absorbent bund behind the geotextile fence.
- Establish a water quality monitoring station and regime to check the effectiveness of the water quality control measures established for both the construction and initial operation phases. Monitoring specifications are as follows:
  - — Typical monitoring would include tests for turbidity, hydrocarbons, heavy metals, litter, conductivity, temperature and pH.
  - — Monitoring frequencies: once every two months in the first year of operations; quarterly for the second and third operational years if the monitoring results from the first year are stable. Monitoring after the third operational year would be subject to review.
  - — Monitoring during the construction phase should be far more frequent. Testing should be at least weekly whilst construction is occurring in areas which drain directly to the wetlands.
- Construct floodwalls to a height of RL 4.00 metres AHD or levees at the eastern tunnel portal to protect against the extreme flood. They would be incorporated into sound barriers where appropriate.
- Construct streamlined motorway viaduct piers to minimise any disturbance to flood flows.
- Construct a vertical face to the river embankment wall, cantilevering the proposed motorway over the river bank or relocating the South Western and Southern Ocean Outfall Sewer, as an alternative to filling within the Cooks River.

10.9 MITIGATIVE MEASURES FOR FLORA AND FAUNA IMPACTS

The mitigative measures are largely incorporated through the choice of sites for the air intakes and exhaust stacks, and treatment of the sites during and after construction. Specific mitigation measures relating to flora and fauna impacts of construction and operation of the motorway and air intake and exhaust facilities are dealt with in the 1994 M5 East EIS and the applicable Roads and Traffic Authority undertakings in **Appendix I** of the 1994 M5 East EIS.

10.9.1 MITIGATIVE MEASURES REQUIRED FOR THE PROPOSAL

The 1994 M5 East EIS incorporated a Fauna Impact Statement. Mount King Ecological Surveys indicated that, in relation to the matters in

Sections 8.3.3 and **8.3.4** of this Supplement, a supplement to that Fauna Impact Statement was required. This was subsequently prepared by Mount King Ecological Surveys in 1995.

As part of the environmental assessment and to assist the committee responsible for the plan of management for Riverine Park, the Roads and Traffic Authority would appoint a consultant to undertake an assessment of the potential Green and Golden Bell Frog habitat within the Marsh Street wetland. The consultant would prepare a plan of management for the Green and Golden Bell Frog and, if necessary, would consider alternative sites for relocation of the frog. The Roads and Traffic Authority would also appoint a consultant to undertake a study of the bird habitat and flight paths within the Riverine Park habitat area, to determine impacts associated with the proposal.

Mitigative measures to protect and enhance natural vegetation communities along the motorway route would include the following:

- Carrying out vegetation identification surveys prior to any clearing of land or construction.
- Consultations with the National Parks and Wildlife Service and with Rockdale Council prior to the preparation and implementation of a Vegetation Management Plan.
- Minimising the clearing of native vegetation from wetlands, grasslands, scrubland and mangrove areas, and revegetation with native species where appropriate.
- Design and placement of air intake and exhaust vents in areas of low ecological sensitivity to reduce impacts on remaining native vegetation and wildlife habitats, and to enable fauna movements where practicable.

10.10 MITIGATIVE MEASURES FOR WETLAND IMPACTS

Construction of the proposal would affect the Eve Street and Marsh Street wetlands. Wetland re-creation would therefore be required before construction is undertaken. Preventing a net loss of wetland area would be the guiding principle and indeed, it would be highly desirable to increase the area of the wetlands adjacent to Riverine Park. A major risk in re-creating disturbed wetland is the possible loss of endangered or vulnerable flora and fauna.

Mitigative measures detailed in the hydrology section (**Section 10.8**) above are relevant for mitigating impacts on the wetlands.

In addition, the Roads and Traffic Authority would:

- Through specialist consultants, develop an appropriate plan of management for the affected area. The Marsh Street and the Eve Street (fresh water) wetlands would be enhanced and possibly linked to adjoining council land to extend the wetlands and form a more viable wetland area. Options for extending the Eve Street (salt water) wetlands towards the Cooks River and Muddy Creek would be considered and a preferred strategy implemented.
- Establish a Riverine Park Management Committee, and request representation from NPWS, Rockdale Council, Sydney Water, Department of Land and Water Conservation, Rockdale Wetlands Preservation Society, the Coastal Wetlands Society, Bicycle NSW and relevant sporting groups. The Roads and Traffic Authority would provide funds to support the committee. Committee actions would be linked to the recommendations contained within the Species Impact Statement, the plan of management and the requirements of the National Parks and Wildlife Service.
- Require the contractor to develop a wetland rehabilitation plan prior to construction. Implementation of the plan, prior to construction, in the Marsh Street and Eve Street (fresh water) wetlands, would mitigate the impact of construction. Issues to be addressed include management of Green and Golden Bell Frog populations during rehabilitation and construction, control of sediment loads, litter and garbage.
- Ensure that the works to protect the wetlands be undertaken as one of the first stages of the proposal, and before any motorway construction takes place in the wetlands area. This would ensure that suitable wetland habitat is maintained throughout the construction period.
- Require the design of the motorway to have as low a profile in the vicinity of the Marsh and Eve Street wetlands as possible. Such a profile would have less impact on birds approaching the wetland as their line of sight would be less restricted.
- Require the contractor to ensure that an effective runoff monitoring program is implemented during and after construction.
- Require the contractor to ensure that the tidal channel linking the Eve Street (salt water) wetland with the Cooks River, remains open throughout the construction period.

Environmental mitigation measures are based on the 1994 M5 East EIS and FIS and a follow-up supplement prepared by Mount King Ecological Surveys (1995). In addition to those documents, a flora and fauna survey was carried out by Lesryk Environmental Consultants (1996, contained in **Appendix F**) within the Marsh and Eve Street wetlands. This identified the likely significant impact of the proposal upon the Green and Golden Bell

Frog and, therefore, the need for a Species Impact Statement to be prepared. The Species Impact Statement was subsequently prepared by Gunninah Environmental Consultants (1996) and is contained in **Appendix F**.

10.10.1 WETLAND HABITATS

As part of the environmental assessment, and to assist in the preparation of the plan of management for Riverine Park, the Roads and Traffic Authority would appoint a consultant to undertake further assessments of the Green and Golden Bell Frog habitat within the Marsh Street wetland. The Roads and Traffic Authority would also appoint a consultant to undertake a study of bird habitat and flight paths within the Riverine Park habitat area if further ecological assessment is required.

The Roads and Transport Authority would ensure:

- Application of 'best practice' throughout the construction phase of the proposal.
- Application of environmentally sound construction methods for all construction operations (involving minimal vegetation removal, sediment and water controls, avoidance of unnecessary damage to trees or native vegetation), to optimise the retention of resources in the vicinity and to avoid the discharge of sediment or contaminants into ponds on the site or into surrounding lands.
- Use of hay-bale filters, silt screens, sediment traps and macrophyte wetlands (as appropriate) to retain sediment and contaminants or nutrients from all discharge areas.
- Implementation of standard contaminant control measures (such as the protection of exposed surfaces, bunding of potential contaminant sites, proper waste management protocols etc) to limit the potential for adverse impacts.
- Minimal clearing of any native vegetation on the site, wherever possible.
- Careful management and disposal of all waste materials generated during construction activities on the subject site, to prevent contamination of natural or newly created habitats on the site, in particular of the Eve Street wetland and its adjoining vegetation communities.
- Appropriate location and management of areas where oils, fuels, chemicals or other liquid contaminants are stored during construction, to avoid accidental spillages.
- Adequate provision for the collection and removal of human and construction waste materials during the construction program, with bins and appropriate ablution facilities. This approach would avoid

further degradation or contamination of the limited areas of native vegetation on the subject site and areas of vegetation in the vicinity.

- Establishment of a weed management program and bush regeneration program over the site to prevent the spread of existing weeds, to reduce the potential for introduction of additional weed species, and to control noxious species which are present.
- Use of appropriate measures to control the discharge of sediment into retained or newly created ponds. Exposed surfaces and construction areas would need to be carefully managed to avoid significant discharge of sediment and sand into ponds and water bodies which could reduce water quality and potentially render the ponds unsuitable for native fauna species.
- A detailed management and monitoring protocol as part of the environmental management plan for the Eve Street and Marsh Street wetlands, and for the native fauna which use them.

The Roads and Transport Authority would ensure that a management plan for the Marsh Street and Eve Street wetlands and the Green and Golden Bell Frog be prepared prior to the commencement of construction activities at this locality. Particular attention would be paid to ensuring that management of the on-site population is initiated well prior to construction, and that the establishment of a captive breeding population, to ensure the survival of this population, is implemented well before construction activities commence.

The Management Plan should include:

- Measures to ensure that the road works would not discharge contaminants or sediment into the Eve Street wetland. Gross pollutant traps would be installed to trap sediments, and artificial wetlands constructed to treat runoff from the motorway.
- A detailed rehabilitation program for the Marsh Street wetland area, involving removal of the substantial amounts of rubble and waste which currently occupy the site, vegetation re-establishment, landscaping to provide resources and features for the Green and Golden Bell Frog and other fauna, and a detailed staged approach to ensure that the Green and Golden Bell Frog would be able to either survive in situ during the operations, or would be removed for its protection and reintroduced following the rehabilitation program.
- A captive breeding colony of Green and Golden Bell Frogs from the Marsh Street wetland would be established, to ensure their survival and to provide offspring for re-introduction once rehabilitation works have been completed.
- Design of stormwater discharge from the completed road and an upgrading of the existing stormwater discharge into the Marsh

Street wetland to ensure better water quality. The Marsh Street wetland currently appears to exist primarily as a result of stormwater discharge.

- Installation of culverts under the M5 East Motorway to enable the Green and Golden Bell Frog to retain access to lands adjacent to the Kogarah Golf Course. Culverts would be of moderate size (up to 2m in diameter), and would include some moisture and some cover at the entrance if possible.

The Roads and Traffic Authority would also ensure that monitoring and auditing is carried out as follows:

- During construction environmental scientists would monitor run-off. A sampling program would be designed providing details of sampling sites, sampling frequency, and water quality measurements.
- The effectiveness of pollution control measures would be assessed following the opening of the motorway and a monitoring program would be designed to carry out this program.

10.11 General mitigative measures

The Roads and Traffic Authority would require the contractor to provide a detailed construction program and traffic management plan prior to any work being undertaken. These plans would be made available to the community using the forum of the Community Liaison Group.

10.11.1 Construction traffic routes

Construction traffic would use Bexley Road, Princes Highway, Marsh Street and General Holmes Drive to access the construction sites. Darley Road and Slade Road would be used by construction traffic removing material from the tunnel construction site off Bardwell Road and transporting it to the roadworks west of Bexley Road. Local streets would be used to obtain access to the exhaust stack locations. The Roads and Traffic Authority would require the contractor to consult with Council and the Community Liaison Group in the development of a site access and construction traffic management plan as part of an environmental management plan, to be prepared before construction commences.

10.11.2 Balance of earthworks and spoil disposal

The Roads and Traffic Authority would require the contractor to consult with councils in the area to identify appropriate sites where tunnel spoil could be used to enhance existing areas and the roads to be used for transporting material.

The provision of noise mounds and the rehabilitation of existing open space areas would be considered in the development of a tunnel spoil waste management plan as part of an environmental management plan to be prepared before construction commences.

10.11.3 Waste management

As specified in the 1994 M5 East EIS, an environmental management plan would be prepared prior to construction and would address waste management comprehensively. All waste materials found or produced on site would be handled in a responsible manner and in accordance with relevant legislation or codes of practice. Recycling of materials would be undertaken wherever possible.

Except where a sewer is available, site amenities would discharge all sewage to holding tanks for regular removal by tanker. Rubbish skips would be provided at all site compounds and regularly emptied or removed.

10.11.4 Road Safety

The Roads and Traffic Authority would require the contractor to develop a traffic incident management system and to prepare a traffic incident management plan as part of the environmental management plan. Dangerous goods would be restricted from using the M5 East Motorway tunnel.

CHAPTER 11 FINDINGS AND JUSTIFICATION

The salient findings of this Supplement to the 1994 M5 East EIS are that, notwithstanding the fact that Variation runs under more properties than the M5 East EIS proposal (either the shorter or extended tunnel alternative), on balance the Variation is preferred over the M5 East EIS proposal for the following main reasons:

- The traffic outcomes are essentially the same. However, the overall route length of the Variation is shorter.
- The direct impacts on the social and natural environment are, for the most part, considerably less for the Variation than for either of the shorter or extended tunnel alternatives in the 1994 M5 East EIS. The impacts of the extended tunnel are marginally greater than for the Variation.
- The Variation would require less land acquisition than either of the shorter or extended tunnel alternatives in the 1994 M5 East EIS.
- The cost of the Variation is less expensive than the extended tunnel alternative (which has marginally greater impacts than the Variation), but more expensive than the shorter tunnel alternative (which has the greatest impacts).

This Supplement confirms the conclusion of the 1994 M5 East EIS that the M5 East motorway should be built. Construction and operation would be subject to the mitigative measures outlined in **Chapter 10**.

If the motorway were not built, the same consequences would occur in traffic delays and reduced road safety as were identified in the 1994 M5 East EIS.

In the light of the investigations undertaken for this Supplement, and when considering the cost of the Variation and the direct land use impacts, the Variation is the preferred proposal for the M5 East motorway and comprises:

- Duplication of the existing 2 lanes to provide a 4 lane motorway between Fairford Road and King Georges Road.
- A new 4 lane motorway between King Georges Road and Bexley Road at Bexley North.

- A new direct tunnel from Bexley Road at Bexley North to Marsh Street at Valda Avenue, Arncliffe.
- A new 4 lane road from Marsh Street to General Holmes Drive just north of the Cooks River at Kyeemagh.
- Grade-separated interchanges at Fairford Road, King Georges Road, Bexley Road, Princes Highway, Marsh Street and General Holmes Drive.
- Three tunnel exhaust stacks and three air intakes between Bexley Road and Marsh Street.

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APPENDICES

APPENDIX A NEWSLETTER M5 EAST UPDATE

APPENDIX B DIRECTOR OF DEPARTMENT OF URBAN AFFAIRS AND PLANNING REQUIREMENTS

New South Wales Government

FILE M5 East.

Department of Urban Affairs and Planning

Mr John Brewer
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Our Reference : R93/00026/002

Your Reference :

11 AUG 1995

Dear Mr Brewer,

M5 East Motorway-Variation of Route Between Bexley Road and Cooks River to Provide For A Direct Tunnel.

Thank you for your letter of 18 July 1995, indicating that you are consulting with the Director with regard to the preparation of supplementary information for the above proposal.

The Department acknowledges the RTA's commitment to refer the M5 East motorway together with the proposed variation to the Minister for Urban Affairs and Planning for approval. Requirements for seeking the Minister's approval are outlined in the Attachment.

The Director also requires that the following matters be specifically addressed in the supplement to the 1994 EIS.

Key Issues

- justification of the proposal in comparison to the previously exhibited proposal including the option of the extended tunnel.
- relationship of the proposal to the RTA' s State Road Network Strategy and in particular consideration of facilities to encourage public transport use, high efficiency passenger and freight vehicles and all day transport needs in accordance with the main themes of the Strategy.
- outline of other feasible tunnel alignment options including procedures for evaluation and justification of the preferred tunnel alignment with reference to community consultation.
- impacts of the proposal on noise, vibration and regenerated noise (i.e. structural borne noise) during construction and when operational, measures to mitigate. Results of consultation with the EPA in terms of the appropriate noise, vibration and regenerated noise assessment criteria.

- impacts on property, including requirements for demolitions, acquisitions, property adjustments and below ground easements. Potential impacts on property values, acquisitions policy and means for compensation.
- potential for tunnel subsidence during construction and when operational.
- impacts on air quality from tunnel exhaust emissions and proposed measures to mitigate. Means and cost effectiveness of potential treatment of tunnel exhaust. Results of consultation with the EPA with respect to metropolitan air quality issues.
- impacts on groundwater, including results of discussions with Department of Land and Water Conservation (previously Department of Water Resources).
- a quantitative risk assessment in accordance with the Department's Hazardous Industry Planning Advisory Paper No 6 Guidelines for Hazard Analysis and the Draft Route Selection Guidelines: Guidelines for Landuse and Environmental Safety Planning for Hazardous Materials - Road Transport Considerations. The risk assessment is to assess and compare the transportation of dangerous goods through the tunnel against alternate road transport routes. The comparison should take into account current and projected future traffic volumes. A discussion on the design concepts outlining the essential physical and engineering features and management processes. Emphasis should be given to such features as road grades, horizontal alignment, pavement type, fire protection measures, ventilation and emergency systems. The study should be carried out in consultation and in accordance with the detail requirements of the Major Hazards Policy Unit of the Department. (The Department notes that this would incorporate work already carried out but adjusted to the re-aligned tunnel.)
- implications of any potential variation to proposed toll option as identified in the previous EIS.
- presence and severity of acid sulfate or potential acid sulfate soil problems, management methods to mitigate impacts in accordance with the EPA's Environmental Guideline "*Assessing and Managing Acid Sulfate Soils*".

Other Specific Issues

- full description of the proposed changes including: plan and profile of the tunnel and the section east of the Illawarra Line, drainage works, location of air intake and air exhaust vents/shafts, tunnelling methods, balance of earthworks and spoil disposal, tunnel dewatering requirements, requirements for stockpiling, requirements for cut and cover sections, wastes generated and waste management, hours of construction.
- full description of the proposed new interchange at the Princes Highway, Illawarra Railway Line and Marsh Street and results of consultations with the State Rail Authority.
- location of all changes with respect to property boundaries and landuse types.
- impacts on hydrology in terms of flood flows entering the tunnel, surface stormwater run-off entering open cut sections during construction, water entering any permanent open slot(s).
- impacts on Eve Street wetlands and results of consultations with National Parks and Wildlife Service, Department of Land and Water Conservation (DLWC) and Environment Protection Authority (EPA).

- impacts on water quality from dewatering, and discharge of stormwater from pump out system.
- traffic impacts of changed eastern portal location during construction and when operational.
- economic evaluation including identification of major costs and major benefits.
- impacts on any major services such as the SWOOS, results of discussions with relevant key service providers.
- cumulative impacts with the construction of the approved New Southern Railway and the proposed East Hills railway amplification. Results of discussions with the State Rail Authority.
- results of consultations with Canterbury and Rockdale Councils.

The supplementary information should provide a systematic and detailed comparison with the previously exhibited proposal (including the extended tunnel option) such that the need and justification for the proposed variation as well as the need and justification for the complete project is clearly identified.

The supplementary information should also be publicly exhibited for a period of no less than 30 days along with the EIS exhibited in 1994.

Should you have any further enquiries please contact Mark Hather on (02) 391 2162.

Yours sincerely

for Ken Sullivan
Manager,
Government Infrastructure Assessments Branch
As Delegate for the Director

ATTACHMENT

Seeking the Ministers Approval

The Proponent can seek the Minister's approval once it has obtained and exhibited the EIS and the supplementary information, examined and considered any representation relating to the EIS and the supplementary information and forwarded copies of all representations to the Department.

The Department's Best Practice Guideline encourages proponents when seeking approval to provide:

- a comprehensive report which addresses in detail it consideration of all issues raised in representations, any proposed change to the activity and any further measures to mitigate impacts;

- all relevant technical information relating to the proposed activity; and,

- any other material as reasonably requested by the Department.

Mr J Brewer JDB:jb
Telephone: 9831 0158

Mr Mark Hather
Department of Urban Affairs and Planning
Governor Macquarie Tower
1 Farrer Place
SYDNEY NSW 2000

Dear Sir

Supplement to the M5 East EIS ("the Supplement")

I refer to the Department's letter of 11 August 1995 and our recent conversations.

The letter set out your Director's requirements as to matters which were to be specifically addressed in the Supplement as then proposed.

As you know, on 2 November 1996 the Government announced that, if constructed, the M5 East would not be tolled.

This letter is to confirm that, as discussed, for the Supplement as now proposed in light of this announcement your Director's requirements remain the same as set out in the letter of 11 August 1995.

Yours sincerely

J D Brewer
Special Projects Manager

15.11.96

SENT BY:RTA 20-11-96 ; 7:52 ;REGIONAL DEVELOPMENT→ +02 9281 9406:# 2/ 2

New South Wales Government
Department of Urban Affairs and Planning

Mr John Brewer
Special Projects Manager
Roads and Traffic Authority
PO Box 558
BLACKTOWN NSW 2148

Contact: M. Hather

Our Reference: R93/00026/002

Your Reference:

Dear Mr Brewer,

M5 EAST MOTORWAY- SUPPLEMENT

Thank you for your letter of 15 November 1996 regarding the above project.

The Department confirms that the issues identified in our letter of 11 August 1996 would be applicable to the proposal with or without a toll imposed. This is on the proviso that the implications of a likely increase in traffic using the motorway (when compared to the previous proposal) has been considered in the key assessment issues such as roadway and intersection capacity, use by heavy vehicle traffic (including dangerous goods), noise/vibration, air quality, residential amenity and any other relevant areas. This issue would apply to feeder roads as well as along the corridor itself. The benefits of likely reduced traffic on parallel routes should also be assessed.

Should you have any further enquiries please contact Mark Hather on 9391-2162.

Yours sincerely,

26/11/96

David Mutton
Acting Manager
Major Assessments and Hazards Branch
as delegate for the Director-General

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

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

APPENDIX C TUNNEL EXHAUST STACK ASSESSMENT

APPENDIX C ASSESSMENT OF TUNNEL EXHAUST STACKS

VENT LOCATIONS: EAST

	Engineering /cost	Air quality	Land use	Visual	Community impact
Duff St - Arncliffe	Suitable	Suitable	Poor	Poor	Poor
Arncliffe Park - Arncliffe	Suitable	Suitable	Poor	Less suitable	Poor
Heath St - north of the rail line - Turrella	Less suitable	Not suitable	Suitable	Less suitable	Suitable
Henderson St factories area - Turrella	Less suitable	Suitable	Suitable	Suitable	Suitable
Loftus/Kelsey/Hirst Sts - Arncliffe	Less suitable	Less suitable	Less suitable	Suitable	Less suitable
Wollongong Rd/Bonar St factory - Arncliffe	Less suitable	Suitable	Suitable	Suitable	Suitable
Firth St, Illawarra rail line - Arncliffe	Less suitable	Suitable	Less suitable	Suitable	Less suitable
Cooke & Reede Sts - Turrella	Suitable	Suitable	Suitable	Poor	Less suitable
Arncliffe Defence site	Suitable	Suitable	Suitable	Suitable	Suitable

VENT LOCATIONS: WEST

	Engineering /cost	Air quality	Land use	Visual	Community impact
Bardwell Park RSL/ Slade Rd reserve	Suitable	Suitable	Suitable	Suitable	Suitable
Shepherd Park - Bardwell Park		Suitable	Poor	Poor	Poor
Bardwell Park Golf Course - Moore St	Suitable	Suitable	Suitable	Suitable	Suitable
Bardwell Park Golf Course - May St		Suitable	Less suitable	Suitable	Suitable
Bardwell Park Golf Course - Royal Place		Suitable	Less suitable	Suitable	Suitable
Coolabah Reserve - air intake - Bardwell Park	half way point	Suitable	Suitable	Suitable	Suitable
Ron Gosling Reserve - Bardwell Park	Less suitable	Poor	Suitable	Suitable	Suitable
Earlwood Car Park		Suitable	Suitable	Suitable	Suitable

APPENDIX D ECONOMIC EVALUATION TABLES

Applied Economics
Level 3, 101 Sussex Street, Sydney, NSW 2000, Telephone (02) 290 2498 Fax (02) 290 1150

To: Helen Ketelby, Manidis Roberts

Subject: **Revised economic evaluation results**

From: Peter Abelson:

Date: 28 November 1996

Pages: Two including this one

Dear Helen

Please find attached revised spreadsheet plus sensitivity tests. The key results are:

Best estimates:	NPV @ 7%	$671 million	BCR @ 7%	2.4
Sensitivity test[a]:	NPV @ 7%	$388 million	BCR @ 7%	1.7

(a) Construction costs up 20%, travel time savings down by 20%.

These results are based on the cost inputs provided by you and the user benefit estimates provided by Chris Wilson.

Points to note are that the land costs may not include all the (opportunity) costs of land owned by the government or all the social costs of land take. The user benefits now allow for an expansion factor (from one peak hour to the year) of 2300. Savings in vehicle operating costs are lower because only $0.13 has been allowed per vehicle km saved. Estimated savings in accident costs are higher than before (in 1994 figures).

I believe that the text should recognise the risk that the construction costs could be higher than the "best estimate" and the travel savings lower. But the BCR would still be 1.7 and the estimated net benefits over $300 million.

If you have any queries please contact me. Perhaps you will fax me a copy of the amended text to go with these results (as the text is now on your WP system).

Regards

Peter Abelson

Peter Abelson

ECONOMIC EVALUATION OF M5 EAST VARIATION ROUTE ($M, 1996 PRICES)

	Costs				User Benefits				Net
	Land (a)	Constr. (b)	Maint.	Total	Time	Veh.op.	Safety	Total	Benefits
1997	19.0	80.0	0.0	99.0	0.0	0.0	0.0	0.0	-99.0
1998	56.0	155.0	0.0	211.0	0.0	0.0	0.0	0.0	-211.0
1999		155.0	0.0	155.0	0.0	0.0	0.0	0.0	-155.0
2000		95.0	4.0	99.0	44.2	1.9	6.8	52.9	-46.1
2001			4.0	4.0	88.5	3.8	13.7	106.0	102.0
2002			4.0	4.0	91.8	3.8	13.9	109.5	105.5
2003			4.0	4.0	95.1	3.9	14.1	113.1	109.1
2004			4.0	4.0	98.4	3.9	14.3	116.6	112.6
2005			4.0	4.0	101.7	4.0	14.5	120.2	116.2
2006			4.0	4.0	105.0	4.0	14.7	123.7	119.7
2007			4.0	4.0	108.3	4.1	14.9	127.3	123.3
2008			4.0	4.0	111.6	4.1	15.2	130.9	126.9
2009			4.0	4.0	114.9	4.2	15.4	134.5	130.5
2010			4.0	4.0	118.3	4.3	15.7	138.3	134.3
2011			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2012			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2013			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2014			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2015			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2016			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2017			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2018			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2019			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2020			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2021			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2022			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2023			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2024			4.0	4.0	121.7	4.4	16.0	142.1	138.1
2025			4.0	4.0	121.7	4.4	16.0	142.1	138.1
NPV @ 4%	70.0	439.2	56.8	566.1	1528.5	57.3	209.6	1795.4	**1229.3**
NPV @ 7%	66.7	409.2	38.6	514.4	1007.7	38.2	139.5	1185.4	**670.9**
NPV @ 10%	63.6	382.2	27.5	473.3	697.0	26.7	97.4	821.1	**347.9**
BCR @ 4% (c)									**3.4**
BCR @ 7%									**2.4**
BCR @ 10%									**1.8**

(a) Land acquisition costs.
(b) Includes utilities, roads, bridges, tunnels, and engineering administration.
(c) Present value of benefits less maintenance costs divided by present value of land and construction costs.

Sensitivity Test: construction costs up 20%; time savings down 20%.

NPV @ 4%	70.0	527.1	56.8	654.0	1222.8	57.3	209.6	1489.7	**835.8**
NPV @ 7%	66.7	491.0	38.6	596.3	806.1	38.2	139.5	983.8	**387.6**
NPV @ 10%	63.6	458.6	27.5	549.7	557.6	26.7	97.4	681.7	**132.1**
BCR @ 4% (c)									**2.4**
BCR @ 7%									**1.7**
BCR @ 10%									**1.3**

APPENDIX E DIRECTOR-GENERAL OF NATIONAL PARKS AND WILDLIFE REQUIREMENTS

FAXED 18/11

NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE

Mr John Brewer
Special Projects Manager, Sydney Region
Roads and Traffic Authority
Level 2, 83 Flushcombe Road
BLACKTOWN NSW 2148

Dear Mr Brewer

RE: DIRECTOR-GENERAL'S REQUIREMENTS FOR A SPECIES IMPACT STATEMENT FOR THE PROPOSED M5 EAST MOTORWAY

Thank you for your letter dated 8 November 1996 requesting the Director-General's requirements for a Species Impact Statement (SIS) for the proposal cited above.

Sections 109 and 110 of the *Threatened Species Conservation Act 1995* (TSC Act) describe the form and content of an SIS. Pursuant to Section 111 of this Act, I have limited and modified these matters and provided additional matters to be addressed, as described below.

Definitions

The definitions given below are relevant to these requirements:

development has the same meaning as in the *Environmental Planning and Assessment Act 1979.*
activity has the same meaning as in the *Environmental Planning and Assessment Act 1979.*
Locality is the area within a 5km radius of the subject site.
subject site means the area directly affected by the proposal.
study area is the subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly.
subject species means those threatened species which are known or considered likely to occur in the study area.
proposal is the development, activity or action proposed

All other definitions are the same as those contained in the TSC Act.

Sydney Zone
9th Floor
43 Bridge Street
Hurstville NSW
Australia
PO Box 1967
Hurstville 2220
Fax: (02) 585 6442
Tel: (02) 585 6678

Australian-made 100% recycled paper

Matters which have been limited or modified

I consider that the following Section 110 matters need not be addressed by your SIS.

- All reference to endangered populations and endangered ecological communities. The TSC Act does not currently list any ecological communities and no listed endangered populations occur in the subject area.
- Reference to recovery plans and threat abatement plans in Section 110(2)(c). No recovery plans or threat abatement plans have been approved in accordance with the TSC Act.
- Reference to key threatening processes in Section 110(2)(c). The TSC Act does not currently list any key threatening processes.
- Section 110(2)(e). This section is a replication of Section 110(2)(a).
- All reference to critical habitat. There is currently no declared critical habitat in NSW.
- Section 110(2)(g). The matters raised in this section of the TSC Act have been clarified by the requirements below.

Matters to be Addressed

The SIS must meet all the matters specified in Sections 109 and 110 of the TSC Act with the exception of those matters limited above. In addition to the statutory requirements, (Appendix 1), I require the matters described below to be addressed. Previous surveys and assessments may be used to assist in addressing these requirements. All references used throughout the SIS must be cited and listed in a bibliography.

1. Description

The SIS must include the information outlined below.

The proposal and surrounding areas

1.1 The type of proposal shall be detailed, including the timetable for the construction of the proposal and the number of hectares affected. This shall include details of the location of any auxiliary infrastructure and all component parts of the proposal.

1.2 A plan of the subject area shall be provided. This plan shall show the location and type of vegetation communities present within the subject area and the scale of the plan.

1.3 An aerial photograph (preferably colour) of the locality (or reproduction of such a photograph) shall be provided, if possible. This aerial photograph should clearly show the subject site and the scale of the photograph.

1.4 A topographic map of the site and immediate surrounds at a scale of at least 1:25,000 will be provided. This map will detail the location of the proposal and location of works on site.

1.5 A map of the locality, showing any locally significant areas for threatened species such as parks and reserves, and areas of high human activity such as townships, regional centres and major roads will also be provided.

The habitat of threatened species

1.6 The location of the subject species recorded during the SIS survey shall be represented on a map of the study area.

1.7 Where the habitat of each subject species within the study area can be clearly delineated, this habitat shall be represented on a map of the study area.

Initial site assessment

1.8 A list of subject species shall be provided. In determining these species, consideration shall be given to the habitat types present within the study area, recent records of threatened species in the locality and the known distribution of threatened species. The following species shall be considered for inclusion in the list of subject species: Green and Golden Bell Frog (*Litoria aurea*), Australaisian Bittern (*Botaurus poiciloptilus*), Greater Sand Plover (*Charadrius leschenaultii*), Terek Sandpiper (*Xenus cinereus*), Great Knot (*Calidris tenuirostris*), Black-tailed Godwit (*Limosa limosa*), Little Tern (*Sterna albifrons*), Sotty Oystercatcher (*Haematopus fuliginosus*), Pied Oystercatcher (*Haematopus longirostris*), Mongolian Plover (*Charadrius mongolus*), Sanderling (*Calidris alba*), Broad-billed Sandpiper (*Limicola falcinellus*), *Deyeuxia appressa, Syzygium paniculatum*. Databases such as the NPWS Atlas of NSW Wildlife, Australian Museum and Royal Botanic Gardens may be used to assist in compiling the list.

Justification for excluding any of the above listed species from the list of subject species must be given in the SIS.

1.9 In describing the study area, consideration shall be given to the previous land uses and the effect of these land uses on the study area. Relevant historical events may include fire history, clearing, logging, recreational use and agricultural activities.

1.10 A description of habitat including such components as the frequency of tree hollows, density of understorey vegetation, description of ground cover, soil type and/or presence of rock outcrops shall be given. The condition of the habitat within the study area shall be discussed, including the prevalence of introduced species. A description of the habitat requirements of threatened species likely to occur in the study area shall be provided.

1.11 In defining the study area consideration shall be given to possible indirect effects of the action on species/habitats in the area surrounding the subject site: for example through altered hydrology regimes, soil erosion or pollution.

Threatened species survey methods

1.12 A fauna and flora survey is to be conducted in the study area. Targeted surveys shall be conducted for all subject species determined in accordance with Section 1.7 above. Species of taxonomic uncertainty shall be confirmed by a recognised authority such as the Australian Museum or National Herbarium at the Royal Botanic Gardens, Sydney.

1.13 A full description of methods used in the fauna and flora surveys and habitat assessment shall be provided, including survey techniques employed, number and location of traps, size of survey sites, dates of surveys, the time spent on surveys and weather conditions. Where possible, surveys should be undertaken during seasons and climatic conditions during which the subject species are most likely to be detected.

1.14 Any areas which may act as corridors between the study area and adjacent areas of likely habitat for subject species shall be identified and described.

1.15 A full list of the protected fauna and flora found during the course of surveys shall be included. Such information is indicative of the habitat quality of the site.

1.16 The effect of the season and weather at the time of the field survey shall be considered with respect to the adequacy of survey results.

2. Assessment of likely impacts

The assessment matters listed below shall be addressed.

2.1 For all subject species, the SIS shall state the following:

- the location, nature and extent of habitat removal or modification which may result from the proposed action;
- the potential impact of the removal of habitat; and
- the likely contribution of the proposed action to the threatening processes acting on populations of those species in the locality.

2.2 A discussion of other populations of subject species in the locality shall be provided. The long term security of the other habitats shall be examined as part of this discussion. The relative significance of the subject site for subject species in the locality shall be discussed.

2.3 If movement corridors for subject species are present within the subject site, the impact of the proposal on these areas shall be discussed.

3. Amelioration

The following issues shall be addressed:

3.1 While no recovery plans or threat abatement plans have been approved in accordance with the TSC Act as yet, draft recovery plans have been prepared for the species listed in Appendix 2. Where a draft recovery plan is relevant to any subject species,

consideration shall be given to the information contained in these plans and whether any draft recovery plan recommendation is applicable to the proposal.

3.2 In discussing alternatives to the proposal, and the measures proposed to mitigate the effect of the proposal, consideration shall be given to developing long term management strategies to protect areas within the study area which are of particular importance for the subject species. This may include proposals to restore or improve habitat.

3.3 Any proposed on-going monitoring of the effectiveness of the mitigation measures shall be provided.

4. Additional Information

4.1 In providing a list of other approvals the following shall be included;

- any consent required under Part 4 of the *Environmental Planning and Assessment Act 1979* including the name of the consent authority and when it is proposed to make the development application; or
- any approvals required under Part 5 of the *Environmental Planning and Assessment Act 1979* including the name of the determining authority(ies), the basis for the approval and when these approvals are proposed to be obtained.

Four copies of the SIS will need to be provided to the Service in order for the concurrence to be speedily processed. Should you require any further information on these requirements please contact Ray Giddins, Sydney Zone Threatened Species Officer, on (02) 5856911.

Yours sincerely

Robert Humphries 18/11/96

Robert Humphries
A/Manager, Threatened Species Unit
Sydney Zone

As delegate to the Director-General

Appendix 1 : Section 109 & 110 of the Threatened Species Conservation Act

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Division 2 Species impact statements

109 Form of species impact statements

(1) A species impact statement must be in writing.

(2) A species impact statement must be signed by the principal author of the statement and by:

(a) the applicant for the licence, or

(b) if the species impact statement is prepared for the purposes of the *Environmental Planning and Assessment Act 1979*, the applicant for development consent or the proponent of the activity proposed to be carried out (as the case requires).

110 Content of species impact statements

(1) A species impact statement must include a full description of the action proposed, including its nature, extent, location, timing and, layout and to the fullest extent reasonably practicable, the information referred to in this section.

(2) A species impact statement must include the following information as to threatened species and populations:

(a) a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action,

(b) an assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action,

(c) for each species or population likely to be affected, details of it's local, regional and State-wide conservation status, the key threatening processes generally affecting it, habitat requirements and any recovery plan or threat abatement plan applying to it,

(d) an estimate of the local and regional abundance of those species or populations,

(e) a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action,

(f) a full description of the type, location, size and condition of the habitat (including critical habitat) of those species andpopulations and details of the distribution and condition of similar habitats in the region,

(g) a full assessment of the likely effect of the action on those species and populations, including, if possible, the quantitative effect of local populations in the cumulative effect in the region,

(h) a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,

(i) a full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those measures,

(j) a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population.

(3) A species impact statement must include the following information as to ecological communities:

(a) a general description of the ecological community present in the area that is subject of the action and in any area that is likely to be affected by the action,

(b) for each ecological community present, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or any threat abatement plan applying to it,

(c) a full description of the type, location, size and condition of the habitat of the ecological community, and details of the distribution and condition of similar habitat in the region,

(d) a full assessment of the likely effect of the action on the ecological community, including, if possible, the quantitative effect of local populations in the cumulative effect in the region,

(e) a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and

social considerations and the principles of ecologically sustainable development,

(f) a full description and justification of the measures proposed to mitigate any adverse effect of the action on the ecological community, including a compilation (in a single section of the statement) of those measures,

(g) a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the ecological community.

(4) A species impact statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement.

(5) The requirements of subsections (2) and (3) in relation to information concerning the State-wide conservation status of any species or population, or any ecological community, are taken to be satisfied by the information in that regard supplied to the principal author of the species impact statement by the National Parks and Wildlife Service, which information that Service is by this subsection authorised and required to provide.

Appendix 2: Draft Recovery Plans as of 1/1/96.

Recovery Plans for Threatened Species occurring in New South Wales

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A recovery plan delineates, justifies and schedules the research and management actions necessary to support recovery of the threatened species, population or ecological community.

The following recovery plans have been prepared in conjunction with the Australian Nature Conservation Agency (ANCA).

Under the NSW *Threatened Species Conservation Act 1995,* these plans are considered as drafts and will go through the process as outlined in the Act.

SPECIES	COMMON NAME	AUTHOR	DATE
Plants			
Acronychia littoralis	Scented Acronychia	J Hunter et al	1991
Acrophyllum australe		M Henderson	1994
Allocasuarina defungens		A Benwell	1992
Allocasuarina portuensis		S Nash, M Matthes	1994
Apatophyllum constablei		W Jones, J Volmer	1994
Asterolasia elegans		J Scott	1994
Cynanchum elegans	White Cynanchum	S Nash, M Matthes	1993
Diospyros mabacea	Red -fruited Ebony	A S Murray	1995
Diploglottis campbellii	Small-leaved Tamarind	J Hunter et al	1992
Elaeocarpus williamsianus	Hairy Quandong	J Hunter et al	
Epacris hamiltonii		J Cohn	
Fontainea oraria	Coastal Fontainea	J Hunter et al	
Gentiana wingecarribiensis		J Cohn	
Grevillea beadleana		J Benson	1991
Grevillea caleyi		J Scott et al	1995
Grevillea iaspicula	Wee Jasper Grevillea		
Grevillea kennedyana		A Duncan	1992
Haloragodendron lucasii		S Nash, M Matthes	1994
Kunzea rupestris		J Cohn	1993
Olearia flocktoniae		S Griffiths	1992
Phaius australis	Swamp Orchid	A Benwell	1994
Phaius tancarvilliae	Swamp Orchid	A Benwell	1994
Phebalium lachnaeoides		J Cohn	
Pimelea spicata	Pink Pimelea	S Nash, M Matthes	1993
Pterostylis gibbosa	Illawarra Greenhood Orchid	QEM Pty Ltd	1994
Rutidosis leptorrhynchoides	Button Wrinklewort	F Zich et al	1995
Swainsona plagiotropis			
Thesium australe	Austral Toadflax	S Griffiths	1992
Velleia perfoliata		K Maryott-Brown	1994
Zieria involucrata		K Maryott-Brown	1994
Zieria prostrata		S Griffith	1992

APPENDIX F THREATENED SPECIES IMPACT STATEMENT

M5 EAST MOTORWAY

Eve Street and Marsh Street Wetlands

ROADS & TRAFFIC AUTHORITY

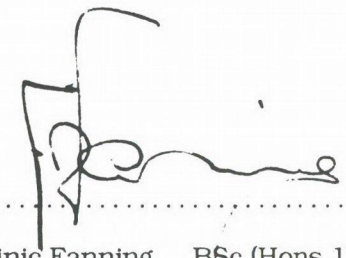
SPECIES IMPACT STATEMENT

November 1996

Declaration

This Species Impact Statement has been prepared in accordance with Sections 109, 110 and 111 of the *NSW Threatened Species Conservation Act 1995*, after consultation with the Director-General of the NSW National Parks & Wildlife Service, as required.

For Gunninah Environmental Consultants:



.....

F Dominic Fanning BSc (Hons 1) MEIA MAIBiol MESA
Director and Principal

For the Roads & Traffic Authority:

.....

22nd November 1996

M5 EAST MOTORWAY

Eve Street and Marsh Street Wetlands

ROADS & TRAFFIC AUTHORITY

SPECIES IMPACT STATEMENT

November 1996

Gunninah Environmental Consultants

M5 EAST MOTORWAY

Eve Street and Marsh Street Wetlands

ROADS & TRAFFIC AUTHORITY

SPECIES IMPACT STATEMENT

November 1996

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M5 EAST MOTORWAY
Eve Street and Marsh Street Wetlands

ROADS AND TRAFFIC AUTHORITY, NSW

SPECIES IMPACT STATEMENT

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M5 EAST MOTORWAY
Eve Street & Marsh Street Wetlands

ROADS & TRAFFIC AUTHORITY

SPECIES IMPACT STATEMENT

November 1996

1 INTRODUCTION and BACKGROUND

1.1 INTRODUCTION

The Roads & Traffic Authority (RTA) proposes to construct an extension to the M5 Motorway connecting, it to General Holmes Drive near Sydney (Kingsford Smith Airport). In response to submissions from the community made to the 1994 Environmental Impact Statement (EIS) for the M5 East Motorway, the RTA has examined a number of alternatives for the eastern portion of the M5 East Motorway. The current preferred option involves the construction of a tunnel for much of the M5 East Motorway through the Wolli Creek area, with the road emerging at Marsh Street, to the west of the Cooks River. From this point the Motorway will proceed overland across the Cooks River and join General Holmes Drive south of the road tunnel beneath Kingsford Smith Airport.

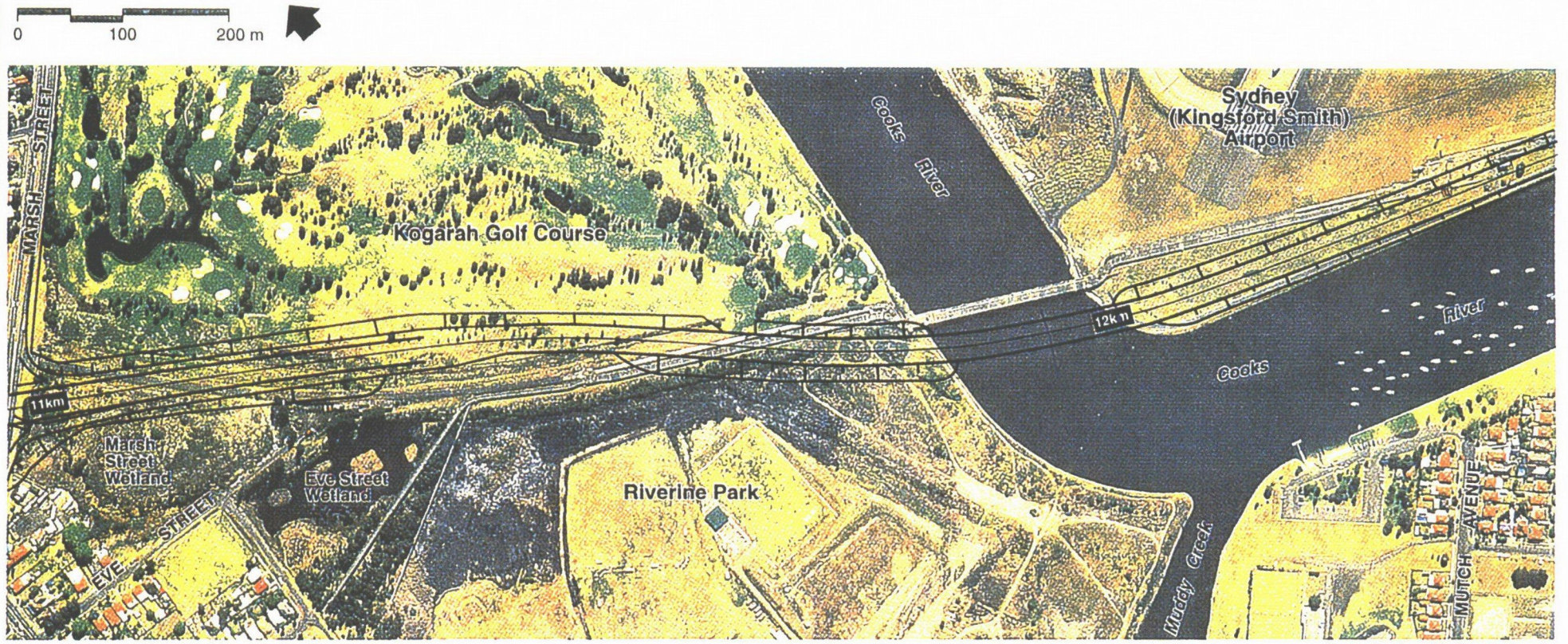
This Species Impact Statement (SIS) has been prepared specifically to consider the impacts of the proposed M5 East Motorway on wetlands and their associated fauna and flora located between Marsh Street, Arncliffe and the Cooks River. Two main wetlands are present in this locality, the Marsh Street wetland (adjacent to Marsh Street) and the Eve Street wetland (at the end of Eve Street, Arncliffe). These wetlands are located at the northern end of Barton Park, and are separated from the Kogarah Golf Course (to the north) by the South West Ocean Outfall Sewer.

The proposed M5 East Motorway is the subject of an EIS prepared by Manidis Roberts Pty Ltd. This SIS has been prepared as an Appendix to the EIS, and consideration of the specific details of the proposed development (location, staging, construction activities etc) are contained within the EIS, and are not repeated here.

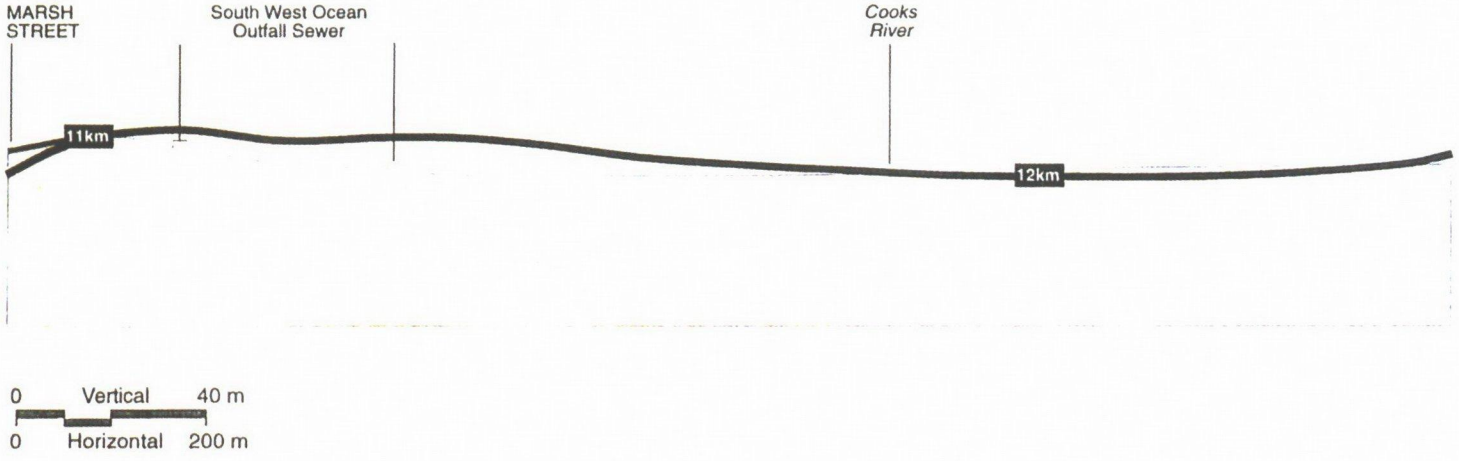
1.2 CONTEXT

General fauna and flora issues are considered in the EIS, and in the supporting documents (Adcock & Osborne 1994a, 1994b; Osborne 1995; Osborne & Adcock 1994; MKES 1994, 1995; LesryK 1996). These reports and investigations have involved an extensive array of surveys over the subject site (which includes the proposed alignment, the Eve Street and Marsh Street wetlands, and nearby vicinity), and have involved dedicated surveys for threatened species, investigations of habitats and vegetation in the areas, the establishment of fauna and flora inventories, and discussion of the potential impacts and conservation issues of relevance. Additional information from the previous investigations and from wildlife databases has been incorporated into this SIS, along with supplementary information from the general and scientific literature (particularly with regard to threatened species).

Whilst the Marsh/Eve Street wetland complex has been investigated in some detail for native fauna and flora, no formal Section 5A assessment of the significance of potential impacts on threatened species has been conducted. However, one threatened amphibian (the Green & Golden Bell Frog *Litoria aurea*) and a number of threatened avian species (see Appendix C) have been recorded on the Marsh Street or Eve Street wetlands (MKES 1994; LesryK 1996; Rockdale Wetlands Preservation Society). Although the proposed roadworks will avoid the Eve Street wetland (which is a salt marsh) there is some possibility of adverse



Source: Roads and Traffic Authority, 1995



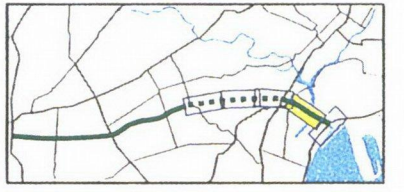


FIGURE 1 Location of the Eve Street and Marsh Street Wetlands, and their relationship to surrounding features.

effects upon the threatened bird species which utilise this resource.

Conversely, the proposed roadworks will have a substantial effect upon at least part of the Marsh Street wetland (which is freshwater), and which is used by the Green & Golden Bell Frog. The roadway is to be located on an earthen embankment, which is likely to prevent Frogs from moving onto the Kogarah Golf Course and utilising areas on that site as a foraging resource. On this basis, it has been determined that there is a significant potential for a "*significant effect*" on at least the Green & Golden Bell Frog, and possibly also on some threatened avian species. Consequently, this SIS has been prepared to address the potential issues.

DEFINITIONS used in this REPORT - derived from the NP&WS Director-General's requirements (Appendix A).

Development in relation to land, means:
(a) the erection of a building on that land;
(b) the carrying out of a work in, on, over or under that land;
(c) the use of that land or of a building or work on that land; and
(d) the subdivision of that land,
but does not include any development of a class or description prescribed by the regulations for the purposes of this definition.

Activity means:
(a) the erection of a building;
(b) the carrying out of a work in, on, over or under land;
(c) the use of land or of a building or work; and
(d) the subdivision of land,
and includes any act, matter or thing for which provision may be made under section 26 and which is prescribed for the purposes of this definition, but does not include:
(e) any act, matter or thing for which development consent under Part 4 is required or has been obtained; or
(f) any act, matter or thing which is prohibited under an environmental planning instrument.

Locality means the area within a 10km radius of the study area.

Subject Site means the area which is proposed for development/activity.

Study Area is the subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly.

Subject Species means those threatened species which are considered known or likely to occur in the study area.

Proposal is the development, activity or action proposed.

All other definitions are as contained in the *NSW Threatened Species Conservation Act 1995* (TSC Act).

1.3 LEGISLATIVE BACKGROUND

This SIS provides details of the threatened fauna and flora and their habitats on the proposed M5 East Motorway roadworks between Marsh St Arncliffe and the Cooks River (the "*subject site*"). It addresses the potential impacts of the proposal on biota and their habitats, and recommends a range of impact amelioration measures to minimise the effects on threatened species and habitats.

The SIS has been prepared to satisfy the requirements of the *NSW Threatened Species Conservation Act* 1995 (TSC Act) and of the *Environmental Planning & Assessment Act 1979* (EP&A Act), as amended by the TSC Act.

The TSC Act requires that the planning and development approval process for developments and activities have regard to the potential for adverse impacts to be imposed upon threatened fauna and flora, and their habitats. For developments or activities which require approval under Parts 3, 4 or 5 of the EP&A Act, the TSC Act requires that a determining or consent authority assess "*whether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats*" This assessment is conducted on the basis of eight factors which are included in Section 5A of the EP&A Act.

If it is determined on the basis of Section 5A of the EP&A Act that the proposed development or activity is "*on land that is, or is part of, critical habitat or is likely to significantly affect threatened species, populations or communities, or their habitats*", then a SIS is required to be prepared. The SIS accompanies, or is part of, an EIS, Development Application (DA) or other impact assessment documents prepared for the proposed development.

Where a significant effect on threatened species or their habitats is likely to arise from a proposed development, and an SIS is required, the proponent must obtain specific requirements for the preparation of the SIS from the Director-General of the NSW National Parks & Wildlife Service (NP&WS), in addition to fulfilling the requirements of Sections 109, 110 and 111 of the TSC Act. Furthermore, the Director-General of the NP&WS must concur with or be consulted regarding any development approval associated with the proposed activity.

1.4 REPORT STRUCTURE and COMPLIANCE

This SIS has been prepared in accordance with the requirements of Sections 109, 110 and 111 of the TSC Act. Details of the compliance of the SIS with the requirements of the Act and with those of the Director-General of the NSW NP&WS are provided below, and are also detailed in Appendix B.

As required under Section 109(1) of the TSC Act, this SIS is in writing.

As required under Section 109(2) of the TSC Act, the SIS has been signed by the principal author (F Dominic Fanning of Gunninah Environmental Consultants) and by "*the proponent of the activity proposed to be carried out*" (the Roads & Traffic Authority - see Declaration at the front of this document).

The SIS has been structured according to Section 110 of the TSC Act, and by reference to the Director-General's requirements, which were obtained for its preparation, as required under Section 111(1) of the TSC Act (Appendix A).

The following chapters in this document contain the information required under Sections 110 and 111 of the TSC Act:

- Chapter 2 provides a description of the proposed development - Section 110(1);
- Chapter 3 presents details of the survey methods applied to the fauna and flora investigation - as required in the Director-General's requirements under Section 111(1) of the TSC Act;
- Chapter 4 provides a "*general description of the threatened species or populations known or likely to be present in the area*" - Section 110(2)(a);
- Chapter 5 indicates the threatened species considered of relevance to the proposed development - Section 110(2)(b);
- Chapter 6 provides details of the conservation status of threatened species of relevance - Section 110(2)(c);
- Chapter 7 provides information regarding the abundance of threatened species relevant to the proposed development - Section 110(2)(d);
- Chapter 8 deals with the types and distributions of the relevant habitats for threatened species - Section 110(2)(f);

- Chapter 9 provides an assessment of the likely effects of the proposed development on relevant threatened species - Section 110(2)(g);
- Chapter 10 provides information regarding alternatives to the proposal - Section 110(2)(h);
- Chapter 11 provides information regarding proposed impact amelioration measures - Section 110(2)(i); and
- Chapter 12 details other approvals that are required - Section 110(2)(j).

Note that Section 110(2)(e) of the TSC Act is identical to Section 110(2)(a), and is consequently not addressed separately (see Appendix A).

As is noted in the Director-General's requirements, a number of elements of the TSC Act have not been completed, and consequently do not require addressing in this SIS. There are, at the time of preparation of this SIS, no relevant listings of the following elements included in the TSC Act:

- critical habitats;
- endangered populations[1] ;
- ecological communities[2] ;
- key threatening processes;
- species recovery plans[3] ; and
- threat abatement plans.

2 DESCRIPTION of the PROPOSED DEVELOPMENT

The TSC Act requires, under Section 110(1), that a SIS includes:

> "*a full description of the action proposed, including its nature, extent, location, timing and layout and, to the fullest extent reasonably practicable, the information referred to in this section*".

The NP&WS Director-General's requirements for this SIS re-iterate the requirements of Section 110(1). Points 1.1, 1.2, 1.3, 1.4, 1.5 and 1.9 of the Director-General's requirements request details of the proposal, plans and maps of the proposal and locality, and a description of the existing environment. These issues are discussed in detail below.

The EIS to which this SIS is appended contains "*a full description of the action proposed, including its nature, extent, location, timing and layout*", as required under Section 110 (i) of the TSC Act.

2.1 EXISTING ENVIRONMENT

The NP&WS Director-General's requirements include:

> "*1.9 In describing the study area, consideration shall be given to the previous land uses and the effect of these land uses on the study area. Relevant historical events may include fire history, clearing, logging, recreational use and agricultural activities.*"

Details of the existing condition of the subject site are provided in the EIS.

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1 The Director-General's requirements note that "*no listed endangered populations occur in the subject area*".

2 The Director-Generals's requirements note that "*the TSC Act does not list any ecological communities*".

3 Whilst no "*species recovery plans*" have yet been approved in accordance with the TSC Act, the Director-General requires that relevant "*draft recovery plans*" be addressed - see Chapter 6.

In essence, the majority of the subject site has been highly modified from its original condition. Whilst the majority of the surrounding area, and the Marsh Street and Eve Street wetlands, were almost probably natural wetland communities, most of the surrounding landscape has been highly modified, and appears to consist of areas which have been used as fill and rubble dumping sites. To the southwest and northwest of the Marsh Street wetland, urban development and infrastructure (particularly along Marsh Street, Eve Street and the South West Ocean Outfall Sewer) constitute highly disturbed landscapes. The Kogarah Golf Course to the northeast and east, and Barton Park (to the south and southeast) are artificial landscapes, and appear to be partly or largely based on fill and degraded lands.

The Eve Street and Marsh Street wetlands, which are the primary subject of this SIS, are also highly modified and degraded. Whilst native wetlands may have originally occurred in these localities, the existing Marsh Street and Eve Street wetlands appear to be essentially an artefact of artificial drainage conditions and the degraded nature of the surrounding land uses.

Nevertheless, both of these wetlands clearly provide resources which are of some significance to a range of threatened native species. However, surrounding existing land uses are potentially of some concern with respect to the ongoing survival of these wetland areas and the biota which they support, and active management would be required for the Eve Street and Marsh Street wetlands regardless of the construction of the M5 East Motorway. There are current rehabilitation and wetland management programs being implemented on the subject site, and it is intended that these be supplemented and enhanced as a result of the proposed motorway construction.

2.2 PROPOSED DEVELOPMENT

The NP&WS Director-General's requirements (Appendix E in the EIS) for this SIS include:

> "*1.1 The type of proposal shall be detailed, including the timetable for the construction of the proposal, and the number of hectares affected. This shall include details of the location of any auxiliary infrastructure and all component parts of the proposal*".

The detailed information contained in the EIS provides material addressing "*the timetable for the construction of the proposal, ... any auxiliary infrastructure and all component parts of the proposal*", as required in Section 1.1 of the Director-General's requirements.

With respect to the effects of the proposal on the Marsh Street and Eve Street wetlands, the proposed roadworks will not involve the removal of any of the Eve Street wetland, but will require approximately 1.5 hectares of the Marsh Street wetland area to be removed for the roadworks. However, most of this area is highly disturbed. In addition, several hectares of land adjacent to the South West Ocean Outfall Sewer and Kogarah Golf Course (which constitutes, at least in part, foraging habitat for the Green & Golden Bell Frog) will require removal for the proposed roadworks.

The NP&WS Director-General's requirements for this SIS also includes that:

> "*1.2 A plan of the subject area shall be provided. This plan shall show the location and type of vegetation communities present within the subject area and the scale of the plan*".

The area which is to be subjected to the proposed roadworks (east of Marsh Street) is indicated in Figure 1. This aerial photograph provides a depiction of the proposed roadworks, and indicates the vegetation communities and habitats which are present in the vicinity. The vegetation communities within the roadworks area and vicinity are indicated, with the majority of the area (as noted above) comprising a highly disturbed and modified landscape. The areas of the proposed M5 East Motorway of most relevance with regard to the threatened species of concern are the modified and degraded wetland habitats known as the Marsh Street and Eve Street wetlands.

The NP&WS Director-General's requirements for this SIS also require:

> "*1.3 An aerial photograph (preferably colour) of the locality (or reproduction of such a photograph) shall be provided, if possible. This aerial photograph should clearly show the subject site and the scale of the photograph*".

A colour aerial photograph of the wetlands and associated earthworks is provided as Figure 1 of this report. The "*subject site*" comprises the proposed new road alignment, and is considered to include the whole of the Marsh and Eve Street wetlands, and areas immediately adjacent to the proposed roadworks.

The NP&WS Director-General's requirements for this SIS also require:

> "*1.4 A topographic map of the site and immediate surrounds at a scale of 1:25,000 will be provided. This map will detail the location of the proposal, and location of water on site*".

In place of a topographic map of the "*subject site*", the aerial photograph indicated in Figure 1 provides details of the site. This photograph details "*the location of the proposal*" and indicates the "*location of water on site*".

The NP&WS Director-General requires that this SIS provides:

> *1.5 A map of the locality, showing habitat of subject species, any locally significant areas for threatened species such as parks, reserves and known populations, and areas of high human activity such as townships, regional centres and major roads* will also be provided."

Figure 1 provides a generalised map of the locality, which includes identification of areas which are of likely relevance to those threatened species which may utilise the Eve Street and Marsh Street wetlands, and generally indicates the land use patterns throughout the locality. Given the nature of surrounding land uses, it is considered unlikely that the majority of lands surrounding the subject site are of relevance to terrestrial fauna species or native flora of conservation significance. Conversely, many of the avian species which are known from the Eve Street wetlands could potentially utilise other resources within the general locality, given that many of these species are migratory and some of them travel thousands of kilometres between winter and summer habitat sites.

3 METHODS

The NP&WS Director-General's requirements (Appendix A) for this SIS includes:

> "*1.12 A fauna and flora survey is to be conducted in the study area. Targeted surveys shall be conducted for all subject species determined in accordance with Section 1.8 above. Species of taxonomic uncertainty shall be confirmed by a recognised authority such as the Australian Museum or National Herbarium at the Botanic gardens, Sydney*".

Several investigations for flora and fauna have been conducted on the site and in the general vicinity (MKES 1994, 1995; Adcock & Osborne 1994a, 1994b; Osborne 1995; Osborne & Adcock 1994; LesryK 1996). The report by LesryK focuses specifically on the Marsh and Eve Street wetlands.

"*Targeted surveys*" for the Green & Golden Bell Frog were conducted in the Marsh and Eve Street wetlands, and adjacent areas of suitable habitat, as described in Section 3.1.3. In addition, "*targeted surveys*" were conducted for the array of waterbirds listed in Section 1.8 of the Director-General's requirements, including the Australasian Bittern, Terek Sandpiper, Pied Oystercatcher and Broad-billed Sandpiper. Furthermore, the field investigations determined the value of the habitat present for these species of conservation significance, as compared with their habitat requirements outlined in Appendix 3. The methods employed for the biological surveys to date are detailed in Section 3.1.3.

The NP&WS Director-General's requirements for this SIS includes:

> "*1.13 A full description of methods used in the fauna and flora surveys and habitat assessment shall be provided, including survey techniques employed, number and location of traps, size of survey sites, dates of surveys, the time spent on surveys and weather conditions. Where possible, surveys should be undertaken during seasons and climatic conditions during which the subject species are most likely to be detected*".

As noted above, several investigations for fauna and flora have been conducted in the Marsh and Eve Street wetlands, and in the vicinity. Whilst the descriptions of the techniques employed in some of the past reports are not comprehensive, other reports included detailed discussions regarding survey methods. Sections 3.1.2 and 3.1.3 of this SIS detail the methods employed during the flora and fauna investigations, including weather conditions, where available.

The NP&WS Director-General's requirements for this SIS includes:

> "*1.14 Any areas which may act as corridors between the study area and adjacent areas of likely habitat for subject species shall be identified and described*".

The variety of surveys conducted for the Marsh and Eve Street wetlands and other areas along the proposed M5 route (such as Salt Pan Creek and the Wolli Wetlands) has identified, and provided a comprehensive description of, all relevant areas of habitat in the vicinity, including those areas which may act as "*corridors*" for native fauna between areas of adjacent habitat. Section 3.1.2 of this SIS provides information regarding the habitat in the vicinity, and Section 9.3 considers "*corridors*".

The NP&WS Director-General's requirements for this SIS includes:

> "*1.15 A full list of the protected fauna and flora found during the course of surveys shall be included. Such information is indicative of the habitat quality of the site*".

The field investigations of the Marsh and Eve Street Wetlands included the preparation of flora and fauna inventories for the site. In addition, may of the studies utilised previous reports and databases, such as the NP&WS Wildlife Atlas and RAOU Bird Atlas, so that the lists of species are comprehensive. Detailed lists of all fauna and flora are provided in Appendices 1 and 2 , including "*protected fauna and flora*" and all species recorded on the site and in the vicinity during all the previous investigations.

The NP&WS Director-General's requirements for this SIS includes:

> "*1.16 The effect of the season and weather at the time of the field survey shall be considered with respect to the adequacy of survey results.*"

In general, the field investigations were conducted at such times to ensure that the weather conditions did not negatively influence the results. Examples of timing of field work in this regard includes reptile searches undertaken during sunny days and amphibian searches conducted on wet evenings. The timing of the field investigations is discussed further in section 3.1.3, and the efficacy of survey methods are discussed in Sections 3.1.3 and 3.2.

3.1 SURVEY ACTIVITIES

3.1.1 General

An array of investigations have been conducted along the proposed M5 East Motorway, many of which have been primarily focussed on the wetlands in the vicinity, including the Wolli Creek wetlands and the Barton Park (Eve and Marsh Street) wetlands. The most

extensive survey of the M5 route was undertaken for the EIS by Mount King Ecological Surveys (MKES 1994), which provides details of vegetation, fauna habitats and plant and animal assemblages of the area. Supplementary investigations have been conducted on the Wolli Creek and Salt Pan Creek wetlands (Adcock & Osborne 1994a; Osborne & Adcock 1994) and on the Eve and Marsh Street wetlands (Adcock & Osborne 1994b; Osborne 1995). A specific investigation was conducted on the Eve and Marsh Street wetlands (LesryK 1996), for the latest version of the M5 East Motorway, which provides a comprehensive overview of all previous work, including species lists incorporating information from previous studies and relevant databases, such as the NP&WS Wildlife Atlas and the RAOU Bird Atlas (Appendix 4).

3.1.2 Flora

Several investigations for flora have been conducted over the proposed route for the M5 East Motorway, along Wolli Creek to Barton Park. The most extensive surveys for flora were conducted for the original EIS (MKES 1994). These surveys were undertaken over a two week period in March 1989, and included field surveys, vegetation mapping and literature reviews. During the field investigations, records were made of vegetation communities, dominant plant species, projective foliage cover, and the nature of the communities, including the extent of understorey and weed invasion. Stands of vegetation were described with reference to structure as outlined by Specht (1970). Additional investigations by MKES were conducted in 1994 and involved the identification of dominant species and the compilation of species lists. In addition to field work, previous investigations and aerial photographs were utilised.

An additional investigation was conducted to supplement the EIS (MKES 1995), which addressed the requirement for exhaust emission and air intake vents for the proposed tunnel. Potential sites along the route, in the vicinity of the Barton Park wetlands, were surveyed for flora to determine the value of vegetation communities in this area. This investigation also included a literature review and incorporated information from the previous investigations for the EIS.

The wetlands of Barton Park have been the subject of an investigation (Adcock & Osborne 1994b) aimed at determining the values of these wetlands. This study primarily involved the compilation of a species list from previous reports and an assessment of the value of the vegetation communities in this area. A supplementary survey was conducted as an addendum to this report (Osborne 1995), which included a detailed field investigation of the proposed M5 route. This study primarily involved investigations of the flora of the Wolli Creek and Marsh and Eve Street wetlands, including species identification and community descriptions, such as canopy height and understorey condition. This study also involved a literature review.

The most recent investigation of the Marsh and Eve Street wetlands was conducted by LesryK (1996). This study addressed flora species lists prepared during previous investigations and involved a supplementary survey of the area to ensure the completeness of the species lists. The field investigations for this study were conducted over one day at each wetland in April and June, 1996. The field investigations focussed primarily on the suite of species present within and adjacent to the wetlands, and paid particular attention to the possible presence of threatened flora species.

In addition to these surveys in the vicinity of the Barton Park wetlands, two other studies have been conducted in the area (Adcock & Osborne 1994b; Osborne & Adcock 1994), along Salt Pan Creek (approximately 10km west of Barton Park) and the Wolli Creek wetlands (approximately 2km to the northwest). These investigations provide a description of the wetlands in these areas, including vegetation characteristics (such as species present and canopy height) and water quality estimations. These investigations also involved review of literature and historical aerial photographs.

3.1.3 Fauna

Fauna investigations for the EIS were conducted in 1989 (MKES 1989) along the original route for the M5 Motorway. This investigation focussed on those areas which support the greatest area of bushland. Supplementary investigations were conducted in 1993/94 when

the new route for the Motorway was decided.

The initial fauna investigations were comprehensive and included transect-based avifauna surveys throughout the area, intensive reptile searches, including lifting of rocks and leaf litter, and small mammal trapping using Elliot Traps (500 trap days) and 'Bandicoot' Traps. Spotlighting was conducted over the area on foot, paying particular attention to the possible presence of arboreal mammals and amphibians. Given the known occurrence of Green & Golden Bell Frogs, dedicated searches for this species were conducted in the evening, involving listening for calls and spotlighting around the edges of ponds. In addition, indirect evidence for the presence of fauna, such as scratchings and scats, was recorded and the habitat characteristics of each survey site were determined.

Microchiropteran bat surveys were conducted by MKES in March 1993, using Anabat II echolocation detectors at 12 sites for 45 minutes each. Traps were not used due to the lack of suitable sites and the prevalence of vandalism.

The supplementary investigations for the exhaust and air intake vents (MKES 1995) assessed the value of fauna and fauna habitats present in a series of sites along the M5 route. Whilst this study included some field work, it based many of its conclusions on the original work done for the EIS and other data from the area.

A comprehensive survey of the Eve and Marsh Street wetlands was conducted between at the end of April and the beginning of May 1996 (LesryK). The weather conditions during the day were warm and fine, and the evenings chosen for surveys were cool and wet.

Particular attention was paid during these investigations to the presence of the Green & Golden Bell Frog. This species was targeted during spotlighting surveys around the wetlands, and on one evening, call playback was implemented to determine the presence of this species. In addition, the wetlands were netted and tadpoles caught were identified and released. Frogs were identified by call or captured and subsequently released.

Avifauna surveys were conducted at dawn and dusk, and techniques included call identification, direct observation and habitat assessment. Surveys for reptiles were conducted during sunny days, and included direct observations and searches through potential habitat (such as under rocks and leaf litter). The presence of mammals was determined by spotlighting, scat analysis, indirect evidence (such as scratchings and tracks), and direct observation. Specific surveys for small mammals and microchiropteran bats were not conducted during this investigation.

In addition, a general assessment of habitat in the area was conducted to determine the value of these areas for native fauna. Databases, including the NP&WS Wildlife Atlas, Australian Museum and NSW Bird Atlassers, were accessed for information regarding the species, particularly threatened species, which are known from the general vicinity.

In general, the other surveys of the M5 Motorway route (Adcock & Osborne 1994a; Osborne & Adcock 1994; MKES 1995) concentrated on the flora values of the area, and did not include dedicated investigations of the faunal assemblages.

3.2 ADEQUACY of SURVEY TECHNIQUES

The NP&WS Director-General requires (Appendix E of the EIS) that the SIS consider:

> "*1.16 The effect of the season and weather at the time of the field survey shall be considered with respect to the adequacy of survey results.*"

The field surveys included a range of relevant techniques for the collection of data on native fauna and flora, with field studies conducted over a number of years, from 1989 to 1996, along the with proressive development of the proposal. These fauna surveys provide an adequate survey base, particularly given the number of site inspections conducted on the site and in the vicinity.

TABLE 1 Survey methods applied on the subject site for threatened species listed in the NP&WS Director-General's requirements.

NAME	SURVEY METHODS
BIRDS	
Australasian Bittern	habitat assessment; surveys around ponds
Terek Sandpiper	habitat assessment; surveys around ponds
Black-tailed Godwit	habitat assessment; surveys around ponds
Great Knot	habitat assessment; surveys around ponds
Sanderling	habitat assessment; surveys around ponds
Broad-billed Sandpiper	habitat assessment; surveys around ponds
Pied Oystercatcher	habitat assessment
Sooty Oystercatcher	habitat assessment
Lesser Sand Plover	habitat assessment
Greater Sand Plover	habitat assessment
Little Tern	habitat assessment
AMPHIBIANS	
Green & Golden Bell Frog	active diurnal and spotlight searches through potential habitat
PLANTS	
Deyeuxia appressa	active searches through potential habitat
Syzygium paniculatum	active searches through potential habitat

Because of the disturbed nature and condition of the subject site, and the high mobility and nomadism of most of the threatened fauna species (particularly birds and microchiropteran bats), fauna survey activities concentrated on habitat searches and the assessment of available resources on the site, rather than principally on trapping or other direct techniques. Little habitat suitable for the use of some microchiropteran bat survey equipment (the nets or harp traps) was available. In most instances, therefore, surveys concentrated on the availability and relevance of habitat present on the site.

Similarly, the suitability of the habitats on the site for avian species was assessed, to supplement active avifauna searches. Habitat assessment formed the major determination of the relevance of most species to the proposed development, particularly given the nature of the habitats and the highly disturbed condition of the site.

With regard to seasonal requirements, many species (including reptiles, amphibians and microchiropteran bats) enter a state of hibernation during the winter months and are consequently less likely to be recorded during field investigations at this time. The majority of the surveys on the site and in the vicinity were conducted in the warmer months of the year, and are therefore considered to adequately represent the likely complement of species which occur in the area.

Weather conditions during the recent survey of the subject site (LesryK 1996) consisted of mild to warm days. Evening surveys were conducted during cool and wet conditions. These conditions are considered to provide ideal circumstances for diurnal reptile surveys and nocturnal amphibian species, and the Green & Golden Bell Frog was recorded widely on the subject site. The weather conditions were considered satisfactory for the surveying of microchiropteran bats and birds, as well as for other fauna or flora species likely to occur on the subject site or in the vicinity.

4 GENERAL DESCRIPTION of THREATENED SPECIES

The TSC Act requires, under Section 110(2)(a), that a SIS includes:

> *"a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action".*

As no relevant "*endangered populations*" have been defined under the NSW Scientific Committee procedures outlined in the TSC Act at the time of this report, no consideration of such populations is possible.

The NP&WS Director-General's requirements include:

> "1.8 *A list of subject species shall be provided. In determining these species, consideration shall be given to the habitat types present within the study area, recent records of threatened species in the locality and the known distribution of threatened species. The following species shall be considered for inclusion in the list of subject species: Green and Golden Bell Frog (Litoria aurea),* Australasian Bittern (*Botaurus poiciloptilus*), Greater Sand Plover (*Charadrius leschenaultii*), Terek Sandpiper (*Xenus cinereus*), Great Knot (*Calidris tenuirostris*), Black-tailed Godwit (*Limosa limosa*), Little Tern (*Sterna albifrons*), Sooty Oystercatcher (*Haematopus fuliginosus*), Pied Oystercatcher (*Haematopus longirostris*), Mongolian Plover (*Charadrius mongolus*), Sanderling (*Calidris alba*), Broad-billed Sandpiper (*Limicola falcinellus*), *Deyeuxia appressa, Syzygium paniculatum. Databases such as the NPWS Atlas of NSW Wildlife, Australian Museum and Royal Botanic Gardens may be used to assist in compiling the list.*"

A "*list of subject species*", including those in the Director-General's requirements, is provided in Appendix C.

4.1 FAUNA

The field investigations which have been conducted in the Marsh Street and Eve Street wetlands and in the vicinity for the proposed M5 East Motorway, and the accessing of databases and other information, indicate the presence of several threatened fauna species and the previous occurrence of a threatened plant species in the subject site.

The Green & Golden Bell Frog *Litoria aurea* has been recorded in the Marsh Street wetland, as well as in parts of the Kogarah Golf Course and beneath a sewer main to the south of the Marsh Street wetland (LesryK 1996). That investigation also notes the presence of a range of aquatic and migratory birds in the Eve Street wetland, several of which are listed as threatened species in the TSC Act. An attempt was made to obtain a listing of avifauna on the Eve Street wetland, apparently compiled by the Rockdale Wetlands Preservation Society, but no positive response was forthcoming from that organisation. Consequently, the assessment of threatened species provided by LesryK (1996) is adopted for the purposes of this SIS, in conjunction with a review of the NP&WS database and previous investigations in the vicinity (MKES 1994, 1995; Adcock & Osborne 1994a, 1994b; Osborne 1995; Osborne & Adcock 1994).

Ten threatened wetland bird species (Table 2) are noted as utilising the Eve Street wetland (LesryK 1996). Several of these are international migratory species, listed on International Treaties to which Australia is a signatory (JAMBA[4] and CAMBA[5]). It is also noted by LesryK (1996) that the Eve Street wetland in particular is regarded as a significant site for many of these migratory and threatened bird species. LesryK notes that of the migratory waders and threatened bird species which utilise wetlands which have been recorded in the general area, "*a number are only known to utilise this wetland* [the Eve Street wetland], *not being found in any other part of the Botany Bay wetland system (Rockdale Wetland Preservation Society pers comm)*".

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[4] JAMBA - Japan-Australia Migratory Bird Agreement.

[5] CAMBA - China-Australia Migratory Bird Agreement.

TABLE 2 Threatened avian species (Schedules 1 and 2 of the TSC Act) known to occur in the vicinity of the Eve and Marsh Street wetlands (derived from LesryK 1996).

SCIENTIFIC NAME	COMMON NAME
Botaurus poiciloptilus	Australasian Bittern
Charadrius leschenaultii	Greater Sand Plover
Xenus cinereus	Terek Sandpiper
Calidris tenuirostris	Great Knot
Limosa limosa	Black-tailed Godwit
Sterna albifrons	Little Tern
Haematopus fuliginosus	Sooty Oystercatcher
Haematopus longirostris	Pied Oystercatcher
Charadrius mongolus	Mongolian Plover
Calidris alba	Sanderling
Limicola falcinellus	Broad-billed Sandpiper

A range of migratory and non-migratory seabirds, including the Providence, Kermadec and Black-winged Petrels, Flesh-footed and Little Shearwaters, Wandering Albatross, Sooty and White Terns and Grey Ternlet, have been recorded in the general area (NP&WS Wildlife Atlas; NSW Bird Atlassers). However, these birds spend the majority of their time at sea, or breeding on offshore islands, and are rarely found on the mainland (Marchant & Higgins 1990; Higgins & Davies 1996). They are not likely to occur on the subject site except as vagrants, and will not be adversely affected by the proposed development. They are therefore not considered relevant to this SIS.

The Australasian Bittern and Blue-billed Duck are wetland species which inhabit densely vegetated and permanent wetlands (the Australasian Bittern) or deep pools (the Blue-billed Duck), primarily along rivers and floodplains within the Murray-Darling Basin (Marchant & Higgins 1990). Both species have been recorded in the general vicinity of the subject site (NP&WS Wildlife Atlas). The Eve St wetland provides potentially suitable habitat for these species. Although no evidence for the presence of these species was obtained during field investigations on the subject site, nor has been obtained recently in the vicinity (LesryK 1996), these species are included in the consideration of the Eve Street wetlands and the potential for impacts upon it.

A substantial number of other threatened fauna species, including avifauna, mammals and amphibians, have been recorded from the general region or within approximately 10km of the Eve Street and Marsh Street wetlands. Avifauna recorded in the region include the Osprey, Square-tailed Kite, Glossy Black Cockatoo, Regent Honeyeater, Swift Parrot, Superb Parrot, Purple-crowned Lorikeet and Powerful, Sooty and Masked Owls, but the subject site does not provide relevant resources or features for these species. It is considered extremely unlikely that any of these species would be present in the vicinity or would utilise the habitats and resources present on the site to any significant extent, if at all.

With respect to native mammals, the Koala has been recorded in Royal National Park and in parts of Sydney to the south west (NP&WS Wildlife Atlas). However, the site does not support suitable habitat or features for this species, and it is not considered of relevance to this SIS.

Several species of threatened microchiropteran bat are known from the general area (NP&WS Wildlife Atlas; LesryK 1996), with one threatened species (the Large Bent-wing Bat *Miniopterus schreibersii*) having been recorded in the general area (MKES 1990, 1994). Several other threatened microchiropteran bats, such as the Eastern Freetail Bat, Yellow-bellied Sheathtail Bat and Large-footed Myotis have been recorded in the general region. Given their wide ranging nature, these species could potentially or theoretically occur on the subject site, although specific resources of particular value to these species are not characteristic of the areas to be disturbed.

The Marsh Street wetland does not support suitable features or resources for any of these microchiropteran bats, and the Eve Street wetland is to be retained. Thus, the Large-footed Myotis, which forages over water bodies and ponds, could continue to use the area (if it currently does so). Similarly, other microchiropteran bats which drink from or forage over ponds and pools while flying, would be able to continue using this resource if they are

present in the vicinity. As a consequence of the above considerations, the microchiropteran bats are not considered of particular relevance with regard to the likely impacts of the proposed roadway. Consequently, they are not regarded further in this SIS.

No threatened reptile species have been recorded on the subject site or in the general region, and it is considered that the proposed development will have no impact upon threatened reptilian species.

Several threatened amphibians are known to occur in the general region, with the Wallum Froglet, Green & Golden Bell Frog and Giant Burrowing Frog having been recorded in the general region (NP&WS Wildlife Atlas). Neither the Giant Burrowing Frog nor Wallum Froglet are considered likely to occur on the subject site, given the nature of the habitats present. Conversely, the Green & Golden Bell Frog is known to be present, and the Marsh Street wetland in particular provides a breeding and habitation resource for this species.

4.2 FLORA

Only one threatened plant species has been recorded from the subject site during previous investigations. The grass *Deyeuxia appressa* was recorded during an investigation of the Eve Street wetland (Blick 1990, cited by LesryK 1996). However, in more recent investigations of the Eve Street and Marsh Street wetlands, following some extensive earthworks and replanting programs in the vicinity, no evidence for the presence of this species was obtained (MKES 1994; LesryK 1996). Given the extreme level of disturbance in the Marsh Street wetland (which is to be affected by the proposed Motorway), it is considered unlikely that this species is present in that locality.

No other threatened plant species have been recorded during any of the previous investigations conducted at the Eve Street and Marsh Street wetlands (MKES 1994a,1995; Adcock & Osborne 1994b; Osborne 1995; LesryK 1996). Given the very high levels of disturbance which characterise the subject site, it is considered unlikely that significant populations of threatened species would be present. Furthermore, it is considered likely that a subsequent landscaping and rehabilitation program for the wetlands, following the roadworks, would provide potentially suitable habitat for these and other threatened species in the vicinity.

5 RELEVANT THREATENED SPECIES

The TSC Act requires, under Section 110(2)(b) that a SIS includes the following information:

> "*an assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action.*"

At the time of preparation of this report, no relevant "*endangered populations*" had been listed in the TSC Act, and no further consideration of such populations is included in this SIS.

In assessing which of the threatened fauna and flora species known from the study area and subject site or considered likely to occur in the region "*are likely to be affected by the action*", the following issues were considered:

- has the species been recorded on the subject site or within the study area ?
- does the study area support potentially suitable habitats or resources for the threatened species?
- does the subject site support potentially suitable habitats or resources ?
- are the resources or habitat features which are to be affected by the development widespread throughout the region or are they restricted to the subject site or its immediate vicinity ?

- will "*a significant area of known habitat*" for a threatened species "*be modified or removed*" as a result of the proposed development ?

- is the species likely to occur on the subject site or in the immediate vicinity on other than a transitory basis ?

- is it likely that a "*viable local population*" of the species is dependent on the resources or habitats to be affected ?

Of the threatened fauna and flora species considered in the preceding section of this SIS, one amphibian species, and at least ten avian species, are regarded as of relevance with respect to the potential for impacts arising from the proposed roadworks. The Green & Golden Bell Frog *Litoria aurea* has been recorded on the subject site and in adjoining lands, and is considered a resident of the Marsh Street wetland. Ten avian species (Table 2), all wetland inhabitants, have been recorded utilising the Eve Street wetland, and are considered likely to be adversely affected by the proposed roadworks (Rockdale Preservation Society; LesryK 1996).

Whilst the proposed roadworks will not directly affect the Eve Street wetland (which is of relevance to the avifauna species), there is the potential for alterations to the hydraulic regime of the wetland, the possibility of contaminant discharge from the roadway, and the possibility of effects on the flight paths of wading birds into and out of the Eve Street wetland. Whilst these potential impacts are regarded as readily amenable to management, the potential for adverse effects upon the migratory and threatened bird species are considered sufficient to render the species of relevance to this SIS. Consequently, the potential effects on the ten threatened wetland birds are considered further in this document.

Given that a substantial proportion of the Marsh Street wetland area (which is bordered by Marsh Street to the northeast, the South West Ocean Outfall Sewer to the northeast, Eve Street to the south and existing developments to the west), and notwithstanding the highly disturbed and degraded condition of this area, it is likely that there will be an adverse effect upon Green & Golden Bell Frogs which inhabit the site. Consequently, this species is regarded as of particular relevance to the proposed development.

6 CONSERVATION STATUS and HABITAT REQUIREMENTS

The TSC Act requires, under Section 110(2)(c), that a SIS must include the following information:

> "*for each species or population likely to be affected, details of its local, regional and state wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or threat abatement plan applying to it*".

At the time of preparing this SIS, no "*key threatening processes*", and no relevant "*recovery plan*" or "*threat abatement plan*", had been listed in the TSC Act. Consequently, these features of the TSC Act cannot be addressed. Furthermore, the Director-General's requirements note that "*these matters need not be addressed*" by the SIS (Appendix E of the EIS).

The NP&WS Director-General's requirements do, however, include:

> "*3.1 While no recovery plans or threat abatement plans have been approved in accordance with the TSC Act as yet, draft recovery plans have been prepared for the species listed in Appendix 2* [of the DG's requirements]. *Where a draft recovery plan is relevant to any subject species, consideration shall be given to the information contained in these plans and whether any draft recovery plan recommendation is applicable to the proposal*".

None of the species for which "*draft recovery plans*" have been prepared was recorded on the

subject site. Furthermore, it is considered highly unlikely that any such species would be present, and no further consideration of "*draft recovery plans*" is required in this SIS.

6.1 LOCAL, REGIONAL and STATE-WIDE CONSERVATION STATUS

The threatened status of the Green & Golden Bell Frog *Litoria aurea* has been formally recognised in a number of conservation fora. The status ascribed to the Green & Golden Bell Frog in respect of the state of NSW is:

- Schedule 1 - endangered (*NSW Threatened Species Conservation Act 1995*;);

There is no specific or recognised conservation status for the Green & Golden Bell Frog on either a regional or local basis. However, given the condition of this species in the greater metropolitan area of Sydney, and the significant decline in populations and distribution which has apparently occurred in recent decades throughout the region (AMBS 1996a, 1996b), it is clear that the species is vulnerable in those areas where it is still located.

In regional terms (the 'Sydney Basin' region as defined by the Interim Biogeographic Regionalisation for Australia), the Green & Golden Bell Frog should be considered endangered, in accordance with its status in NSW.

In local terms (*ie* within a kilometre of the Marsh Street wetland), the Green & Golden Bell Frog is uncommon and almost certainly endangered. There are no accurate assessments of the population size at this locality, but it is unlikely to exceed 20 adults, and maybe significantly smaller.

In respect of the threatened bird species known to utilise the Eve Street wetlands, one (the Little Tern) is listed in the TSC Act as endangered (Schedule 1), and the remaining nine are listed as vulnerable (Schedule 2). Species are regarded as vulnerable (Schedule 2) if "*the species is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate*". A species is considered endangered (Schedule 1) if it is considered "*likely to become extinct in nature in NSW unless the circumstances and factors threatening its survival or evolutionary development cease to operate, or .. its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction*".

Little suitable information is available at the regional or local level to provide an accurate characterisation of the conservation status of these wide-ranging wetland birds. However, given the high level of degradation and removal of wetland habitats which have occurred along coastal NSW (and particularly in the Sydney region), it may be assumed that the regional conservation status of these species reflects their state conservation status, as detailed above. In local terms, the ten threatened species discussed above are noted as utilising only the Eve Street wetland in the whole Botany Bay area (Rockdale Wetland Preservation Society - cited by LesryK 1996). Thus, on a local basis, it would appear that these species are extremely vulnerable, although the migratory species which are listed on JAMBA and CAMBA do not breed in this locality.

6.2 HABITAT REQUIREMENTS

The preferred habitat of the Green & Golden Bell Frog is permanent and vegetated water bodies, including streams, swamps, farm dams and ponds (Goldingay 1996), particularly on sandy soil (White 1995). This species also inhabits artificial environments, such as quarry sites, brick pits and lakes created by sand extraction (on the Kurnell peninsula). Many of the known sites of Green & Golden Bell Frogs are less than 20 years old, are artificial and have been created as a result of human disturbance, and all currently known sites have been subjected to some level of human disturbance (Pyke & White 1996a). Despite this apparent tolerance of disturbed sites, this species is thought to be intolerant of chemical pollutants (White 1995), and ponds created and managed for them should be unpolluted (Pyke & White 1996a).

Important habitat requirements for the Green & Golden Bell Frog include:

- still, shallow and ephemeral ponds with a sand or rock substrate (Pyke & White 1996a);
- diurnal shelter and basking sites. This species is known to bask during the day on a variety of structures, ranging from vegetation to mounds of rubble. An abundance of aquatic and emergent vegetation, including *Typha*, *Phragmites*, *Eleochaeris* and *Juncus* is thought to provide important diurnal refuge sites;
- refuge sites for shelter or hibernation during winter. Piles of rubble or rock are important as shelter or hibernation sites. The length of hibernation can vary, depending upon the severity of the winter. In warmer months, individuals often shelter within rock piles, but during longer periods of hibernation, animals may shelter in a burrow some depth beneath the soil surface (White 1995);
- aquatic and semi-aquatic vegetation along the pond edge and native vegetation in areas adjacent to the pond, in particular native grassland and low shrubland (Pyke & White 1996a), are important foraging resources for this species. These adjacent areas are a source of prey for the Green & Golden Bell Frog, including cockroaches, crickets and grasshoppers (White 1995). This species may be found some distance from its principle wetland habitat, and may utilise more of a site than just the water body; and
- breeding areas comprising shallow ponds. Some fish species can pose a significant threat to the survival of this species by preying on eggs and tadpoles. Consequently, ephemeral ponds, devoid of fish, may also provide important breeding habitat for this species.

Habitat requirements for the wetland birds known from the subject site include sandy beaches, sand flats and mud flats, coastal swamps and lakes, lagoons, mangroves, intertidal mud flats and sandbanks and rocky shores (Appendix C). For several of the species listed as occurring in the Eve Street and Marsh Street wetlands (Rockdale Wetland Preservation Society, cited by LesryK 1996), the resources present in the Eve Street wetland are regarded as likely to be of only limited value, whilst for other species the habitats present are of potentially significant value. Species such as the Australasian Bittern, Great Knot, Broad-billed Sandpiper and Mongolian Plover are considered likely to utilise the Eve Street wetland to a moderate extent, at least, whereas the Oystercatchers, Little Tern and Sanderling are regarded as unlikely to utilise this site to a substantial extent. Nevertheless, all species appear to have been recorded on the Eve Street wetland.

Conversely, the Marsh Street wetland, which does not support open water for most of the time, and comprises reed filled ponds and small shallow freshwater wetlands, are apparently of little significance for any of these wetland bird species. The information provided by the Rockdale Wetland Preservation Society (cited by LesryK 1996) suggests that the Eve Street salt marsh is of particular value for these wetland birds, but there is no mention of their using the Marsh Street wetland at all.

7 ABUNDANCE of THREATENED SPECIES

The TSC Act 1995 requires, under Section 110(2)(d), a SIS to include the following information:

> "*an estimate of the local and regional abundance of those species or populations*".

At the time of preparing this SIS, no relevant "*endangered populations*" had been listed in the TSC Act.

Until recently, the Green & Golden Bell Frog was considered to be a relatively common species throughout Greater Sydney and NSW in general. However, with increasing research on this species since 1990, the Green & Golden Bell Frog appears to have disappeared from

over 100 locations, with indications that this declining trend is continuing (Pyke & White 1996b). Areas such as Botany, which used to support large numbers of this species, have since been taken over by industry, and the Frog populations have subsequently disappeared.

As noted above, the Green & Golden Bell Frog has declined substantially both in distribution and in abundance in recent times. On a regional basis, the Green & Golden Bell Frog is present only in a patchy distribution, and generally only in small numbers. In local terms, the total number of individuals in the Marsh Street wetlands will be limited by the size of the wetland, and is likely to involve only 20 or 30 adults, at most.

With respect to the wetland birds, there are no relevant measures of abundance with respect to the Eve Street wetland. Given the small size of the wetland, and the existence of other wetlands throughout Botany Bay, it is likely that only small numbers of these species will occur on the Eve Street wetlands at any time. In regional terms, moderate to large numbers of several of these wetland species are likely to be present. Whilst the Oystercatchers are likely to occur in only small numbers at any one location, some of the migratory bird species appear in substantial numbers in Botany Bay and elsewhere throughout the region.

8 HABITAT of THREATENED SPECIES

The TSC Act 1995 requires, under Section 110(2)(f), that a SIS must include the following information:

> "*a full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region*".

At the time of preparing this SIS, "*critical habitat*" had not been listed within the TSC Act. Consequently, this aspect of the requirements for an SIS cannot yet be fulfilled. Similarly, as noted above, there are no relevant "*endangered populations*", and the Director-General's requirements exclude consideration of such populations.

The NP&WS Director-General's requirements include:

> "*1.6 The location of the subject species recorded during the SIS survey shall be represented on a map of the study area*".

Figure 3 of the SIS indicates the location of records of the Green & Golden Bell Frog obtained during the investigations for this SIS, and identifies the Eve Street wetland, which is the location of records of a number of threatened avian species (Rockdale Wetland Preservation Society, cited in LesryK 1996).

The NP&WS Director-General's requirements also include:

> "*1.7 Where the habitat of each subject species within the study area can be clearly delineated, this habitat shall be represented on a map of the study area*".

Figure 2 of the SIS provides a map of the vegetation communities recorded on the subject site, and Figure 3 indicates the locations of Green & Golden Bell Frogs recorded during the specific survey for this SIS. Figure 1 also identifies the Eve Street wetland, which is noted as the location of records of threatened avian species from the subject site. These species have not apparently been recorded from the Marsh Street wetland, which comprises a significantly different habitat and suite of vegetation communities.

Figure 3 of the SIS also provides an indication of the habitat features and resources of potential value to Green & Golden Bell Frogs on the subject site and in the vicinity. These

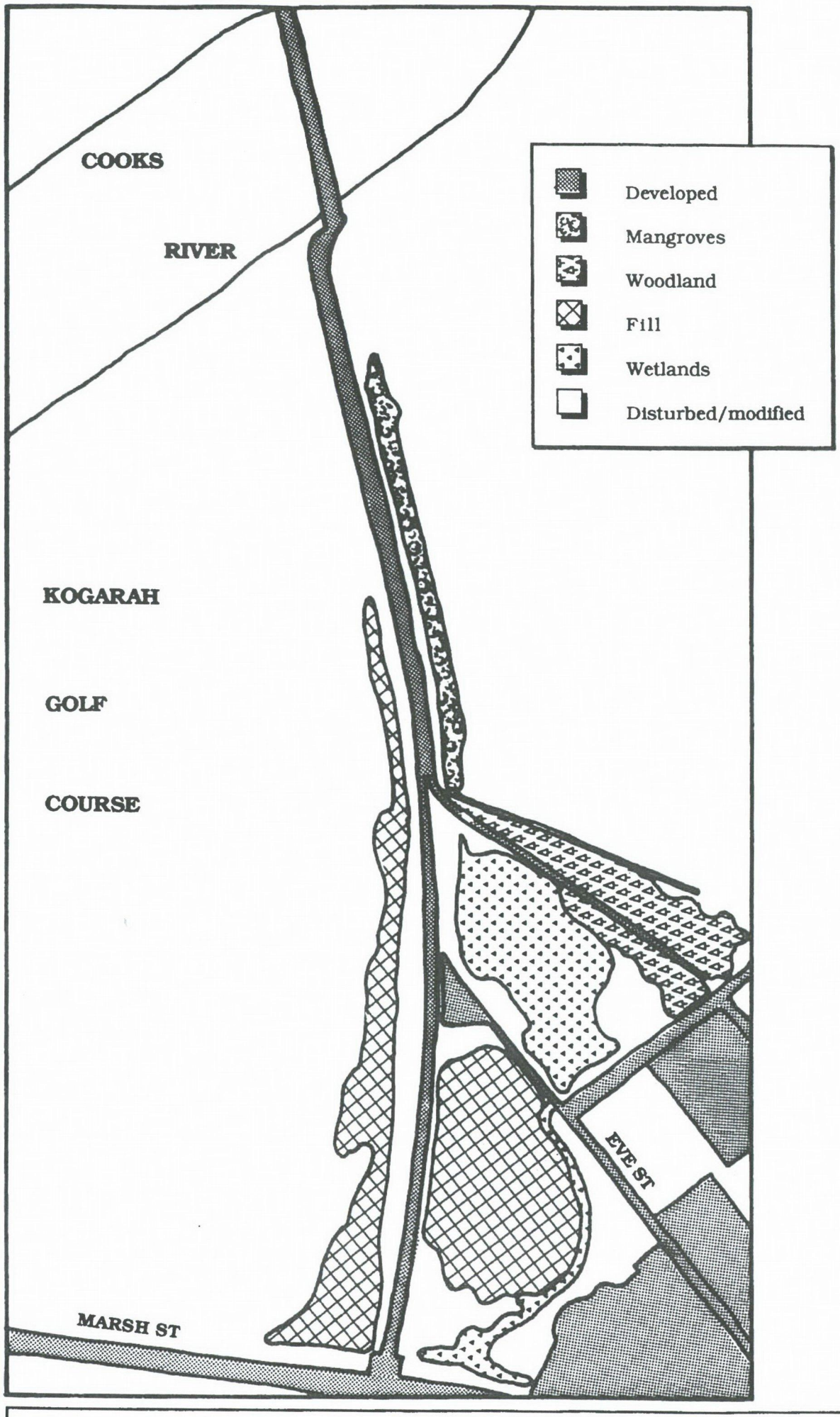

FIGURE 2 Vegetation communities in the vicinity of the Eve Street and Marsh Street Wetlands

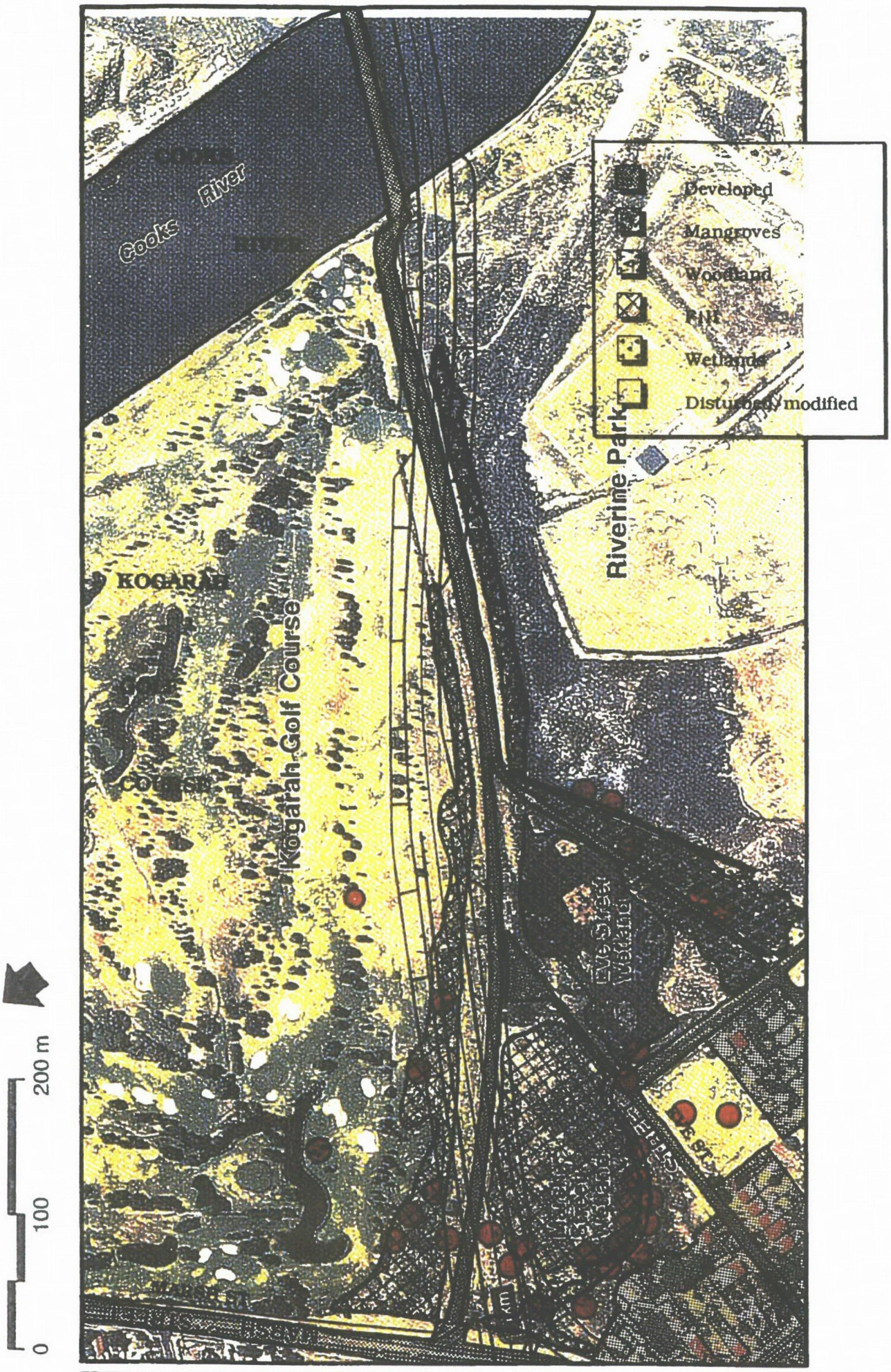

FIGURE 2 Vegetation communities in the vicinity of the Eve Street and Marsh Street Wetlands

FIGURE 3 Locations & records of Green & Golden Bell Frogs (red circles), as described by LesryK (1998).

FIGURE 3 Locations of records of Green & Golden Bell Frogs (red circles), as described by LesryK (1996).

include the ponds which are present and surrounding vegetation, as well as more extensive foraging habitat and areas of rubble or rock piles which constitute shelter and over-wintering sites.

Habitat for the Green & Golden Bell Frog on the subject site includes breeding resources and sites of relevance to tadpoles and morphlings (the existing ephemeral stormwater ponds on the site), foraging habitat (areas of grass, weeds and low shrubs, and piles of fill), and possible over-wintering and shelter sites (piles of rubble or small areas of rock debris).

The area of most significance for Green & Golden Bell Frogs (the Marsh Street wetland) is essentially artificial in nature. Whilst this area may originally have supported wetland communities, it has long been disturbed by fill, earthworks, stormwater discharge and other activities. In general, the site is characterised by rubble and earth fill, excavation areas, stormwater drains, rubbish, weeds and artificial vegetation communities. Notwithstanding the poor condition and artificial nature of the habitats and resources present on the subject site for Green & Golden Bell Frogs, the site clearly constitutes suitable habitat.

Green & Golden Bell Frogs also apparently utilise other habitats and areas of resource in the immediate vicinity. Records from the locality indicate that animals forage or disperse onto the Kogarah Golf Course (to the north and northeast, and also utilise areas underlying existing sewerage drains on the southern side of the Eve Street wetland). Conversely, Green & Golden Bell Frogs do not appear to utilise the Eve Street wetland, as this is a saline environment.

With respect to the threatened avian species which have been recorded on the subject site or which could potentially occur there, the Marsh Street wetland provides little of significance or relevance. It is possible for the Australasian Bittern to utilise some of the dense vegetation around the Marsh Street wetland, but this area generally is highly disturbed and modified, and does not support standing water or beach habitats which are required by most of the other threatened wetland birds.

Conversely, the Eve Street wetland supports a large area of open water, and is fringed by reeds and dense vegetation. This area provides potential or theoretical habitat for many of the threatened avian species which have been recorded, and it is noted by the Rockdale Wetland Preservation Society that several of these threatened wetland birds utilise the Eve Street wetland exclusively (LesryK 1996).

9 ASSESSMENT of LIKELY IMPACTS

The TSC Act requires, under Section 110(2)(g), that a SIS includes:

> *"a full assessment of the likely effect of the action on those species and populations, including, if possible, the quantitative effect of local populations in the cumulative effect in the region"*

The Director-General's requirements for the preparation of this SIS indicate that Section 110(2)(g) of the TSC Act need not be addressed. That section of the Act has been replaced by a series of matters included in the Director-General's requirements (Appendix E of the EIS), as discussed below.

9.1 HABITAT REMOVAL and MODIFICATION

The NP&WS Director-General's requirements indicate that the SIS must include a statement regarding:

> *"2.1 For all subject species, the SIS shall state the following:*
>
> - *the location, nature and extent of habitat removal or modification which may result from the proposed action.*
> - *the potential impact of the removal of habitat; and*

- *the likely contribution of the proposed action to the threatening processes acting on populations of those species in the locality".*

9.1.1 Location, Nature and Extent

As detailed in the EIS for the proposed M5 East Motorway, the roadworks between Marsh Street and the Cooks River will comprise establishment of a four-lane motorway with on/off ramps on earth fill placed on the ground between these two points. To the west, the M5 East Motorway will enter a tunnel beneath Wolli Creek, and to the east a bridge will carry the roadway across the Cooks River.

The roadworks will involve reconstruction and filling of a significant portion of the Marsh Street wetland, including a substantial depression in the northwestern portion of the wetland area, which is apparently the site of regular sightings of the Green & Golden Bell Frog (LesryK 1996). Much of the remainder of this area, however, is comprised of fill and weed species, and is not likely to constitute significant breeding habitat for the Green & Golden Bell Frog.

The roadworks will also require covering of land to the north of the South Western Ocean Outfall Sewer, which is utilised by Green & Golden Bell Frogs for foraging and possibly for migration. These areas are adjacent to the Kogarah Golf Course. Conversely, the design of the roadway ensures that the Eve Street wetland is not directly affected by roadwork activities.

At the southeastern end of the portion of the M5 Motorway East which is the subject of this SIS, near the Cooks River, part of a narrow band of mangroves and a substantial area of artificial and degraded lands on the northern side of Barton Park will require removal. In this locality, the road will be constructed on fill placed on the existing ground surface.

On the basis of the current design for the M5 East Motorway, the roadworks will require the destruction or removal of a portion of the Marsh Street wetland which is currently utilised by Green & Golden Bell Frogs for breeding, part of the Marsh Street wetland and Kogarah Golf Course which support habitat apparently utilised by Green & Golden Bell Frogs for foraging or movement, and a disturbed and degraded area of mangrove and introduced vegetation at the southeastern end. It is intended that none of the Eve Street wetland, which is of apparent significance for the wetland birds, will be removed.

9.1.2 Potential Impacts

As discussed in detail elsewhere in this SIS, two issues of significance with respect to threatened species arise as a result of the proposed M5 East Motorway. The proposed roadworks will involve the destruction or removal of wetland habitats in the Marsh Street wetland (at the western end of the study area), which is known habitat for the Green & Golden Bell Frog.

In addition, parts of an area of disturbed land and fill with grass and weed growth on the southwestern side of the Kogarah Golf Course will be affected by the proposed roadworks. This area is known to be utilised by Green & Golden Bell Frogs for foraging and possibly for dispersal, and will result in the reduction of available habitat for this species in the immediate vicinity.

The second issue relates to the use of the Eve Street wetland by a number of internationally protected migratory wetland birds and species of conservation significance. Whilst the proposed roadway will avoid direct impacts on the Eve Street wetland, and will enable retention of this habitat, there is some potential for indirect impacts as a result of changes in hydrologic regimes or in contaminant ingress.

With respect to the Green & Golden Bell Frog, the potential for an adverse impact arising from the proposed roadworks is high. The area of suitable breeding habitat, in the form of wetlands, in the vicinity or on the subject site is small, and the proposed roadworks are likely to destroy or modify a significant proportion of those available. Whilst there will be some habitat retained on the subject site or in the vicinity, by way of wetlands and suitable foraging habitat, a substantial proportion of the area of relevance to this species

(particularly with respect to breeding) is to be removed, notwithstanding the highly disturbed and degraded condition of this environment.

In addition, the proposed roadworks involve construction activities to the northeast of the South Western Ocean Outfall Sewer, adjacent to the Kogarah Golf Course. This area supports weed species and grasses, and appears to be of potential value for Green & Golden Bell Frogs with respect to dispersal and foraging. The proposal will involve not only the removal of foraging habitat, but as it is to be constructed on an earth fill, the Motorway has the potential to prevent Green & Golden Bell Frogs moving between the remaining portion of the Marsh Street wetland and Kogarah Golf Course. It should be noted, however, that this potential impact is to be ameliorated by the provision of tunnels under the roadway for Green & Golden Bell Frogs. It is proposed that a number of other ameliorative measures be implemented on the subject site to retain and enhance habitat for Green & Golden Bell Frogs, with the aim of compensating for any habitat loss and providing a more secure and better managed environment for this species at this locality.

For the Green & Golden Bell Frog in the Marsh Street wetland area, the proposed M5 East Motorway has the potential to impose a significant and substantial effect upon the population which resides in this locality. It is possible, without the implementation of appropriate management methods, that the population of this species at this locality could be rendered extinct by the proposed activity. Conversely, the potential impacts of the removal of breeding habitat and foraging habitat, and of changes in hydrologic regimes and contaminant discharges, can be managed in a manner which will ensure the continued survival of this species at this locality, and which can potentially improve the habitat for Green & Golden Bell Frogs in the Marsh Street wetland area.

The array of threatened bird species which utilise the Eve Street wetland (Rockdale Wetland Preservation Society, as cited in LesryK 1996), could potentially be adversely affected by the proposed motorway, by the imposition of a significant disturbance in the immediate vicinity of the wetland, or by indirect effects such as changes in hydrologic regimes, water quality or the imposition of bird mortalities. Indirect impacts are discussed in the following section of this SIS.

The proposed roadworks are designed in a manner which avoids direct impacts on the Eve Street wetland. No area of the wetland will be removed or directly affected by the proposed roadworks, although significant erosion and sediment discharge control measures will be required. In the vicinity of the Eve Street wetland, the proposed Motorway lies essentially to the northeast of the existing South Western Ocean Outfall Sewer. Consequently, there is no requirement for removal of the wetland communities in the Eve Street wetland area.

At the southeastern end of the study area, adjacent to the Cooks River, a small area of mangroves (which occur along an artificial drainage line), as well as some artificial land dominated by weeds and introduced plant species, will be removed for the roadworks. It is considered unlikely that the removal of these resources will be of any relevance to any threatened fauna or flora species.

9.1.3 Threatening Processes

The proposed M5 East Motorway will involve the removal of habitat (both breeding and foraging habitat) for Green & Golden Bell Frogs at this site. Whilst it will not involve the removal of habitat for the threatened wetland birds which occur in the Eve Street wetland, there is the potential for the imposition of adverse impacts arising from bird-strike and disturbance as a result of the proposed Motorway.

Generally speaking, the removal or degradation of habitat for threatened species is regarded as the single most significant adverse impact imposed by development and infrastructure activities. This is particularly the case for species which are dependent upon wetland communities and habitats, and is also of particular significance with respect to species which occupy wetland communities in the Sydney area.

The removal or degradation of wetlands has been a contributing factor, and possibly the single most significant adverse factor, in the decline of Green & Golden Bell Frogs throughout their range. Whilst this species appears to be tolerant of disturbed and degraded conditions, it has significantly contracted over the last 20 years, and has disappeared from

a large proportion of its former range (Pyke & White 1996b). As a consequence, the species is patchily distributed throughout the Sydney metropolitan area and elsewhere in its range, and there are few opportunities for populations to maintain contact. As a consequence, removal of wetlands which are utilised by Green & Golden Bell Frogs is regarded as a potentially significant adverse impact upon the species.

Conversely, it is proposed for the M5 East Motorway that a range of impact amelioration measures be implemented. These will include the retention of wetland habitats in the Marsh Street wetland where possible, and the reconstruction of suitable habitats both on this locality and in the vicinity. It is proposed to provide tunnels beneath the M5 East Motorway to permit Green & Golden Bell Frogs to access the Kogarah Golf Course, and to enter discussions to enhance the golf course and habitats on it for this species. In addition, a detailed Environmental Management Plan will be required to protect the species during earthworks and to ensure its re-introduction or continued survival. These measures are intended to avoid the imposition of significant adverse effects upon Green & Golden Bell Frogs in the Marsh Street wetland area and to avoid the increase in "*the threatening processes acting on populations*" of this species "*in the locality*".

With respect to the threatened wetland birds which utilise the Eve Street wetland, the proposed roadworks have the potential to increase "*threatening processes*" for these species. The main threatening processes which are likely to apply to wetland birds involve the destruction or removal of habitat, and effects arising from contamination or alterations to hydrologic regimes as a result of increasing urbanisation. The proposed M5 East Motorway avoids the Eve Street wetland, but there is the potential for discharge of contaminated water or changes to the hydrologic regime. There is also an increased potential for mortalities arising from birds hitting motor vehicles on the newly constructed Motorway.

Conversely, a number of measures are to be implemented to ameliorate these potential impacts, and thus to minimise any increase in the "*threatening processes*" which affect wetland birds at this locality. By constructing appropriate bunds on each side of the motorway, birds will be required to fly over the top of the traffic, and thus minimise the likely effects of bird mortality. An appropriate water management regime will be required to avoid the discharge of contaminated water from the roadway into the Eve Street wetland, and to avoid alterations in the hydrologic regime associated with this wetland and the Marsh Street wetland. Implementation of these measures is intended to avoid the potential for the proposed roadworks significantly increasing the "*threatening processes*" on these species.

9.2 OTHER POPULATIONS of THREATENED SPECIES

The requirements of the Director-General for this SIS include that the following matter shall be addressed:

> "*2.2 A discussion of other populations of subject species in the locality shall be provided. The long term security of the other habitats shall be examined as part of this discussion. The relative significance of the subject site for subject species in the locality shall be discussed*".

9.2.1 Other Populations

The Green & Golden Bell Frog population in the Marsh Street wetland is likely to be isolated from other populations of this species throughout the region. There are no known populations of the species within 'hopping range' of the subject site, and the intervening developed area would preclude any interaction between such populations, even if they existed.

Approximately 20 other populations of the Green & Golden Bell Frog are known from the Greater Sydney Region (AMBS 1996a, 1996b). Small populations have been recorded from North Ryde, Mount Druitt, Mascot, La Perouse, Holsworthy, Hammondville, Greenacre, Enfield, East Lakes and East Hills. Larger populations are known to occur at Homebush Bay (around the brick pit on the Olympic Site), at Newington (on the RANAD Site), and on the Kurnell peninsula.

With respect to the wetland birds which utilise the Eve Street wetland, these are all extremely wide-ranging and highly mobile species. Consequently, it is not possible to assess the extent of "*other populations*" of these species "*in the locality*". It is noted by the Rockdale Wetland Preservation Society that many of these threatened or migratory wetland birds appear to only utilise the Eve Street wetland, and that several of these species utilise this wetland to the exclusion of all others in the Botany Bay area (cited by LesryK 1996). Conversely, many of these species are known to occur relatively widely throughout the Botany Bay area, and for those migratory species which conduct winter summer migrations between the northern hemisphere and Australia, it is difficult to ascertain the population status of these species "*in the locality*".

9.2.2 Long Term Security

The Eve Street and Marsh Street wetlands are located on land controlled by Sydney Water. They are consequently unlikely to be developed, but could be subject to inappropriate land uses depending on the activities to be conducted on them by Sydney Water. Conversely, the Eve Street wetland appears to have been the subject of recent rehabilitation works, and the Marsh Street wetland could also be substantially enhanced following the Motorway construction. Given the ownership of the Eve Street and Marsh Street wetlands by Sydney Water, and the likely long term tenure of the areas north of the proposed roadworks by the Kogarah Golf Course, it appears likely that long term security of the wetlands and the relevant habitats for Green & Golden Bell Frogs and wetland birds can readily be secured.

9.2.3 Relative Significance of the Subject Site

The information currently available with respect to the Green & Golden Bell Frog and to the threatened wetland birds which utilise the Eve Street wetland suggests that the subject site (particularly the Marsh Street and Eve Street wetlands themselves) constitute highly significant habitats and resources for these species.

For the Green & Golden Bell Frog, there is little or no likelihood of this species being able to migrate to other suitable habitats in the general "*locality*" (which constitutes an area of approximately 10km radius around the subject site - NP&WS definition). Given the apparent isolation of this population, and the absence of other suitable habitat in the vicinity, it appears that the area of the Marsh Street wetland which is of relevance to the Green & Golden Bell Frog is highly significant.

With respect to the threatened avian wetland species, the Rockdale Wetland Preservation Society indicates that several of these species only utilise the Eve Street wetland, and are not located elsewhere in the Botany Bay area (cited by LesryK 1996). If this situation pertains, the Eve Street wetland would appear to be a highly significant site for these avian species. Conversely, it is known that several of the avian species recorded at the Eve Street wetland do occur elsewhere in the "*locality*", and the Eve Street wetland is therefore considered of rather less significance. It is, however, a habitat of value for several threatened and migratory wetland birds, and is to be retained during the proposed roadworks.

9.3 MOVEMENT CORRIDORS

The requirements of the Director-General for this SIS include that the following matter is to be addressed:

> "2.3 *if movement corridors for subject species are present within the subject site, the impact of the proposal on these areas shall be discussed*".

It appears from studies conducted on the subject site (LesryK 1996) that Green & Golden Bell Frogs move from the Marsh Street wetland across the South West Ocean Outfall Sewer and forage on the Kogarah Golf Course or use it for dispersal. The proposed M5 East Motorway will cut across this apparent "*movement corridor*" for this species, and has the potential to isolate the Marsh Street wetland (or its remnant) from potential foraging and dispersal habitat on the Kogarah Golf Course. For this reason, it is proposed that substantial culverts be constructed under the roadway, to enable Green & Golden Bell Frogs to move between the

rehabilitated Marsh Street wetland and Kogarah Golf Course, as they require.

With respect to the wetland birds which utilise the Eve Street wetland, many of these species are extremely wide-ranging or migratory, with several species migrating thousands of kilometres on an annual basis. It would appear unlikely that the proposed roadworks would sever any "*movement corridor*" for these species, although there is some potential for the road to impose mortalities on wetland birds flying into the Eve Street wetland.

The Rockdale Wetland Preservation Society has indicated (as cited by LesryK 1996) that the wetland birds fly into and out of the Eve Street wetland from the north and northeast. On this basis, it would be possible for the proposed M5 East Motorway to impose a partial barrier to these birds' normal movement patterns. Conversely, as indicated above, many of these species travel thousands of kilometres on an annual basis, and the remainder are relatively wide-ranging. It is regarded as unlikely that species capable of such long range movements would be deterred from accessing the Eve Street wetland on the basis of the location of a single road.

Nevertheless, the potential for the roadway to impose a barrier will be addressed, with the use of bunds on each side of the roadway near the Eve Street wetland to force birds to fly up and over the roadway. This is intended to minimise the potential for bird mortalities from strikes with motor vehicles, and to ensure that migrating and wetland birds will be able to continue utilising the Eve Street wetland.

10 ALTERNATIVES to the PROPOSAL

The TSC Act requires, under Section 110(2)(h), that a SIS includes the following information:

> "*a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development*".

Extensive consideration of alternatives to the proposed M5 East Motorway has been a characteristic of the project to date. Details of alternatives to the proposed M5 East Motorway, including a range of locations and a number of tunnel alternatives, as well as the 'do nothing' approach are provided in the EIS to which this SIS is appended.

There are potentially a number of "*feasible alternatives*" to the specific design M5 East Motorway. These are considered in the EIS, and have formed the basis for the current design for the M5 East Motorway, which involves extensive tunnelling, and re-routing of the original proposal.

With respect to the Marsh and Eve Street wetlands, several alternative engineering solutions exist. Continuation of the M5 East Motorway in a tunnel further to the east would enable the Marsh and Eve Street wetlands to be avoided altogether. However, there are considerable economic costs associated with tunnelling, and this approach is not regarded as a preferred option. Given the highly disturbed and artificial nature of the wetlands present, and the retention of the whole of the Eve Street wetland, it appears difficult to justify the increased expenditure associated with this option.

Other engineering solutions could be applied in the vicinity of the Marsh and Eve Street wetlands, including alternative structures for the M5 East Motorway. The employment of a vertical retaining wall instead of an earth embankment at this locality, or the construction of the motorway on piers rather than on an earth embankment could provide partial solutions to the potential adverse impacts, particularly on the Marsh Street wetland and the Green & Golden Bell Frogs. However, as with tunnelling, these approaches require the expenditure of additional funds. Conversely, they may reduce the damage to the Marsh Street wetlands.

An alternative approach would involve the rehabilitation of the remnant of Marsh Street wetland and the Eve Street wetland, and of other land in the vicinity, to provide additional

long-term secure habitat for Green & Golden Bell Frogs and for the wetland bird species. The RTA could fund a program of habitat creation and maintenance, utilising land on the south western edge of Kogarah Golf Course as well as other lands adjacent to these wetlands. The Marsh Street wetland, for example, is located on a patch of land which has predominantly been covered by fill and rubble. A substantial habitat regeneration program in this locality could involve removal of the rubble and the establishment of a more extensive complex of suitable ponds and foraging habitat for this species.

As discussed below (in Chapter 11) it is proposed that tunnels be constructed underneath the M5 East Motorway to enable Green & Golden Bell Frogs from the Marsh Street wetlands to cross the M5 Motorway and continue utilising disturbed lands and the Kogarah Golf Course for foraging. Again, in this locality, fill and rubble have been deposited, and weeds characterise part of the land on the southwestern edge of the golf course. The M5 East Motorway project could involve rehabilitation of this area and the provision of enhanced habitat for Green & Golden Bell Frogs in this locality. It may also be possible to modify the golf course activities so that the ponds and rough areas on the golf course provide habitat for this species.

Consideration of "*economic and social*" issues is provided in the EIS. In economic terms, it is likely to be more appropriate to utilise funds to recreate and enhance habitat for Green & Golden Bell Frogs and the wetland bird species, and to provide some long-term security for these species in terms of habitat maintenance. This approach is considered likely to have a long term beneficial outcome for the conservation of these fauna, and the rehabilitation program could also involve the use of threatened native plants from the locality.

Ecologically Sustainable Development (ESD) involves an activity which "*meets the needs of the present generation without reducing the opportunities available to future generations*" (Lowe 1995). The issues relating to ESD with respect to the M5 East Motorway have been canvassed in the EIS. The proposed development will have significant beneficial effects with respect to vehicle movements and air pollution control in the Sydney area, and is regarded as satisfying the requirements of ecologically sustainable development.

11 IMPACT AMELIORATION MEASURES

The TSC Act requires, under Section 110(2)(i), that a SIS include the following information:

> "*a full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those measures*".

The full suite of impact amelioration measures which are to be applied along the M5 East Motorway include a range of general measures, many of which will be of benefit to the Green & Golden Bell Frog and its habitat, and the wetland birds in the Eve Street wetland. These general impact amelioration measures are discussed in the EIS, and in the previous EIS's which have been prepared for the M5 East Motorway.

The SIS includes (below) a range of measures which are specifically designed for the Green & Golden Bell Frog in the Marsh Street wetland, and several measures which should be applied to protect the Eve Street wetland from disturbance. However, the application of an approach which involves "*best practice*", particularly with respect to sediment and contaminant discharge from the proposed roadworks, is recommended as the appropriate solution with respect to these habitats and the species they support.

11.1 GENERAL

Features of the general impact amelioration measures which should be applied along the M5 East Motorway, particularly in the vicinity of the Marsh Street and Eve Street wetlands, require the application of "*best practice*" throughout the construction phase of the project. Additionally, the completed roadway will require the inclusion of measures which ensure that reductions in water quality in the Marsh Street remnant, Eve Street wetland and other discharge points is avoided.

General amelioration measures which should be applied include:

- the application of environmentally sound construction methods for all construction operations (involving minimal vegetation removal, sediment and water controls, avoidance of unnecessary damage to trees or native vegetation), to optimise the retention of resources in the vicinity and to avoid the discharge of sediment or contaminants into ponds on the site or into surrounding lands;

- the use of hay-bale filters, silt screens, sediment traps and macrophyte wetlands (as appropriate) to retain sediment and contaminants or nutrients from all discharge areas;

- the implementation of standard contaminant control measures (such as the protection of exposed surfaces, bunding of potential contaminant sites, proper waste management protocols etc) to limit the potential for adverse impacts;

- the minimal clearing of any native vegetation on the site, wherever possible;

- careful management and disposal of all waste materials generated during construction activities on the subject site, to prevent contamination of natural or newly created habitats on the site, in particular of the Eve Street wetland and their adjoining vegetation communities;

- appropriate location and management of areas where oils, fuels, chemicals or other liquid contaminants are stored during construction, to avoid accidental discharge to adjacent habitats;

- adequate provision for the collection and removal of human and construction waste materials during the construction program, with bins and appropriate ablution facilities. This approach will avoid further degradation or contamination of the limited areas of native vegetation on the subject site and areas of vegetation in the vicinity;

- establishment of a weed management program and bush regeneration program over the site to prevent the spread of existing weeds, to reduce the potential for introduction of additional weed species, and to control noxious species which are present; and

- the use of appropriate measures to control the discharge of sediment into retained or newly created ponds. Exposed surfaces and construction areas will need to be carefully managed to avoid significant discharge of sediment and sand into ponds and water bodies which could reduce water quality and potentially render the ponds unsuitable for native fauna species.

11.2 MEASURES for the GREEN & GOLDEN BELL FROG

A series of specific impact amelioration measures will need to be implemented to deal with the Green & Golden Bell Frog population which currently inhabits the Marsh Street wetland. Whilst a portion of this wetland and the degraded land upon which it resides are to be retained, there is considerable potential for a significant adverse impact upon the population as a result of the earthworks. Adverse impacts are likely to be imposed by the removal or destruction of habitat directly, and also possibly by increased mortality of individual frogs. Conversely, a substantial portion of land in this immediate locality will be retained, and it would be possible to implement a significant habitat recreation and rehabilitation program.

It is recommended that a Management Plan for the Marsh and Eve Street wetlands be generated prior to the onset of construction activities at this locality. It is particularly important for the Green & Golden Bell Frog that management of the on-site population be initiated well prior to construction, and that the establishment of a captive breeding population, to ensure the survival of this population, be implemented well before construction activities commence.

The Management Plan for the wetlands and for Green & Golden Bell Frogs should include:

- Measures to ensure that the roadworks do not involve the discharge of contaminants or sediment into the Eve Street wetland;
- a detailed rehabilitation program for the Marsh Street wetland area, involving removal of the substantial amount of rubble and waste which currently occupy the site, vegetation re-establishment, landscaping to provide resources and features for Green & Golden Bell Frogs and other fauna, and a detailed staged approach to ensure that Green & Golden Bell Frogs are able to either survive *in situ* during the operations, or are removed for their protection and reintroduced following the rehabilitation program.
- establishment of a captive breeding colony of Green & Golden Bell Frogs from the Marsh Street wetland, to ensure their survival and to provide offspring for re-introduction once rehabilitation works have been completed;
- design of stormwater discharge from the completed road and an upgrading of the existing stormwater discharge into the Marsh Street wetland to ensure better water quality. The Marsh Street wetland currently appears to exist primarily as a result of stormwater discharge; and
- the installation of culverts under the M5 East Motorway to enable Green & Golden Bell Frogs to retain access to lands adjacent to the Kogarah Golf Course. Culverts should be of moderate size (at least 2m in diameter), and should include some moisture and cover if possible.

11.3 MONITORING

The Director-General of the NP&WS requires this SIS to address the following matters:

> "*3.3 Any proposed on-going monitoring of the effectiveness of the mitigation measures shall be provided.*"

The Management Plan for the Marsh Street and Eve Street wetlands will include a detailed monitoring program. This will require the monitoring of various aspects of the project, particularly of the captive breeding program for Green & Golden Bell Frogs, of the condition of water discharge and sediment discharge from the roadworks into the Marsh and Eve Street wetlands, use of the Eve Street wetland by wading birds, and use and success of the Green & Golden Bell Frog population in the rehabilitated Marsh Street wetland. A detailed management and monitoring protocol will be established as part of the environmental management plan for the Eve and Marsh Street wetlands and for the native fauna which use them.

12 ADDITIONAL APPROVALS

The TSC Act requires, under Section 110(2)(j), that a SIS include;

> "*a list of any approvals that must be obtained under any other Act or Law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or populations*".

The NP&WS Director-General's requirements also include:

> "*4.1 In providing a list of other approvals the following shall be included;*
>
> - *any consent required under Part 4 of the Environmental Planning and Assessment Act 1979 including the name of the consent authority and when it is proposed to make the development application; or*

- *any approvals required under Part 5 of the Environmental Planning and Assessment Act 1979 including the name of the determining authority(ies), the basis for the approval and when these approvals are proposed to be obtained."*

It is not clear at this stage of the development approval process which government departments are to be "*determining authorities*" for the M5 East Motorway. Consequently, there are no indications regarding the requirement or otherwise for additional licences or approvals.

However, it is likely that a licence will be required from the Environment Protection Authority for certain aspects of the proposed roadworks in general, and it is possible that other approvals will be required from Sydney Water, the Department of Land & Water Conservation and/or the Department of Urban Affairs & Planning. Determination of the additional requirements will occur through the development approval process, and will become conditions of consent.

13 QUALIFICATIONS and EXPERIENCE

Section 110(4) of the TSC Act requires that:

> "*a Species Impact Statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement*".

The qualifications and experience of the principle author of this SIS (F Dominic Fanning of Gunninah Environmental Consultants) are included in Appendix 5 to this SIS.

This SIS has been prepared on the basis of reports and material provided by a number of investigators, in some instances for the whole M5 Motorway (MKES 1990, 1994a, 1995; Adcock and Osborne 1994a, 1994b; Osborne 1995). A specific investigation of the Marsh Street and Eve Street wetland was conducted by LesryK (1996), attached as Appendix 4 to this report. The *Curriculum Vitae* of Mr D Engel, who conducted the report, is also attached in Appendix 5.

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M5 EAST MOTORWAY

Eve Street and Marsh Street Wetlands

ROADS & TRAFFIC AUTHORITY

SPECIES IMPACT STATEMENT

APPENDIX 1

FAUNA SPECIES RECORDED on or in the VICINITY of the SUBJECT SITE

KEY

A Fauna species recorded on the subject site during the 1996 survey by LesryK Environmental Consultants.

B Species recorded by the Rockdale Wetland Preservation Society.

C Species recorded during surveys in the vicinity by Mt King Ecological Surveys (1995, 1994, 1990).

D Records contained within 3 km of the site from the NP&WS Wildlife Atlas (June 1996) and within 7km of the site from the NSW Bird Atlassers (June 1996).

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APPENDIX 1 Fauna species recorded on or in the vicinity of the subject site.

COMMON NAME	SCIENTIFIC NAME	A	B	C	D
BIRDS					
Phasianidae					
Brown Quail	*Coturnix ypsilophora*			●	●
Anatidae					
Musk Duck	*Biziura lobata*			●	●
Black Swan	*Cygnus atratus*			●	
Australian Wood Duck	*Chenonetta jubata*	●		●	●
*Mallard	*Anas platyrhynchos*				●
Pacific Black Duck	*Anas superciliosa*	●		●	●
Australasian Shoveller	*Anas rhynchotis*			●	●
Grey Teal	*Anas gracilis*	●		●	●
Chestnut Teal	*Anas castanea*	●		●	●
Pink-eared Duck	*Malacorhynchus membranaceus*				●
Hardhead	*Aythya australis*			●	●
Podicipedidae					
Australasian Grebe	*Tachybaptus novaehollandiae*			●	●
Hoary-headed Grebe	*Poliocephalus poliocephalus*			●	●
Procellariidae					
Cape Petrel	*Daption capense*				●
Great-winged Petrel	*Pterodroma macroptera*				●
Wedge-tailed Shearwater	*Puffinus pacificus*				●
Sooty Shearwater	*Puffinus griseus*				●
Short-tailed Shearwater	*Puffinus tenuirostris*				●
Fluttering Shearwater	*Puffinus gavia*				●
Anhingidae					
Darter	*Anhinga melanogaster*			●	●
Phalacrocoracidae					
Little Pied Cormorant	*Phalacrocorax melanoleucos*			●	●
Pied Cormorant	*Phalacrocorax varius*	●		●	●
Little Black Cormorant	*Phalacrocorax sulcirostris*			●	●
Great Cormorant	*Phalacrocorax carbo*			●	●
Pelecanidae					
Australian Pelican	*Pelecanus conspicillatus*	●		●	●
Ardeidae					
White-faced Heron	*Egretta novaehollandiae*	●		●	●
Little Egret	*Egretta garzetta*			●	●
White-necked Heron	*Ardea pacifica*			●	
Striated Heron	*Ardea striatus*				●
Great Egret	*Ardea alba*			●	●
Intermediate Egret	*Ardea intermedia*			●	
Nankeen Night Heron	*Nycticorax caledonicus*			●	●
Little Bittern	*Ixobrychus minutus*			●	
★(V) Australasian Bittern	*Botaurus poiciloptilus*			●	●
Threskiornithidae					
Australian White Ibis	*Threskiornis molucca*			●	●
Straw-necked Ibis	*Threskiornis spinicollis*	●		●	●
Royal Spoonbill	*Platalea regia*	●		●	●
Yellow-billed Spoonbill	*Platalea flavipes*			●	●
Accipitridae					
Black-shouldered Kite	*Elanus axillaris*			●	●
Whistling Kite	*Haliastur sphenurus*			●	●
Swamp Harrier	*Circus approximans*			●	●
Brown Goshawk	*Accipiter fasciatus*			●	●
Grey Goshawk	*Accipiter novaehollandiae*				●
Collared Sparrowhawk	*Accipiter cirrhocephalus*	●			●
Falconidae					
Brown Falcon	*Falco berigora*	●		●	

APPENDIX 1 cont Fauna species recorded on or in the vicinity of the subject site.

COMMON NAME	SCIENTIFIC NAME	A	B	C	D
Australian Hobby	*Falco longipennis*			●	●
Peregrine Falcon	*Falco peregrinus*				●
Nankeen Kestrel	*Falco cenchroides*	●		●	
Rallidae					
Baillon's Crake	*Porzana pusilla*			●	
Australian Spotted Crake	*Porzana fluminea*			●	
Spotless Crake	*Porzana tabeunsis*			●	●
Purple Swamphen	*Porphyrio porphyrio*	●		●	●
Dusky Moorhen	*Gallinula tenebrosa*	●		●	●
Eurasian Coot	*Fulica atra*			●	●
Scolopacidae					
Latham's Snipe	*Gallinago hardwickii*				●
★(V) Black-tailed Godwit	*Limosa limosa*				●
Bar-tailed Godwit	*Limosa lapponica*				●
Whimbrel	*Numenius phaeopus*				●
Eastern Curlew	*Numenius madagascariensis*				●
Common Sandpiper	*Tringa hypoleucos*				●
Marsh Sandpiper	*Tringa stagnatilis*				●
Common Greenshank	*Tringa nebularia*				●
Ruddy Turnstone	*Arenaria interpres*				●
★(V) Great Knot	*Calidris tenuirostris*				●
Red Knot	*Calidris canutus*				●
★(V) Sanderling	*Calidris alba*				●
Red-necked Stint	*Calidris ruficollis*				●
Sharp-tailed Sandpiper	*Calidris acuminata*				●
Curlew Sandpiper	*Calidris ferruginea*				●
★(V) Broad-billed Sandpiper	*Limicola falcinellus*				●
★(V) Terek Sandpiper	*Xenus cinereus*				●
Haematopodidae					
★(V) Pied Oystercatcher	*Haematopus longirostris*				●
★(V) Sooty Oystercatcher	*Haematopus fuliginosus*				●
Recurvirostridae					
Black-winged Stilt	*Himantopus himantopus*	●		●	
Charadriidae					
Red-capped Plover	*Charadrius ruficapillus*				●
★(V) Mongolian Plover	*Charadrius mongolus*				●
★(V) Greater Sand Plover	*Charadrius leschenaultii*				●
Double-banded Plover	*Charadrius bicinctus*				●
Black-fronted Plover	*Elseyornis melanops*				●
Red-kneed Dotterel	*Erythrogonys cinctus*				●
Lesser Golden Plover	*Pluvialis dominica*				●
Masked Lapwing	*Vanellus miles*	●			●
Laridae					
Pacific Gull	*Larus pacificus*				●
Franklin's Gull	*Larus pipixcan*				●
Silver Gull	*Larus novaehollandiae*	●			●
Whiskered Tern	*Chlidonias hybrida*				●
White-fronted Tern	*Sterna striata*				●
★(E) Little Tern	*Sterna albifrons*				●
Crested Tern	*Sterna bergii*				●
Columbidae					
* Rock Dove	*Columba livia*	●			●
* Spotted Turtle-Dove	*Streptopelia chinensis*	●			●
Crested Pigeon	*Ocyphaps lophotes*	●			
Cacatuidae					
Yellow-tailed Black Cockatoo	*Calyptoryhnchus funereus*				●
Galah	*Cacatua roseicapilla*				●
Long-billed Corella	*Cacatua tenuirostris*				●
Little Corella	*Cacatua sanguinea*				●

APPENDIX 1 cont Fauna species recorded on or in the vicinity of the subject site.

COMMON NAME	SCIENTIFIC NAME	A	B	C	D
Cacatuidae cont					
Sulphur-crested Cockatoo	*Cacatua galerita*				●
Psittacidae					
Rainbow Lorikeet	*Trichoglossus haematodus*				●
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*				●
Australian King-Parrot	*Alisterus scapularis*				●
Budgerigar	*Melopsittacus undulatus*				●
Crimson Rosella	*Platycercus elegans*				●
Eastern Rosella	*Platycercus eximius*				●
Red-rumped Parrot	*Psephotus haematonotus*				●
Cuculidae					
Pallid Cuckoo	*Cuculus pallidus*				●
Fan-tailed Cuckoo	*Cacomantis flabelliformis*				●
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*				●
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*				●
Common Koel	*Eudynamis scolopacea*				●
Channel-billed Cuckoo	*Scythrops novaehollandiae*				●
Strigidae					
Southern Boobook	*Ninox novaeseelandiae*				●
Tytonidae					
Barn Owl	*Tyto alba*				●
Podargidae					
Tawny Frogmouth	*Podargus strigoides*				●
Alcedinidae					
Azure Kingfisher	*Alcedo azurea*				●
Halcyonidae					
Laughing Kookaburra	*Dacelo novaeguineae*				●
Sacred Kingfisher	*Todiramphus sanctus*				●
Coraciidae					
Dollarbird	*Eurystomus orientalis*				●
Maluridae					
Superb Fairy-wren	*Malurus cyaneus*				●
Variegated Fairy-wren	*Malurus lamberti*				●
Pardalotidae					
Spotted Pardalote	*Pardalotus punctatus*				●
White-browed Scrubwren	*Sericornis frontalis*				●
Brown Thornbill	*Acanthiza pusilla*				●
Buff-rumped Thornbill	*Acanthiza reguloides*				●
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	●			●
Yellow Thornbill	*Acanthiza nana*				●
Meliphagidae					
Red Wattlebird	*Anthochaera carunculata*	●			
Little Wattlebird	*Anthochaera chrysoptera*				●
Noisy Friarbird	*Philemon corniculatus*				●
Noisy Miner	*Manorina melanocephala*				●
Lewin's Honeyeater	*Meliphaga lewinii*				●
Yellow-faced Honeyeater	*Lichenostomus chrysops*				●
White-plumed Honeyeater	*Lichenostomus penicillatus*	●			
New Holland Honeyeater	*Phylidonyris novaehollandiae*	●			●
White-cheeked Honeyeater	*Phylidonyris nigra*				●
Meliphagidae					
Tawny-crowned Honeyeater	*Phylidonyris melanops*				●
Eastern Spinebill	*Acanthorhynchus tenuirostris*				●
White-fronted Chat	*Epthianura albifrons*				●
Dicruridae					
Restless Flycatcher	*Myiagra inquieta*				●

APPENDIX 1 cont Fauna species recorded on or in the vicinity of the subject site.

COMMON NAME	SCIENTIFIC NAME	A	B	C	D
Dicruridae cont					
Magpie-lark	*Grallina cyanoleuca*	●			
Grey Fantail	*Rhipidura fuliginosa*	●			
Willie Wagtail	*Rhipidura leucophrys*	●			●
Spangled Drongo	*Dicrurus bracteatus*				●
Campephagidae					
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*				●
White-winged Triller	*Lalage sueurii*				●
Oriolidae					
Olive-backed Oriole	*Oriolus sagittatus*				●
Artamidae					
Dusky Woodswallow	*Artamus cyanopterus*				●
Grey Butcherbird	*Cracticus torquatus*				●
Australian Magpie	*Gymnorhina tibicen*	●			●
Pied Currawong	*Strepera graculina*	●			●
Corvidae					
Australian Raven	*Corvus coronoides*	●			●
Alaudidae					
* Skylark	*Alauda arvensis*				●
Motacillidae					
Richard's Pipit	*Anthus novaeseelandiae*				●
Passeridae					
* House Sparrow	*Passer domesticus*	●			●
Zebra Finch	*Taeniopygia guttata*				●
Double-barred Finch	*Taeniopygia bichenovii*	●			●
Red-browed Finch	*Neochmia temporalis*	●			●
Fringillidae					
* European Goldfinch	*Cardeulis carduelis*	●			●
* European Greenfinch	*Carduelis chloris*				●
Dicaeidae					
Mistletoebird	*Dicaeum hirundinaceum*				●
Hirundinidae					
Welcome Swallow	*Hirundo neoxena*	●			●
Tree Martin	*Hirundo nigricans*				●
Fairy Martin	*Hirundo ariel*				●
Pycnonotidae					
* Red-whiskered Bulbul	*Pycnonotus jocosus*	●			●
Sylviidae					
Clamorous Reed-Warbler	*Acrocephalus stentoreus*	●			●
Tawny Grassbird	*Megalurus timoriensis*				●
Little Grassbird	*Megalurus gramineus*				●
Golden-headed Cisticola	*Cisticola exilis*	●			●
Zosteropidae					
Silvereye	*Zosterops lateralis*	●			●
Muscicapidae					
* Common Blackbird	*Turdus merula*	●			●
Sturnidae					
* Common Starling	*Sturnus vulgaris*	●			●
* Common Mynah	*Acridotheres tristis*	●			●
MAMMALS					
Long-nosed Bandicoot	*Perameles nasuta*		●	●	
Common Ringtail Possum	*Pseudocheirus peregrinus*			●	
Common Brushtail Possum	*Trichosurus vulpecula*		●	●	
Grey-headed Flying-fox	*Pteropus poliocephalus*	●	●		

APPENDIX 1 cont Fauna species recorded on or in the vicinity of the subject site.

COMMON NAME	SCIENTIFIC NAME	A	B	C	D
MAMMALS cont					
Eastern Horseshoe Bat	*Rhinolophus megaphyllus*			●	
★(V) Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*			●	
★(V) Eastern Little Mastiff Bat	*Mormopterus norfolcensis*			●	
Gould's Long-eared Bat	*Nycophilus gouldii*			●	
Lesser Long-eared Bat	*Nyctophilus geoffroyi*			●	
Gould's Wattled Bat	*Chalinolobus gouldii*			●	
★(V) Common Bent-wing Bat	*Miniopterus shreibersii*			●	
Little Cave Eptesicus	*Eptesicus pumilus*			●	
Water Rat	*Hydromys chrysogaster*		●	●	
*Black Rat	*Rattus rattus*	●	●	●	
*House Mouse	*Mus musculus*		●	●	
*Rabbit	*Oryctolagus cuniculus*		●	●	
*Fox	*Vulpes vulpes*	●	●	●	
*Feral Cat	*Felis catus*		●	●	
*Dog	*Canis familiaris*	●	●	●	
REPTILES					
Eastern Snake-necked Turtle	*Chelodina longicollis*			●	
Common Scaly-foot	*Pygopus lepidopodus*			●	●
Jacky Lizard	*Amphibolurus muricatus*		●	●	
Wall Skink	*Crytoblepharus virgatus*			●	
Copper-tailed Skink	*Ctenotus taeniolatus*			●	
Striped Skink	*Ctenotus robustus*	●	●		
Eastern Water Skink	*Eulamprus quoyii*	●	●	●	
Grass Skink	*Lampropholis delicata*	●	●	●	
Garden Skink	*Lampropholis guichenotti*	●	●	●	
Eastern Blue-tongued Lizard	*Tiliqua scincoides*		●	●	
Three-toed Skink	*Saiphos equalis*		●	●	
Blind or Worm Snake	*Ramphotyphlops nigrescens*			●	
Green Tree Snake	*Dendrelaphis punctulata*			●	
Yellow-faced Whip Snake	*Demansia psammophis*		●	●	
Black-bellied Swamp Snake	*Hemiaspis signata*		●	●	
Eastern Brown Snake	*Pseudonaja textilis*			●	
Eastern Tiger Snake	*Notechis scutatus*		●	●	
Red-bellied Black Snake	*Pseudechis porphyriacus*		●	●	
AMPHIBIANS					
Common Eastern Froglet	*Crinia signifera*	●	●	●	
Brown-striped Frog	*Limnodynastes peronii*	●	●	●	
Spotted Grass Frog	*Limnodynastes tasmaniensis*			●	
★(E) Green & Golden Bell Frog	*Litoria aurea*	●	●	●	●
Green Tree Frog	*Litoria caerulea*		●		
Bleating Tree Frog	*Litoria dentata*		●		
Eastern Dwarf Tree Frog	*Litoria fallax*		●	●	
Peron's Tree Frog	*Litoria peronii*		●		
Leseur's Tree Frog	*Litoria leseuri*			●	
Brown Toadlet	*Pseudophryne bibronii*			●	
Smooth Toadlet	*Uperoleia laevigata*			●	

M5 EAST MOTORWAY

Eve Street and Marsh Street Wetlands

ROADS & TRAFFIC AUTHORITY

SPECIES IMPACT STATEMENT

APPENDIX 2

FLORA SPECIES RECORDED on the SUBJECT SITE

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APPENDIX 2 Flora species recorded on the subject site by Blick (1990) and Lesryk (1996).

TABLE A Flora species recorded on the Eve Street Wetlands.

SCIENTIFIC NAME	COMMON NAME
Abutilon grandifolium	Lantern-bush
Acacia falcata	Sickle Wattle
Acacia longifolia var sophorae	Sydney Golden Wattle
Acacia saligna	Golden Wreath Wattle
Acacia suaveolens	Sweet-scented Wattle
Agrostis billardieri	Coastal Blown Grass
Alternanthera denticulata	Lesser Joyweed
Amaranthus viridis	herb
Araucaria heterophylla	Norfolk Island Pine
Avicennia marina	Grey Mangrove
Banksia ericifolia	Heath-leaved Banksia
Banksia serrata	Old Man Banksia
Cakile edentula	herb
Callistemon citrinus	Lemon-scented Bottlebrush
Callistemon linearis	Narrow-leaved Bottlebrush
Callitriche stagnalis	herb
**Canna indica*	Canna
Carpobrotus glaucescens	Pigface
Casuarina glauca	Swamp Oak
Centaurium spicatum	herb
**Coronopus didymus*	Lesser Swinecress
Correa alba	White Correa
Cotula coronopifolia	Waterbuttons
**Cyperus albostriatus*	sedge
**Cyperus congestus*	sedge
**Cyperus eragrostis*	Umbrella Sedge
Cyperus polystachyos	sedge
Cyperus sphaeroideus	sedge
Danthonia tenuior	Wallaby Grass
Epaltes australis	herb
Eucalyptus botryoides	Bangalay
Eucalyptus robusta	Swamp Mahogany
Ficus rubiginosa	Port Jackson Fig
Glochidion ferdinandi	Cheese Tree
**Hydrocotyle bonariensis*	Pennywort
Isolepis nodosa	Knobby Club-rush
**Isolepis prolifera*	sedge
**Juncus acutus*	rush
**Juncus articulatus*	rush
**Juncus cognatus*	rush
Juncus flavidus	rush
Juncus krausii	Sea Rush
Juncus pallidus	rush
Kunzea ambigua	Tickbush
Lagunaria patersonii	Norfolk Island Hibiscus
Leptospermum laevigatum	Coastal Tea-tree
Lomandra longifolia	Mat-rush
Lythrum hyssopifolia	Lesser Loosestrife
Melaleuca armillaris	Bracelet Honey-myrtle
Melaleuca ericifolia	Swamp Paperbark
Melaleuca quinquenervia	Paperbark Tea-tree
Melaleuca stypheloides	Prickly-leaved Paperbark
Microlaena stipoides	Weeping Grass
Mimulus repens	Creeping Monkey-flower
Panicum obseptum	White Water Panic
Paspalum distichum	Salt-water Couch
Persicaria decipiens	Slender Knotweed
Phragmites australis	Common Reed
Pittosporum undulatum	Sweet Pittosporum
**Ranunculus sceleratus*	Celery-leaf Buttercup
Rumex brownii	herb
Samolus repens	Creeping Brookweed
Sarcocornia quinqueflora	Samphire or Glasswort
Schoenoplectus validus	River Club-rush

APPENDIX 2 cont Flora species recorded on the subject site by Blick (1990) and Lesryk (1996).

TABLE A cont Flora species recorded on the Eve Street Wetlands.

SCIENTIFIC NAME	COMMON NAME
Scirpus fluviatilis	sedge
**Scirpus prolifer*	sedge
Scirpus validus	sedge
Senecio lautus	Fire Weed
Sporobolus virginicus	Sand Couch
Suaeda australis	Seablite
Tetragonia tetragonoides	New Zealand Spinach
Themeda australis	Kangaroo Grass
Triglochin striatum	Streaked Arrowgrass
Typha orientalis	Cumbungi or Bullrush
Viminaria juncea	Native Broom
Westringia fruticosa	Coast Rosemary

TABLE B Flora species recorded on the Marsh Street Swamp.

SCIENTIFIC NAME	COMMON NAME
Cotula coronopifolia	Waterbuttons
Saudea australis	
Paspalum distichium	Water Couch
Persicaria lapathifolia	Pale Knotweed
**Pennisetum purpureum*	Elephant Grass
Phragmites australis	Common Reed
Pittosporum undulatum	Sweet Pittosporum
Typha orientalis	Cumbungi

M5 EAST MOTORWAY

Eve Street and Marsh Street Wetlands

ROADS & TRAFFIC AUTHORITY

SPECIES IMPACT STATEMENT

APPENDIX 3

HABITATS of THREATENED FAUNA and FLORA

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APPENDIX 3 Habitat requirements of threatened species listed in the NP&WS Director-General's requirements, on the NP&WS Wildlife Atlas within 3km of the site, on the NSW Bird Atlassers database within 7km of the site or recorded in previous studies conducted in the area.

SPECIES	HABITAT REQUIREMENTS
BIRDS	
Australasian Bittern	Densely vegetated permanent terrestrial wetlands, occasionally occur in estuaries. Nest within a dense cover of vegetation. Mostly occur in Murray Darling Basin, although commonly recorded in coastal areas. Diet includes eels, frogs and freshwater crustaceans (Marchant & Higgins 1990).
Black-tailed Godwit	Migratory. Inhabits sheltered, coastal bays, estuaries and lagoons with large intertidal mudflats or sandflats. Forages in soft mud or shallow water, sometimes amongst mangroves. Roosts on low banks of mud etc, usually in unvegetated areas, sometimes in low vegetation.
Great Knot	Migratory. Inhabit mudflats or sandflats, sandy beaches, occasionally mangroves and coastal swamps and lakes. Forage in soft mud or sand at water's edge. May roost in coastal dunes and mangroves, but usually in sheltered sites at water's edge (Higgins & Davies 1996).
Sanderling	Migratory. Inhabit open sandy beaches, rarely occur in sub-coastal wetlands. Forage in wave zone of beaches, in seaweed as well as mudflats. Roost on bare sand, in coastal dunes and rock outcrops (Higgins & Davies 1996).
Broad-billed Sandpiper	Migratory. Inhabit sheltered coastal mudflats, within harbours, lagoons and mangroves. Also coastal lakes, particularly with bare sand. Forage on mud and sand exposed by receding water. Roost on beaches (Higgins & Davies 1996).
Terek Sandpiper	Migratory. Inhabit intertidal mudflats, sandbanks, mangroves and occasionally sandy beaches. Forage on mudflats in mangroves and among seaweed on sandy beaches. Roost within mangroves, or on the shore (Higgins & Davies 1996).
Pied Oystercatcher	Inhabits intertidal mudflats, sandy beaches, rocky shores, rarely away from shore. Occasionally recorded in farm dams near the coast. Roosting sites include sandy beaches, foredunes and mangroves. Forage mainly on mudflats and beaches (Marchant & Higgins 1993).
Sooty Oystercatcher	Usually occurs within 50m of the shore, on exposed sandy beaches or rocky shores. Offshore islands form breeding sites and usually roosting sites (Marchant & Higgins 1993).
Mongolian Plover	Migratory. Coastal distribution, inhabiting and foraging on, sandflats and mudflats, and occasionally sandy beaches. Roost on beaches and occasionally mangroves. Rarely observed around inland lakes. In NSW, most common on North coast, becoming rare further south (Marchant & Higgins 1993).
Greater Sand Plover	Migratory. Primarily coastal, mainly occurring on sheltered beaches with sand and mud flats for foraging. rarely recorded on shallow freshwater wetlands. Diet includes molluscs, worms and aquatic invertebrates (Marchant & Higgins 1993).
Little Tern	Partly migratory. Prefers sheltered coastal habitats, including river mouths and estuaries, as well as beaches. Recorded breeding in Botany Bay (Higgins & Davies 1996).
MAMMALS	
Common Bent-wing Bat	Distributed along the eastern Australian coast, from Cape York to the south-east of South Australia. Roosts in a variety of structures, including caves, mine tunnels, and under bridges. Occurs in forests and woodlands were it forages above the canopy (Dwyer 1995).

APPENDIX 3 cont Habitat requirements of threatened species listed in the NP&WS Director-General's requirements, on the NP&WS Wildlife Atlas within 3km of the site, on the NSW Bird Atlassers database within 7km of the site or recorded in previous studies conducted in the area.

SPECIES	HABITAT REQUIREMENTS
AMPHIBIANS	
Green & Golden Bell Frog	Occurs in a variety of wetland habitats along the east coast of Australia, including swamps, wetlands and ponds, where there is adjacent grassland and shrubland for foraging (Pyke & White 1996). Often inhabits degraded and ephemeral waterbodies (Pyke & White 1996). Shelters under rocks or within emergent vegetation, burrowing into the banks during winter (Pyke & White 1996).
PLANTS	
Deyeuxia appressa	Erect perennial grass to 0.9m high. Grows on wet ground in the Hornsby area.
Syzygium paniculatum	A tall shrub or small tree which occurs in subtropical and littoral rainforest on sandy soils or stabilised quaternary sand dunes (Harden 1991). Occurs in disjunct populations between Jervis Bay and Bulahdelah (Harden 1991).

M5 EAST MOTORWAY

Eve Street and Marsh Street Wetlands

ROADS TRAFFIC AUTHORITY

SPECIES IMPACT STATEMENT

APPENDIX 4

COMPLIANCE of the SPECIES IMPACT STATEMENT with the REQUIREMENTS of the *THREATENED SPECIES CONSERVATION ACT 1995* and of the DIRECTOR-GENERAL of the NSW NP&WS

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APPENDIX 4 Compliance of the Species Impact Statement with the TSC Act and with the requirements of the NSW NP&WS Director-General.

TABLE 1 Compliance with requirements of the *Threatened Species Conservation Act 1995.*

SECTION	ISSUE	LOCATION in SIS
109(1)	A Species Impact Statement must be in writing	complies
109(2)	A Species Impact Statement must be signed by the principal author of the statement and by the applicant	Declaration at front of SIS
110(1)	A Species Impact Statement must include a full description of the action proposed, including its nature, extent, location, timing and layout and, to the fullest extent reasonably practicable, the information referred to in this section	EIS; Chapter 2 of SIS
110(2)	A Species Impact Statement must include:	
110(2)(a)	a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action;	Chapter 4
110(2)(b)	an assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action;	Chapter 5
110(2)(c)	for each species or population to be affected, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or threat abatement plan applying to it;	Chapter 6
110(2)(d)	an estimate of local and regional abundance of those species or populations;	Chapter 7
110(2)(e)	a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action;	Not relevant
110(2)(f)	a full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region;	Chapter 8
110(2)(g)	a full assessment of the likely effect of the action on those species and populations, including, if possible, the quantitative effect of local populations in the cumulative effect in the region;	Chapter 9
110(2)(h)	a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development;	Chapter 10
110(2)(i)	a full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those measures;	Chapter 11
110(2)(j)	a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population.	Chapter 12

APPENDIX 4 cont Compliance of the Species Impact Statement with the TSC Act and with the requirements of the NSW NP&WS Director-General.

TABLE 1 cont Compliance with requirements of the *Threatened Species Conservation Act 1995.*

SECTION	ISSUE	LOCATION in SIS
110(3)	A Species Impact Statement must include information as to "*ecological communities*".	no relevant "*ecological communities*" yet defined; Director-General's requirements
110(4)	A Species Impact Statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement.	Chapter 13; Appendix 5
110(5)	The requirements of subsections (2) and (3) in relation to information concerning the State-wide conservation status of any species or population, or any ecological community, are taken to be satisfied by the information in that regard supplied to the principal author of the Species Impact Statement by the NP&WS, which information that Service is by this subsection authorised and required to provide.	
111	Director-General's Requirements	EIS

TABLE 2 Compliance with requirements of the Director-General of the NSW NP&WS.

SECTION	ISSUE	LOCATION in SIS
1	**Description**	
1.1	*The type of proposal shall be detailed, including the timetable for the construction of the proposal and the number of hectares affected. This shall include details of the location of any auxiliary infrastructure and all component parts of the proposal.*	Chapter 2
1.2	*A plan of the subject area shall be provided. This plan shall show the location and type of vegetation communities present within the subject area and the scale of the plan.*	Chapter 2; Figure 2
1.3	*An aerial photograph (preferably colour) of the locality (or reproduction of such a photograph) shall be provided, if possible. This aerial photograph should clearly show the subject site and the scale of the photograph.*	Chapter 2; Figure 1
1.4	*A topographic map of the site and immediate surrounds at a scale of 1:25,000 will be provided. This map will detail the location of the proposal and location of works on site.*	Chapter 2; Figure 1
1.5	*A map of the locality, showing any locally significant areas for threatened species such as parks, reserves and known populations or habitat of subject species, and areas of high human activity such as townships, regional centres and major roads will also be provided.*	Chapter 2; Figure 1
1.6	*The location of the subject species recorded during the SIS survey shall be represented on a map of the study area.*	Chapter 4; Figure 3
1.7	*Where the habitat of each subject species within the study area can be clearly delineated, this habitat shall be represented on a map of the study area.*	Chapter 6; Figure 2

APPENDIX 4 cont Compliance of the Species Impact Statement with the TSC Act and with the requirements of the NSW NP&WS Director-General.

TABLE 2 cont Compliance with requirements of the Director-General of the NSW NP&WS.

SECTION	ISSUE	LOCATION in SIS
1.8	*A list of subject species shall be provided. In determining these species, consideration shall be given to the habitat types present within the study area, recent records of threatened species in the locality and the known distribution of threatened species. The following species shall be considered for inclusion in the list of subject species: Green and Golden Bell Frog (Litoria aurea),* Australasian Bittern (*Botaurus poiciloptilus*), Greater Sand Plover (*Charadrius tenuirostris*), Black-tailed Godwit (*Limosa limosa*), Little Tern (*Sterna albifrons*), Sooty Oystercatcher (*Haematopus fuliginosus*), Pied Oystercatcher (*Haematopus longirostris*), Mongolian Plover (*Charadrius mongolus*), Sanderling (*Calidris alba*), Broad-billed Sandpiper (*Limicola falcinellus*), *Deyeuxia appressa Syzygium paniculatum.*	Chapter 4
1.9	*In describing the study area, consideration shall be given to the previous land uses and the effect of these land uses on the study area. Relevant historical events may include fire history, clearing, recreational use and agricultural activities.*	Chapter 2
1.10	*A description of habitat including such components as the frequency of tree hollows, density of understorey vegetation, description of ground cover, soil type and/or presence of rock outcrops shall be given. The condition of the habitat within the study area shall be discussed, including the prevalence of introduced species. A description of the habitat requirements of threatened species likely to occur in the study area shall be provided.*	Chapter 6
1.11	*In defining the study area consideration shall be given to possible indirect effects of the action on species/habitats in the area surrounding the subject site: for example through altered hydrology regimes, soil erosion or pollution.*	Chapter 9
1.12	*A fauna and flora survey is to be conducted in the study area. Targeted surveys shall be conducted for all subject species determined in accordance with Section 1.7 above. Species of taxonomic uncertainty shall be confirmed by a recognised authority such as the Australian Museum or National Herbarium at the Botanic gardens, Sydney.*	Chapter 3
1.13	*A full description of methods used in the fauna and flora surveys and habitat assessment shall be provided, including survey techniques employed, number and location of traps, size of survey sites, dates of surveys, the time spent on surveys and weather conditions. Where possible, surveys should be undertaken during seasons and climatic conditions during which the subject species are most likely to be detected.*	Chapter 3
1.14	*Any areas which may act as corridors between the study area and adjacent areas of likely habitat for subject species shall be identified and described.*	Chapter 9
1.15	*A full list of the protected fauna and flora found during the course of surveys shall be included. Such information is indicative of the habitat quality of the site.*	Chapter 3
1.16	*The effect of the season and weather at the time of the field survey shall be considered with respect to the adequacy of survey results.*	Chapter 3

APPENDIX 4 cont Compliance of the Species Impact Statement with the TSC Act and with the requirements of the NSW NP&WS Director-General.

TABLE 2 cont Compliance with requirements of the Director-General of the NSW NP&WS.

SECTION	ISSUE	LOCATION in SIS
2	***Assessment of likely impacts***	
2.1	*For all subject species:. the SIS shall state the following:* • *the location, nature and extent of habitat removal or modification which may result from the proposed action;* • *the potential impact of the removal of habitat; and* • *the likely contribution of the proposed action to the threatening processes acting on populations of those species in the locality.*	Chapter 9
2.2	*A discussion of other populations of subject species in the locality shall be provided. The long term security of the other habitats shall be examined as part of this discussion. The relative significance of the subject site for subject species in the locality shall be discussed.*	Chapter 9
2.3	*If movement corridors for subject species are present within the subject site, the impact of the proposal on these areas shall be discussed.*	Chapter 9
3	***Amelioration***	
3.1	*While no recovery plans or threat abatement plans have been approved in accordance with the TSC Act as yet, draft recovery plans have been prepared for the species listed in Appendix 2. Where a draft recovery plan is relevant to any subject species, consideration shall be given to the information contained in these plans and whether any draft recovery plan recommendation is applicable to the proposal.*	Chapter 6
3.2	*In discussing alternatives to the proposal, and the measures proposed to mitigate the effect of the proposal, consideration shall be given to developing long term management strategies to protect areas within the study area which are of particular importance for the subject species. This may include proposals to restore or improve habitat.*	Chapter 11
3.3	*Any proposed on-going monitoring of the effectiveness of the mitigation measures shall be provided.*	Chapter 11
4	***Additional information***	
4.1	*In providing a list of other approvals the following shall be included;* • *any consent required under Part 4 of the Environmental Planning and Assessment Act 1979 including the name of the consent authority and when it is proposed to make the development application; or* *any approvals required under Part 5 of the Environmental Planning and Assessment Act 1979 including the name of the determining authority(ies), the basis for the approval and when these approvals are proposed to be obtained.*	Chapter 12

M5 EAST MOTORWAY

Eve Street and Marsh Street Wetlands

ROADS & TRAFFIC AUTHORITY

SPECIES IMPACT STATEMENT

APPENDIX 5

QUALIFICATIONS of COMPANY and AUTHOR

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Gunninah Environmental Consultants

ASSESSMENT, ADVICE and MANAGEMENT in the BIOLOGICAL and PHYSICAL ENVIRONMENT

REPORTS and PUBLICATIONS

1983

Fauna survey for proposed open cut mine extension near Warkworth, Hunter Valley. Buchanan Borehole Collieries.

Preliminary survey of flora and fauna along proposed rail link from Glenfield to East Hills.

1984

Flora and fauna survey on a proposed hard rock quarry at Seaham Hill, near Raymond Terrace, NSW.

Fauna survey - Grain Handling Facility at Port Kembla inner harbour.

Preliminary fauna survey on proposed army training facilities southwest of Cobar, NSW.

Preliminary fauna survey on proposed army training facilities northeast of Tamworth, NSW.

1985

Army training facilities project, northwest of Cobar, NSW - Fauna Survey.

Army training facilities project, schools training area, Bathurst/Orange, NSW - Fauna Survey.

1986

Fauna survey for the F4 Freeway Section - Dog Kennel Road, Prospect to Coleman Street, Mays Hill.

Fauna survey for BMI - Dunmore Quarry proposed extension.

1987

Wombats on the Hume Highway from Hoddles Crossroads to Marulan.

1988

Tantawangalo State Forest Study Area - vegetation project.

Tantawangalo State Forest South Study Area - fauna report. I. Terrestrial mammals with observations on arboreal species.

Natural resource survey on the South Rockton section of Bondi State Forest, southern NSW.

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1989

Natural resource survey on the North Rockton section of Bondi State Forest, southern NSW.

Fauna and flora survey, Palm Beach subdivision.

Wombats on the Hume Highway: a supplementary report.

Nepean Dam flood protection measures - supplementary environmental surveys - preliminary report.

Nepean Dam flood protection measures - supplementary environmental surveys - final report.

Natural Habitats Study - Half Moon Farm, Hawkesbury River.

A Natural Resource Survey of Rockton Section, Bondi State Forest. III. Birds, Reptiles and Amphibians.

Widening of Forest Way: Vegetation Survey.

1990

Fauna survey on a proposed bridge and approaches over the Woronora River between Sutherland and Bangor.

Koalas in the Southeast Forests.

An environmental survey of the Myanba Creek catchment in Coolangubra State Forest, southern NSW.

Koala Surveys: Compartments 950 and 953, Tantawangalo State Forest.

An environmental survey of the upper Wog Wog River catchment (Mines Road area) in Coolangubra and Nalbaugh State Forests, southern NSW.

Duck Creek Survey for Parramatta City Council.

Proposed Concrete Batching Plant, West Gosford: Fauna Survey and Environmental Assessment.

Platypus: Conservation Status and Future Management. Final Report.

Widening of Forest Way: Vegetation Survey. Hews Parade to Ralston Avenue.

Report on Proposed Sand Mining at Sackville, NSW.

Proposed Limestone Mine at Attunga, NSW.
Appraisal of EIS for Attunga Residents Action Group.

Proposed Canal Development at Dunbogan, NSW.
Appraisal of EIS for the Total Environment Centre.

Physical constraints to urban development. In Cardew, R. *Wyong Urban Growth Study.*

Description and evaluation of potential release areas. In Cardew, R. *Wyong Urban Growth Study.*

Aspects of the flood hazard on the Central Coast. In Cardew, R. *Wyong Urban Growth Study.*

Implications of climatic change on urban growth on the Central Coast. In Cardew, R. *Wyong Urban Growth Study.*

Survey of Vegetation along New Line Road.

1990 continued

Gold Ridge Mine - Solomon Islands. Freshwater fauna survey and contaminant analysis.

Proposed Gunnedah Power Station - Gunnedah Coal Company. Report on flora and fauna surveys and assessment of potential environmental impacts.

1991

An environmental survey of the Stockyard Creek catchment in Coolangubra State Forest, southern NSW.

An environmental survey of the Jingo Creek catchment in Nullica State Forest, southern NSW.

AGL Site, Tennyson Road, Mortlake: A Fauna Survey.

Fauna and conservation study on Australian Defence Industries land at St Marys, western Sydney.

Fauna and Flora study on SEPP 26 Littoral Rainforest at Crescent Head, NSW.

Environmental Guidelines for International Projects.

Surveys for Koalas and other animals on coupes to be logged in the Tantawangalo State Forest in southeastern NSW.

Surveys for Koalas along a roadline in the Tantawangalo State Forest in southeastern NSW.

Fauna and Flora Surveys for a Gold and Antimony mine near Tamworth.

Resolution of land use conflict between Titanium-mining and 'endangered' fauna near Tea Gardens, NSW.

Wombats on the Hume Highway: implementation of impact mitigation measures.

Assessment of the native fauna and the potential impacts of the proposed construction of single dwellings on fourteen blocks in the Kedumba Valley.
Presentation (expert witness) in Land & Environment Court.

1992

Interactions between Koalas and Roads: a Review and Assessment of Preventative Measures.

Comprehensive fauna surveys in the State Forests of the Tenterfield District northern NSW.

Fauna Impact Statement for Commission of Inquiry on a Titanium-mining venture at Saltwater, NSW.

Submissions to the Commission of Inquiry on a Titanium-mining venture at Saltwater, NSW.
Presentation of expert evidence to Saltwater Commission of Inquiry.

Rehabilitation of SEPP 26 Littoral Rainforest at Crescent Head, NSW.
Ongoing.

Assessment of impact on fauna of a proposed subdivision at Avalon, Sydney.

Assessment of impact on fauna of sand and soil extraction at Elderslie, Sydney.

1992 continued

Vegetation mapping and conservation assessment on rural land at Coolongolook, NSW.
Assessment of impact on fauna of an export woodchip industry in NSW. Input into preparation of EIS for SEPL.
Assessment of impact on fauna of a proposed subdivision at Glenhaven, Sydney.

Possible biological and hydrological impacts of the extraction of water from the Duck River, Sydney.

Goulburn Wool Scour Ltd proposed wastewater management operation: assessment of environmental significance for native fauna and flora.

Assessment of impact on fauna of road widening on the Pacific Highway, between Port Macquarie and Taree.

Assessment of impact on vegetation of road widening along New Line Road, Cherrybrook.

Assessment of impact on fauna of proposed Titanium-mining operation on Moffats Dune near Raymond Terrace, NSW.

Advice on fauna requirements for a proposed house at Corrimal, NSW.

Management of wildlife issues on Australian Defence Industries land at St Marys, western Sydney.
Ongoing.

EIS studies on fauna and flora impacts of a chemical laboratory development at Wagga Wagga, NSW.

Assessment of impact on fauna of proposed subdivision at Kenthurst, Sydney.

Assessment of impact on fauna of proposed subdivision at Annangrove, Sydney.

1993

Monitoring of the impacts of a Titanium-mining operation on the Eastern Chestnut Mouse, and recolonisation of mined land by fauna, Hawks Nest, NSW.
Ongoing.

Monitoring of Platypus populations above and below a major dam expansion project in northern NSW, at Pindari Dam near Inverell.
Ongoing.

Management of wildlife issues on Australian Defence Industries land at St Marys, western Sydney.
Ongoing.

Rehabilitation of SEPP 26 Littoral Rainforest at Crescent Head, NSW.
Ongoing (from 1992).

Assessment of impact on vegetation, native fauna and fauna habitats of road widening along the Great Western Highway, Linden.

Assessment of impact on fauna and fauna habitats of road widening along New Line Road, Cherrybrook.

Assessment of impact on fauna of proposed Titanium-mining operation at Big Swan Bay near Lemon Tree Passage, NSW.

Assessment of impact on fauna and fauna habitats in an SEPP wetland of a proposed retirement village at Toukley.
Presentation (expert witness) in Land & Environment Court.

1993 continued

Assessment of impact on flora, fauna and fauna habitats of a proposed water and sewerage treatment works at Fern Bay, NSW.

Environmental Impact Statement of a proposed Titanium-mining operation near Stockton, NSW.

Assessment of impact on fauna of proposed Titanium-mining at Nabiac, NSW.

Review of fauna survey and report for proposed forestry operations in north coastal NSW.

Review of fauna surveys and assessment of impact on fauna of proposed development at North Bonville, NSW.

Monitoring of the impacts of a Titanium-mining operation on the Queensland Blossom Bat, and recolonisation of mined land by fauna at Saltwater, NSW.
Ongoing.

Assessment of impact on fauna and fauna habitats of a proposed mining operation near Mt Isa, western Queensland.

Preliminary assessment of impact on fauna and fauna habitats of a proposed tourist development on the Murray River, near Albury, NSW.

Assessment of impact on fauna and fauna habitats of a proposed power transmission line between Lismore and Mullumbimby, NSW.

Fauna and flora surveys; assessment of impacts of a proposed subdivision at Dural, NSW.

Fauna and flora surveys and assessment of impacts of a proposed Telecom repeater tower in Ku-ring-gai Chase National Park, NSW.

Assessment of impact on fauna of a proposed subdivision at Avalon, Sydney.
Preparation of evidence for presentation (expert witness) in Land & Environment Court.

Submissions on native fauna to a Commonwealth Commission of Inquiry on the Shoalwater Bay Area, Queensland.
Expert evidence presented to the Commission of Inquiry.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats of a proposed major bypass road at Bangor, western Sydney.

Assessment of impact on vegetation, native fauna and fauna habitats of further road widening along the Great Western Highway, Linden.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats of road widening at Picton, NSW.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats of a realignment of the New England Highway near Murrurundi.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats and heritage values of a proposed rail deviation at Banyabba.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats for the proposed expansion of a piggery near Scone, NSW.

Fauna survey and assessment of a proposed dwelling on land near Wyong, NSW.
Expert witness in the NSW Land & Environment Court.

Review of Environmental Factors for vegetation disturbance in the eastern portion of the St Mary's site.

Assessment of the potential impacts of a proposed walking track on Dobroyd Head, Sydney Harbour National Park, NSW.

1994

Ongoing:

Monitoring of Queensland Blossom Bat at Saltwater.

Monitoring of Eastern Chestnut Mouse at Viney Creek.

Monitoring of Platypus around Pindari Dam.

Monitoring rainforest rehabilitation at Crescent Head.

Management of wildlife and vegetation issues at St Marys.

Assessment of the potential impacts on fauna and flora of a proposed urban development at Pennant Hills, including a Bushland Management Plan.

Environmental assessment of a water supply augmentation scheme at Tumbarumba in southern NSW.

Fauna surveys on a potential coal mine extension in the Hunter Valley.

Fauna surveys and impact assessment on a proposed quarry at Hartley, NSW.

Review of Fauna Impact Statement - Crown Land, Pambula.

Review of Fauna Impact Statement - development at Taree.

Fauna surveys and impact assessment on a proposed residential subdivision site at Byron Bay, NSW.

Assessment of impact on fauna and fauna habitats of a proposed mining operation near Mt Isa, western Queensland.

Impact assessment on native fauna for a proposed helipad at Arcadia, NSW.
Report preparation and expert witness in the Land & Environment Court.

Assessment of significance for native fauna of a proposed development at City Hill, Coffs Harbour.

Survey of native fauna and flora and assessment of potential impacts of a housing development at Stonequarry Creek, Picton.

Development of a Management Plan for a population of Green & Golden Bell Frogs at Rosebery, NSW.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats of the Albury-Wodonga bypass along the Hume Highway.

Urban development design to accommodate fauna issues, and preparation of a Fauna Impact Statement - North Bonville, NSW.

Impact assessment on native fauna and flora of proposed road widening, Eternity Corner, the Putty Road.

Impact assessment on native fauna and flora of proposed road widening and safety ramp on the Putty Road.

Fauna and flora surveys and impact assessment on 2 proposed residential subdivision sites at Blaxland, NSW.
Report preparation and expert witness in the Land & Environment Court.

Survey of native fauna and flora and assessment of potential impacts of expansion of the Mount Thorley Coal Loader, NSW.

Assessment of potential impacts on fauna and flora of proposed additional extraction at a limestone mine at Marulan, NSW.

1994 continued

Fauna and flora surveys and impact assessment on a proposed residential subdivision sites at Blaxland, NSW.
Report preparation and expert witness in the Land & Environment Court.

Fauna and flora surveys and impact assessment on a proposed tourist and golf course development at Cattai, NSW.

Assessment of impacts on fauna and on flooding of quarrying operations and horse training facilities at Muskoka Farm, Gunderman, NSW.
Statement of Evidence for the NSW Land & Environment Court.

Assessment of the potential impacts on native fauna and fauna habitats for a proposed Gold Mine Prospect at Lake Cowal, NSW.

Fauna and flora assessment for a proposed Grafton water supply pipeline.

Fauna and flora surveys and assessment of a proposed quarry at Jugiong, NSW.

Impact assessment on native fauna and flora of a proposed quarry at Windellama, NSW.

Fauna Impact Statement for a proposed Golf Course at Pambula - Merimbula.

Assessment of potential impacts on fauna and flora of continuing operations at the limestone mine at Marulan, NSW.

Assessment of potential impacts on fauna and fauna habitats of the construction of a transmission line between Lismore and Mullumbimby, NSW.
Independent report and input into Environmental Impact Statement.

Preparation of the Fauna Impact Statement for a transmission line between Lismore and Mullumbimby, NSW.

Monitoring of the effects of discharges from Windamere Dam on Platypus populations in the Cudgegong River and the storage.

Consideration of the fauna and flora issues, and assessment of the potential impacts, for a proposed urban development at South Dural, Sydney.

Management of disturbance to vegetation for site investigation and decontamination at the St Mary's facility.
Proceeding.

Survey and assessment of vegetation at the St Mary's facility.

Assessment of potential impacts on fauna and fauna habitats of a proposed deviation of the Pacific Highway north of Raleigh near Coffs Harbour.

Fauna and flora surveys, and preparation of an Environmental Audit and Environmental Management Plan at the Myambat Logistics Co, Denman, NSW.

Assessment of the potential impacts on flora and fauna of a mining operation at Hillgrove, NSW.

1995

Ongoing:

Monitoring of Queensland Blossom Bat at Saltwater.

Monitoring of Eastern Chestnut Mouse at Viney Creek.

Monitoring of Platypus around Pindari Dam.

Monitoring of Platypus around Windamere Dam.

1995 continued

Monitoring rainforest rehabilitation at Crescent Head.

Management of wildlife and vegetation issues at St Marys.

Fauna and flora surveys and reports for a horse and pony trail in Ku-ring-gai Chase National Park, Sydney.

Fauna monitoring for the construction of the M2 Motorway in Sydney. Pre-clearing and clearing stages

Survey and tracking of the Squirrel Glider at Lake Macquarie (Caves Beach), and preparation of a Fauna Impact Statement.

Impacts of a proposed development at Byron Bay on endangered fauna: preparation of Statement of Evidence, appearance as expert witness in the Land & Environment Court.

Environmental Assessment Report for fauna and flora - North Boambee Valley urban release project.

Koala Management Plan - North Boambee Valley, Coffs Harbour.

Assessment of the potential impacts on flora and fauna of a proposed reconstruction of Delhi Road, between the Crematorium and the CSIRO Riverside Park.

Review of environmental factors and potential fauna impacts of proposed reservoir and aqueduct re-painting in Northern Sydney.

Preparation of the Fauna Impact Statement for existing and future operations of two Sand Mining Plants in the Tomago Sandbeds.

Fauna Impact Statement for a proposed deviation of the Pacific Highway north of Raleigh near Coffs Harbour.

Preparation of the Fauna Impact Statement for existing and future operations of a Sand Mining Plants at Hawks Nest.

Assessment of the flora and fauna issues for an extraction site, Canoelands, including assessment of SEPP 44.

Preparation of A Fauna Impact Statement for residential development, Salamander Way.

Preparation of the Fauna Impact Statement for a proposed Gold Mine Prospect at Lake Cowal, NSW.

Assessment of the fauna issues for a proposed dam on the Perry River, QLD.

Fauna and flora investigations for the upgrading of Elizabeth Drive (access to Badgerys Creek Airport). Input into Elizabeth Drive Environmental Impact Statement.

Fauna and flora investigations for the Western Sydney Orbital - Prestons to Cecil Park. Input into Environmental Impact Statement for National Highway - Western Sydney Orbital.

Fauna and flora investigations for the Western Sydney Orbital - Cecil Park to West Baulkham Hills. Input into Environmental Impact Statement for National Highway - Western Sydney Orbital.

Fauna survey and impact assessment for a residential subdivision at Waterfall, including assessment of SEPP 44.

Assessment of the flora and fauna issues for a proposed development site, Padstow.

Fauna and flora investigations for a residential subdivision, Menai.

Assessment of the flora and fauna issues for a residential subdivision, Kellyville.

1995 continued

Fauna and flora investigations for a proposed coal washery reject emplacement site, Maddens Plains.

Fauna and flora investigations for the upgrade of the Federal Highway between Sutton, NSW and North Canberra, ACT.

Fauna and flora investigations for the upgrade of a sewerage treatment plant, Morpeth.

Fauna investigations for a proposed deviation of Main Road #84, Binalong NSW.

Fauna investigations for a proposed golf course re-development, Katoomba, including assessment of SEPP 44.

Fauna investigations for a proposed residential subdivision, Yarramundi, Coffs Harbour, including assessment of SEPP 44.

Assessment of fauna issues for the Newington RANAD site, Sydney.

SEPP 44 Assessment Report for proposed residential development sites and associated drainage lines, Casula.

SEPP 44 Assessment Report for proposed residential development sites, Dural.

SEPP 44 Assessment Report for a proposed golf course extension, Pambula-Merimbula.

SEPP 44 Assessment Report for a proposed subdivision, Cawdor.

SEPP 44 Assessment Report for a proposed residential development, Hoxton Park.

SEPP 44 Assessment Report for a proposed residential development, Carnes Hill.

Fauna and flora assessment for the Holsworthy Sewerage Scheme Transfer Environmental Impact Statement.

Flora and fauna assessment for a Development Control Plan, Kings Beach, Tweed Shire.

Flora and fauna assessment for the proposed Queanbeyan Bypass, ACT.

Fauna and flora assessment for a proposed residential development Palmtrees Nursery site, North Bonville.

Assessment of impact on fauna and fauna habitats of a proposed mining operation near Bundaberg, Queensland.

Assessment of impact on fauna and fauna habitats of a proposed quarry extension near Coffs Harbour.

Fauna and flora assessment for two proposed residential developments at Castle Hill.

Tree inspections for two proposed residential developments at Castle Hill.

Fauna Impact Assessment for a proposed tailings dam near Parkes, NSW.

Fauna and flora assessment for a proposed mine extension in the Hunter Valley, including SEPP44 assessment.

Review of information and preparation of a fauna and flora assessment report for inclusion in a Local Environmental Plan for Seven Mile Beach, NSW.

Assessment of impacts of a proposed residential development at Brooklyn on the Red-crowned Toadlet.

Assessment of impacts on fauna and flora for a proposed gas pipeline from Wodonga to Wagga Wagga, NSW.

1995 continued

Assessment of impact on fauna, flora and hydrology of a proposed quarry extension at Wyong, NSW.
Preparation of evidence for presentation (expert witness) in Land & Environment Court.

Assessment of the potential impact on Koalas of a proposed residential development on Lady Belmore Drive, Coffs Harbour, NSW.

Assessment of impact on fauna of a proposed bus depot at St Ives, Sydney.
Preparation of evidence for presentation (expert witness) in Land & Environment Court.

Assessment of impact on fauna of a proposed residential subdivision at Suffolk Park, Byron Bay.
Preparation of evidence for presentation (expert witness) in Land & Environment Court.

Fauna Assessment for a proposed sandmine at Fullerton.

1996

Ongoing:

Management of the Rosebery Green & Golden Bell Frog Population.

Monitoring of Queensland Blossom Bat at Saltwater.

Monitoring of Eastern Chestnut Mouse at Viney Creek.

Monitoring of Platypus around Pindari Dam.

Monitoring of Platypus around Windamere Dam.

Monitoring rainforest rehabilitation at Crescent Head.

Management of wildlife and vegetation issues at St Marys.

Flora and Fauna Assessment for a proposed rezoning for residential development at Castle Hill, Sydney.

Flora and Fauna Assessment for a proposed residential/recreational estate at Rossmore Park, Bathurst, NSW.

Flora and Fauna Assessment for a proposed deviation in the Albury to Australian Newspaper Mill 132KV transmission line.

Flora and Fauna Assessment for a proposed deviation in the Albury-Hume 132KV transmission line.

Assessment of Flora and Fauna issues for a proposed hospital site at Newports Creek, Coffs Harbour, NSW.

Flora and Fauna Assessment for an Environmental Impact Statement on the Basalt Hill Quarry, Kulnura.

Flora and Fauna Assessment for 'The Glades' housing development, West Pennant Hills, NSW.

Investigation of flora and fauna issues for the proposed Federal Highway upgrade and re-alignment.

Vegetation and Fauna Habitat Assessment Report for a proposed road widening at Abbott Road, Seven Hills.

Fauna and Fauna Habitat Assessment Report for the Eastlink Transmission Line from Armidale (NSW) to Springdale (QLD).

1996 continued

Fauna and Flora Assessment Report for a proposed convention centre and tourism development on the Kurnell Peninsula, North Cronulla.

Sewerage overflow licensing project - assessment of the significance of impacts on fauna and flora, and measures to ameliorate them.

Investigations of flora and fauna issues and consequent impacts of development site at Rosebery Road, Kellyville.

Investigations of flora and fauna issues and consequent impacts of development site at Green Road, Kellyville.

Environmental Management Plan for the subdivisions at Rosebery Road and Green Road, Kellyville.

Investigations of flora and fauna issues and consequent impacts of development at Poole Road, Kellyville.

Flora and Fauna issues, and consequent biological constraints on proposed development at Myall St, Teagardens.

Flora and Fauna Impact Assessment at Kings Beach, including a SEPP44 Assessment and Koala Management Plan and Section 5A Assessment.

Species Impact Assessment for a residential and tourist development at Kings Beach, Tweed Shire.

Post-clearing fauna monitoring for the construction of the M2 Motorway in Sydney.

Assessment of flora and fauna issues for proposed expansion of the Raleigh bypass of the Pacific Highway.

Assessment of impacts on flora and fauna of a proposed Telstra communications tower, near Mt Victoria.

Assessment of impacts on flora and fauna of a proposed residential development at Queanbeyan.

SEPP 44 Assessment Report for a proposed residential development site at Bonville, near Coffs Harbour.

Fauna and Flora Assessment Report for proposed residential development at Valla Beach, south of Coffs Harbour.

Assessment of impacts on flora and fauna of a proposed water storage facility for a mining operation near Helensburgh.

SEPP 44 Assessment Report for a proposed development site, Glenfield.

Preparation of a Species Impact Statement for the proposed Federal Highway upgrade between Sutton, NSW and North Canberra, ACT.

Fauna and flora investigations for proposed flood mitigation works for the Western Sydney Orbital - Prestons to Cecil Park.

Assessment of impacts on flora and fauna of a proposed transmission line from Forbes to Lake Cowal, NSW.

Review of an Environmental Impact Statement and Fauna Impact Statement for the F3 Motorway, northern end.

Assessment of flora and fauna issues for a proposed residential development site at Bonville, near Coffs Harbour.

1996 continued

Impact assessment on native fauna for existing and future operations of a mineral sand mining operation in the Tomago Sandbeds. Report preparation and expert witness in the Land & Environment Court.

Consideration of the potential impacts on the Green & Golden Bell Frog of a proposed development at Botany.
Report preparation and expert witness in the Land & Environment Court.

Assessment of the flora and fauna issues for a proposed development site along the foreshores of the Georges River at Padstow.
Expert witness in the Land & Environment Court.

Flora and Fauna Assessment for a proposed bridge over the Lachlan River at Willanthry, NSW.

Flora and Fauna Assessment for a proposed gravel quarry near Hillston, NSW.

SEPP 44 Assessment Report for a proposed development site, Prestons.

Survey and Mapping of Threatened Flora at the ADI facility at St Marys.

Assessment of flora and fauna issues for a proposed subdivision at Chisholm Ave, Avalon.

Assessment and Review of Potential Impacts of a proposed residential subdivision at North Boambee Valley, Coffs Harbour.

Impacts on flora and fauna issues of a proposed development site at Killcare.
Report preparation and expert witness in the Land & Environment Court.

Review of a Rural Land Study Report prepared by Hornsby Shire Council.

Assessment of flora and fauna issues for a proposed mining operation at the North Parkes Mine.

Assessment of Impacts of soil fill on Flora and Fauna.

Flora and Fauna Assessment for a proposed subdivision at Barina Downs Road, Baulkham Hills.

Flora and Fauna Assessment for a proposed subdivision of Lots 1, 2 & 12, Castle Hill.

Flora and Fauna Assessment for a proposed industrial development at Menai.

Assessment of flora and fauna issues for extensions to the existing Warnervale Airport.

Assessment of flora and fauna issues for a proposed bypass of the Bruxner Highway at Alstonville.

Impact on Flora and Fauna of a proposed Subdivision at Frenchs Forest.
Report preparation and expert witness in the Land & Environment Court.

Impact on Flora and Fauna of a proposed Subdivision at Kurrajong.
Report preparation and expert witness in the Land & Environment Court.

Development of Planning Strategies and Management Concepts for the Olympic Village Site.

Impacts of a proposed driveway on Flora and Fauna, Avalon.
Report preparation and expert witness in the Land & Environment Court.

Effects on Flora and Fauna of a proposed subdivision at South Dural.
Report preparation and expert witness in the Land & Environment Court.

Flora and Fauna Assessment for a proposed site for a telecommunications tower at Ourimbah.

1996 continued

Flora and Fauna Assessment for a proposed quarry at Central Bucca near Coffs Harbour.

Flora and Fauna Assessment for a proposed industrial development at Park Hill Road, Minchinbury

Flora and Fauna Assessment for a proposed site for a telecommunications tower at Jannali.

Fauna survey of a proposed Chemical Plant at Botany.

Fuel Reduction Zone and Development Application at Merrilyne Ave, West Pennant Hills.

Tree Assessment for a proposed school at Oakhurst.

Flora and Fauna Issues for the Strathfield Planning Strategy.

Consideration of Impacts on Green & Golden Bell Frogs at Botany.
Report preparation and expert witness in the Land & Environment Court.

Management Plan for the Plains Wanderer at Morundah,

Management Plan for Native Grasslands at Morundah.

Review of Environmental Factors for the proposed installation of a sewer pipeline at South Dural.

Review of Environmental Factors for proposed flood mitigation works at Middle Creek, Sawtell.

Flora and Fauna Assessment for a proposed residential development at Fern Bay.

Flora and Fauna Assessment for a proposed open cut coal mine at Kayuga, near Muswellbrook.

Flora and Fauna Assessment for a proposed Environmental Interpretive Centre near Ebor.

Flora and Fauna Assessment for proposed duplication of the Pacific Highway at Brunswick Heads.

Flora and Fauna Assessment for proposed Brunswick to Billinudgel re-alignment of the Pacific Highway.

Flora and Fauna Assessment for a proposed re-development at Walsh Bay, Sydney.

Gunninah Environmental Consultants

Assessment Advice Management

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PO Box 513
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email: gunninah@s054.aone.net.au

CURRICULUM VITAE

Mr FRANCIS DOMINIC FANNING BSc(Hons1) MAIBiol MEIA MESA

33 King William St Greenwich NSW 2065.
phone: 02 - 439 5436 fax: 02 - 439 7770

ACADEMIC QUALIFICATIONS :

BSc with 1st class Honours, University of NSW, 1977.

EMPLOYMENT HISTORY :

1975 to 1979	-	Technical Officer (research assistant) School of Biological Science, UNSW.
1979 to 1990	-	Professional Officer (assistant researcher) School of Biological Science, UNSW.
1983 to 1989	-	Principal Environmental Consultant and Partner, Gunninah Consultants.
1989 to present	-	Director and Principal, Gunninah Holdings Pty Ltd, environmental consultants.
1989 to 1992	-	Scientific Associate of the Zoological Parks Board of NSW at Taronga Zoo.
1990 to July 1991	-	Research Fellow, Platypus Breeding and Conservation Research Program, the Conservation Research Centre, Taronga Zoo.
1990 to present	-	Visiting Fellow, School of Biological Science, UNSW.

RELEVANT EXPERIENCE and EXPERTISE :

Research field trips for UNSW from 1974 to 1990, throughout NSW, South Australia, Queensland and the Northern Territory, studying the native vertebrate fauna of Australia.

Micro-computer programming (the development of dedicated programs for biological research) and the use of micro-computers for data analysis and report preparation.

Wildlife illustration (three books published) and photography of native wildlife.

Conference convenor - an international workshop on Platypus Conservation at Taronga Zoo, 1988, to discuss the directions for future research into the biology of the Platypus and methods for the management of the species in captivity.

RELEVANT EXPERIENCE and EXPERTISE (continued):

Design of research studies and development of research techniques and equipment, including electronic and data acquisition equipment, radio-tracking techniques, design and implementation of research programs on the conservation and captive management of the Platypus. This last program involved the identification of land use practices throughout the range of the Platypus and analysis of their impacts, determination of the effects of pollutants, erosion and waterway controls on the species, assessment of the habitat and food requirements of the Platypus, analysis of the environmental limitations of Platypus in the wild, and determination of the appropriate captive maintenance techniques for this species.

Management of environmental consulting business (Gunninah Consultants), involved in biological and physical environment assessment, Environmental Impact Statement and Fauna Impact Statement preparation, impact analysis, environmental management, and ecosystem management for rare species, presentation of expert evidence at Commissions of Inquiry and in the Land & Environment Court.

Design, co-ordination and supervision, and execution of fauna and flora surveys and of natural resource surveys, ranging from one-day surveys of the fauna and flora of proposed developments to broad conservation assessments of large areas - one thousand to one million hectares (for example, proposed logging operations in southeastern and northeastern NSW, proposed army bases in NSW). Surveys have involved soils analysis, vegetation and wildlife identification and assessment, habitat evaluation, pollutant identification and assessment, recommendations regarding impact amelioration, and the design of management options.

Research, compilation, writing and presentation of consulting reports (from 5 to 300 pages), promotional material (for the Conservation Research Centre at Taronga Zoo), a journal (production editor of the *Australian Biologist* Special Issue 1990), a workshop proceedings and scientific research papers.

Author and illustrator of books on Australian animals, including two on the Platypus.

RESEARCH INTERESTS :

Conservation and habitat management of the Platypus and other native fauna (particularly the Koala and kangaroos).

The ecology, environmental requirements and life histories of native fauna.

Computing and technology in biological research, including the application of GIS and other remote-sensing techniques, and the development and application of radio-telemetry for biological survey and research.

The development of methods for environmental survey.

PROFESSIONAL :

Member of the Australian Institute of Biology - MAIBiol
member of Executive and Chairman of Credentials Committee (1989/91), Deputy Registrar (1991/92).

Member of the Environment Institute of Australia - MEIA
member of committee to establish Professional Credentials for Environmental Practitioners (1991).

Member of - the Ecological Society of Australia,
the Royal Zoological Society of NSW,
the Royal Australasian Ornithologists Union,
the Australian Wildlife Management Society,
the Australian Mammal Society (past Executive Member & Treasurer).

Past Scientific Associate of the Zoological Parks Board at Taronga Zoo.
Visiting Fellow in the School of Biological Science at the University of NSW.

PUBLICATION LIST

F DOMINIC FANNING BSc(Hons1) MAIBiol MEIA MESA

CONSULTANCIES

Additional publications include the majority of consultancy reports on projects listed in the *Projects List* for GUNNINAH CONSULTANTS.

BOOKS

Illustrator of

Monotremes and Marsupials by TJ Dawson. Edward Arnold. 1983.

The Platypus by TR Grant. NSW University Press. 1984, 1989.

Author and illustrator of

Platypus published by Houghton Mifflin. 1991.

SCIENTIFIC PAPERS

Fanning FD. 1977. Temperature regulation of the Australian water rat, *Hydromys chrysogaster*. Honours thesis, University of NSW.

Fanning FD and Dawson TJ. 1977. Is *Hydromys* really a water-rat ? *Aust Mamm Soc Bull* **4(1):** 25.

Fanning FD and Dawson TJ. 1978. Thermoregulation of the Australian water rat, *Hydromys chrysogaster*. *Aust Mamm Soc Bull* **5(1):** 19.

Dawson TJ, Fanning FD and Bergin TJ. 1978. Metabolism and temperature regulation in the New Guinea monotreme *Zaglossus bruijni*. *Aust Zoologist* **20(1):** 99-103.

Dawson TJ, Grant TR and Fanning FD. 1979. Standard metabolism of monotremes and the evolution of homeothermy. *Aust J Zool* **27:** 511-515.

Fanning FD. 1980. Nests of the Feathertail glider, *Acrobates pygmaeus* (Burramyidae: Marsupialia), from Sydney, New South Wales. *Aust Mammal* **3:** 55-56.

Fanning FD and Watkins KM. 1980. Growth and development in *Acrobates pygmaeus* (Burramyidae: Marsupialia). *Aust Mammal* **3:** 57-69.

Fanning FD and Dawson TJ. 1980. Body temperature variability in the Australian water rat, *Hydromys chrysogaster*, in air and water. *Aust J Zool* **28:** 229-238.

Fanning FD and Dawson TJ. 1980. Thermal energetic problems of a small semiaquatic mammal, *Hydromys chrysogaster*. *Aust Mamm Soc Bull* **6(2):** 33-34.

Dawson TJ and Fanning FD. 1981. Thermal and energetic problems of semiaquatic mammals: a study of the Australian water rat, including comparisons with the platypus. *Physiol Zool* **54(3):** 285-296.

SCIENTIFIC PAPERS continued

Fanning FD. 1982. Reproduction, growth and development in *Ningaui* sp. (Dasyuridae: Marsupialia) from the Northern Territory. pp 23-37 in *Carnivorous Marsupials*. Archer M (ed). Royal Zool Soc NSW, Sydney.

Whitford D, Fanning FD and White AW. 1982. Some information on reproduction, growth and development in *Planigale gilesi* (Dasyuridae: Marsupialia). pp 77-81 in *Carnivorous Marsupials*. Archer M (ed). Royal Zool Soc NSW, Sydney.

Fanning FD and Dawson TJ. 1984. Insulative components of the thermal balance of semiaquatic mammals. pp 319-322 in *Thermal Physiology*. Hales JRS (ed). Raven Press, New York.

Fanning FD. 1988. Australia's Mr Platypus. *Aust Geographic* **12:** 64-65.

Fanning FD and Dawson TJ. 1989. The use of heart rate telemetry in the measurement of energy expenditure in free-ranging Red Kangaroos. pp 239-244 in *Kangaroos, Wallabies and Rat-kangaroos*. Grigg G, Jarman P and Hume I (eds). Surrey Beatty & Sons, Sydney.

Lutz PL, Dawson TJ, Bonnet E and Fanning FD. 1989. Oxygen affinities of Monotreme blood: Hypoxic adaptations. *J Exp Zoology* **251:** 285-289.

Wicken AJ and Fanning FD. 1989. The Australian Institute of Biology and a Biological Council of Australia: Their Roles and Relationships. *Australian Biologist* **2**(3): 15-18.

Fanning FD and Hughes RL. *In press.* Unearthing more questions than answers. In *Strategic Planning for Conservation I: The Platypus*. Woodside DP and Fanning FD (eds). CSIRO Publications, Melbourne.

Woodside DP and Fanning (eds). *In prep. Strategic Planning for Conservation I: The Platypus. Proceedings of a Symposium at Taronga Zoo.* CSIRO Publications, Melbourne.

Fanning FD, Woodside DP and Kotlash A. *in prep.* Habitat Criteria and Platypus Populations: A Modelling Approach.

Hawkins M and Fanning FD. 1992. Courtship and mating behaviour of captive Platypuses at Taronga Zoo. In Augee ML (*ed*). *Platypus and Echidnas*. Royal Zoological Society of NSW, Sydney.

RESUME OF
DERYK. C. ENGEL

Date of Birth:	24 March 1966
Tertiary Qualifications:	University of Wollongong Bachelor of Environmental Science 1985 - 1988 University of Wollongong Honours in Environmental Science 1989 - 1990
Professional Affiliations:	Environment Institute of Australia Australian Mammal Society Ecological Society of Australia Royal Australian Ornithological Union Royal Zoological Society NSW Bird Atlassers Australian Society of Herpetologists
Licences:	Class A National Parks & Wildlife Scientific Licence NSW Agriculture Animal Research Licence Animal Care and Ethics Committee Research Authority through the Director-General of the NSW Agriculture Class A Drivers Licence

Publications:

Engel, D. and Rose, T. (in press) The dietary requirements of Black-shouldered Kites (Elanus axillaris) in urban areas;

Quin, D., Goldingay, R., Churchill, S. and Engel, D. (1996) Feeding behaviour and food availability of the Yellow-bellied Glider in north Queensland Wildlife Research Vol 23 (6) pp 637-648.

Recent Large Contracts :	Ecological Assessment of Grose Wold for Hawkesbury City Council Biodiversity Study of East Buxton for Wollondilly Council Fauna Assessment of the Liverpool Local Government Area as part of Liverpool Councils State of the Environment Report
Areas of Specialisation :	Environmental Management and implementation of best practice management. A solid working knowledge of techniques used to identify native fauna, including spotlighting, scat analysis, track and markings identification, bird watching, ultrasonic bat detection, Radio tracking, habitat and fauna mapping, computer analysis. A sound, working knowledge of those birds, reptiles and amphibians which inhabit New South Wales. Environmental Education Data storage, project management, report preparation.

Research Projects :

1990 Impact of native herbivores species on plant regeneration post-fire, Water Catchment Area, Wollongong. Eight months study involving fauna identification, plant establishment and monitoring of seedling development and strike rate.

1991 Habitat use, group size and foraging movements of Yellow-bellied Gliders, Tully
Millstream Hydro-electric Scheme Ravenshoe Queensland. A one year monitoring programme involving radiotracking, scat analysis and mapping of foraging movements.

1992/1993 Bio-diversity study of Tenterfield, Walcha and Dorrigo Forestry Coupes.

1996 Impact of feral pests on native populations, Royal National Park, Sydney

1996 Bio-diversity study of native fauna populations occurring within remnant bushland patches, Liverpool Local Government Area, Sydney

1996 Habitat preference and population size of Broad-headed Snakes, Royal National Park, Sydney

Consulting Projects (for example) :

Bushland Management Plans

1996 Clinches Pond, Liverpool, for Liverpool City Council
1996 Riverside Park, Liverpool, for Environmental Partnership Pty Ltd
1995 de Freitas Wetland, Fairfield, for Professional Power
1995 Cox's Creek, Greenacre, for Urban Bushland Management
1994 Mason Park Wetlands, Homebush Bay for Urban Bushland Management
1994 Anzac Creek bushland, Holsworthy for Georges River Field Studies Centre
1994 Mill Creek, West Menai for Georges River Catchment Management Committee

Housing Developments

1996 Ecological Assessment for Hawkesbury City Council
1996 Biodiversity study for Wollondilly Shire Council
1996 Biodiversity study for Hawkesbury City Council
1995 Kellyville Residential Subdivision - Australian Housing and Land

Road Alignments

1996 Pacific Highway Upgrade, Ulladulla - landscape Environmental Consultants
1996 Pacific Highway Upgrade, Tomerong - landscape Environmental Consultants
1996 Pacific Highway Upgrade, Eungai - CMPS&F Environmental
1995 Federal Highway Upgrade Canberra Route Selection - Gunninah Consultants
1995 Elizabeth Drive, Western Sydney Orbital, Badgery's Creek - Gunninah Consultants
1994 Picton Road deviation, Mount Ousley - Gunninah Consultants
1993 New England Highway Realignment, Murrurundi - Gunninah Consultants
1992 Woronora Bridge & Bangor Bypass - Gunninah Consultants

Extractive Industries

1996 Continual Operation of Molong Quarry, Molong - CMPS&F Environmental
1996 Continual Operation of North Shore Quarry, Port Macquarie - CMPS&F Environmental
1995 CSR Ready Mix Quarry Expansion, Queanbeyan - CMPS&F Environmental
1994 Water Board overburden study, Appin, New South Wales - QEM
1994 Mine extension proposal, Singleton - Gunninah Consultants
1992 Sand Mine proposals Gerroa, Maroota & Ulan (NSW)
- Quality Environmental Management
- Mount King Ecological Surveys

Industrial Works

1993 Upgrade proposal, Ben Chifley Dam, Bathurst - CMPS&F Environmental
1992 Chemical Plant, Wagga Wagga - Gunninah Consultants
1992 Coalcliff Embankment Fauna Impact Statement
- Quality Environmental Management
1989 Helensburgh & Metropolitan Railway Embankment Surveys
- Quality Environmental Management

M5 EAST MOTORWAY

Eve Street and Marsh Street Wetlands

ROADS & TRAFFIC AUTHORITY

SPECIES IMPACT STATEMENT

APPENDIX 6

FAUNA and FLORA ASSESSMENT of EVE and MARSH STREET WETLANDS, ROCKDALE by LESRYK ENVIRONMENTAL CONSULTANTS

Gunninah Environmental Consultants
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FAUNA AND FLORA ASSESSMENT OF

EVE AND MARSH STREET WETLANDS, ROCKDALE.

JUNE 1996

1. INTRODUCTION

This report describes the flora and fauna communities within and adjacent to the Eve Street and Marsh Street Wetlands at Rockdale (Figure 1). The study has been carried out at the request of the Roads and Traffic Authority (RTA) as part of an environmental assessment for a design change to the proposed extension of the M5 Motorway from King Georges Road to General Holmes Drive.

The assessment is based on field surveys of the two wetlands as well as adjacent vegetation communities. A literature review of previous studies carried out in the region was also undertaken.

2. ENVIRONMENTAL SETTING

The study area is located to the east of both Eve and Marsh Streets. The topography of this area varies from flat to gently undulating with an underlying geology derived from Quaternary alluviums (Chapman and Murphy 1989). In reality there are five (5) wetland areas in the vicinity of the proposed road works, and these are either tidally fed or collect freshwater runoff.

Surrounding landuses include :-

- Kogarah Golf Course to the north,
- the Cooks River and Kingsford Smith Airport to the west,
- Playing field and recreation areas to the south and
- Residential developments to the west and both further to the north and south.

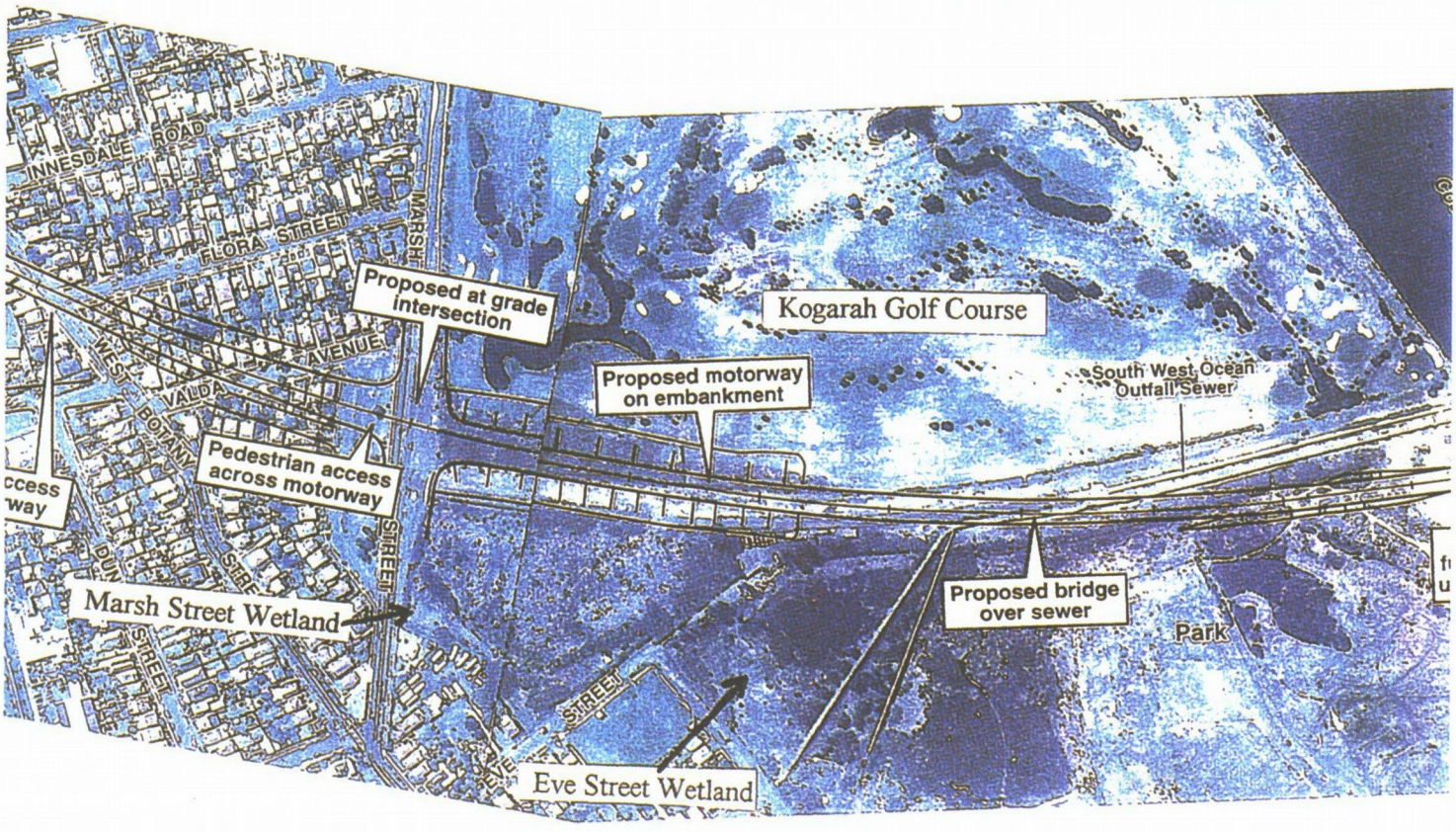
Within these areas, little native vegetation and habitat remains. Conservation areas in the vicinity of the study area are limited, and restricted to a series of Council parks and open space areas. The main conservation reserves in the region would be the Towra Point Nature Reserve and Botany Bay National Park. Both of these occur along the southern shores of Botany Bay.

Of the five wetlands, "Eve Street" is the larger. This is a saline wetland comprises a large area of rehabilitated salt marsh. This wetland has been designed and been recreated from capital provided by Sydney Water, as part of a major habitat recreation program. This programme has been instigated to provide resources for both resident and migratory wading birds. Many of the migratory birds are of conservation significance, being listed under either the *Threatened Species Conservation Act 1995* (*TSC Act 1995*), or on international treaties, such as Japan-Australia Migratory Bird Agreement (J.A.M.B.A.) and China-Australia Migratory Bird Agreement (C.A.M.B.A.).

PART A COMMUNITY CONSULTATION

As part of the flora and fauna assessment of the wetlands, government agencies and community groups were approached. Due to the timing and duration of the survey, these organisations were asked to provide specific knowledge in relation to the study area. These groups were asked to provide listings of species known for the area, their habitat and movement patterns and any recommendations, concerns or other comments regarding the management or mitigation of likely impacts.

STUDY LOCATION
Undercliffe
Canterbury
Creek
TURRELLA
ARNCLIFFE
BANKSIA
ROCKDALE
Marrickville
Tempe
Recreation
Reserve
Kogarah
Golf Course
Barton
Park
Banksia
Field
KYEEMAGH
SYDNEY AIRPORT
Kingsford Smith
Domestic
Terminals
International Terminal
QANTAS
Cargo
Gough Whitlam
Park
Waterworth
Park
Cahill
Park
Rockdale
Park
Proposed
Freeway
Sydney
Haulage
Terminal
North
Pond
Control Tower &
Operations Centre
Floating Net
HIGHWAY
PRINCES
ROAD
WICKHAM ST
EVE ST
MARSH ST
FLORA ST
INNESDALE
ARNCLIFFE
WOLLI
INTERCHANGE
STN
RIVER
Creek
Mudflats
Reserve
PERIMETER
AIRPORT
TUNNEL
2205
2206
2216
2020
2044


Proposed at grade intersection
Proposed motorway on embankment
Pedestrian access across motorway
Kogarah Golf Course
South West Ocean Outfall Sewer
Proposed bridge over sewer
Marsh Street Wetland
Eve Street Wetland
Park
INNESDALE ROAD
FLORA STREET
MARSH STREET
VALDA AVENUE
BOTANY

The majority of organisations approached responded verbally to the letters sent out. Summaries of the response of each of these organisations are provided. The original letter, where received, is included in Appendix 1.

3. ORGANISATION AND GROUPS APPROACHED

Organisations and groups approached as part of this assessment include :-

- NSW Fisheries
- Sydney Water
- National Parks and Wildlife Service
- Rockdale City Council
- Royal Australian Ornithological Union
- Rockdale Wetland Preservation Society
- University of Western Sydney

NSW Fisheries

- No specific concerns or comments.

Sydney Water

- No specific concerns or comments.

National Parks and Wildlife Service

- No specific concerns or comments.

Rockdale City Council

- No specific concerns or comments.
- Provided list of plants successfully planted at Eve Street by Sydney water during rehabilitation works.

Royal Australian Ornithological Union

- Potential of proposed Motorway to impact on the flight paths of migratory birds.
- Potential of traffic noise proposed Motorway to impact on migratory birds roosting at Eve Street Wetland.
- Some migratory birds only utilise Eve street as opposed to other wetland areas in the Botany Bay area.

Rockdale Wetland Preservation Society

- Provided fauna species listings in relation to the study area.
- Concerned over possible impacts to the Green and Golden Bell Frog (*Litoria aurea*) and migratory birds.
- In relation to migratory birds, the potential impact on flight paths and migratory routes.

- Potential to disturb migratory bird populations which only use Eve Street Wetland.
- Potential to disturb resident bird populations.
- Is able to provide detailed information on the flight paths of migratory birds.

University of Western Sydney

- No specific concerns or comments.

PART B FLORA

4. BACKGROUND

A flora and fauna Working Paper for the M5 East Motorway was prepared by Mount King Ecological Surveys and the Water Research Laboratory of the University of Western Sydney in 1994.

This report included a description of the Eve Street and Marsh Street wetlands (the Barton Park wetlands), by P W Adcock and P L Osborne in February 1994, and a flora and fauna assessment along the entire route (including the Eve Street and Marsh Street wetlands) by Mount King Ecological Surveys in May 1994.

The report by Adcock and Osborne provided plant species lists for both wetland areas. The list for the Eve Street wetland was taken from a previous Water Board study by Blick (1990) which was conducted prior to the rehabilitation of the site. That study recorded 51 native and 95 exotic plant species at the study site, including one species, the grass *Deyeuxia appressa*, that is now listed on Schedule 1 of the *Threatened Species Conservation Act 1995*. The species list for the Marsh Street wetland prepared by the authors and contains four native species but does not record exotic species.

The present study re-surveyed both wetlands to verify the occurrence of plant species previously recorded at the sites, and identify any unrecorded species listed on the schedules to the *Threatened Species Conservation Act 1995*.

5. METHODOLOGY

One day field surveys were undertaken at each of the two wetland sites by John Speight on 18 April and 22 June 1996. The occurrence of previously recorded species were ascertained and any other species identified. The plant species list provided by Blick (1990) also provides grid references for their occurrence, however Sydney Water was unable to locate the accompanying map to the report. The previous location of the endangered species *Deyeuxia appressa* was therefore unable to be determined.

6. RESULTS

6.1 Eve Street

Of the fifty one (51) native plant species recorded at the Eve Street wetland by Blick (1990), six of those native species were not found during the present survey, while an additional twenty native species were identified (Table 1). All of these additional species are likely to have been planted by the Water Board during rehabilitation works.

The species previously recorded by Blick (1990) but not relocated during the present survey were:

Deyeuxia appressa	Bent grass
Dichelachne crinata	Long-haired Plume grass
Grevillea robusta	Silky Oak
Wahlenbergia gracilis	Australian Bluebell
Bolboschoenus caldwellii	Clubrush
Bolboschoenus fluviatilis	Marsh Club-rush

None of these species were recorded for the Eve Street or the Marsh wetland (the Barton wetlands) in the 1994 survey by Mount King Ecological Surveys.

TABLE 1. Plant Species Recorded At Eve Street Wetland, In Addition To Those Listed in Adcock and Osborne (1994).

Scientific Name	Common Name
Acacia suaveolens	Sweet-scented Wattle
Acacia falcata	Sickle Wattle
Banksia ericifolia	Heath-leaved Banksia
Banksia serrata	Old Man Banksia
Callistemon citrinus	Lemon-scented Bottlebrush
Callistemon linearis	Narrow-leaved Bottlebrush
Correa alba	White Correa
Danthonia tenior	Wallaby Grass
Eucalyptus botryoides	Bangalay
Eucalyptus robusta	Swamp Mahogany
Kunzea ambigua	Tickbush
Leptospermum laevigatum	Coastal Tea-tree
Lomandra longifolia	Mat-rush
Melaleuca armillaris	Bracelet Honey-myrtle
Melaleuca ericifolia	Swamp Paperbark
Melaleuca stypheloides	Prickly-leaved Paperbark
Microlaena stipoides	Weeping Grass
Themeda australis	Kangaroo Grass
Viminaria juncea	Native Broom
Westringia fruticosa	Coast Rosemary

6.2 Marsh Street

In addition to the 4 native plant species recorded at the Eve Street wetland by Adcock and Osborne (1994), four other native species were identified during the present survey (Table 2).

TABLE 2. Plant Species Recorded At Marsh Street Wetland. In Addition To Those Listed in Adcock and Osborne (1994).

Scientific Name	Common Name
Typha orientalis	Cumbungi
Cotula coronopifolia	Waterbuttons
Paspalum distichum	Water Couch
Pittosporum undulatum	Sweet Pittosporum

7. FLORA DISCUSSION

The Marsh Street wetland complex contains few native plant species and all of these are common in similar habitats in the Sydney region. The most common native species is Common Reed *Phragmites australis*. The majority of vegetation comprises Common Reed and exotic species including Castor Oil plant *Ricinus communis*.

The Eve Street wetland was extensively altered and "redesigned" during rehabilitation works in the early 1990's. This included the use of heavy earth moving equipment such as bulldozers to create the pond and islands and shape the banks. Only one species of conservation significance: *Deyeuxia appressa*, was recorded at the Eve Street wetland by Blick (1990) in a baseline vegetation survey prior to the restoration works. In that report *Deyeuxia appressa* was not highlighted as a species of conservation significance. It is now listed on Schedule 1 of the *Threatened Species Conservation Act 1995*, and is coded 2E on the national ROTAP listing by Briggs and Leigh (1992).

It is possible that during the restoration works *Deyeuxia appressa* and the other plant species that were not recorded during the present survey were displaced or destroyed. The 1994 survey of the wetland for the M5 East Environmental Impact Statement also does not list these species as occurring at any of the sites.

8. RECOMMENDATIONS

The only plant species of conservation significance that was previously recorded in the Eve Street or Marsh Street wetlands, and which still potentially occurs in the area is the grass *Deyeuxia appressa*. Although the species was not recorded during the present survey, or the previous vegetation survey for the M5 East Motorway Environmental Impact Statement in 1994, the plant may still exist in the area. And given the availability of suitable habitat within and adjacent to the Eve Street wetland, the species may re-establish in the future. It is recommended that a short survey be undertaken of the specific area likely to be affected by the proposed design modification of the Motorway alignment when that is known.

Given the type of plant (a grass) and habitat of *Deyeuxia appressa* (wet places), if any plants are found within or adjacent to the proposed construction area, their transplantation to another location is likely to be successful and would be preferable to their destruction.

PART C FAUNA

9. METHODS

A survey of the wetland areas and adjacent habitats was carried out by both Deryk Engel and Arthur White between April and May 1996. The weather during the daytime searches was warm and fine. Spotlighting conditions on the 1, 3, 4 and 14 of May were overcast and wet.

Techniques employed for this investigation included:-

TECHNIQUE	FAUNA GROUP TARGETED
direct observation	birds, reptiles, amphibians, mammals
searches of ground debris and litter	reptiles, amphibians
bird watching	terrestrial and aquatic birds
identification of indirect faunal evidence	mammals
identification of distinctive calls	mammals, birds, amphibians
scat analysis	predator and prey species
spotlighting	amphibians, nocturnal birds, mammals
habitat assessment	birds, reptiles, amphibians, mammals

During the daytime sessions, specific target groups were searched for when these species were most likely to be active. Birdwatching was undertaken during the early morning and dusk periods, reptile and frog surveyed during daylight hours or at night.

The diurnal reptile and frog surveys consisting primarily of hand searches of potential reptile shelter sites and were carried out during sunny days. Active reptiles were caught when possible, if not, they were recorded only if their identity was satisfactorily established. These surveys were carried out on the 21, 23, 25 of April and the 9 of May 1996.

Nocturnal surveys were carried out on wet evenings on the 1, 3, 4 and 14 of May 1996. These surveys consisted a spot-light searches of the ground and vegetation around the wetlands. Calling frogs were caught and identified. Each water body was netted and tadpoles that were caught were released after being identified. If the tadpoles were too small too be immediately identified, they were retained in captivity are reared to a size where they could be identified, and then returned to the capture site for release. Playback recordings of the call of Green and Golden Bell Frogs were played at each water body for at least 15 minutes on one evening. The position of responding male frogs was noted.

A review of previous studies undertaken in the area was carried out to identify additional fauna species known to occur in the study area. A search of the National Parks and Wildlife Service Atlas, Australian Museum and New South Wales Bird Atlassers databases was also undertaken.

10. RESULTS

10.1 Habitat Types Available For Native Fauna Species

The study area contains a variety of habitat types available for native fauna. These include aquatic environments, grasslands and a small patch of woodland.

10.1.1 Aquatic Environments

The major aquatic areas in the two wetlands can be divided into six distinctive habitats (Figure 2) namely :-

i) Marsh Street Freshwater Wetland.
ii) Eve Street Saltmarsh Area.
iii) Eve Street Freshwater Wetland.
iv) Eve Street Mangrove Area.
v) Cooks River Freshwater Wetlands.
vi) Cooks River.

i) Marsh Street Freshwater Wetland

The Marsh Street wetland area is centred around a storm water basin adjacent to Marsh Street. This basin is fed by an enclosed storm water pipe that enters the basin from under Marsh Street. The water overflow from the basin leaves via a narrow channel to the south, eventually flowing into the Eve Street salt marsh area. The narrow exit channel is difficult to see as it is concealed by a tall growth of bulrushes and exotic plants. The entire basin is surrounded by rubble infill that has become overgrown by a mixture of exotic and native "weeds". The basin is irregular in shape and relatively shallow. It holds water all year around but open water is only visible for about 8 months in the year.

Four frog species have been recorded at this site. One species, the Green and Golden Bell Frog, *Litoria aurea*, is listed on Schedule 1 of the *TSC Act 1995*.

ii) Eve Street Saltmarsh Area

The Eve Street Marsh area is probably the best known component of the greater Rockdale Wetlands. Sydney Water provided major capital funding for the restoration of this site. A largish shallow salt marsh basin was excavated with four small islands for bird roostings being constructed. The islands are vegetated by salt marshes and reeds. Dense stands of aquatic vegetation also occur at several location around the wetland. The site is subject to tidal salt water movements but the water flow over the site is regulated by a small weir at the south eastern end of the marsh. The surrounding areas have been planted with a mixture of native trees, shrubs and ground cover plants. These plants are all about 2 metres in height and of medium density.

This wetland is used by a range of migratory wetland birds, a number of which are listed under international treaties, such as J.A.M.B.A. and C.A.M.B.A. Through information provided by both the Rockdale Wetland Preservation Society and Royal Australian Ornithological Union (RAOU), there are birds which only use this area and no other wetlands in the region.

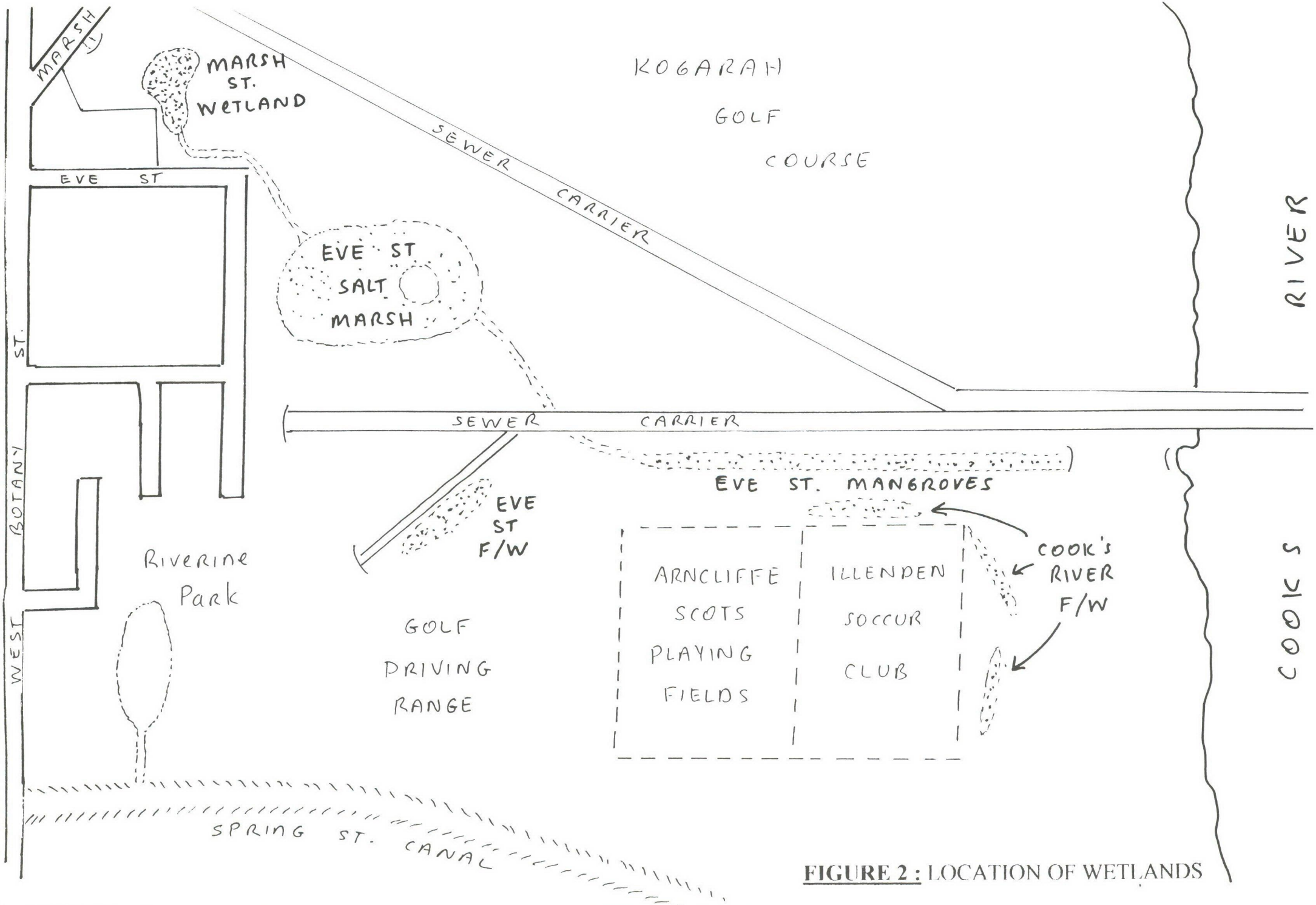


FIGURE 2 : LOCATION OF WETLANDS

iii) Eve Street Freshwater Wetland

This wetland area is an ephemeral area near the old sewer carrier. It is demarcated by stands of *Phragmites* spp. and *Typha* spp. The site remains open water for only a few months each year. It receives direct rainfall and does not collect water from other areas. Overflow water, during periods of heavy rain, runs into the mangrove channels to the east, before entering the Cooks River.

Frog species that have been recorded from this area include the Green and Golden Bell Frog (*L.aurea*), Common Green Tree Frog (*Litoria caerulea*), Bleating Tree Frog (*L.dentata*) and Striped Grass Frog (*Limnodynastes peronii*). Reed birds and numerous small passerine species also use this area.

iv) Eve Street Mangrove Area

Trees within this community are approximately 6 metres in height, the canopy being essentially continuous both along, and across the channel. The mangroves have been greatly reduced in size due to land filling. This has reduced this community to a narrow mangrove lined tidal channel. The channel runs from the weir below the Eve Street saltmarsh area into the Cooks River, the last 20 metres of this being through a 600mm culvert. During peak high tides the water backs up in the channel and overflows into the salt marsh areas. Adjacent to this community, revegetation of native shrubs and ground cover species has taken place.

The channel, although limited in area, still functions as a nursery area for small estuarine fish and is used by larger wading birds for feeding.

v) Cooks River Freshwater Wetlands

These wetlands are small in size and run below the outer embankment of a raised soccer playing field area. They consist of small boggy, open water areas surrounded by reed beds. These wetlands are supplied by local water runoff and are not part of a major drainage system. Shrubs and grasslands surround these wetlands.

The wetlands are home to a number of frog species, most notably the Striped Grass Frog and Common Eastern Froglet. The grassland/rubble areas nearby provide resources for a number of reptile species, including Garden Skinks, Robust Skinks, Blue Tongue Lizards and Black Bellied Swamp Snakes.

vi) Cooks River

A sixth aquatic environment in the vicinity of the study area is the Cooks River. This is a tidally affected, saline water body which eventually feeds into Botany Bay. In the vicinity of the study area, no riparian or aquatic vegetation is present, the majority of this being cleared to allow for the construction of bank stabilisation work.

10.1.2 Grasslands

This is a dense community of weed and grass species, which reaches about 2 metres where it is not maintained. Within this community some isolated exotic and native shrubs, to 3 metres, are

present, as is ground debris and some urban rubbish. This community occurs throughout the study area, its structure varying on the degree of regeneration.

10.1.3 Open Woodland

The open woodland is approximately 7 metres in height, with the occasional isolated remnant to 15 metres. The majority of this community has rehabilitated from landscape and revegetated plantings. The density of trees is dependant upon the success of revegetation work, and range from medium to high. No suitable nesting hollows for possums and microchiropteran bats are present. Understorey is a medium density mixture of native shrubs and sapling species to 2 metres while the ground cover consists of native grasses, forbs and weed species. Lots of ground debris and leaf litter is present. This community occurs to the south of Eve Street Wetland and is not expected to be impacted upon by the proposed Motorway.

Of those habitats observed within the vicinity of the proposed Motorway, the Marsh Street Freshwater and Eve Street Saltmarsh Wetlands are considered to be the most significant. These wetland supports a range of endangered species, a number of which are listed under the *TSC Act 1995*. These habitats are a limited resource in the area, the modification or removal of which has the potential to see the local extinction of a range of fauna species. Given the limit availability of these resources, and the fact that they support threatened species, a Species Impact Statement would be required if these communities are to be modified in any way which reduces their value to those threatened species they support.

11. FIELD SURVEY RESULTS

During the investigation of the wetlands and the surrounding vegetated communities, 1 mammal, 42 birds, 4 reptiles and 3 frogs were identified (Appendix 2). Of those animals recorded by the completion of the field work, one, the Green and Golden Bell Frog (*Litoria aurea*), is listed under Schedule 1 of the *TSC Act 1995* as being Endangered. None of those species recorded are considered to reach their distribution limit in the vicinity of the study area. Previous studies and fauna surveys in the region have identified a further 12 native mammals, 129 birds, 14 reptiles and 8 amphibian species (Appendix 2). Of those species recorded in the region during previous studies, 12 are listed under Schedule 1 and/or 2 and 10 of these are listed under international agreements (Table 3).

11.1 Mammal Species

Only one native mammal, the Grey-headed Flying Fox (*Pteropus poliocephalus*), was recorded as using the habitats found within the study area (Appendix 2). This species was observed during one spotlighting session, feeding in a Morton Bay Fig Tree. This fig is located to the south of the Eve Street Saltmarsh Wetland, and is not expected to be removed. Known to feed on eucalypt nectar and pollen, and on native and introduced fruits, this species is the most common fruit bat to be observed on the eastern seaboard. Roosting or breeding "camps" may be located in the branches of large trees in forests, thick scrub, swamps or mangroves with colonies containing from 500 to 5,000 individuals (Hall and Richards 1979, Strahan 1995). Two major Flying Fox colonies are known for the Sydney area, the first is located to the north east in the suburb of Gordon, the other to the north west, in the vicinity of Fairfield.

TABLE 3. Schedule 1 and 2 species known to occur in the vicinity of Eve and Marsh Street Wetlands.

Scientific Name	Common Name
Botaurus poiciloptilus	Australasian Bittern
Charadrius leschenaultii	Greater Sand Plover
Xenus cinereus	Terek Sandpiper
Calidris tenuirostris	Great Knot
Limosa limosa	Black-tailed Godwit
Sterna albifrons	Little Tern
Haematopus fuliginosus	Sooty Oystercatcher
Haematopus longirostris	Pied Oystercatcher
Charadrius mongolus	Mongolian Plover
Calidris alba	Sanderling
Limicola falcinellus	Broad-billed Sandpiper
Litoria aurea	Green and Golden Bell Frog

An additional twelve native mammals are known, or have the potential to, occur within the study area (Appendix 2). Of these, one, the Common Bent-wing Bat (*Miniopterus schreibersii*), is listed under Schedule 2 of the *TSC Act 1995*. This species is the dominant cave-dwelling bat in south-eastern Australia (Smith and Smith 1990, Parnaby 1992). Occurring along the east coast and ranges of Australia from south-eastern South Australia through to Queensland, and the northern parts of Western Australia and the Northern Territory, this species roosts in caves, storm water channels, mines and houses (Hall and Richards 1979, Strahan 1995). Estimates of home ranges for the Common Bent-wing Bat are in the order of 10Km^2 (G.Hoye pers.comm.). This species prefers well timbered valleys and is confined to areas where there are caves (or suitable substitutes), generally near the coast (Strahan 1995). Large distances are travelled between different roosts according to this species seasonal requirements (Hall and Richards 1979, Reardon and Flavel 1987, Smith and Smith 1990, Strahan 1995). During winter, cold roosts are sought to allow for hibernation while during the warmer months, females will travel great distances (up to 200 Km) to suitable nursery caves where the temperature, humidity and physical dimensions permit breeding (Baudinette *et al.* 1994, Strahan 1995). Nursery caves may support up to 150,000 females and juveniles and these may be used by a number of groups year after year (Reardon and Flavel 1987). This species' dependence on suitable seasonal caves has put the population in jeopardy (Strahan 1995). Given the lack of suitable sheltering habitat existing already in the vicinity of the proposed Motorway, it is unlikely that this species will be adversely affected.

11.2 Avian Species

During the present survey a range of aquatic and terrestrial birds were identified. The majority of these species were either observed on, or around, the Eve Street Saltmarsh Wetland, utilising the recreated habitats. Eve Street Saltmarsh Wetland was identified as supporting the greatest diversity of aquatic birds, while the terrestrial birds appeared to be more common in the woodland and denser vegetation communities. In relation to the terrestrial birds, the majority of those species observed are highly adaptive, often being recorded in urban areas. These birds require dense stands of trees and shrubs in which to roost, nest and shelter, and these vegetation stands are also used for

foraging. Some of those birds observed will venture into the adjacent grasslands looking for insects or seeds, though few nest and roost in these areas.

The main value of the Eve Street Saltmarsh Wetland is as a foraging and roosting habitat for migratory waders. Of those species known to utilise and rely on this area, ten are listed under Schedule 1 and/or 2 of the *TSC Act 1995* (Appendix 2). Of these species, a number are only known to utilise this wetland, not being found in any other part of the Botany Bay wetland system (Rockdale Wetland Preservation Society pers.comm.). A number of other migratory birds are also known to use this wetland (Appendix 2). These birds, though not endangered, are protected and listed on international agreements. Prior to the onset of winter, most of the migratory birds leave the Eve Street Saltmarsh Wetland and migrate northwards to summer breeding sites. The migratory routes of these species as they leave the wetlands have been studies by organisations such as the RAOU and Rockdale Wetland Preservation Society and appear to indicate that these birds fly north, north-east when they leave the wetland. The impact of the proposed Motorway on these migratory routes may need to be assessed if the height of the road is likely to impact on flight paths. In relation to the eight point test under 5A of the *Environmental Planning and Assessment Act 1979*, there is the potential that the Motorway, if its height impacts on migratory movements, may have a significant effect on threatened species, populations or ecological communities, or their habitats. Consequently a Species Impact Statement would need to be prepared.

11.3 Reptile Species

Four species of lizard were found during the survey period. Of these, three, namely the Eastern Water Skink (*Eulampus quoyii*), the Delicate Skink (*Lampropholis delicata*) and the Garden Skink (*L.guichenoti*), were widespread and common throughout the wetlands. Only two Robust Skinks (*Ctenotus robustus*) were caught and these were both in the southern section of the Eve Street Wetland.

Other reptile species have been recorded from the wetlands; these include the Yellow-faced Whip Snake (*Demansia psammophis*), Black Bellied Swamp Snake (*Hemiaspis signata*) and Eastern Blue Tongue Lizard (*Tiliqua scincoides*) (Rockdale Wetlands Preservation Society pers.comm.). Appendix 2 lists an additional six reptiles which have been recorded in the region during previous surveys.

Of those reptiles previously recorded, or known for the study area, none are considered to be of national conservation significance. Similarly none are considered to be of local significance in relation to species conservation.

11.4 Frog Species

Only three species of frog, the Green and Golden Bell Frog (*Litoria aurea*), Striped Grass Frog (*Limnodynastes peronii*) and Common Eastern Froglet (*Crinia signifera*), were found during the survey. All three species were recorded in the Marsh Street Wetland. The most notable of these species was the Green and Golden Bell Frog which was found on two evenings (the 3 and 4 of May). A male Bell Frog was caught on the first evening and it had almost completely lost its nuptial pads. The Bell Frogs that were sighted foraging, sitting in the base of bulrushes or moving about the rubble wall in the south-east corner of the wetlands. No frogs were found on the nearby Kogarah Golf Course, an area where Bell Frogs have been found openly foraging in the past. No

calling Bell Frogs were heard during the spotlighting sessions, and no animals responded to playback recordings.

During the rainy evenings large choruses of Striped Grass Frogs were heard at Marsh Street and in the Eve Street Freshwater Wetlands. The latter choruses consisted of at least 30 calling males. Common Eastern Froglets were also calling but their choruses were less distinctive.

Other frog species are known from the wetland areas (Appendix 2), these include the Common Green Tree Frog (*Litoria caerulea*) and the Bleating Tree Frog (*Litoria dentata*), both of which are regarded as locally very uncommon (Rockdale Wetlands Preservation Society pers.comm.). These species were unlikely to have been picked up in this fauna survey as they are species that are active only in the spring/summer period.

12. FAUNA DISCUSSION

The Green and Golden Bell Frog is listed under Schedule 1 of the *TSC Act 1995*. This species has been the subject of a number of recent studies (White and Pyke 1996, Osborne *et al.* 1996) in an attempt to explain its rapid decline in New South Wales. Various factors have been identified as contributing to the decline and, apart from one or two publicised attempts to actively conserve the species, these frogs still appear to be declining (White and Pyke 1996).

Of special interest with Green and Golden Bell Frogs is their propensity to inhabit highly disturbed, and sometimes completely artificial, sites (White 1995). This ability has enabled the species to survive in urban and industrial areas that are otherwise devoid of frog life. Unfortunately, this also leaves the frogs vulnerable to dislocation as the result of impending site re-developments. For example, in NSW, the two largest populations of Green and Golden Bell Frogs, one at Homebush, the other North Cronulla, are subject to development applications.

The Cooks River valley is an area that was known to support a number of populations of Green and Golden Bell Frogs before 1965. Since that time, all known populations in the valley have disappeared. Two populations remain in the Cooks River catchment area, one at Greenacre and the other at Marsh Street. Both of these populations were discovered since 1965 and it is not known whether they are remnants of previous populations or if they are dispersed survivors of now extinct local populations.

12.1 Eve Street Wetlands

The Eve Street Saltmarsh Wetland is not used by the Green and Golden Bell Frogs.

Bell frogs have been observed four times since 1980 in the Eve Street area (in 1980, 1982, 1983 and 1990). On each of these occasions, the frogs were heard calling from temporary fresh-water sites under the two sewer carriers that cross the Eve Street Wetlands. The main sewer carrier is on piers and, during heavy rain, pools form underneath the carrier. These pools often only last for one or two weeks although in 1982 pools lasted for 7 weeks. The smaller and older sewer carrier to the south of the main carrier is also raised on piers. There is a major section underneath this carrier where fresh-water pools for up to 5 months at a time. This area is demarcated by a permanent stand of bulrushes *Typha* spp. The only time that amplexing frogs have been seen at Eve Street was in the bulrush beds under the old sewer carrier.

12.2 Riverine Park

Occasional sightings of Green and Golden Bell Frogs were made in Riverine Park in 1980, 1982 and 1983. Riverine Park was connected with the Eve Street Wetlands by a continuous vegetated corridor (although most of the plants were introduced species). Green and Golden Bell Frogs were recorded on several occasions calling from the northern edge of the pond in this park after heavy rain. On these occasions, Bell Frogs were also heard calling from under the sewer carriers and at Marsh Street. It seems most likely that these frogs had originally dispersed from Marsh Street, entered Eve Street and finally moved south to Riverine Park. No amplexus or spawn masses were ever observed within Riverine Park.

12.3 Marsh Street Wetlands

The Marsh Street Bell Frogs are generally confined to the area around a small storm water basin off Marsh Street, Rockdale. This basin holds water for about 8 months in the year. It is not a natural basin and is bounded by raised rubble and earth banks. There is a small channel that runs south-east from the basin, eventually discharging into the Eve Street Wetland area. The basin contains two permanent stands of bulrushes (*Typha* spp.) and is surrounded by unmaintained areas of grass and weeds.

The population of Green and Golden Bell Frogs in the Marsh Street Wetlands is small with a maximum number of 15 adult frogs being seen on one night in 1983. The frogs use the storm-water basin as their main breeding and refuge area (Figure 3), although breeding has occurred in the Eve Street Freshwater Wetland area and calling frogs have been found on the nearby Kogarah Golf Course.

In, general, it appears that Bell Frogs normally remained in the general area of the Marsh Street storm-water basin except on 5 to 10 occasions each year when they dispersed. Dispersal was always associated with heavy rain and localised flooding in the spring and summer. During these episodes, when the frogs left the basin area, they were observed actively foraging for food (especially along the edges of the fairways of the Kogarah Golf Course or around the drain at the bottom of Eve Street). Calling frogs often remained at Marsh Street with the bulrushes at the northern and southern end of the site being the most commonly used calling areas. During winter, during dry periods the frogs retreated to the southern end of the basin, taking refuge in the bases of the bulrushes or under rocks in the lower parts of the rubble bank.

For foraging frogs to reach the Kogarah Golf Course, they had to cross the northern sewer carrier and enter degraded reed bed areas between the access road for the carrier and the golf course. The frogs may continue to cross the reed beds to reach the fairways of the golf course. Bell Frogs have been observed feeding on insects (especially crickets) along the edges of the reed beds. On a few occasions Bell Frogs have been heard calling from within the reed beds but spawning has not been observed. For dispersing frogs to reach Eve Street the frogs appear to travel along the drain from Marsh Street, sometimes leaving the drain to forage in the grassed reserve opposite. If they continue along the drain, they enter the Eve Street Wetlands and eventually find their way to the fresh-water pools under the sewer carriers.

It is not known if the foraging frogs always return to the storm-water basin in the Marsh Street Wetlands after feeding. This appears to be the case for some adult frogs but not for the majority of recently metamorphosed froglets. No tagging studies have been conducted on these frogs.

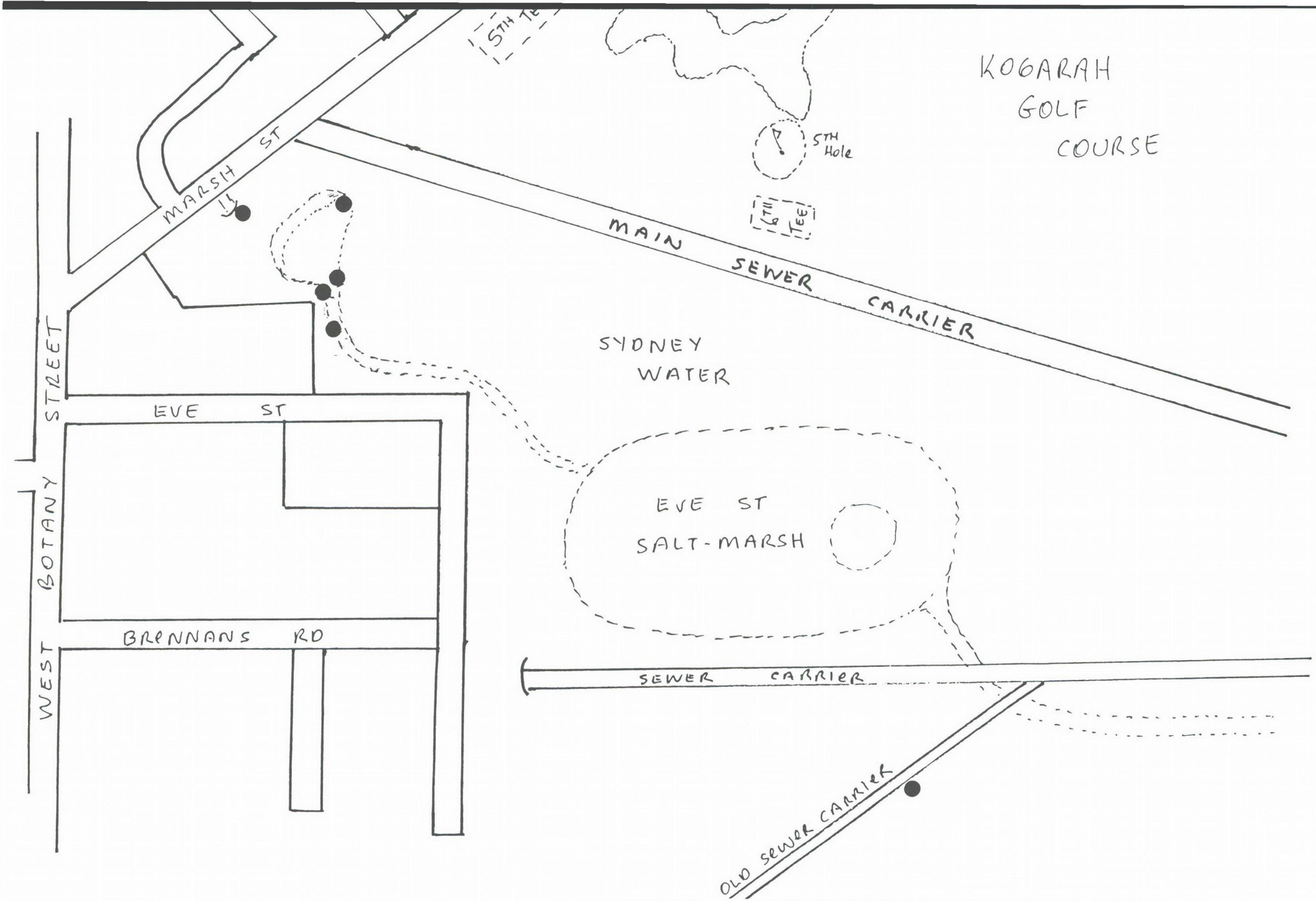


FIGURE 3 : LOCATION OF GREEN AND GOLDEN BELL FROG SPAWNING SITES

It is notable that the Bell Frogs have not permanently colonised any of the ponds on the Kogarah Golf Course, nor is there any evidence that they even attempt to breed in these ponds. Calling Bell frogs have been found near golf course ponds but this does not necessarily mean that breeding has taken place. The only site where spawn has been found outside of the Marsh Street basin was in the Eve Street Wetlands.

Green and Golden Bell Frogs have been found on the Kogarah Golf Course every year since 1980 (see Figure 4 for locations of Bell Frogs on the golf course since 1990). Most of the frogs found there were actively hunting crickets and other invertebrates. The most recent record of Bell Frogs on the Kogarah Golf Course was on the evening of the 3 of October 1995. It is likely that the frogs are present on the golf course at other times as the monitoring of these frogs is limited to relatively few nights in the year (in 1995, the site was visited on 23 occasions, in other years it has been less frequent).

The monitoring study suggests that Green and Golden Bell Frogs only use the Kogarah Golf Course as a feeding area. Juvenile frogs disperse across the golf course each year but no evidence exists in relation to the establishment a secure population elsewhere in the district. The reed-dominated fringe areas parallel to the fairways, especially in damp soil locations, seem to be the most commonly used foraging areas. These sites are often lined with *Phragmites* and infested with exotic weeds. It is likely that movement into these areas for feeding is necessary for this population as the storm-water basin is very limited in area and suitable feeding zones are restricted. Bell Frogs have been observed eating cockroaches and other insects in the Marsh Street Wetland.

The Marsh Street Wetlands are also home to other frogs species. These are permanent populations of Striped Grass Frogs *Limnodynastes peronii* and Common Eastern froglets *Crinia signifera*, and occasional populations of Bleating Tree Frogs *Litoria dentata*. The Striped Grass Frogs are also widespread across the golf course and have permanent populations there.

13. FAUNA CONCLUSION

Given the habit of Green and Golden Bell Frogs to forage throughout the area proposed for the construction of the Motorway, and the use of this area by a number of migratory birds of conservation significance, the potential impacts of the Motorway on these species should be assessed. The construction of the Motorway on piers, while not impacting on the Bell Frogs foraging movements may have an influence on the flight paths of migratory birds. On the other hand, the construction of the Motorway at ground level, would reduce the potential impacts on migratory birds but could reduce the amount of available foraging habitat for Bell Frogs. There is also the potential for polluted runoff to enter the wetland from the Motorway, and the disturbance of the wetland itself due to the movements of vehicles and the construction of piers or earth mounds.

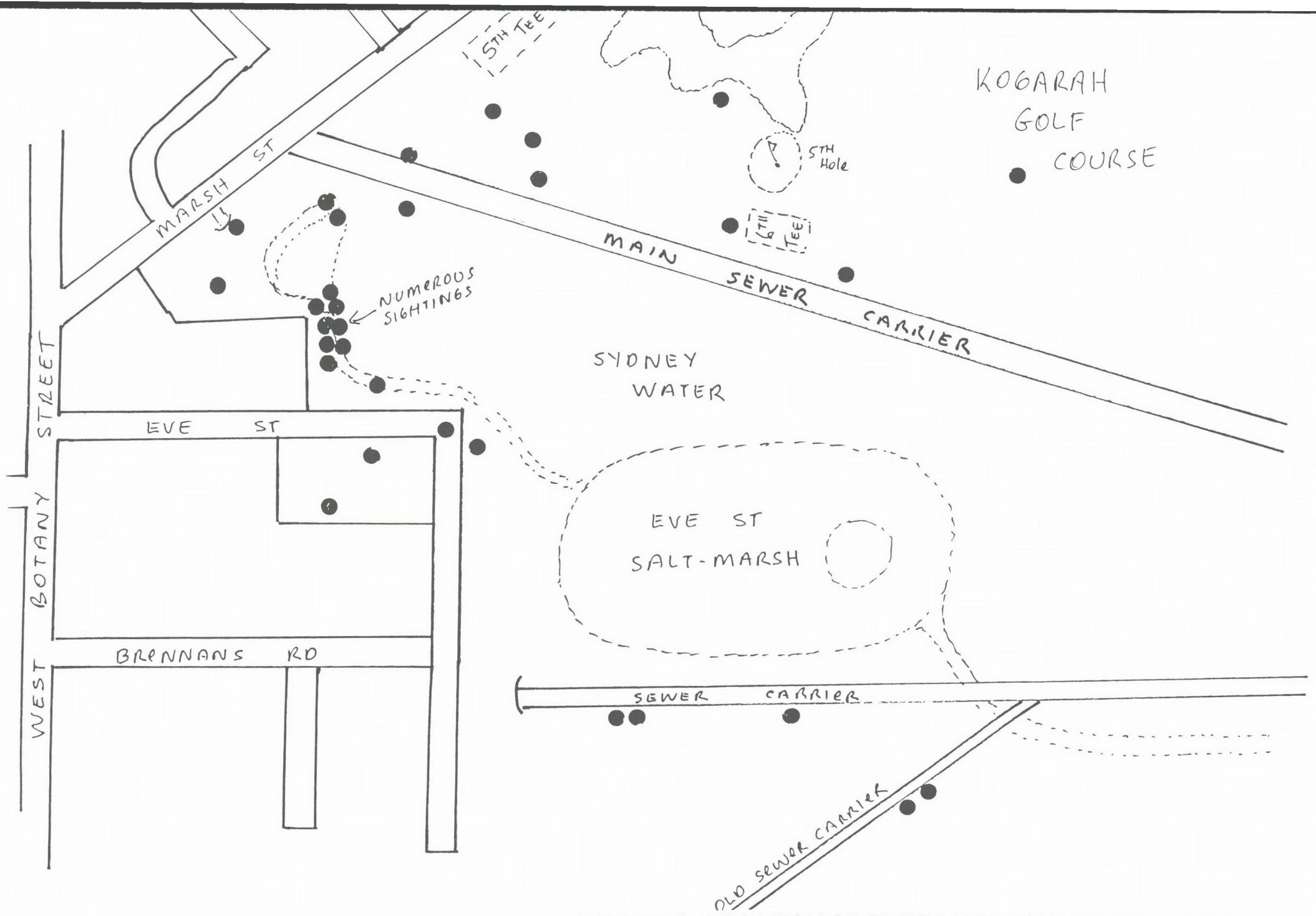


FIGURE 4 : LOCATION OF GREEN AND GOLDEN BELL FROG SIGHTINGS SINCE 1990

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APPENDIX 1

Fax sent by : 562 1888 ROCKDALE CITY COUNCL A4->A4 03/05/96 12:15 Pg: 1/2

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ROCKDALE COUNCIL
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All correspondence to: General Manager,
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DX 25308 Rockdale

Sydney WATER

fax message

To	Andrew Reid		
Company / Division	Engineering Services, Rockdale Council		
Fax	562 1853	Phone	562 1856
From	Annette Williams, Natural Resource Officer.		
Division / Section	Environment Unit, Central Region		
Fax	5514470	Phone	5514426
Date	19 December, 1995	Number of pages including cover	1

Message

successfully

I have provided a list of plants that where planted at the Eve Street Wetland at your request.

These plants naturally occur in the area but I strongly recommend that consideration is given to the site at Cahill Park as to which of the following species to plant.

Native Grasses

Danthonia temulor, Dichelachne crinita, Microleana stipoides, Themeda australis.

Trees

6×5 8×5 4×3 2×1 6×3

Melaleuca armillaris, Melaleuca styphelioides, Melaleuca ericifolia, Acacia suavelolens, Acacia longifolia, ~~Banksia ericifolia~~, Banksia ericifolia, Banksia serrata, Casuarina glauca, Euc. botryoides, Euc. robusta.

4×3 10×3 10×5 15×10 15×10

Shrubs/Ground cover.

1×1 2×3 1×1 2×2 6×5

Lomandra longifolia, Westringia fruticosa, Correa alba, Kunzea ambigua, Leptospermum laevigatum, Viminaria juncea.

6×3

Saltmarsh plants.

Cotula coronopifolia, Juncus krausii, Tetragonia tetragoniodes. — salt water. will work in any region of the intertidal area.

Annette Williams

Lean Smith Reserve

& bike path plants

vert. Wall Monterey

I00

APPENDIX 2

APPENDIX 2: Fauna species known to occur in the vicinity of Eve and Marsh Street Wetlands

Source
1 = Species Recorded During Present Study
2 = National Parks and Wildlife Service (1996)
3 = New South Wales Bird Atlassers (1996)
4 = Rockdale Wetland Preservation Society (1996)
5 = Mount King Ecological Surveys (1995)
6 = Mount King Ecological Surveys (1994)
7 = Mount King Ecological Surveys (1990)

* = *Indicates Introduced Species*
# = *Indicates Species of Conservation Significance*
O = *Indicates Species Listed Under International Agreements*

BIRDS		1	2	3	4	5	6	7
Australian Pelican	*Pelecanus conspicillatus*	x		x				x
O Wedge-tailed Shearwater	*Puffinus pacificus*			x				
O Sooty Shearwater	*Puffinus griseus*			x				
O Short-tailed Shearwater	*Puffinus tenuirostris*			x				
O Fluttering Shearwater	*Puffinus gavia*			x				
O Great-winged Petrel	*Pterodroma macroptera*			x				
O Cape Petrel	*Daption capense*			x				
Darter	*Anhinga melanogaster*			x				x
Pied Cormorant	*Phalacrocorax varius*	x		x				x
Little Pied Cormorant	*Phalacrocorax melanoleucos*			x				x
Great (Black) Cormorant	*Phalacrocorax carbo*		x	x				x
Little Black Cormorant	*Phalacrocorax sulcirostris*			x				x
Hoary-headed Grebe	*Poliocephalus poliocephalus*			x				x
Australasian (little) Grebe	*Tachybaptus novaehollandiae*			x				x
Black Swan	*Cygnus atratus*							x
Pacific Black Duck	*Anas superciliosa*	x	x	x				x
Grey Teal	*Anas gibberifrons*	x	x	x				x
Chestnut Teal	*Anas castanea*	x	x	x				x
* Mallard	*Anas platyrhynchos*			x				
Hardhead	*Aythya australis*			x				x
Australian Wood Duck	*Chenonetta jubata*	x		x				x
Australasian Shoveller	*Anas rhynchotis*			x				x
Pink-eared Duck	*Malacorhynchus membranaceus*		x	x				
Musk Duck	*Biziura lobata*			x				x
# Australasian Bittern	*Botaurus poiciloptilus*			x				x
Little Bittern	*Ixobrychus minutus*							x
Brown Quail	*Coturnix australis*			x				x
Baillon's Crake	*Porzana pusilla*							x
Australian Spotted Crake	*Porzana fluminea*							x

Spottless Crake	*Porzana tabuensis*			x				x
Dusky Moorhen	*Gallinula tenebrosa*	x	x	x				x
Purple Swamphen	*Porphyrio porphyrio*	x	x	x				x
Eurasian Coot	*Fulica atra*			x				x
White-faced Heron	*Ardea novaehollandiae*	x		x				x
White-necked Heron	*Ardea pacifica*							x
Little Egret	*Ardea garzetta*			x				x
o Great Egret	*Ardea alba*			x				x
Intermediate Egret	*Ardea intermedia*							x
Striated Heron	*Ardeola striatus*		x					
Rufous Night Heron	*Nycticorax caledonicus*			x				x
Australain White Ibis	*Threskiornis aethiopica*		x	x				x
Straw-necked Ibis	*Threskiornis spinicollis*	x		x				x
Royal Spoonbill	*Platalea regia*	x		x				x
Yellow-billed Spoonbill	*Platalea flavipes*			x				x
Masked Lapwing (Plover)	*Vanellus miles*	x	x	x				
o # Greater Sand Plover	*Charadrius leschenaultii*		x					
Black-fronted Plover	*Charadrius melanops*		x	x				
Black-winged Stilt	*Himantopus himantopus*	x	x					x
o Marsh Sandpiper	*Tringa stagnatilis*		x	x				
o # Terek Sandpiper	*Xenus cinereus*		x					
o Common Sandpiper	*Tringa hyoleucos*		x	x				
o Curlew Sandpiper	*Calidris ferruginea*		x	x				
o Sharp-tailed Sandpiper	*Calidris acuminata*		x	x				
o # Great Knot	*Calidris tenuirostris*		x	x				
o # Black-tailed Godwit	*Limosa limosa*			x				
o Bar-tailed Godwit	*Limosa lapponica*			x				
Whiskered (Marsh) Tern	*Chlidonias hybrida*			x				
o White-fronted Tern	*Sterna striata*			x				
o # Little Tern	*Sterna albifrons*			x				
o Crested Tern	*Sterna bergii*			x				
# Sooty Oystercatcher	*Haematopus fuliginosus*			x				
# Pied Oystercatcher	*Haematopus longirostris*			x				
o Lesser Golden Plover	*Pluvialis dominica*			x				
Red-kneed Dotterel	*Erythrogonys cinctus*			x				
o # Mongolian Plover	*Charadrius mongolus*			x				
o Double-banded Plover	*Charadrius bicinctus*			x				
Red-capped Plover	*Charadrius ruficapillus*			x				
o Ruddy Turnstone	*Arenaria interpres*			x				
o Eastern Curlew	*Numenius madagascariensis*			x				
o Wimbrel	*Numenius phaeopus*			x				
o Greenshank	*Tringa nebularia*			x				
o Latham's (Japanese) Snipe	*Gallinago hardwickii*			x				
o # Sanderling	*Calidris alba*			x				
o # Broad-billed Sandpiper	*Limicola falcinellus*			x				
o Red-necked Stint	*Calidris ruficollis*			x				

o Red Knot	*Calidris canutus*			x				
Pacific Gull	*Larus pacificus*		x	x				
Silver Gull	*Larus novaehollandiae*	x	x	x				
Franklin's Gull	*Larus pipixcan*		x					
Black-shouldered Kite	*Elanus notatus*			x				x
Whistling Kite	*Milvus sphenurus*			x				x
Grey Goshawk	*Accipiter novaehollandiae*			x				
Brown Goshawk	*Accipiter fasciatus*			x				x
Collared Sparrowhawk	*Accipter cirrhocephalus*	x		x				
Swamp (Marsh) Harrier	*Circus approximans*			x				x
Brown Falcon	*Falco berigora*	x						x
Peregrine Falcon	*Falco peregrinus*			x				
Australian Hobby	*Falco longipennis*			x				x
Australian Kestrel	*Falco cenchroides*	x						x
* Rock Dove	*Columba livia*	x	x	x				
* Spotted Turtle-Dove	*Streptopelia chinensis*	x	x	x				
Crested Pigeon	*Geophaps lophotes*	x						
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*		x					
Galah	*Cacatua roseicapilla*			x				
Long-billed Corella	*Cacatua tenuirostris*			x				
Little Corella	*Cacatua sanguinea*			x				
Sulphur-crested Cockatoo	*Cacatua galerita*			x				
Rainbow Lorikeet	*Trichoglossus haematodus*			x				
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*			x				
Australian King Parrot	*Alisterus scapularis*			x				
Budgerigar	*Melopsittacus undulatus*			x				
Crimson Rosella	*Platycercus elegans*			x				
Eastern Rosella	*Platycercus eximius*			x				
Red-rumped Parrot	*Psephotus haematonotus*			x				
Pallid Cuckoo	*Cuculus pallidus*			x				
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*			x				
Fan-tailed Cuckoo	*Cacomantis flabelliformis*			x				
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*			x				
Common Koel	*Eudynamys scolopacea*			x				
Channel-billed Cuckoo	*Scythrops novaehollandiae*			x				
Southern Boobook	*Ninox novaeseelandiae*			x				
Barn Owl	*Tyto alba*			x				
Tawny Frogmouth	*Podargus strigoides*			x				
Dollarbird	*Eurystomus orientalis*			x				
Azure Kingfisher	*Alcedo azurea*			x				
Sacred Kingfisher	*Halcyon sancta*			x				
Kookaburra	*Dacelo novaeguineae*			x				
Skylark	*Alauda arvensis*			x				
Welcome Swallow	*Hirundo neoxena*	x	x	x				
Tree Martin	*Hirundo nigricans*			x				

Fairy Martin	*Hirundo ariel*		x	x				
Richard's Pipit	*Anthus novaeseelandiae*			x				
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*			x				
White-winged Triller	*Lalage sueurii*			x				
* Red-whiskered Bulbul	*Pycnonotus jocosus*	x	x	x				
* Blackbird	*Turdus merula*	x	x	x				
Restless Flycatcher	*Myiagra inquieta*			x				
Grey Fantail	*Rhipidura fuliginosa*	x						
Willie Wagtail	*Rhipidura leucophrys*	x	x	x				
Clamorous Reed-warbler	*Acrocephalus stentoreus*	x		x				
Little Grassbird	*Megalurus gramineus*			x				
Tawny Grassbird	*Megalurus timoriensis*			x				
Golden-headed Cisticola	*Cisticola exilis*			x				
Superb Fairy-wren	*Malurus cyaneus*	x	x	x				
Varigated Fairy-wren	*Malurus lamberti*			x				
White-browed Scrubwren	*Sericornis frontalis*			x				
Brown Thornbill	*Acanthiza pusilla*			x				
Yellow Thornbill	*Acanthiza nana*			x				
Buff-rumped Thornbill	*Acanthiza reguloides*			x				
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	x	x	x				
Red Wattlebird	*Anthochaera carunculata*	x						
Little Wattlebird	*Anthochaera chrysoptera*			x				
Noisy Friarbird	*Philemon corniculatus*			x				
Noisy Miner	*Manorina melanocephala*			x				
White-plumed Honeyeater	*Lichenostomus penicillatus*	x						
Lewins Honeyeater	*Meliphaga lewinii*			x				
Yellow-faced Honeyeater	*Lichenostomus chrysops*			x				
White-cheeked Honeyeater	*Phylidonyris nigra*			x				
New Holland Honeyeater	*Phylidonyris novaehollandiae*	x	x	x				
Tawny-crowned Honeyeater	*Phylidonyris melanops*			x				
Eastern Spinebill	*Acanthorhynchus tenuirostris*			x				
White-fronted Chat	*Ephthianura albifrons*			x				
Silvereye	*Zosterops lateralis*	x	x	x				
* House Sparrow	*Passer domesticus*	x	x	x				
* European Greenfinch	*Carduelis chloris*			x				
* European Goldfinch	*Carduelis carduelis*	x		x				
Spotted Pardalote	*Pardalotus punctatus*			x				
Mistletoebird	*Dicaeum hirundinaceum*			x				
Red-browed Firetail	*Neochmia temporalis*	x		x				
Zebra Finch	*Taeniopygia guttata*			x				
Double-barred Finch	*Taeniopygia bichenovii*	x		x				
* Common Mynah	*Acridotheres tristis*	x		x				
* Common Starling	*Sturnus vulgaris*	x	x	x				
Spangled Drongo	*Dicrurus bracteatus*			x				
Olive-backed Oriole	*Oriolus sagittatus*			x				
Dusky Woodswallow	*Artamus cyanopterus*			x				

Australian Magpie-lark	*Grallina cyanoeuca*	x		x				
Grey Butcherbird	*Cracticus torquatus*			x				
Australian Magpie	*Gymnorhina tibicen*	x		x				
Pied Currawong	*Strepera graculina*	x		x				
Australian Raven	*Corvus coronoides*	x		x				

MAMMALS		1	4	5	6	7
Long-nosed Bandicoot	*Perameles nasuta*		x			x
Common Ringtail Possum	*Pseudocheirus peregrinus*				x	x
Common Brushtail Possum	*Trichosurus vulpecula*		x		x	x
Grey-headed Flying Fox		x	x			
Eastern Horseshoe Bat	*Rhinolophus megaphyllus*					x
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*					x
Eastern Little Mastiff Bat	*Mormopterus norfokensis*					x
Gould's Long-eared Bat	*Nyctophilus gouldi*					x
Lesser Long-eared Bat	*Nyctophilus geoffroyi*					x
Gould's Wattled Bat	*Chalinolobus gouldii*				x	x
# Common Bent-wing Bat	*Miniopterus schreibersii*				x	x
Little Cave Eptsicus	*Eptesicus pumilus*					x
Water Rat	*Hydromys chrysogaster*		x			x
* Black Rat	*Rattus rattus*	x	x		x	x
* House Mouse	*Mus musculus*		x		x	x
* Rabbit	*Oryctolagus cuniculus*		x		x	x
* Fox	*Vulpes vulpes*	x	x		x	x
* Feral Cat	*Felis catus*		x		x	x
* Dog	*Canis familiaris*	x	x		x	x

REPTILES		1	2	4	6	7
Eastern Snake-necked Turtle	*Chelodina longicollis*				x	
Common Scaly-foot	*Pygopus lepidopodus*		x			x
Jacky Lizard	*Amphibolurus muricatus*			x	x	x
Wall Skink	*Cryptoblepharus virgatus*				x	
Copper-tailed Skink	*Ctenotus taeniolatus*				x	x
Striped Skink	*Ctenotus robustus*	x		x		
Eastern Water Skink	*Eulamprus quoyii*	x		x	x	
Grass Skink	*Lampropholis delicata*	x		x	x	x
Garden Skink	*Lampropholis guichenoti*	x		x	x	x
Eastern Blue-tongued	*Tiliqua scincoides*			x	x	x
Three-toed Skink	*Saiphos equalis*			x	x	
Blind or Worm Snake	*Ramphotyphlpos nigrescens*				x	x
Green Tree Snake	*Dendrelaphis punctulata*				x	
Yellow-faced Whip Snake	*Demansia psammophis*			x	x	x
Black-bellied Swamp Snake	*Hemiaspis signata*			x		x
Eastern Brown Snake	*Pseudonaja textilis*				x	x
Eastern Tiger Snake	*Notechis scutatus*			x		x

Red-bellied Black Snake	*Pseudechis porphyriacus*			x	x	x

AMPHIBAINS		**1**	**2**	**4**	**6**	**7**
Common Eastern Froglet	*Crinia signifera*	x		x	x	x
Brown-striped Frog	*Limnodynastes peronii*	x		x	x	x
Spotted Grass Frog	*Limnodynastes tasmaniensis*				x	x
# Green and Golden Bell Frog	*Litoria aurea*	x	x	x	x	
Green Tree Frog	*Litoria caerulea*			x		
Bleating Tree Frog	*Litoria dentata*			x		
Eastern Dwarf Tree Frog	*Litoria fallax*			x		x
Peron`s Tree Frog	*Litoria peronii*			x		
Leseur`s Tree Frog	*Litoria lesueuri*					x
Brown Toadlet	*Pseudophryne bibronii*					x
Smooth Toadlet	*Uperoleia laevigata*					x

FISH		**1**	**2**	**4**
Long-finned Eel	*Anguilla australis*			x
Flat-tail Mullet	*Liza argentea*			x
Common Silverbiddy	*Gerres ovatus*			x
Yellowfin Bream	*Acanthopagrus australis*			x
* Plague Minnow	*Gambusia holbrooki*			x

APPENDIX 3

PLATE 1 : Looking north west across Eve Street Wetland
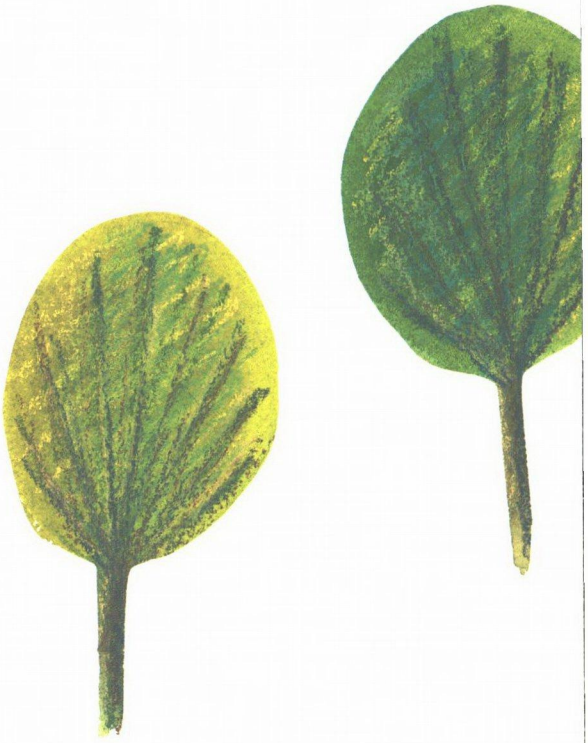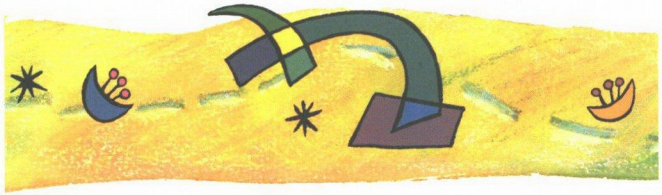
PLATE 2 : Looking north west across Eve Street Wetland. Note saltmarsh islands.