Supplement to Draft

Environmental Impact Statement

Second Sydney Airport Proposal

Volume 5

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COMMONWEALTH DEPARTMENT OF
TRANSPORT AND
REGIONAL SERVICES

PPK
Environment & Infrastructure

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Explanatory and Limitations Statements

This Supplement to the Draft Environmental Impact Statement (Supplement) has been prepared by PPK Environment & Infrastructure Pty Ltd (PPK) and the Commonwealth Department of Transport and Regional Services (DoTRS). The Supplement includes text, data, analyses and other material prepared by DoTRS (inclusive of information from Airservices Australia, Atech Group and Corporate Economics Australia Pty Limited) and other individuals and organisations, most of which are referenced in this Supplement. Except as otherwise stated in this Supplement, PPK has not verified the accuracy or completeness of the material prepared by DoTRS.

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To ensure clarity on some of the figures, names of some suburbs have been deleted from inner western, eastern, south-eastern and north-eastern areas of Sydney. On other figures, only 'Primary' and 'Secondary' centres identified by the Department of Urban Affairs and Planning's Metropolitan Strategy, in addition to Camden, Fairfield and Sutherland, have been shown.

Acknowledgments

The Department of Transport and Regional Services, as proponent of the proposal, would like to thank all members of the EIS team for their dedication to a large, complex and challenging project. The Department would also like to thank all those who took part in the community consultation program and those who lodged submissions on the Draft EIS.

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Appendix F1

Review of Western Sydney Urban Bushland Biodiversity Survey

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Appendix F1

Review of Western Sydney Urban Bushland Biodiversity Study

1. Introduction

During preparation of the Draft EIS, the National Parks and Wildlife Service was conducting an extensive survey of the flora and fauna of western Sydney. The results are now published in the *Western Sydney Urban Bushland Biodiversity Survey* (National Parks and Wildlife Service, 1997a). This survey represents the most recent assessment of the conservation status of native flora and fauna species in the region. The *Western Sydney Urban Bushland Biodiversity Survey* has been reviewed as part of the flora and fauna assessment for the EIS Supplement. It is referred to in the following review as the "Survey".

This review summarises the methodology and compares the results of the Survey with the Draft EIS and the Supplement to the Draft EIS.

Key findings of the Survey include:

- a high level of flora diversity exists in western Sydney despite past and present threatening processes;
- a high proportion of plant species are considered regionally threatened;
- survival of some vegetation (or ecological) communities is seriously threatened;
- low levels of mammal diversity;
- a diverse assemblage of bird species; and
- riparian corridors are important for biodiversity conservation in western Sydney.

2. Survey Areas

Western Sydney Urban Bushland Biodiversity Survey

The sites of the airport options lie within the western Sydney region. The definition of the western Sydney region adopted in this Supplement for the purpose of the flora and fauna assessment is taken from that of the Survey and includes the local government areas of Auburn, Bankstown, Blacktown, Baulkham Hills, Camden, Campbelltown, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta and Penrith. The region covers an area of approximately 245,120 hectares.

Flora studies for the survey in areas relevant to the airport sites included Badgerys Creek between The Northern Road and Elizabeth Drive. Badgerys Creek occurs within the Liverpool Local Government Area and is considered to be regionally significant for flora. Protection of this riparian corridor was recommended. The corridor lies within the sites of the airport options.

The only remnants of fauna habitat surveyed in the Liverpool Local Government Area were Duncans Creek, Hoxton Park Aerodrome and Kemps Creek (National Parks and Wildlife Service 1997a). None of these remnants occur within the airport sites. Badgerys Creek was not identified as significant fauna habitat in the Survey.

Draft EIS

The survey area for the flora and fauna assessment in the Draft EIS included the area covered by the sites of the airport options at Badgerys Creek shown on Figures 9.2, 9.3 and 9.4 in the Draft EIS. This area lies approximately east of Duncans Creek, west of South Creek and between Elizabeth Drive and Bringelly Road, Badgerys Creek. The study area occurs entirely within the Liverpool Local Government Area.

For the purpose of flora and fauna assessment use of the term 'region' in the Draft EIS refers to the Sydney basin biogeographical region, as defined by the *Interim Biogeographic Regionalisation of Australia* (Thackway and Cresswell, 1995).

3. Levels of Significance

The Draft EIS and the *Western Sydney Urban Bushland Biodiversity Study* categorised flora and fauna species into three levels of conservation significance: regional, State and national. The criteria adopted in each document to determine conservation significance are discussed below. Flora and fauna species of regional, State and national significance recorded in the Badgerys Creek area are listed in *Attachments 1* and *2*, respectively.

3.1 Regional Significance

3.1.1 Western Sydney Urban Bushland Biodiversity Survey

Flora

The regional significance of flora is assessed in the Survey using criteria adapted from Benson and McDougal (1991) and Sheringham and Westaway (1995). The Survey identifies two levels of significance for flora in western Sydney: "regionally significant" and "vulnerable". Regionally significant flora conform to one or more of the following criteria:

- *endemic taxa* with known distribution restricted to western Sydney or the Sydney region;
- *rare taxa* that are uncommon within western Sydney, that is recorded from only five or less localities (mostly within the last 30 years) or occurring in less than three of the 12 local government areas;
- *rare or threatened habitats*. Taxa restricted to rare or endangered habitats, for example, rainforest or river-flat forest;
- *disjunct taxa* with populations remote from other known populations outside of western Sydney; and
- *distributional limit*. Taxa reaching their or close to their natural geographic limit within western Sydney or the Sydney region.

Vulnerable species are defined as those which are protected within less than three conservation reserves in western Sydney. The vulnerable sub-category is further divided into V1, V2 and V3, as follows:

- V1 = Regionally vulnerable taxa which are also listed nationally as *Rare or Threatened Australian Plants* (Briggs and Leigh, 1995) or state-wide on the *Threatened Species Conservation Act, 1995*, as regionally significant or rare. These taxa are considered to be the most vulnerable. The regionally significant and rarer taxa are not protected by legislation, are at particular risk and may face extinction within the next ten years;
- V2 = Regionally vulnerable taxa which are uncommon (6-10 records). These taxa will move into the V1 classification in the near future if not adequately protected now; and
- V3 = Regionally vulnerable taxa which are relatively uncommon to widespread and are unlikely to become regionally extinct in the near future. With the implementation of the "Comprehensive, Adequate and Representative" reserve system (National Parks and Wildlife Service, 1997a) or 'CAR', within the

region these species should be adequately protected both within and outside of reserves.

Regionally significant flora species recorded in the Badgerys Creek area are listed in *Table 1.1* of *Attachment 1*.

Fauna

The Survey assesses regional significance of fauna using criteria derived from consideration of the *Threatened Species Conservation Act, 1995*, CAR criteria and the International Union for the Conservation of Nature (1994) "Red List" categories. Regionally significant fauna recorded in the Badgerys Creek area are listed in *Table 2.1* of *Attachment 2*.

3.1.2 Draft EIS

Flora

The significance of flora at a regional level is assessed in the Draft EIS by reference to relevant government reports, consultation with experts familiar with the area, scientific literature, and the experience of the consultants (refer *Table 1.1 of Attachment 1*). Benson and McDougall (1991), Benson (1992) and Keith (1994) are also referred to in determining regional significance for plant species.

Fauna

The regional significance of fauna is assessed in the Draft EIS by reference to relevant government reports, consultation with experts familiar with the area, scientific literature, and the experience of the consultants. Species listed under international treaties were also considered, including the Japan–Australia Migratory Birds Agreement (JAMBA) and the China–Australia Migratory Birds Agreement (CAMBA). They are referred to as J/C in *Table 2.1* of *Attachment 2*.

3.2 State Significance

The significance of flora and fauna at a State level was determined in both the Survey and the Draft EIS according to listings under the *Threatened Species Conservation Act, 1995*. Vulnerable species are those listed under Schedule 2 of the Act and endangered species are those listed under Schedule 1 of the Act. Flora and fauna species of State significance recorded during the Survey in Liverpool Local Government Area and during the Draft EIS are listed in *Tables 1.2* and *2.2* of *Attachments 1* and *2* respectively.

3.3 National Significance

Flora of national significance in the Draft EIS and in the Survey are those listed as *Rare or Threatened Australian Plants* (Briggs and Leigh, 1995) and those listed under the *Endangered Species Protection Act, 1992*.

There is no statement on how the national significance of fauna was assessed in the Survey. Nationally significant fauna in the Draft EIS are those listed under the *List of Threatened Australian Vertebrate Fauna* (Australian and New Zealand Environment Conservation Council, 1995) and those listed under the *Endangered Species Protection Act.*

4. Results

4.1 Flora Species

4.1.1 Regionally Significant Flora

Badgerys Creek was considered to be of regional significance for western Sydney flora in the Survey and in the Draft EIS. Regionally significant species whose significance ratings differed between the Survey and Draft EIS are listed in *Table F1.1*. Regionally significant flora species recorded within the Liverpool Local Government Area during the Survey that were not recorded within the sites of the airport options are presented in *Table 1.1* of *Attachment 1*.

Table F1.1: Regionally Significant Flora Species from the Sites of the Airport Options Differing in their Recorded Occurrence and/or Significance in Western Sydney Urban Bushland Biodiversity Survey and Draft EIS

Flora species	Western Sydney Urban Bushland Biodiversity Survey Rating	Draft EIS Rating
Angophora subvelutina	Vulnerable (V3)	Regional
Eriochloa pseudoacrotricha	Vulnerable (V2)	Not recorded
Eucalyptus amplifolia	Vulnerable (V3)	Regional

The significance ratings presented in *Table F1.1* differ as a result of the different scopes of each report. The geographic scope of the Survey incorporated all of western Sydney, whereas studies for the Draft EIS were site specific and were conducted over a shorter time period.

4.1.2 Threatened Flora

All threatened flora species identified in the Survey in the Badgerys Creek area were considered in the Draft EIS. However, within Liverpool Local Government Area six additional threatened species were identified in the Survey and are listed in *Table 1.2* of *Attachment 1*.

4.2 Vegetation Communities

Vegetation communities recorded during the Survey and the Draft EIS are presented in *Table F1.2*. The survey identified two significant vegetation communities along the Badgerys Creek corridor, Swamp Oak Forest and Red Gum-Cabbage Gum Forest. As the Survey only covered the riparian corridor of Badgerys Creek and not the surrounding areas, the vegetation community Grey Box Woodland was not recorded in this area. The River-flat Forest community recorded in the Draft EIS incorporates the Swamp Oak Forest and Red Gum-Cabbage Gum Forest communities listed in the Survey. River-flat Forest has received preliminary listing as an endangered ecological community under Schedule 1 of the *Threatened Species Conservation Act*.

Table F1.2: Vegetation Communities Recorded within the Sites of the Airport Options

Vegetation Communities	Western Sydney Urban Bushland Biodiversity Survey Rating	Draft EIS Rating
Grey Box Woodland	(Not recorded)	Regional
River-Flat Forest	(Different name)	Local
Pasture/Disturbed Woodland	(Not recorded)	Local
Swamp Oak Forest	Regional	(Different name)
Red Gum-Cabbage Gum Forest	Regional	(Different name)

4.3 Fauna

4.3.1 Regionally Significant Fauna

There are no site specific fauna records in the Survey for the sites of the airport options or the Badgerys Creek area. However, a total of 28 regionally significant fauna species were recorded in the Liverpool Local Government Area, that were not recorded on the airport sites. In addition, there are differences in the ratings given to regionally significant fauna species between the Survey and the Draft EIS. These species are presented in *Table 2.1* of *Attachment 2*.

Threatened Fauna

The Survey does not specifically identify any threatened fauna species from Badgerys Creek. However, within the Liverpool Local Government Area there were three threatened fauna species listed in the Survey that were not recorded on the airport sites. Two of these threatened species are amphibians that are restricted to Hawkesbury Sandstone, which does not occur within the sites of the airport options.

Threatened fauna species recorded in the area surrounding the sites of the airport options are presented in *Table 2.2* of *Attachment 2*.

4.4 Local Biodiversity

The Survey identifies "core biodiversity areas" that contain significant remnants of threatened vegetation communities that are not protected in conservation reserves. The sites of the airport options are not listed as a core biodiversity area for flora or fauna conservation. Badgerys Creek however, from The Northern Road to Elizabeth Drive, is considered to be a riparian corridor of regional significance and protection of the corridor is recommended (National Parks and Wildlife Service, 1997a). The Survey focused on important vegetation remnants in the Liverpool local government area but did not target the airport sites specifically. A total of 28 fauna species of regional significance and three of State significance were recorded in Liverpool that were not recorded on the airport sites (refer *Attachment 2*).

A number of core biodiversity areas were identified in the vicinity of the airport sites, including Kemps Creek and South Creek. These creeks are also recognised for their riparian corridor values. Up to 75 native flora species have been recorded in Kemps Creek. South Creek forms an important corridor, providing connections between conservation areas. Six regionally significant flora species and 36 regionally vulnerable species have been recorded in the vicinity of South Creek. Duncans Creek, immediately south-west of the airport sites, is identified as a "complementary biodiversity area". These areas are considered important for biodiversity conservation, but have less ecological value than core biodiversity areas. However, two regionally significant and 30 regionally vulnerable flora species have been recorded in Duncans Creek.

4.5 Summary

A summary of the results of the review of the *Western Sydney Urban Bushland Biodiversity Survey* relating to the sites of the airport options is as follows:

Flora

- the Survey recorded three regionally vulnerable flora species along Badgerys Creek. Two of these species were considered to be of regional significance in the Draft EIS (refer *Table 1.1* in *Attachment 1*); and
- all threatened flora species identified along Badgerys Creek in the Survey were considered in the Draft EIS. Within the Liverpool Local Government Area six additional threatened species were identified, and are presented in *Table 1.2* of *Attachment 1*.

Vegetation Communities

- Red Gum-Cabbage Gum Forest and Swamp Oak Forest recorded along Badgerys Creek are considered to be of regional significance as a riparian habitat in the Survey;

- the Survey only examined Badgerys Creek, and not other remnants within the sites of the airport options. Therefore only two vegetation communities were recorded whereas Draft EIS examined three vegetation communities;

Fauna

- fauna studies for the Survey are based on the entire Liverpool Local Government Area, whereas the Draft EIS is specific to the sites of the airport options;
- the Survey considers Badgerys Creek to have no significance for fauna in western Sydney; and
- the Survey recorded 28 species of regional significance and three species of State significance in the Liverpool Local Government Area that were not considered in Draft EIS (refer *Attachment 2*).

5. Conservation Significance

The Survey does not provide a rating for the conservation significance of the airport sites. It does, however, provide significance ratings for flora species and vegetation communities recorded along Badgerys Creek. Significance levels for fauna along Badgerys Creek were not provided.

- flora species - regional significance;
- vegetation communities - regional significance as a creek corridor; and
- fauna – not significant. Badgerys Creek was not mentioned as being of significance for fauna.

The conservation significance of the sites of the airport options was previously assessed in Section 5.2.2 of the Draft EIS. The assessment criteria incorporating *Western Sydney Urban Bushland Biodiversity Survey* alterations are presented below in *Table F1.3*.

Table F1.3: Assessment of Conservation Significance for the Sites of the Airport Options

Significance Assessment Criteria	Assessment
Ecological integrity	Unchanged (still applicable)
Habitat quality	Unchanged (still applicable)
Introduced flora species	Unchanged (insufficient details available)

Significance Assessment Criteria	Assessment
Significant flora species	Unchanged (still applicable)
Significant fauna species (predicted)[1]	Two national (unchanged), 13 State (three additional), 48 Regional (28 additional)
Significant vegetation community	River Flat forest (additional) and Grey Box Woodland (unchanged) of regional significance (unchanged)
Fauna – international agreements	Unchanged (insufficient site information available)
Size	Unchanged (still applicable)
Connectivity	Unchanged (still applicable)
Viability	Unchanged (still applicable)
Representativeness	Regional examples of Grey Box Woodland (unchanged) and River-flat Forest (additional)
Richness and diversity	Five vegetation communities (two additional); 176 native flora species (unchanged – insufficient site information) and 211 fauna species (unchanged – insufficient site information)
Social values	Unchanged (still applicable)

Note: 1. Species recorded in the area and considered to be potential visitors to the airport sites.

The sites of the airport options are considered to have regional significance for nature conservation in the Draft EIS. The findings of the Survey are generally consistent with those of the Draft EIS and do not necessitate a change in the given significance rating. However, populations of *Meridolum corneovirens* (Cumberland Plain Large Land Snail) listed as endangered under Schedule 1 of the *Threatened Species Conservation Act, 1995*, were recorded within the airport sites during studies for the EIS Supplement. As a result of this finding, the conservation significance of the airport sites has been reassessed to be of State significance.

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Attachment 1

Significant Flora Species

Table 1.1: Flora Species of Regional Significance Recorded in the Badgerys Creek Area

Flora Species	Western Sydney Urban Bushland Biodiversity Survey Rating[1]	Draft EIS Rating[1]
Acacia binervata	-	Regional (Not Recorded)
Acacia falciformis	Regional	-
Acacia filicifolia	Regional	-
Acacia implexa	-	Regional (Recorded)
Aegicerus corniculatum	Vulnerable (V1)	-
Agrostis aemula	Vulnerable (V1)	-
Allocasuarina nana	-	Regional (Not Recorded)
Alphitonia exelsa	-	Regional (Not Recorded)
Alternanthera Sp. A	Regional	-
Amyema gaudichaudii	Vulnerable (V3)	Regional (Recorded)
Amyema miquelii	-	Regional (Recorded)
Angophora hispida	-	Regional (Recorded)
Aotus ericoides	-	Regional (Not Recorded)
Arthropodium milleflorum	Vulnerable (V3)	Regional (Recorded)
Austrostipa setacea	Regional	-
Avicennia marina	Vulnerable (V3)	Regional (Not Recorded)
Beyeria viscosa	Regional	-
Blechnum ambiguum	-	Regional (Not Recorded)
Bolboschoenus fluviatilis	Regional	-
Bossiaea neo-anglica	-	Regional (Not Recorded)
Bothriochloa decipiens	-	Regional (Not Recorded)
Bothriochloa macra	Vulnerable (V3)	Regional (Recorded)
Bracteantha viscosa	Regional	-
Bulbophyllum exiguum	Regional	-
Caleana major	Vulnerable (V2)	Regional (Not Recorded)
Calomeria amaranthoides	Regional	-
Calotis lappulacea	-	Regional (Not Recorded)
Capillipedium parviflorum	Regional	-
Cardamine paucijuga	Regional	-
Carex breviculmis	Vulnerable (V3)	Regional (Recorded)
Carex fascicularis	Regional	-
Cassinia aureonitens	Vulnerable (V2)	Regional (Not Recorded)
Chenopodium carinatum	Regional	-

Flora Species	Western Sydney Urban Bushland Biodiversity Survey Rating[1]	Draft EIS Rating[1]
Chorizema parviflorum	Vulnerable (V3)	Regional (Not Recorded)
Chrysocephalum apiculatum	Vulnerable (V3)	Regional (Recorded)
Cladium procerum	Regional	-
Cleistochloa rigida	Regional	-
Clematis glycinoides	-	Regional (Recorded)
Clerodendrum tomentosum	-	Regional (Not Recorded)
Convolvulus erubescens	Vulnerable (V3)	Regional (Recorded)
Crowea exalata	Regional	-
Cymbonotus lawsonianus	Vulnerable (V3)	Regional (Recorded)
Cymbopogon refractus	-	Regional (Recorded)
Cynoglossum australe	Regional	-
Cyperus difformis	Vulnerable (V3)	Regional (Recorded)
Cyperus fulvus	Regional	-
Cyperus haspan	Regional	-
Cyperus imbecillus	Vulnerable (V1)	-
Cyperus mirus	Vulnerable (V1)	-
Cyperus polystachyos	Vulnerable (V3)	Regional (Recorded)
Danthonia caespitosa	Vulnerable (V1)	-
Danthonia linkii	Vulnerable (V3)	Regional (Not Recorded)
Danthonia longifolia	Vulnerable (V3)	Regional (Not Recorded)
Daviesia alata	Regional	-
Daviesia corymbosa	Vulnerable (V3)	Regional (Not Recorded)
Daviesia genistifolia	Vulnerable (V3)	Regional (Recorded)
Desmodium brachypodum	Vulnerable (V3)	Regional (Recorded)
Dianella caerulea var. *producta*	Vulnerable (V1)	
Digitaria breviglumus	Regional	-
Digitaria longiflora	Regional	-
Doryanthes excelsa	-	Regional (Not Recorded)
Drosera glandulifera	Regional	-
Duboisia myoporoides	-	Regional (Recorded)
Dysphania littoralis	Regional	-
Echinochloa colona	Regional	-
Einadia nutans	Vulnerable (V3)	Regional (Recorded)
Eleocharis acuta	Vulnerable (V2)	Regional (Recorded)

Flora Species	Western Sydney Urban Bushland Biodiversity Survey Rating[1]	Draft EIS Rating[1]
Eleocharis atricha	Vulnerable (V1)	-
Eleocharis pusilla	Regional	-
Epilobium billardierianum ssp. *cinereum*	Vulnerable (V3)	Regional (Recorded)
Epilobium hirtigerum	Regional	-
Eremophila debilis	Vulnerable (V3)	Regional (Recorded)
Eucalyptus botryoides	Vulnerable (V1)	-
Eucalyptus capitellata	Regional	-
Eucalyptus elata	Regional	-
Eucalyptus notabilis	Vulnerable (V1)	-
Eucalyptus paniculata	Vulnerable (V3)	Regional (Not Recorded)
Eucalyptus sclerophylla	-	Regional (Not Recorded)
Euchiton gymnocephalus	Vulnerable (V1)	
Euchiton sphaericus	Vulnerable (V3)	Regional (Not Recorded)
Exocarpus strictus	-	Regional (Recorded)
Fuirena ciliaris	Regional	-
Galium liratum	-	Regional (Not Recorded)
Geranium solanderi	Vulnerable (V3)	Regional (Recorded)
Glycine microphylla	-	Regional (Not Recorded)
Gnaphalium gymnocephalum	-	Regional (Not Recorded)
Gonocarpus longifolius	Regional	-
Grammitis billardiera	Vulnerable (V1)	-
Hibbertia hermannifolia	Regional	-
Hibbertia riparia	Vulnerable (V3)	Regional (Not Recorded)
Hydrocotyle verticillata	Regional	-
Isolepis producta	Regional	-
Juncus flavidus	Regional	-
Juncus fockei	Regional	-
Juncus krausii ssp. *australiensis*	Regional	-
Juncus mollis	Regional	-
Juncus polyanthemos	Regional	-
Lasiopetalum parviflorum	Vulnerable (V3)	Regional (Not Recorded)
Lasiopetalum rufum	Regional	-
Lepidosperma longitudinale	Regional	-
Leptorhynchus nitidulus	Regional	-

Flora Species	Western Sydney Urban Bushland Biodiversity Survey Rating[1]	Draft EIS Rating[1]
Leucopogon juniperinus	Vulnerable (V3)	Regional (Recorded)
Lilaeopsis polyantha	Regional	-
Limosella australis	Regional	-
Linum marginale	Vulnerable (V3)	Regional (Recorded)
Lomandra micrantha	-	Regional (Not Recorded)
Lythrum hyssopifolia	Vulnerable (V3)	Regional (Recorded)
Marsdenia viridiflora	Regional	-
Marsilea hirsuta	Vulnerable (V2)	Regional (Recorded)
Melaleuca squamea	-	Regional (Not Recorded)
Mimulus repens	Regional	-
Muellerina eucalyptoides	Vulnerable (V3)	Regional (Not Recorded)
Muellerina celastroides	Regional	-
Opercularia aspera	Vulnerable (V3)	Regional (Recorded)
Ophioglossum lusitanica ssp. *coriaceum*	Regional	-
Oplismenus aemulus	-	Regional (Recorded)
Ottelia ovalifolia	-	Regional (Recorded)
Oxalis perennans	Vulnerable (V3)	Regional (Recorded)
Oxalis radicosa	Vulnerable (V3)	Regional (Not Recorded)
Pandorea pandorana	-	Regional (Recorded)
Parsonsia lanceolata	Regional	-
Paspalum distichum	-	Regional (Recorded)
Paspalum orbiculare	Regional	-
Pelargonium australe	Regional	-
Pellaea falcata	-	Regional (Not Recorded)
Persicaria praetermissa	Vulnerable (V3)	Regional (Not Recorded)
Phyllanthus gasstroemii	-	Regional (Not Recorded)
Phyllanthus similis	Vulnerable (V3)	Regional (Recorded)
Plantago debilis	Vulnerable (V3)	Regional (Recorded)
Poa labillardieri	Vulnerable (V3)	Regional (Recorded)
Pomaderris aspera	Regional	-
Pomaderris ferruginea	Vulnerable (V3)	Regional (Not Recorded)
Podocarpus spinulosus	Vulnerable (V2)	Regional (Not Recorded)
Potamogeton javanicus	Regional	-
Potamogeton tricarinatus	-	Regional (Recorded)

Flora Species	Western Sydney Urban Bushland Biodiversity Survey Rating[1]	Draft EIS Rating[1]
Prostanthera incana	Regional	-
Prostanthera violacea	Vulnerable (V1)	-
Pterostylis parviflora	Regional	-
Pultenaea hispidula	-	Regional (Not Recorded)
Pultenaea pedunculata	Regional	-
Ranunculus lappaceus	Vulnerable (V3)	Regional (Recorded)
Ranunculus sessiliflorus	Regional	-
Rumex brownii	Vulnerable (V3)	Regional (Recorded)
Samolus repens	Vulnerable (V1)	-
Sarcocornia quinqueflora	Vulnerable (V1)	-
Schizaea bifida	Vulnerable (V3)	Regional (Not Recorded)
Schoenoplectus subulatans	Regional	-
Schoenus imberbis	Vulnerable (V1)	-
Scleria mackaviensis	Regional	-
Selliera radicans	Regional	-
Senecio hispidulus var. *dissectus*	-	Regional (Not Recorded)
Senecio hispidulus var. *hispidulus*	Vulnerable (V3)	Regional (Recorded)
Senecio vagus ssp. *eglandulosus*	Regional	-
Senna odorata	Regional	-
Sida corrugata	Vulnerable (V2)	Regional (Recorded)
Sida spinosa	Regional	-
Solanum campanulatum	Regional	-
Solanum pungetium	Vulnerable (V3)	Regional (Recorded)
Sparaganium subglobosum	Regional	-
Sporabolus virginicus	Vulnerable (V1)	-
Stipa ramosissima	-	Regional (Not Recorded)
Tetratheca neglecta	Regional	-
Teucrium argutum	Regional	-
Thysanotus juncifolius	Vulnerable (V1)	-
Tricoryne simplex	Vulnerable (V3)	Regional (Recorded)
Tristaniopsis laurina	-	Regional (Not Recorded))
Vittadinia cuneata var. *cuneata*	Vulnerable (V3)	Regional (Recorded)
Wahlenbergia luteola	Regional	-

Regional Fauna Species	Western Sydney Urban Bushland Biodiversity Survey Rating[1]	Draft EIS Rating[1]
Short-beaked Echidna	Regional	Local (not recorded)
Brown Antechinus	Regional	-
Long-nosed Bandicoot	Regional	-
Common Wombat	Regional	-
Greater Glider	Regional	-
Eastern Pygmy-possum	Regional	-
Red-necked Wallaby	Regional	-
Eastern Grey Kangaroo	Regional	-
Swamp Wallaby	Regional	-
Grey-headed Flying Fox	Local	Regional
White-striped Mastiff Bat	Local	Regional

Notes: 1. Not recorded and no significance rating provided.
2. Species listed under Japan Australia Migratory Birds Agreement or the China Australia Migratory Birds Agreement.

Table 2.2: Fauna Species of State Significance Recorded in the Area Surrounding the Sites of the Airport Options

Threatened Fauna Species	Western Sydney Urban Bushland Biodiversity Survey Rating[1]	Draft EIS Rating[1]
Birds		
Sooty Owl	Vulnerable	-
Amphibians		
Barred Frog	Vulnerable	-
Red-crowned Toadlet	Vulnerable	-
Mammals		
Eastern False Pipistrelle	-	Vulnerable
Eastern Little Mastiff Bat	-	Vulnerable
Yellow-bellied Sheathtail Bat	-	Vulnerable

Note: 1. Not recorded and no significance rating provided.

Appendix F2

Conservation Significance of Remnant Endangered Ecological Communities

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Appendix F2

Conservation Significance of Remnant Endangered Ecological Communities

1. Introduction

Field surveys of the vegetation communities present within the sites of the airport options were undertaken by Biosis Research from 22 to 25 September 1998, 28 September 1998 and 11 January 1999. Existing vegetation remnants within the airport sites were numbered and assessed. A total of 53 remnants were surveyed. The following report represents the results of these surveys.

The following headings are used to evaluate each remnant and an explanation is provided for each:

- Remnant Number: The number assigned to each remnant, as shown on *Figure 14.1* of this Supplement;
- Size: The area (in hectares) of the remnant;
- Options: the airport options within which the remnant occurs;
- Vegetation Community: The dominant vegetation community(s) present within the remnant;
- Description: The structure, condition and dominant species within the remnant;
- Condition: A brief summary of the overall condition of the vegetation community;
- Conservation Significance: Assessed as either national, State, regional or local, based on criteria described in *Section 14.5* of this Supplement; and
- Status of *Meridolum corneovirens*: The presence of the Cumberland Plain Large Land Snail (*Meridolum corneovirens)* and the condition of potential snail habitat is noted.

2. Survey Results

Remnant Number: 1

Size: 7.9 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest

Description: The vegetation adjacent to Badgerys Creek is dominated by Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* to 20 metres high, Swamp She-Oak *Casuarina glauca* to 15 metres and the Paperbark *Melaleuca decora* reaching heights of eight metres, which are scattered throughout the length of the remnant. The understorey and ground cover layers of this riparian vegetation are highly degraded. These vegetation layers are subject to a high level of disturbance as a result of weed invasion, soil erosion and livestock traffic.

Condition: Very poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was absent from this remnant and no suitable habitat for this species was recorded.

Remnant Number: 2

Size: 6.1 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest

Description: The vegetation adjacent to Badgerys Creek is dominated by Forest Red Gum *Eucalyptus tereticornis* and Grey Box *Eucalyptus moluccana* to 20 metres high, the Paperbarks *Melaleuca decora* and *Melaleuca nodosa* reaching heights of 6 metres. The generally sparse shrub layer is dominated by dense Blackthorn *Bursaria spinosa* patches and Everlasting Paper Daisy *Ozothamnus diosmifolium* throughout. Ground cover species include a mix of native and exotic grasses. These vegetation layers are subject to a high level of disturbance as a result of weed invasion and vehicular access.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 3

Size: 17.9 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest

Description: The vegetation remnant on the eastern side of the junction of Badgerys Creek Road and Badgerys Creek is dominated by Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* with a number of mature trees reaching heights of 20-30 metres. A sparse shrub layer is dominated by Blackthorn *Bursaria spinosa* reaching heights of 1.5 metres. Ground cover is sparse and dominated by weeds with few native herb species scattered throughout. Vegetation directly adjacent to Badgerys Creek is completely weed dominated.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was moderate.

Remnant Number: 4

Size: 3.4 hectares

Options: B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: Not determined as access denied.

Condition: Not determined as access denied.

Conservation Significance: Not determined as access denied.

Status of *Meridolum corneovirens*: Not determined as access denied.

Remnant Number: 5

Size: 25.9 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest

Description: Vegetation adjacent to Badgerys Creek, south-west of Badgerys Creek Road crossing of Badgerys Creek, is dominated by Grey Box *Eucalyptus moluccana*, Forest Red Gum *Eucalyptus tereticornis* (occasionally reaching heights of 15-25 metres), Paperbark *Melaleuca decora* and Swamp She-Oak *Casuarina glauca*. Shrubs occurring within this remnant include Blackthorn *Bursaria spinosa* and the Sydney Green Wattle *Acacia decurrens*. The ground cover layer consists of weed and pasture grasses. Most of the site away from the creek line is open to grazing and livestock traffic.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was moderate.

Remnant Number: 6

Size: 7.9 hectares

Options: B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest

Description: The vegetation of this remnant has a canopy layer consisting of Grey Box *Eucalyptus moluccana*, Forest Red Gum *Eucalyptus tereticornis* and Broad-leaved Apple *Angophora subvelutina* (occasionally reaching heights of 15 to 20 metres). These larger trees occur scattered throughout the remnant. A sparse mono-stand of the Paperbark *Melaleuca decora* occurs within this remnant with plants reaching 10 metres high. The ground cover layer consists of the Native Bluebell *Wahlenbergia gracilis*, weeds and pasture grasses. Other ongoing disturbances within the remnant include grazing and associated livestock disturbance of the soil and ground cover plants.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 7

Size: 6.2 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant occurs as scattered patches of Cumberland Plain Woodland that are dominated by Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis*. Within the patches, larger trees reach heights of 20 to 25 metres and have a scattered distribution. The patches are typically devoid of a shrub layer because of grazing and trampling pressures while the sparse ground cover is dominated by introduced pasture grasses and weed species. Ongoing disturbances within the remnant include grazing and associated livestock disturbance of the soil and ground cover plants and weed invasion.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 8

Size: 1.5 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: Four smaller patches of Cumberland Plain Woodland make up this remnant. These smaller patches typically occur as regrowth woodland where small trees of only 10 metres high form dense stands. This small tree layer is dominated by Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis*. The dense shrub layer of this remnant is dominated by Blackthorn *Bursaria spinosa*, while weeds dominate the sparse to dense ground cover.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 9

Size: 3.1 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: This remnant consists of three patches of Cumberland Plain Woodland that are dominated by Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* which reach heights of 25 metres. The European Olive *Olea europea spp. africana* and Blackthorn *Bursaria spinosa* are the dominant species of a sparse to dense shrub layer. Ground cover species consist of a mix of native and introduced grasses. Ongoing disturbances within the remnant include grazing and associated livestock disturbance of the soil and ground cover plants and weed invasion.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 10

Size: 7.2 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest.

Description: The creek line vegetation and adjacent Cumberland Plain Woodland within this remnant is highly degraded as a result of grazing and associated livestock traffic. The canopy species within this remnant include young Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* to heights of 10 to 15 metres, with small stands of *Angophora subvelutina* occurring away from the creek line. The sparse shrub layer of this remnant is dominated by White Feather Honeymyrtle *Melaleuca decora* and Blackthorn *Bursaria spinosa*. The sparse ground cover layer is weed dominated.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 11

Size: 4.8 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest

Description: The vegetation occurring within this remnant is sparse. The creek line is very disturbed and is dominated by Swamp She-Oak *Casuarina glauca*. The introduced shrub *Olea europea* ssp. *africana* is scattered throughout the understorey of the remnant while the ground cover layer is dominated by pasture grasses and weeds.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. No suitable habitat for this species was recorded.

Remnant Number: 12

Size: 0.2 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The woodland of this remnant is dominated by regrowth Grey Box *Eucalyptus moluccana* to heights of 15 metres. The sparse shrub layer consists only of African Box Thorn *Lycium ferocissimum* and the ground cover is pasture grass and weed dominated. Grazing disturbance is an ongoing threat to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 13

Size: 1.1 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland.

Description: The woodland of this remnant consists of regrowth Grey Box *Eucalyptus moluccana* to heights of 15 metres. The sparse shrub and ground cover layers are dominated by introduced flora species.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 14

Size: 2.1 hectares

Options: A, B and C

Vegetation Community: River-flat Forest

Description: The vegetation of this remnant is highly degraded. Swamp She-Oak *Casuarina glauca* is scattered along the creek line of this remnant. Shrub and ground cover layers are dominated by introduced flora species.

Condition: Very Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 15

Size: 0.7 hectares

Options: A, B and C

Vegetation Community: Pine forest.

Description: Not a native vegetation remnant

Condition: Very poor

Conservation Significance: None

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. No suitable habitat for this species was recorded.

Remnant Number: 16

Size: 4.6 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland.

Description: The canopy of this remnant is dominated by Grey Box *Eucalyptus moluccana*. The canopy is sparse with trees reaching 15 to 20 metres high and occasionally 25 metres high. The shrub layer within this remnant is dominated by the Native Pea *Daviesia ulicifolia* which occurs scattered throughout the remnant. The ground cover consists of native and introduced plant species. Native ground cover species include Blue Trumpet *Brunoniella australis*, Couch Grass *Cynodon dactylon* and Love Creeper *Glycine tabacina*.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 17

Size: 11.7 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The canopy of this remnant is dominated by medium to large Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis*, with average heights of 15 to 20 metres high, with some larger trees to 25 metres high. The predominantly dense shrub layer ranges in height from one to three metres and is dominated by Blackthorn *Bursaria spinosa*. The dense ground cover layer is dominated by native grass and herb species including Kangaroo Grass *Themeda australis*, Three-awned Spear Grass *Aristida* sp., Love Creeper *Glycine tabacina*, Native Blue Bell *Wahlenbergia gracilis* and Bearded Heath *Leucopogon* sp. This remnant is subject to only minimal weed invasion and livestock disturbance.

Condition: Moderate

Conservation Significance: Regional

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was moderate.

Remnant Number: 18

Size: 6.3 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland.

Description: The vegetation of this remnant is predominantly regrowth Cumberland Plain Woodland with Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* reaching heights of 15 metres. Few large Forest Red Gum *Eucalyptus tereticornis* occur scattered throughout the smaller trees reaching heights of 30 metres. Within the remnant small-medium Broad-leaved Ironbark's *Eucalyptus fibrosa* occur scattered at the top of a small rise at the south-eastern corner of the remnant. The shrub layer of this remnant is very sparse with Blackthorn *Bursaria spinosa* scattered throughout. The ground cover layer of this remnant is sparse–moderate consisting of a mix of introduced and native flora species. Disturbances to this remnant include clearing and grazing.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. No suitable habitat for this species was recorded.

Remnant Number: 19

Size: 20.2 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The canopy of this remnant is dominated by medium to large Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis*. Blackthorn *Bursaria spinosa* is scattered throughout this remnant and comprises the major component of a sparse shrub layer. The sparse ground cover layer consists of a mix of native grass and herb species and introduced pasture weeds including Kangaroo Grass *Themeda australis*, Three-awned Spear Grass *Aristida* sp., Love Creeper *Glycine tabacina*. This remnant is subject to weed invasion and grazing disturbance.

Condition: Moderate

Conservation Significance: Regional

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was high.

Remnant Number: 20

Size: 41 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* reaching heights of 20 metres dominate the vegetation of this remnant. The sparse-dense shrub layer is dominated by Blackthorn *Bursaria spinosa* and the occasional introduced shrub *Olea europaea* ssp. *africana*. The ground cover layer consists of a mix of native and introduced flora species including Kangaroo Grass *Themeda australis*, Three-awned Spear Grass *Aristida* sp., Love Creeper *Glycine tabacina*, Native Blue Bell *Wahlenbergia gracilis* and Bearded Heath *Leucopogon* sp. The weeds Paddy's Lucerne *Sida rhombifolia* and Prickly Pear *Opuntia vulgaris* were recorded in this remnant. This remnant is subject to weed and grazing disturbances and includes a number of small clearings.

Condition: Poor to moderate

Conservation Significance: Regional

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was moderate.

Remnant Number: 21

Size: 13.6 hectares

Option: B

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The canopy species of this vegetation consists of trees that vary in age reaching heights of 10 to 20 metres. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the only canopy species. The sparse to dense shrub layer is dominated by a mix of shrub species including the native Blackthorn *Bursaria spinosa* and the introduced *Olea europaea* ssp. *africana.* Ground cover species include a mix of native and exotic grasses. This remnant is subject to ongoing weed invasion and grazing disturbance.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 22

Size: 12.4 hectares

Options: B

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland and River-flat Forest

Description: Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species of this remnant reaching heights of 20 metres. These trees are scattered along the gully at this site where introduced shrub species dominate the understorey and include *Olea europaea* ssp. *africana*, Pampas Grass *Cortaderia selloana* and commercial fruit trees. Weed species associated with drainage and creek lines dominate the sparse-dense ground cover.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 23

Size: 23.5 hectares

Options: B

Vegetation Community: Cumberland Plain Woodland-Grey box Woodland and River-flat Forest

Description: Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species of this remnant reaching heights of 20 metres. These trees are scattered sparsely along the gully at this site. Blackthorn *Bursaria spinosa* and *Olea europaea* ssp. *africana* form the scattered understorey of this remnant with patches of dead Wattles *Acacia* sp. recorded throughout the remnant. Weed species and grasses associated with creek lines dominate the dense ground cover. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 24

Size: 1.8 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest.

Description: The vegetation of this remnant is highly degraded. Shrub and ground cover layers are dominated by introduced flora species.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 25

Size: 15.7 hectares

Options: B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest.

Description: The vegetation of this remnant is highly degraded. Swamp She-Oak *Casuarina glauca* is scattered along the creek line of this remnant. The shrub layer of this remnant consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species associated with creek lines.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 26

Size: 0.3 hectares

Options: B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. The shrub layer of this remnant is very sparse and consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species typically associated with creek or drainage lines.

Condition: Very poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. No suitable habitat for this species was recorded.

Remnant Number: 27

Size: 0.8 hectares

Options: B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation within this remnant on the western side of Badgerys Creek Road is dominated by Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* reaching heights of 15 metres. The shrub and ground cover layer comprises a mix of native and exotic flora species.

Condition: Very Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 28

Size: 2.5 hectares

Options: B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* is the dominant canopy species. The shrub layer of this remnant consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: Not surveyed

Remnant Number: 29

Size: 1.1 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* is the dominant canopy species. The shrub layer of this remnant consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species.

Condition: Very poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. No suitable habitat for this species was recorded.

Remnant Number: 30

Size: 22.2 hectares

Options: B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The canopy layer of this remnant is dominated by Forest Red Gum. Swamp She-Oak *Casuarina glauca* and Cherry Ballart *Exocarpus cupressiformis* occur near the creek line adjacent to Francis Street. The sparse shrub layer of this remnant consist of *Olea europaea* ssp. *africana*. The very sparse ground cover is weed dominated. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Very poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 31

Size: 1.6 hectares

Options: B

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* is the dominant canopy species. The shrub layer of this remnant consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Very poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 32

Size: 1.6 hectares

Options: B

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* is the dominant canopy species. The shrub layer of this remnant consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species. Weed invasion is the major threat to this remnant.

Condition: Very poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. No suitable habitat for this species was recorded.

Remnant Number: 33

Size: 0.6 hectares

Options: B

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* is the dominant canopy species. The shrub layer of this remnant consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Very poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 34

Size: 0.6 hectares

Options: B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* is the dominant canopy species. The shrub layer of this remnant consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 35

Size: 2.1 hectares

Options: C

Vegetation Community: River-flat Forest

Description: The canopy of this vegetation remnant is dominated by a thin line of Swamp She-Oak *Casuarina glauca*, which has an understorey dominated by Blackthorn *Bursaria spinosa* to 2.5 metres high. The ground cover layer of this remnant is weed dominated.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: Not Surveyed

Remnant Number: 36

Size: 2.8 hectares

Options: B

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: Not determined as access denied

Condition: Not determined as access denied

Conservation Significance: Not determined as access denied

Status of *Meridolum corneovirens*: Not determined as access denied

Remnant Number: 37

Size: 0.3 hectares

Options: B and C

Vegetation Community: River-flat Forest

Description: The vegetation of this remnant is highly disturbed. The canopy layer of this remnant is dominated by Forest Red Gum *Eucalyptus tereticornis*, with an understorey of Blackthorn *Bursaria spinosa* and Wattles *Acacia* sp. The ground cover layer of this remnant is weed dominated.

Condition: Very poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 38

Size: 3.1 hectares

Options: C

Vegetation Community: River-flat Forest

Description: Swamp She-Oak *Casuarina glauca* is the only canopy species of this remnant. These plants reach heights of 15 metres. The sparse understorey of this remnant is dominated by Blackthorn *Bursaria spinosa*. The dense ground cover layer consists of a mix of native grasses including Kangaroo Grass *Themeda australis* and introduced pasture species.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: Not Surveyed

Remnant Number: 39

Size: 1.1 hectares

Options: B and C

Vegetation Community: River-flat Forest

Description: The vegetation is highly degraded. The canopy layer of this remnant is dominated by Forest Red Gum *Eucalyptus tereticornis* that intergrades with Swamp She-Oak *Casuarina glauca*. The canopy layer of this remnant reaches heights of 10 to 15 metres. The understorey vegetation is dominated by Blackthorn *Bursaria spinosa* while the ground cover layer consists of a mix of native and introduced flora species.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was moderate.

Remnant Number: 40

Size: 4.9 hectares

Options: C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* is the dominant canopy species. The shrub layer consists of a mix of Black Thorn *Bursaria spinosa* and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species. Weed invasion and grazing activities are the major threats to most of this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 41

Size: 4.5 hectares

Options: C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant consists of four smaller and highly degraded vegetation patches. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species. The shrub layer is sparse and consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 42

Size: 3.5 hectares

Options: C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species reaching heights of 15 metres. The shrub layer is sparse and consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species with patches of native grasses occurring throughout. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 43

Size: 3.8 hectares

Options: C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* and occasionally White Feather Honeymyrtle *Melaleuca decora* are the dominant canopy species reaching heights of 10 to 15 metres. The shrub layer is absent to sparse and consists of a mix of native and introduced shrub species scattered throughout. The sparse ground cover layer is dominated by weed species. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was not recorded in this remnant. The suitability of the habitat for this species within this remnant was low.

Remnant Number: 44

Size: 0.9 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species reaching heights of 15 to 20 metres. The shrub layer is sparse and consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 45

Size: 0.9 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species reaching heights of 15 metres. Exotic tree species were also recorded in this remnant. The shrub layer is sparse and is dominated by introduced shrub species. The ground cover layer is dominated by weed species. Weed invasion and grazing activities, and litter dumping are the major threats to this remnant.

Condition: Very Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 46

Size: 16.1 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland; River-flat Forest

Description: The vegetation of this remnant is degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species reaching heights of 15 metres. Much of the canopy layer consists of regrowth forming dense stands in places. Highly degraded River-flat Forest was recorded along the drainage line in the north-east of the remnant. The shrub layer is sparse and consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species with patches of native grasses occurring throughout. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The land snail was recorded in this remnant. The suitability of the habitat for this species within this remnant was moderate.

Remnant Number: 47

Size: 6.6 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation in this remnant is highly degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species reaching heights of 15 metres. The shrub layer is absent and ground cover species are heavily grazed.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 48

Size: 1.1 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* is the dominant canopy species reaching heights of 15 metres, and several exotic tree species were recorded in this remnant. The shrub layer of this remnant is absent and the ground cover layer is dominated by weed species. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Very Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 49

Size: 2.8 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species. The trees of the canopy layer of this remnant range in size from three to 15 metres tall. The shrub layer is absent to sparse and consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species with patches of native grasses. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 50

Size: 1.2 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species, varying in height from three to 15 metres tall. The shrub layer is sparse and consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species with patches of native grasses occurring throughout. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 51

Size: 1.7 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species reaching heights of 15 metres. Patches of regrowth canopy species were recorded among remnant trees. The shrub layer is sparse and consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species with patches of native grasses occurring throughout. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 52

Size: 0.1 hectares

Options: A, B and C

Vegetation Community: *Casuarina glauca* regrowth: Not representative of any native vegetation community

Description: The vegetation of this remnant occurs as a stand of Swamp She-Oak *Casuarina glauca*. There is no shrub layer with this patch. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Very poor

Conservation Significance: Local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Remnant Number: 53

Size: 0.9 hectares

Options: A, B and C

Vegetation Community: Cumberland Plain Woodland-Grey Box Woodland

Description: The vegetation of this remnant is highly degraded. Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* are the dominant canopy species reaching heights of 15 metres. Patches of regrowth canopy species were recorded among remnant trees. The shrub layer is sparse and consists of a mix of native and introduced shrub species scattered throughout. The ground cover layer is dominated by weed species with patches of native grasses occurring throughout. Weed invasion and grazing activities are the major threats to this remnant.

Condition: Poor

Conservation Significance: High local

Status of *Meridolum corneovirens*: The suitability of the habitat for this species within this remnant was low.

Appendix F3

Location of *Pultenaea parviflora* Population

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Appendix F3

Location of *Pultenaea parviflora* Population

1. Background

A population of the nationally endangered plant, *Pultenaea parviflora* was identified during studies for the *Second Sydney Airport Site Selection Programme Draft Environmental Impact Statement* (Kinhill Stearns, 1985).

The population was subsequently recorded during studies for the Draft EIS and occurs on Longleys Road, Badgerys Creek. In response to submissions to the Draft EIS, the population has been accurately mapped to allow further analysis of the impacts of the airport on threatened flora species.

Targeted surveys for *Pultenaea parviflora* were undertaken to map the distribution of this species within the sites of the airport options. The location of the population was determined using a global positioning system with a differential base station, which is accurate to within 10 metres. Clumps of *Pultenaea parviflora* were registered, and the number of plants and the size of each plant within these clumps was recorded.

The location of the *Pultenaea parviflora* population is shown on *Figure F3.1*. The results of the survey are summarised in *Table F3.1*.

Table F3.1 Location of *Pultenaea parviflora* Population

Ref. No.	Easting (AMG)[1]	Northing (AMG)[1]	No. of Plants in Clump	Plant Size and Position on Road Verge[2]
1	289789	6248049	2	1 Plant<15cm Diameter (D); TOR 1 Plant<40cm D; TOR
2	289765	6248060	7	2 Plants 10cm D; TOR 3 Plants 50cm D; TOR 2 Plants 25cm D TOR
3	289787	6248085	3	1 Plant 50cm D; 2 Plants <10cm D
4	289754	6248052	1	1 Plant 60cm; RVE
5	289754	6248051	3	2 Plants 20cm D; TOR 1 Plant 60cm D; TOR

Ref. No.	Easting (AMG)[1]	Northing (AMG)[1]	No. of Plants in Clump	Plant Size and Position on Road Verge[2]
6	289745	6248050	6	2 Plants <20cm D; TOR 1 Plant 50cm D; TOR 3 Plants 1.5m D: TOR
7	289735	6248050	10	3 Plants 50cm D; TOR 4 Plants 60-70cm D: TOR 2 Plants 1m D: TOR 1 Plant 10cm D: TOR
8	289722	6248059	1	1 Plant <20 cm D;
9	289720	6248059	3	2 Plants 1m D; RVE 1 Plant 50cm D
10	289718	6248056	l	1 Plant 15cm D;
11	289717	6248072	7	3 Plant 1.5m D; TOR 4 Plants 60-70 cm D; TOR
12	289772	6248057	1	1 Plant 50cm D; RVE
13	289707	6248056	8	1 Plant 1.5m D; TOR 3 Plants 20cm D; TOR 4 Plants 50cm D; TOR
14	289747	6248036	6	1 Plant 1.5m D; RVE 1 Plant 1mD; RVE 3 Plants 30-40cm D; RVE 1 Plant 10cm D; RVE
15	289653	6248041	3	1 Plant 50cm D 2 Plants 30cm D
16	289706	6248074	1	40cm D; TOR- North side of Longleys Road
17	289716	6248072	2	2 Plants 20 cm D; TOR- North side of Longleys Road
18	289660	6248070	2	2 Plants 25cm D; TOR, most westerly of all plants recorded
19	289891	6248035	1	1 Plant 1m D; RVE, most easterly of all plants recorded

Notes: 1. Australian map grid reference.
2. Abbreviations: TOR Top of Road Verge;
RVE Road Verge Embankment;
D Diameter of Plant Crown;
cm centimetres

References

Kinhill Stearns (1985), *Second Sydney Airport Site Selection Programme Draft Environmental Impact Statement*, prepared for the Department of Aviation, Canberra.

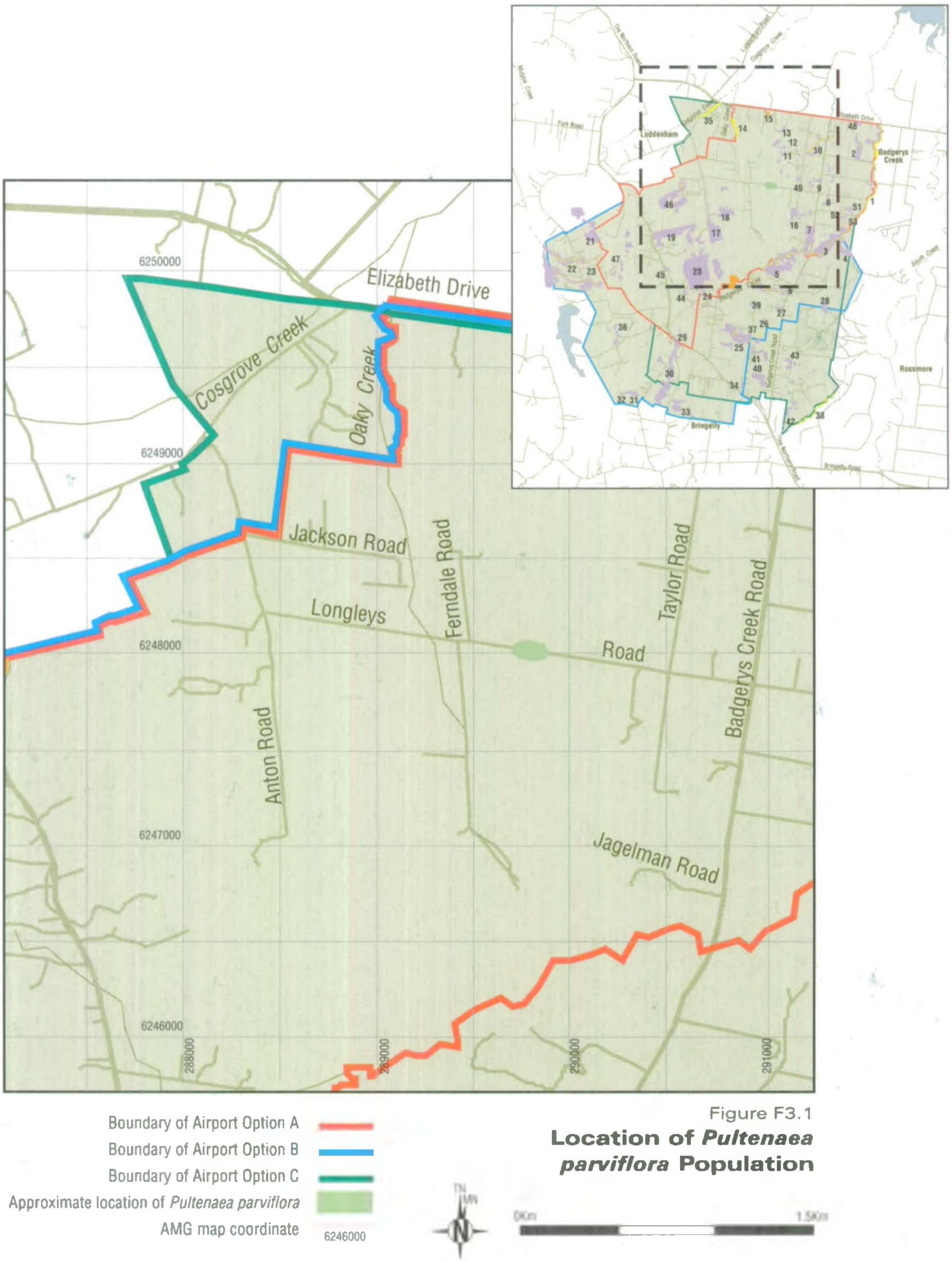

Figure F3.1
Location of *Pultenaea parviflora* Population

Appendix F4

Fauna Survey Results

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Appendix F4

Fauna Survey Results

1. Introduction

Field surveys for threatened fauna were undertaken as part of flora and fauna studies for this Supplement. The methodology adopted for fauna surveys is described in *Section 14.3.2* of this Supplement. Survey methodology, survey effort and weather records for each survey site are listed in *Table F4.1*. Fauna species recorded during field surveys for this Supplement are listed in *Table F4.2*.

Table F4.1 Fauna Survey Effort

Site	Location	Dates	Survey type	Survey effort	Weather	AMG Location
1	Pitt Rd crossing of Badgerys Creek	21/9/98	Bat detector (stationary survey) Creek Site	0.5 hour	16-19°C Cloudy periods, cool to mild, light to moderate SE to NE winds	292030 E 6248000 N
1	Pitt Rd crossing of Badgerys Creek	21/9/98	Nocturnal call playback Creek Site	0.75 hour	16-19°C Cloudy periods, cool to mild, light to moderate SE to NE winds	292030 E 6248000 N
2	Gardiner Rd, behind Badgerys Creek Public School	21-25/9/98	No active survey	Limited habitat value. Mixed age stand of trees, with scattered understorey, degraded and grazed in some sections.		291900 E 6248800 N
3	North east of Badgerys Creek Rd crossing Badgerys Creek	21/9/98	Harp trap Creek Site	One night	16-19°C Cloudy periods, cool to mild, light to moderate SE to NE winds	291000 E 6246600 N
3	Along Badgerys Creek north east from Badgerys Creek Rd	22/9/98	Bird survey Creek and Woodland Sites	1.75 hours	15-23°C Fine, light to moderate E to NE winds	291000 E 6246600 N
4	Behind Boral Brickworks off Martin Rd	21-25/9/98	No active survey	No access to site.		291400 E 6246600 N
5	South west of Badgerys Creek Rd crossing Badgerys Creek	24/9/98	Nocturnal call playback (combined with Sites 6 and 37) Creek and Woodland Sites	0.75 hour	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	290500 E 6246600 N
5	South west of Badgerys Creek Rd crossing Badgerys Creek	24/9/98	Bat detector (stationary survey) Creek Site	0.5 hour	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	290500 E 6246600 N
6	South west of Badgerys Creek Rd crossing Badgerys Creek	24/9/98	Nocturnal call playback (combined with Sites 5 and 37) Creek and Woodland Sites	0.75 hour	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	289900 E 6245900 N
7	Near Badgerys Creek Rd	21-25/9/98	No active survey	Minimal habitat value. Grazed paddock with scattered trees. Trees young to medium regrowth.		290600 E 6247000 N
8	Near Badgerys Creek Rd	21-25/9/98	No active survey	Minimal habitat value. Grazed paddock with scattered trees. Trees young regrowth.		291000 E 6247700 N

Site	Location	Dates	Survey type	Survey effort	Weather	AMG Location
9	Near Badgerys Creek Rd	21-25/9/98	No active survey	Minimal habitat value. Partially grazed with degraded understorey and dead young trees. Canopy trees medium regrowth to mature, no hollows evident.		291000 E 6248300 N
10	Adjacent to Badgerys Creek Park	21/9/98	Bat detector (stationary survey) Woodland Site	0.5 hour	16-19°C Cloudy periods, cool to mild, light to moderate SE to NE winds	291000 E 6249000 N
10	Adjacent to Badgerys Creek Park	21/9/98	Nocturnal Call Playback (combined with Site 11) Creek and Woodland Sites	0.75 hour	16-19°C Cloudy periods, cool to mild, light to moderate SE to NE winds	291000 E 6249000 N
11	Near Badgerys Creek Park	21/9/98	Nocturnal Call Playback (combined with Site 10) Creek and Woodland Sites	0.75 hour	16-19°C Cloudy periods, cool to mild, light to moderate SE to NE winds	290400 E 6248800 N
12	Off Elizabeth Drive	21-25/9/98	No active survey	Minimal habitat value. Grazed paddock with scattered trees. Trees young regrowth.		290400 E 6249000 N
13	Off Elizabeth Drive	21-25/9/98	No active survey	Minimal habitat value. Grazed paddock with scattered trees. Trees young regrowth.		290100 E 6249200 N
14	End of Jackson Rd	23/9/98	Bird Survey Dam and Woodland Sites	0.5 hour	16-27°C Cloudy, mild to warm, moderate N to NE winds	289200 E 6248600 N
15	Off Elizabeth Drive	21-25/9/98	No active survey	Minimal habitat value. Pine forest.		289900 E 6249600 N
16	Off Taylors Rd	21-25/9/98	No active survey	Minimal habitat value. Grazed paddock with scattered trees. Trees young to medium regrowth.		290000 E 6247000 N
17	End of Anton Rd	22/9/98	Harp trap Woodland Site	One night	15-23°C Fine, light to moderate E to NE winds	288600 E 6247200 N
17	End of Anton Rd	22/9/98	Bird Survey Woodland Site	0.5 hour	15-23°C Fine, light to moderate E to NE winds	288600 E 6247200 N
18	Off Anton Rd	21-25/9/98	No active survey	Minimal habitat value. Small patch of very young regrowth trees in a paddock.		288700 E 6247600 N

Site	Location	Dates	Survey type	Survey effort	Weather	AMG Location
19	Off The Northern Rd	23/9/98	Bird survey Dam and Woodland Sites	1.5 hours	16-27°C Cloudy, mild to warm, moderate N to NE winds	287600 E 6247300 N
19	Off The Northern Rd	23/9/98	Bat detector (stationary survey) Dam/Woodland Site	0.5 hour	16-27°C Cloudy, mild to warm, moderate N to NE winds	287600 E 6247300 N
19	Off The Northern Rd	23/9/98	Nocturnal call playback Dam and Woodland Sites	0.75 hour	16-27°C Cloudy, mild to warm, moderate N to NE winds	287600 E 6247300 N
20	Near eastern Private Rd, off The Northern Rd	23/9/98	Harp trap Dam Site	One night	16-27°C Cloudy, mild to warm, moderate N to NE winds	288400 E 6246300 N
20	Near eastern Private Rd, off The Northern Rd	23/9/98	Bat detector (walking survey) Woodland Site	0.33 hour	16-27°C Cloudy, mild to warm, moderate N to NE winds	288400 E 6246300 N
20	Near eastern Private Rd, off The Northern Rd	23/9/98	Spotlight Woodland Site	0.5 hour	16-27°C Cloudy, mild to warm, moderate N to NE winds	288400 E 6246300 N
21	Willowdene Ave (North)	21-25/9/98	No active survey	Minimal habitat value. Medium age regrowth trees with a sparse understorey in a paddock.		285900 E 6246900 N
22	Willowdene Ave (Central)	23/9/98	Nocturnal call playback Creek Site	0.75 hour	16-27°C Cloudy, mild to warm, moderate N to NE winds	285800 E 6246500 N
22	Willowdene Ave (Central)	23/9/98	Harp trap Creek Site	One night	16-27°C Cloudy, mild to warm, moderate N to NE winds	285800 E 6246500 N
23	Willowdene Ave (South)	21-25/9/98	No active survey	Minimal habitat value. Degraded creek, scattered trees in a grassy paddock.		285900 E 6246000 N
24	End of eastern Private Rd	22/9/98	Harp trap Woodland Site	One night	15-23°C Fine, light to moderate E to NE winds	288400 E 6245700 N
24	End of eastern Private Rd	22/9/98	Bat detector (stationary survey) Woodland Site	0.5 hour	15-23°C Fine, light to moderate E to NE winds	288400 E 6245700 N
24	End of eastern Private Rd	22/9/98	Nocturnal call playback Creek and Woodland Sites	0.75 hour	15-23°C Fine, light to moderate E to NE winds	288400 E 6245700 N
25	Between Mersey Rd and Shannon Rd	21-25/9/98	No active survey	Minimal habitat value. Predominantly grasses and young regrowth trees		288900 E 6244900 N

Site	Location	Dates	Survey type	Survey effort	Weather	AMG Location
26	End of Derwent Rd	21-25/9/98	No active survey	Minimal habitat value. Medium to mature trees with no understorey and mown/grazed grasses. No obvious hollows.		289200 E 6245300 N
27	Badgerys Creek Rd	21-25/9/98	No active survey	Minimal habitat value. Predominantly cleared. Small patch of scattered trees in grassy paddock.		290100 E 6245400 N
28	Telstra OTC property	21-25/9/98	No active survey	Access to site not possible.		291100 E 6245500 N
29	Off The Northern Rd	21-25/9/98	No active survey	Minimal habitat value. Scattered trees along degraded creek.		287900 E 6244900 N
30	Francis St	22/9/98	Nocturnal call playback Creek and Woodland Sites	0.75 hour	15-23°C Fine, light to moderate E to NE winds	287700 E 6244000 N
30	Francis St	22/9/98	Bat detector (stationary survey) Woodland Site	0.5 hour	15-23°C Fine, light to moderate E to NE winds	287700 E 6244000 N
31	Dwyer Rd	24/9/98	Bird survey (combined with Site 32) Dam and Woodland Sites	0.5 hour	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	287100 E 6243600 N
32	Dwyer Rd	24/9/98	Bird survey (combined with Site 31) Woodland Site	0.5 hour	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	286800 E 6243600 N
33	Off Carr Rd	21-25/9/98	No active survey	Minimal habitat value. Predominantly grasses and young regrowth trees		288300 E 6243100 N
34	Off Derwent Rd	21-25/9/98	No active survey	No fauna habitat present. Scattered trees in paddock nearby.		289200 E 6243800 N
35	Off Adams Rd	21-25/9/98	No active survey	Minimal habitat value. Disturbed patches of regrowth scattered along creek with large areas cleared.		288600 E 6249800 N
36	Off Anton Rd	21-25/9/98	No active survey	Sparsely scattered young trees along a degraded creek with large cleared areas.		288400 E 6249000 N

Site	Location	Dates	Survey type	Survey effort	Weather	AMG Location
37	Derwent Rd crossing of Badgerys Creek side arm	24/9/98	Harp trap (vandalised) Creek Site	Not included in total effort due to vandalism.	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	289400 E 6244800 N
37	Derwent Rd crossing of Badgerys Creek side arm	24/9/98	Bird survey Creek Site	0.75 hour	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	289400 E 6244800 N
37	South west of Badgerys Creek Rd crossing Badgerys Creek	24/9/98	Nocturnal call playback (combined with Sites 5 and 6) Creek Site	0.75 hour s	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	290500 E 6246200 N
38	Off Kelvin Park Drive	24/9/98	Harp trap Creek Site	One night	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	291200 E 6243600 N
38	Off Kelvin Park Drive	24/9/98	Bat detector (stationary survey) Creek Site	0.5 hour	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	291200 E 6243600 N
38	Off Kelvin Park Drive	24/9/98	Bird survey Creek Site	1.5 hours	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	291200 E 6243600 N
38	Off Kelvin Park Drive	24/9/98	Nocturnal call playback Creek Site	0.75 hour	15-18°C Cloudy with moderate N winds, tending cooler moderate S to SE in morning	291200 E 6243600 N
All	Throughout the study area	21-25/9/98	Additional bird surveys Creek, Dam and Woodland Sites	4.5 hours		285000 E to 292500 E 6250500 N to 6243000 N

Table F4.2 Fauna Species Recorded During Field Surveys for the Supplement

Common Name	Scientific Name	Status[1]	Record Type[2]	New Record[3]
Amphibians				
Eastern Dwarf Tree Frog	*Litoria fallax*		T	
Peron's Tree Frog	*Litoria peronii*		T	
Common Froglet	*Crinia signifera*		T	
Striped Marsh Frog	*Limnodynastes peronii*		T	
Smooth Toadlet	*Uperoleia laevigata*	R	T	
Reptiles				
Common Long-necked Tortoise	*Chelodina longicollis*		S	✔
Leaf-tailed Gecko	*Phyllurus platurus*	R	P	✔
Wood Gecko	*Diplodactylus vittatus*		T	✔
Tree Goanna	*Varanus varius*	R	P	
Common Blue-tongue Lizard	*Tiliqua scincoides*		S	✔
Marsh Snake	*Hemiaspis signata*	R	S	✔
Red-bellied Black Snake	*Pseudechis porphyriacus*		S	
Eastern Brown Snake	*Pseudonaja textilis*	R	P	✔
Birds (Native)				
Black Swan	*Cygnus atratus*		S	
Australian Wood Duck	*Chenonetta jubata*		S	
Pacific Black Duck	*Anas superciliosa*		S	
Little Pied Cormorant	*Phalacrocorax melanoleucos*		S	
Little Black Cormorant	*Phalacrocorax sulcirostris*		S	
Great Cormorant	*Phalacrocorax carbo*		S	
White-faced Heron	*Egretta novaehollandiae*		S	
Cattle Egret	*Ardea ibis*	J/C	S	
Straw-necked Ibis	*Threskiornis spinicollis*		S	
Royal Spoonbill	*Platalea regia*		S	
Yellow-billed Spoonbill	*Platalea flavipes*		S	
Black-shouldered Kite	*Elanus axillaris*		S	
Australian Hobby	*Falco longipennis*		S	
Purple Swamphen	*Porphyrio porphyrio*		S	
Dusky Moorhen	*Gallinula tenebrosa*		S	
Eurasian Coot	*Fulica atra*		S	
Masked Lapwing	*Vanellus miles*		S	
Crested Pigeon	*Ocyphaps lophotes*		S	
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*		H	
Galah	*Cacatua roseicapilla*		S	
Long-billed Corella	*Cacatua tenuirostris*		S	

Common Name	Scientific Name	Status[1]	Record Type[2]	New Record[3]
Sulphur-crested Cockatoo	*Cacatua galerita*		S	
Eastern Rosella	*Platycercus eximius*		S	
Red-rumped Parrot	*Psephotus haematonotus*		S	
Brush Cuckoo	*Cacomantis variolosus*		H	✔
Southern Boobook	*Ninox novaeseelandiae*		P	✔
Tawny Frogmouth	*Podargus strigoides*		P	
Laughing Kookaburra	*Dacelo novaeguineae*		S	
Superb Fairy-wren	*Malurus cyaneus*		S	
Spotted Pardalote	*Pardalotus punctatus*		H	
Buff-rumped Thornbill	*Acanthiza reguloides*	R	S	
Yellow Thornbill	*Acanthiza nana*		S	
Noisy Friarbird	*Philemon corniculatus*		S	✔
Noisy Miner	*Manorina melanocephala*		S	
Jacky Winter	*Microeca fascinans*	R	S	
Grey Shrike-thrush	*Colluricincla harmonica*		S	✔
Restless Flycatcher	*Myiagra inquieta*	R	S	
Magpie-lark	*Grallina cyanoleuca*		S	
Grey Fantail	*Rhipidura fuliginosa*		S	
Willie Wagtail	*Rhipidura leucophrys*		S	
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		S	
Olive-backed Oriole	*Oriolus sagittatus*		H	
Grey Butcherbird	*Cracticus torquatus*		S	
Australian Magpie	*Gymnorhina tibicen*		S	
Pied Currawong	*Strepera graculina*		S	
Australian Raven	*Corvus coronoides*		S	
White-winged Chough	*Corcorax melanorhamphos*	R	S	
Richard's Pipit	*Anthus novaeseelandiae*		S	
Double-barred Finch	*Taeniopygia bichenovii*	R	P	
Red-browed Finch	*Neochmia temporalis*		S	
Welcome Swallow	*Hirundo neoxena*		S	
Fairy Martin	*Hirundo ariel*		S	
Silvereye	*Zosterops lateralis*		S	
Birds (Introduced)				
Rock Dove	*Columba livia*		S	
Spotted Turtle-Dove	*Streptopelia chinensis*		S	
House Sparrow	*Passer domesticus*		S	
Red-whiskered Bulbul	*Pycnonotus jocosus*		S	
Common Starling	*Sturnus vulgaris*		S	
Domestic ducks	*Anas sp.*		S	
Domestic chickens	*Gallus gallus*		S	

Common Name	Scientific Name	Status[1]	Record Type[2]	New Record[3]
Peacock	*Pavo cristatus*		H	
Common Myna	*Acridotheres tristis*		S	
Mammals (Native)				
Brushtail Possum	*Trichosurus vulpecula*		S	
Grey-headed Flying-fox	*Pteropus poliocephalus*	R	S	
Chocolate Wattled Bat	*Chalinolobus morio*		H	
Gould's Wattled Bat	*Chalinolobus gouldii*		H	
Little Forest Bat	*Vespadelus vulturnus*		H	
Southern Forest Bat	*Vespadelus regulus*		H	✔
Lesser Long-eared Bat	*Nyctophilus geoffroyi*		T	
Mammals (Introduced)				
Brown Hare	*Lepus capensis*		S	
Rabbit	*Oryctolagus cuniculus*		S	
Dog (feral)	*Canis familiaris*		S	
Cat (feral)	*Felis catus*		S	
Horse (feral)	*Equus caballus*		S	
Cattle (feral)	*Bos taurus*		S	
Goat (feral)	*Capra hircus*		S	
Fox	*Vulpes vulpes*		I	
Invertebrates (native)				
Land Snail	*Meridolum corneovirens*	E	T	✔

Notes:
1. E = Listed as Endangered under Schedule 1 of *Threatened Species Conservation Act, 1995*;
R = Regional, determined from National Parks and Wildlife Service (1997a) and Biosis Research and PPK Environment & Infrastructure (1997). Where there is a difference in conservation rating, the higher rating has been adopted; and
J/C = Listed under JAMBA and CAMBA international agreements.

2. Abbreviations:
H = Heard;
I = Indirect evidence (for example, scats, burrows, etc.);
P = Personal Communication;
S = Seen; and
T = Trapped or hand-held.

3. Not previously recorded in the study area, based on the following reports: Biosis Research and PPK Environment & Infrastructure (1997), Lesryk Environmental Consultants (1996), National Parks and Wildlife Service Atlas of NSW Wildlife (post-1974 records only), Australian Museum Database (post-1974 records only), Kinhill Stearns (1985).

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Appendix F5

Green and Golden Bell Frog Survey Report

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Appendix F5

Green and Golden Bell Frog Survey Report

1. Introduction

The green and golden bell frog, *Litoria aurea*, is a large frog that has suffered serious declines in numbers since the mid-1970s (Pyke and White, 1996). It was once widespread along the coastal plain of NSW, particularly from the Sydney area southwards (Pyke and White, 1996), but has been lost from many known sites and is now sufficiently rare that it has been listed as "endangered" under Schedule 1 of the *Threatened Species Conservation Act, 1995*. Its historic habitat was wide-ranging and included large coastal swamps, slow flowing streams, farm dams and water courses (Cogger, 1992; Robinson, 1993). It appeared to be quite capable and willing to utilise artificial dams and ponds (Barker et al, 1995). The reasons for the decline of the green and golden bell frog are, as yet, unclear, however the spread of the introduced plague minnow (*Gambusia sp.*), which eats the eggs and tadpoles of the frog, has been considered an important factor in its decline.

The aim of this survey was to determine the likely or actual presence of the green and golden bell frog within or immediately adjacent to the proposed site of the Second Sydney Airport at Badgerys Creek.

2. Survey Methods

The survey included a visual assessment of available habitats within the area followed by nocturnal surveys in an attempt to locate individuals of this species. An initial daytime inspection of the airport sites was carried out on 8 October, 1998 to assess the extent of suitable habitat for the green and golden bell frog and note their location for later survey. An assessment of the available habitats also provides an insight as to the likelihood of the green and golden bell frog being present. Water bodies identified as potential breeding habitats for the green and golden bell frog were surveyed over two nights on 14 and 19 October, 1998.

Potential breeding sites were surveyed aurally over a minimum four to five-minute period to identify the frog species calling at the site. Where possible, searches where carried out using headlamp torches to locate eye-shine. Call playbacks in the form of recordings of frog calls and call mimicking were also undertaken at sites offering the optimum habitat for the green and golden bell frog. Where visual surveys were possible, the water was searched to locate tadpoles.

Throughout the survey period, all frogs seen on roads were checked for their identity. The roads traversed were: Badgerys Creek Road, Elizabeth Drive, Taylors Road, Gardiner Road, Pitt Street, Longleys Road, Fuller Street, Jagelman Road, Derwent Road, Northern Road, Severn Road, Mersey Road, Avon Road, Francis Street, Dwyer Road, Willowdene Road, Vicar Park Lane, Eaton Road, Anton Road, Jackson Road, Adams Road, Ferndale Road, Leggo Street, Kelvin Park Drive, Medich Place, The Retreat, Shannon Road and Findley Road.

3. Results

Weather conditions during the survey were as follows:

- 14 October, 1998 - A warm day. Night cool, calm and clear. Rain had fallen within the previous week, but not the previous 48 hours. At 8:45 pm air temperatures were 12.5 degrees Celsius dry bulb and 10 degrees Celsius wet bulb. The moon phase was a quarter and there was little moonlight during the survey.
- 19 October, 1998. An overcast day with persistent rainfall after two days of warm conditions, including thunderstorms the previous morning. There was a slight breeze during the day. Overcast evening with occasional light rainfall. Calm conditions throughout for most of the night, until winds increased at 11:00 pm. Air temperatures were 16.0 degrees Celsius dry bulb and 12.5 degrees Celsius wet bulb at 8:50 pm. Moon phase was irrelevant due to cloud cover.

The habitat assessment revealed the Badgerys Creek area to contain numerous small to large dams and pools from five to more than 30 metres in diameter, as well as several streams and drainage lines which would serve as suitable breeding habitat for the green and golden bell frog. A total of 155 dams or pools and seven streams were surveyed.

Nine frog species were recorded within the sites of the airport options and are listed in *Table H5.1*. No *Litoria aurea* were heard or sighted during the surveys, despite the widespread suitable habitat. Both *Crinia signifera* and *Litoria fallax* were very common, being heard or seen at more than 100 sites (refer *Table F5.1*) representing many thousands of individuals. One individual of *Litoria latopalmata* was recorded on Willowdene Avenue.

Table F5.1: Frog Species Recorded During Targeted Surveys

Species	Number of Sites
Crinia signifera (common froglet)	100
Limondynastes peronii (striped marsh frog)	11
Limnodynastes tasmaniensis (spotted grass frog)	13
Litoria fallax (dwarf tree frog)	103
Litoria latopalmata (broad-palmed rocket frog)	1
Litoria peronii (perons tree frog)	60
Litoria tyleri (laughing tree frog)	10
Litoria verreauxii (whistling tree frog)	17
Uperoleia laevigata (red-groined toadlet)	56

4. Discussion

4.1 Limitations of the Surveys

The weather conditions on the night of the first survey were dry and cool and so not ideal for this species to be located, even though choruses of several other species were commonly heard throughout the night.

Some sites were not surveyed as a result of access restrictions. However, the wet conditions on the second survey night would have allowed frogs to migrate between breeding sites. Given that over 150 sites were surveyed, access restrictions are not considered to be significant.

4.2 Green and Golden Bell Frog Records

The second night of survey however was carried out after a day of significant rainfall at which time frogs should have had some stimulation to call. The roads remained wet throughout the night, allowing frogs to migrate to breeding sites and so allow the opportunity to locate frogs on roads. This night should have provided a good opportunity to locate green and golden bell frogs. Furthermore, green and golden bell frogs had been calling throughout the survey period at sites at Kurnell (A. White, *pers. comm.* 1998), suggesting that this species may have been expected to be active on both occasions if it were present.

Although there are no historic records of the green and golden bell frog from the Badgerys Creek area, the range of records from the Sydney Basin indicates that this area would be within the expected range of this species. The abundance and widespread distribution of the potential breeding sites within the airport sites would also suggest that the green and golden bell frog could very well have been present within the Badgerys Creek area in historical times. However, the absence of recordings during the present survey and surveys carried out for the Draft EIS indicates that this species is likely to be not present in the Badgerys Creek area. This would be a typical situation for this species, as it appears to have become extinct through most of its range, despite the presence of apparently excellent habitat.

4.3 Assessment of Significance

If a population of the green and golden bell frog was actually present within the sites of the airport options, it would be considered of high conservation value. The reduction in the number of populations within the Sydney Basin from hundreds to less than 20 in recent years suggests that any population is significant for the long-term conservation status of this species. At a local level, there are no records from Badgerys Creek, even in early historical times. If a population occurred within the airport sites, it would extend the limited distribution of this species in the Sydney Basin and increase its gene pool for breeding. A new record of the species in the Badgerys Creek area is likely to have distinct genetic variation, which would be of value in maintaining the genetic diversity of the species. If the populations were genetically distinctive, they would have state and national significance.

However results of the current survey, previous surveys, (for example, Kinhill Stearns, 1985) including those of the Draft EIS, and current National Parks and Wildlife Service (1998) records for the local area indicate that the green and golden bell frog is not likely to be present within the sites of the airport options. Based on available information, the airport sites are not considered to be a significant habitat for the green and golden bell frog or critical for the survival of the species.

5. Impact Assessment for the Green and Golden Bell Frog

5.1 Environmental Pressures

The cause of the decline of the green and golden bell frog is not known. Possible causes may include disease and increases in ultra-violet radiation. Land clearing and the destruction of water bodies used as breeding sites also threaten this species and it is considered that the presence of the introduced plague minnow (*Gambusia sp.)* also has a significant negative effect on this frog.

5.2 Critical Habitat

Critical habitat for the green and gold bell frog is based on breeding habitat and includes any water body which is not moderate to fast flowing (Pyke and White, 1996). Longer-term ephemeral pools may be the most important habitat for this species, perhaps because such habitats are not suitable for the plague minnow. The presence of emergent vegetation also appears to be preferred, but not essential. It has been found in a number of disturbed sites and so native vegetation and undisturbed environments appear not to be critical for this species' survival.

The Badgerys Creek area appears to provide large numbers of suitable breeding sites for the green and golden bell frog.

5.3 Sensitivity to Habitat Modification

The sensitivity of the green and golden bell frog to habitat modification is difficult to determine. It can utilise disturbed and modified environments such as the Homebush Bay Olympic site and Port Kembla steel mills. However, it has declined in much of Sydney, probably due to a loss of habitat from development. It appears intolerant of introduced fish and may not adapt successfully to altered hydrological regimes that increase the flooded life of water bodies. The latter results in dense emergent vegetation stands that reduce the area of clear free water, which the tadpole may require for feeding.

This species may be moderately tolerant of changes in water salinity and even some pollution (being near steel works and Port Kembla and oil refineries at Kurnell), but this is not known for certain. The decline of the species suggests that it is highly sensitive to some environmental changes.

5.4 Effects of the Proposed Activities

Filling of water bodies and clearing of the surrounding native vegetation associated with development of the airport would destroy sites of potential habitat. Increased road traffic movements around the airport would result in increased mortality of frogs migrating to and from breeding sites, as is the case at Homebush Bay (A. White, *pers. comm.*, 1998). Hence, development of the airport would almost certainly have a negative effect affect on any green and golden bell frog populations present within the airport sites. However, results of the present survey indicate that the green and golden bell frog does not inhabit the sites of the Second Sydney Airport. Hence, the proposal would not have a significant impact on the species.

5.5 Ability of Habitat and Species to Recover

The development of the airport would preclude any significant habitat regeneration or recovery as large areas of habitat would be permanently removed. Suitable habitat, such as ponds, creeks and dams, may develop in the long term, however, their value as breeding habitat would be uncertain. Attempts to produce new breeding sites in the Homebush Bay area have largely failed (A. White, *pers comm*, 1998).

The green and golden bell frog has a large reproductive potential as each female produces more than 1000 eggs per spawning. Therefore, if suitable habitat remained or developed after the development, this species, if present, should have a good chance of recovering numbers to some degree. However, the continued declines of this frog indicate that this rarely occurs, despite its apparently favourable reproductive habits.

5.6 Representation in Conservation Reserves

There are no populations of the green and golden bell frog currently protected within conservation reserves with the Sydney region.

6. Environmental Management

The development of pond sites on the airport site after construction may assist this species, but it is unclear if it would do so. The retention of old pond sites and undisturbed patches of habitat would provide the best protection for this species. However, the fact that populations are not known to be present makes it impossible to nominate areas for protection. Creation of off-site conservation areas, as outlined in Chapter 14 of the EIS Supplement, should target sites that contain aquatic habitats, such as dams, creeks and ponds, that may provide suitable habitat for the green and golden bell frog.

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Appendix F6

Cumberland Plain Large Land Snail Survey Report

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Appendix F6

Cumberland Plain Large Land Snail Survey Report

1. Introduction

The land snail *Meridolum corneovirens* (Pfeiffer, 1851) is currently restricted to the Cumberland Plain region of western Sydney. It is closely associated with the Cumberland Plain Woodland, particularly those areas with Wianamatta Shale based soils. It typically occurs in eucalypt woodland under logs and other debris and amongst leaf and bark accumulations around bases of trees. Where possible it will burrow into loose soil. The current known distribution of the snail is in an area roughly bounded by Cattai (to the north), Camden (to the south), Prospect Reservoir (to the east) and Mulgoa (to the west). Very little is currently known about the biology and life history of the species, however, it is hermaphroditic. The species can be common when suitable habitat is present, but given the relatively rapid development of western Sydney in the last few decades the snails distribution has been severely fragmented.

2. Methods

A search was conducted of suitable habitat within the remnants of Cumberland Plain Woodland identified within the airport sites (shown on *Figure 14.1* of the EIS Supplement). This included turning all logs and other ground cover debris, plus raking accumulations of bark and leaf litter around the base of some trees.

3. Results

The survey was conducted over the period 22 to 25 September and 1 to 2 December 1998. A total of 35 survey sites were investigated and of these, *Meridolum* *corneovirens* was found at 14 survey sites. *Table F6.1* provides a brief summary of presence/absence and a rating value of the suitability of the habitat present as low, moderate or high. However, of the survey sites visited several were considered to have little or no suitable habitat for *Meridolum corneovirens*.

Survey sites 4, 28, 35, 36 and 38 were not searched due to lack of access or due to lack of suitable habitat, however, it is possible that *Meridolum corneovirens* could be present in site 4 as it is present in the adjoining site 3.

Table F6.1: Summary of Survey Sites Investigated for *Meridolum corneovirens*

Survey Site	Presence/Absence	Suitability of Habitat
1	Absent	No suitable habitat
2	Present	Low
3	Present	Moderate
4	Access Denied	Potentially Moderate
5	Present	Moderate
6	Present	Low
7	Absent	Low
8	Absent	Low
9	Absent	Low
10	Present	Low
11	Absent	No suitable habitat
12	Absent	Low
13	Absent	Low
14	Absent	Low
15	Absent	No suitable habitat
16	Absent	Low
17	Present	Moderate
18	Absent	No suitable habitat
19	Present	High
20	Present	Moderate
21	Present	Low
22	Present	Low
23	Absent	Low
24	Present	Low
25	Absent	Low

Survey Site	Presence/Absence	Suitability of Habitat
26	Absent	No suitable habitat
27	Absent	Low
28	Not Surveyed	Low
29	Absent	No suitable habitat
30	Present	Low
31	Absent	Low
32	Absent	No suitable habitat
33	Absent	Low
34	Absent	Low
35	Not Surveyed	No suitable habitat
36	Not Surveyed	No suitable habitat
37	Absent	Low
38	Not Surveyed	No suitable habitat
39	Present	Moderate
Along Longleys Road Between Ferndale Road and Taylors Rod	Present	Low

The majority of the sites visited were degraded and or otherwise in some state of regeneration. A number were still actively being utilised for agriculture, predominantly grazing. The sites thought to offer the most suitable habitat for *Meridolum corneovirens* include some currently being used in a dwarf horse breeding program. When the airport sites are considered as a whole, they contain a significant number of living individuals, although the actual total numbers are unknown. However, they represent a significant proportion of the living populations currently known from western Sydney (S. Clark, *pers. comm.*, 1998).

The distribution of *Meridolum corneovirens* within the study area strongly indicates that in the past it was more widely distributed. The primary cause of the snail's current fragmented distribution within the study area has been due to clearing for residential and rural development.

The only site that *Meridolum corneovirens* had previously been recorded was at the point where Badgerys Creek Road crosses Badgerys Creek, which were collected in 1974. The present survey revealed that the population still survives in the Badgerys Creek area.

In a supplementary survey conducted by Biosis Research on 11 January 1999, an additional 14 survey sites were identified (see *Table F6.2*). Of these, *Meridolum corneovirens* were found at survey site 46. In addition, the Biosis team identified two other survey sires 40 and 43, which were considered, based on the presence of relatively thick layers of ground cover, to offer a moderate level of habitat suitability for *Meridolum corneovirens*.

Table F6.2: Summary of Additional Survey Sites Identified by Biosis Research

Survey Site	Presence/Absence	Suitability of Habitat
40	Absent	Moderate
41[1]	Not Surveyed	Low
42[1]	Not Surveyed	Low
43	Absent	Moderate
44[1]	Not Surveyed	Low
45[1]	Not Surveyed	Low
46	Present	Moderate
47[1]	Not Surveyed	Low
48[1]	Not Surveyed	Low
49[1]	Not Surveyed	Low
50[1]	Not Surveyed	Low
51[1]	Not Surveyed	Low
52[1]	Not Surveyed	Low
53[1]	Not Surveyed	Low

Note: 1. Sites not surveyed owing to access restrictions.

As a result of both surveys, *Meridolum corneovirens* has been identified within a total of 15 survey sites within the airport sites.

4. Species Profile

4.1 Conservation Status

The Cumberland Plain Large Land Snail *Meridolum corneovirens* (Pfeiffer, 1851) is listed as endangered under Schedule 1 of the *Threatened Species Conservation Act, 1995*. The species was listed in June 1997. It is not currently considered to be adequately protected in conservation reserves in the Western Sydney region.

4.2 Distribution

Restricted to the Cumberland Plain region of western Sydney. It's current known distribution is in an area roughly bounded by Cattai to the north, Camden to the south, Prospect Reservoir to the east and Mulgoa to the west.

4.3 Environmental Pressures

Environmental pressures on this species include habitat loss and population fragmentation due to clearing for agriculture and residential developments. Other pressures include the increased use of poisons such as snail baits and other herbicides to control pests in residential areas adjoining bushland. Fire is another hazard.

4.4 Critical Habitat

Meridolum corneovirens typically occurs in dry eucalypt woodland under ground cover such as logs and amongst leaf and bark accumulations around bases of trees. Where possible it will burrow into loose soil (a unique characteristic of this species among members of the genus *Meridolum*). However, when natural ground cover is not available or in short supply *Meridolum corneovirens* will shelter under other types of non-natural ground cover such as bricks, cardboard, pieces of wood, metal and harder types of plastic.

There is no published literature regarding any aspect of the biology, life history or taxonomy of this species.

4.5 Sensitivity to Habitat Modification

Meridolum corneovirens relies largely on the presence of natural ground cover. Its removal or reduction would have a significant impact on the continued survival of the species. The species would also be sensitive to soil compaction, particularly in association with loss of ground cover (as the species is capable of burrowing into loose soil). In addition it would be susceptible to activities such as grazing and fire which would act to reduce ground cover.

4.6 Ability of Species/Habitat to Recover

The species is largely dependent on the presence of natural ground cover such as logs and layers of leaf and bark accumulations around the bases of trees. However, the species is resilient enough to utilise non-natural forms of ground cover that can provide shelter, cool and moist conditions in which to lay eggs and possibly a source food (in the form of fungal growths).

4.7 Significance Rating

The populations of *Meridolum corneovirens* present within the sites of the airport options though fragmented, represent a cluster of State significance. Considered collectively, rather than as a series of individual sites, it has the highest number of individuals of any location currently known (the species have been collected at over 50 locations with well over 500 individuals sighted, approximately 90 were sighted within the sites of the airport options) (Clark, *pers. comm.*, 1998). It is considered that virtually all the populations found within the boundary of the proposed airport are viable. The populations are at the western edge of the known distribution for *Meridolum corneovirens* and are only a few kilometres south of the type location Mulgoa, where the original material used to describe the species was derived.

The given conservation rating is based on current knowledge and it should be noted that no extensive survey has to date been conducted for this species.

5. Impact Assessment

Without appropriate environmental management, development of the Second Sydney Airport would cause the local extinction of the populations of *Meridolum corneovirens* within the airport sites. The impact on the species as a whole would be a significant loss of genetic and phenotypic diversity.

Option A would cause the extinction of virtually all currently known populations within the study area except those found in sites 21 and 22 (refer to *Figure 14.1* of the EIS Supplement). Option B would involve the complete removal of all currently known populations within the study area. Option C would cause the extinction of all currently known populations within the option boundary, except for those recorded within sites 21 and 22.

The populations of *Meridolum corneovirens* recorded within the airport sites, when considered as a whole, are considered to be of State significance. All three airport options involve the complete removal of these populations. The impact of the Second Sydney Airport on *Meridolum corneovirens* is therefore considered to be of State significance.

Even with the implementation of currently proposed mitigative measures, as discussed in *Section* 6, potential impacts on *Meridolum corneovirens* would be significant. This is because the area considered to have the highest habitat value (sites 17, 19 and 20, refer *Figure 14.1* of the EIS Supplement) would be removed by all three airport options.

6. Environmental Management

The mitigation of potential impacts to *Meridolum corneovirens* would involve:

- minimising habitat removal and fragmentation by careful reconsideration of the siting of the proposed transport and services corridors;
- retention of Cumberland Plain Woodland remnants containing suitable habitat for the snail wherever possible;
- regeneration of existing and potential snail habitats within the airport sites; and
- relocation of snail populations that would be directly affected by the proposal to either on-site conservation areas or to nearby off-site conservation areas.

If some of the survey sites containing remnant Cumberland Plain Woodland known to contain *Meridolum corneovirens* were allowed to regenerate, eventually connecting to form a larger remnant, the continued viability of the local population would be assured. The preferred option would be to preserve sites 17, 19, 20 and 24 and promote vegetation growth between them and the vegetation corridor along Badgerys Creek. The implementation of these management measures would enhance the long term viability of both the local population of *Meridolum corneovirens* and its habitat.

A number of revegetation/regeneration areas have been proposed to mitigate the flora and fauna impacts of each airport option, as discussed in *Chapter 14*. The locations of proposed revegetation areas are shown on *Figures 14.3* to *14.5* of the EIS supplement. The potential impacts of the proposal on the conservation of *Meridolum corneovirens*, taking into consideration the proposed management measures for each of the three airport options, are as follows:

- Option A would force the relocation of the populations from survey sites 2, 10, 17, 19, part of 20, 46 and the site on Longleys Road, to survey sites 3, 5, 21, 22, 24, 30 and 39;
- Option B would force the relocation of the populations from surveys sites 2, 5, part of 6, part of 10, 17, 19, 20, 24, 39, part of 46 and the site on Longleys Road, to survey sites 3, 21, 22, 30 and 46; and
- Option C would force the relocation of populations from survey sites (3 part of), 5, 6, 17, part of 19, 20, 24, 39 and the site on Longleys Road, to survey sites 2, 3, 10, 19, 21, 22, 30 and 46.

Of the three options currently under consideration, Option B has the greatest potential impact on *Meridolum corneovirens*, while Option C appears to hold the least impact in terms of preserving some of the better remnants of Cumberland Plain Woodland. However, Options B and C have a significant effect on Badgerys Creek, while Option A would retain the creekline as intact and would be enhanced overall by the regeneration/ revegetation measures being suggested.

Given the identified potential impacts and the vegetation regeneration options indicated on *Figures 14.3* to *14.5* of the EIS Supplement, it is considered that Option A has the best overall potential for the long-term protection of the species and the diversity of habitats present within the airport sites. It is recommended that the proposed revegetation and regeneration areas indicated on *Figure 14.3* are expanded during the long-term operation of the proposal. This would include increasing the areas of revegetation around survey sites 3, 5, 6, 7, and 39.

In addition to the above issues relating to regeneration/revegetation, it remains to be tested whether relocation of *Meridolum corneovirens* to either on-site or off-site conservation areas would be successful, as this has never been attempted for this species. It is proposed that a compact relocation experiment be set up within the site and monitored for at least two years. This would involve moving a small number of individuals to two different types of locations; one with an existing population of *Meridolum corneovirens* and one without, plus a control population which would be one of the known populations. This would allow new data on fecundity, life history, timing or reproduction, feeding and habitat requirements plus the distance individuals move.

Other issues that need to be addressed include the species susceptibility to fire, various toxins such as herbicides, the spread of exotic plants (for example, African Olive), competition with introduced species of snails and slugs (for example, Garden Snail *Helix aspersa* and predation by rats and the Eastern Blue-tongue Lizard *Tiliqua scincoides*.

However, other major factors that must also be taken into consideration include what implications the relocation would have on the genetic viability and diversity of the populations concerns and the species overall. This becomes especially important if any or all of the populations have to be relocated to off-site conservation areas. It must also be realised that it is highly likely that individuals would be lost and/or left behind during the relocation process, so no guarantees can be given that all individuals from any given population would be found.

Overall it is considered that the likelihood of *Meridolum corneovirens* surviving the relocation process are reasonably good, especially if relocated to areas of a similar nature and close proximity. Therefore, if the above management measures are put into place the continued viability of the local population of *Meridolum corneovirens* is assured.

Appendix G

The Cumulative Impact of the Second Sydney Airport Proposal on Surviving Aboriginal Sites of the Cumberland Plain

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Appendix G

The Cumulative Impact of the Second Sydney Airport Proposal on Surviving Aboriginal Sites of the Cumberland Plain

1. Introduction

This appendix considers the potential cumulative impact of the Second Sydney Airport proposal on Aboriginal sites. The assessment of cumulative impacts supplements and is founded upon the main survey and assessment work documented in the Draft EIS for the Sydney Second Airport proposal (PPK Environment & Infrastructure, 1997).

Aboriginal archaeological sites on the sites of the Badgerys Creek airport options have already been the subject of a detailed technical investigation for the Draft EIS (Navin Officer Heritage Consultants, 1997; PPK Environment & Infrastructure, 1997) and that work provides the foundation for this analysis. *Technical Paper No. 11* included analysis of existing site recordings resultant of selective or non-comprehensive surveys and other site recordings made in the course of comprehensive field survey coverage. It developed predictive statements as to the likely occurrence and characteristics of Aboriginal archaeological sites in areas of the study area not comprehensively surveyed based upon the known regional database, with particular reference to previous studies undertaken (Kinhill Stearns, 1985).

The archaeological surveys undertaken for the Draft EIS employed a topographically stratified sampling strategy. All major landscape units were effectively sampled and the proportion of survey conducted in each landscape unit is calculable and comparable relative to that unit's total incidence within the study area.

The current structure of EIS assessment procedures has been noted to lead to a situation where, as development proceeds within a region and individual projects arise their impact is in turn assessed against reference conditions current at that particular time. The fact that the status of the resources being impacted are constantly changing or diminishing is not taken into account (Buckley, 1994:345).

Cumulative environmental impacts identified by Buckley (1994:344-5) included (among others):

- additional impacts due to new development in an area with prior impacts;
- aggregate environmental impacts of multiple developments in a defined area;

- overall impacts of many similar concurrent developments in a defined area;
- interactive impacts from nearby developments of different types;
- interaction between impacts from various sources; and
- future and increasing impacts over time, from growth in existing activities.

For the purpose of this appendix *cumulative impact* is used to refer to the category of incremental, collective or *aggregate* effect of a proposed development upon a region or area with respect to the existing or surviving regional Aboriginal archaeological/cultural resource.

This type of analysis necessarily takes into consideration past and current impacts upon the cultural heritage resource. The assessment of the cumulative impact aims to consider the potentially deleterious effect of the development from a broad regional perspective, rather than as a localised impact within the proposed development boundary. A requirement for the assessment is therefore a characterisation of the relevant archaeological region within which the development lies. The impact of the development with respect to the regional resource may then be estimated.

In order to counteract cumulative impact weakness in EIS procedures Buckley (1994:346) suggested the development of such fixed 'regional baselines' against which all development proposals may be assessed. He proposed two possible methods of approach:

- the calculation of the total predicted impacts of a development proposal, including all cumulative components, and comparison with estimated baseline conditions prior to any development; or
- the development of a predefined benchmark or ambient standard beneath or exceeding which development may not proceed, and as an example, he cites noise pollution controls.

From current cultural heritage perspectives the first approach is generally adopted. For the purposes of this assessment, the first desirable baseline is the characterisation of an archaeological region in which the Second Sydney Airport proposal lies.

2. Identification of Archaeological Regions

The aim of establishing a study region is to establish a research population (in this case archaeological sites) which is culturally homogeneous, yet which contains a full range of the types of sites formed by that cultural system, is spatially complete and which ultimately enables the definition and retention of an appropriately representative sample.

In order to assess the potential impact of the Sydney Second Airport proposal in terms of a cumulative impact, it is necessary to define the boundaries of the resource within which a net impact can be measured. There are several parameters which could potentially be used to define a relevant context. These include a tribal or an equivalent cultural boundary, a temporal division, or hypothesised behavioural sets. All of these potential parameters are however poorly understood as manifest divisions within the archaeological record of the Sydney region (AMBS, 1997).

The definition and stratification of environmentally and physically defined regions remains one of several valid research and cultural resource management methodologies for assessing the character of, and potential impact of developments upon, cultural resources.

Conventional approaches for determining suitable regional research boundaries include the choice of known language or cultural areas, drainage basins and other combinations of physical geography (O'Connell and Allen, 1995:859; Peterson, 1976). The establishment of valid regional entities may be problematic however, since it is ultimately human patterns of behaviour which result in the patterns of archaeological evidence later considered. The ability to reconstruct cultural regions hinges largely upon the existence of sufficient ethnographic and ethno-historic information to permit the placement of recorded groups within cultural boundaries. The magnitude of time depth during which archaeological sites may have formed further complicates the process, since socioeconomic and environmental change may, over time, have rearranged the configuration of resources and people within the landscape. Hence the entities which an archaeologist may develop as 'regional' cultural boundaries may also have been subject to change over time.

The 'language area' approach is feasible for research areas where good ethno-historical and/or ethnographic information exists as to the location and extent of language groups and where time depth for the study is not immense. This is not the case for the wider Sydney region. Within a short period of time after white settlement, the Sydney Aboriginal population was greatly reduced as a result of two epidemics. The first outbreak of the disease is believed to have killed 50 percent of the Aboriginal population and must have resulted in a major social reorganisation of Aboriginal people (Ross, 1988). The anthropological observations and historical accounts are thus unlikely to present any complete approximation of 18th century Aboriginal culture.

Nevertheless, it is still generally considered that the study area falls within Dharug tribal boundaries. However, the regional area may only have comprised a partial territorial unit at any point in the past. It has been estimated that the Aboriginal population density for the Sydney region lay between five and 10 individuals per square mile prior to European settlement (Maddock, 1972) .

Regional boundaries according to drainage boundaries is another method employed to encapsulate research populations. The definition of drainage basins is relatively simple in classic riverine landscapes but may become difficult in steeply dissected landscapes where drainage regimes are finely differentiated and spatially complex. Also such distinctions may have had little cultural relevance in the past.

A combination of commonly experienced climatic and physical geographic characteristics is a common compromise often employed. Such an approach operates with a somewhat environmentally deterministic perspective, since it makes an assumption that certain sets of physical attributes will generate broadly similar cultural adaptations. The present level of understanding of the archaeological record in the study area remains centred on landscape based variables. Consequently landform provides the most appropriate means of defining a regional context.

This is consistent with modelling of archaeological sites elsewhere within Australia where variation within Aboriginal sites has been found to be closely correlated with landform groups. This correlation is to be expected given the probable close link between archaeological debris and the exploitation of landform based resources. At the same time such an approach is broadly influenced by general ethnographic information which suggest a range of maximum and minimum extents for which 'regions' are likely to exist. For example a minimum areal extent is believed to be 20 square kilometres (AMBS, 1997).

Examination of the history of archaeological endeavour would reveal a fundamental divide between what may be termed 'research' and 'public' archaeology. Research archaeology has had a traditional academic and institutional base and has primarily concerned itself with the explication of patterns of past human behaviour as revealed by a diverse physical archaeological record. The development of specific 'regional' frameworks with reference to which assessment and or characterisation of archaeological resources within such a region is permitted is a long established analytical approach (Binford, 1964).

Such studies generally operate on a well established structure or 'research design' and typically approach the archaeological record from a questioning and theoretical perspective. The record may then be interrogated via a series of research methodologies and the original research questions re-evaluated and perhaps reformulated in light of results. Basically it is a system of modelling the ways in which people may have used particular areas or environments, modelling the nature of residues which such behaviours may have left behind, comparing the physical archaeological record to the model and then reflecting on the degree of fit for the model.

Public archaeology for a variety of reasons, but including study scales, time constraints and resourcing issues, has generally been driven from another angle. Its task has generally commenced with the physical evidence and the requirement to ensure that in the face of rapid environmental alteration sufficient of the archaeological record may be identified and preserved so that future interrogations of that record may be equally able to satisfy future research questions. Equally important concerns which are increasingly factored into the public archaeological assessment also include the assessment of significance of archaeological evidence to Indigenous peoples.

In an ideal world a good foundation of research driven archaeological studies would underlie and facilitate 'public' archaeological work. The provision of such a foundation is underway in some areas and its absence recognised in others (AMBS, 1997). In areas where a solid foundation of research is absent public archaeology has been accused of the 'substitution of research design with analyses based upon simple systems of pattern recognition', in other words, a comparative and statistical analytical approach which deals with physical evidence and its arrangement in space, without a model or understanding of the types of cultural system which have resulted in that pattern. Such pattern based analyses are fallible in their ability to predict cultural responses which may differ completely between like environments and within regions.

It is acknowledged that the types of regions used should have cultural foundation but due to research shortfalls they are in fact more commonly based upon physical environmental factors. However, it is also apparent that studies where models of human adaptation to environments have been developed and the resultant concepts of what types of physical evidence might be predicted to occur in particular situations have been explicated are also subject to change. For example, major theories concerning the rate and character of change in past Aboriginal social and economic systems are still debated. Certain founding theoretical concepts of Australian archaeology such as the existence of 'the small tool tradition' and the absence of backed blades prior to 5000 BP are currently being questioned (Hiscock and Attenbrow, 1998).

Current approaches termed 'off site' or 'non-site' archaeology which analyse overall patterning of archaeological materials in terms of their density and distribution across geographic areas are also amenable to the current approaches of public archaeology.

The AMBS (1997) report suggests certain categories of behavioural site types which ought to be sought, and by which a population of archaeological sites may be stratified. However unless it could be demonstrated that such sites accrue whilst retaining that function uniquely and consistently over time, rather than as a result of numerous occupation events that may add differing residues at any point, the situation is not substantially advanced in favour of simple pattern analyses.

For the current proposal the assessment of potential impact within a framework of a physically defined region is thus deemed the most appropriate approach. The following section discusses the definition of an appropriate study region.

3. Regional Context for the Proposal

The Cumberland Plain is a consistently recognised/used regional category throughout the body of archaeological work for the Sydney region (Byrne, 1994; Kohen, 1986;

McDonald, 1997; McDonald and Rich, 1993; Smith, 1989a). However, despite the quantity of work carried out, as a region, it has not been defined consistently. In most cases, the Plain is recognised as a core area of undulating and low lying terrain derived mainly from the Liverpool subgroup of shale dominated rocks. This area extends south to the Menangle region and includes the Tertiary sediments around Windsor. Variously excluded from this area is the outer gradational zone with the Hawkesbury sandstone and the area east of Parramatta where the coastal margin estuaries are an important feature.

Within the geo-technical literature a more inclusive unit is defined. The soil landscape surveys conducted by the Soil Conservation Service of NSW defined the Cumberland Lowlands as a unit extending as far south as Bargo and inclusive of all landforms based on Triassic shales (Bannerman and Hazelton, 1990; Hazelton and Tille, 1990). This definition included several distinctly different landscapes including the southern portion of the Plain which is dissected by deeply incised and entrenched fluvial corridors within the underlying sandstone, and the transitional zones around the periphery of the plain where shale based upper relief and interfluves are separated by sandstone gullies and lower slopes. The inclusion of these landscapes means that a subdivision of the Plain is needed to arrive at archaeologically useful categories which recognise the contrasting human constraints represented by the different terrain components.

The following major subdivisions of the Cumberland Plain have been previously defined or intuitively recognised within archaeological work (c.f. Smith, 1989a; Kohen, 1986; McDonald, 1997; Navin Officer Heritage Consultants, 1997):

- the tertiary terraces and gravels situated at the north-western end of the Plain extending from Cranebrook to the Windsor and Richmond areas;
- the southern portion of the Plain including the low relief terrain south of Camden, which is bounded and dissected by deeply incised sandstone gorges;
- the uplands situated at the south-western end of the Plain, including the moderately graded ranges between Mowbray Park and Douglas Park, The Oaks and Mount Hunter, and between Theresa Park in the north and Picton in the south;
- the gradational landscapes situated along the margins of the Cumberland Plain and which include significant proportions of terrain derived from both the Wianamatta Group rocks and the Hawkesbury sandstone;
- the southern lowlands, consisting of the low relief terrain, derived mostly from Wianamatta Group rocks which form a recognisable drainage basin centred on Narellan and Camden, including the catchments of Navigation, Narellan, Sickles and Cobbity Creeks; and
- the northern lowlands, consisting of the low relief terrain, derived mostly from Wianamatta Group rocks which forms the northern half of the Plain and a predominate northerly drainage alignment, and dominated by the catchments of South, and Eastern Creeks and the tributaries draining directly into the bordering Georges and Nepean Rivers.

In general, the archaeological use of the Cumberland Plain category attempts to isolate a landform group which is exclusive of sandstone based resources, inclusive of the undulating and lowland terrain associated with the Nepean River and characterises a hinterland zone behind the coastal and estuarine resources of the coastal margin. Nevertheless, the variety of ways in which the 'Cumberland Plain' has been defined in past studies and between disciplines, requires a clear redefinition for the purposes of this assessment.

With regard to the study area, the *northern lowland* subdivision is the most relevant for the definition of a *regional context* for a cumulative impact assessment. This is because the study area is situated within the middle to upper portion of South Creek catchment area - the dominant tributary catchment of the northern lowlands, and contains terrain which is entirely characteristic of the undulating and valley floor topographies of the north draining catchments. The southern lowlands are considered to be distinct from the northern tributary catchments due to the proximity and central location of the Nepean River corridor.

3.1 Regional Physical Environmental Context

The Badgerys Creek area is located within the eastern and middle section of the Cumberland Plain. The Cumberland Plain is a (variously) defined landform unit within the Sydney sedimentary basin which has formed on Triassic and Tertiary sedimentary rocks and sediments. The surface of the Cumberland Plain is predominantly composed of shales of the Wianamatta Group which have weathered to form low to moderately graded and predominantly undulating landscapes. Surrounding the plain are extensive exposures of the underlying Hawkesbury sandstone, which is relatively resistant to erosion compared to the overlying shales. The Hawkesbury sandstones support steep slopes, minor overhangs and often extensive vertical or near vertical escarpments. Sandstone topographies dominate where drainage lines have down-cut through shales to lower valley levels, or where structural uplift has elevated extensive sandstone plateaus which have subsequently become incised by fluvial erosion. Owing to the contrast between these softer rocks and the adjacent and underlying resistant Hawkesbury sandstones, the majority of the Cumberland Plain presents a distinctively contrasting landscape to the incised plateaus of the surrounding sandstone terrain.

The Cumberland Plain therefore effectively constitutes a region defined on a set of physical characteristics with reference to which the study area may be considered.

3.2 Regional Archaeological Context

The Sydney Basin has been the subject of intensive archaeological survey and assessment for many years. This research has resulted in the recording of thousands of Aboriginal sites and a wide range of site types and features. The most prevalent sites or features include isolated finds, open artefact scatters or camp sites, middens, rock shelters containing surface artefacts and/or occupation deposit and/or rock art, open grinding groove sites and open engraving sites. Rare site types include scarred trees, quarry and procurement sites, burials, stone arrangements, carved trees, and traditional story or other ceremonial places. Another feature recorded by archaeologists is the Potential Archaeological Deposit. This is an area where sub-surface artefacts are considered likely but no surface evidence exists. *Attachment 1* provides definitions for these sites.

Evidence from excavations suggests the occurrence of significant cultural change judging by reduced rates of artefact accumulation and shelter based occupation deposits and lack of corresponding evidence for population decline. McDonald (1994) interpreted the change as a shift in occupation strategy favouring open sites. The development of larger group sizes was posed as one possible factor resulting in a shift out of the spatial constraints of rock shelters.

Despite the number of archaeological surveys conducted on the Cumberland Plain, most have involved small areas and little work has been conducted regarding overall site density determinations. A review of the limited quantity of small comprehensive survey results from dissected sandstone plateau topographies in the Sydney Basin suggests that surface site densities range from 11 to 3.1 sites per square kilometre, with frequencies between four and six representing average rates. Determinations of site densities from comprehensive survey of large area samples are, however, not readily available from the existing literature,

The picture of Aboriginal utilisation and occupation of the Cumberland Plain is thus constantly being revised and refined as archaeological methods improve and more archaeological data becomes available for the area. Larger scale projects undertaken on the Cumberland Plain include Kohen's 1986 doctoral research on the western Cumberland Plain (Kohen, 1986), Smith's major compilation and analysis of data for the northern Plain (Smith, 1989a), McDonald and Rich's more recent investigations at Rouse Hill (McDonald and Rich, 1993) and McDonald's 1997 ADI survey located approximately 14 kilometres north of the current study area (McDonald, 1997). These have enabled development of general predictive models of Aboriginal site location on the Cumberland Plain.

Haglund (1980) developed a predictive model of site location based on early survey work in the Blacktown area. She predicted that sites would most likely be located near water courses such as creeks and soaks and on high ground near water.

Kohen (1986) postulated that the availability of water was the most important factor influencing the distribution of sites across the landscape. Other criteria which appear to play a role in site location are proximity to a diversity of economic resources such as food and lithic materials and to a lesser extent, elevation. Smith (1989a) supported the predictions made by Haglund (1980) and Kohen (1986) that sites will most commonly be found near water sources.

Smith (1989a) concluded that sites will occur in all areas of the Cumberland Plain, except where destroyed by non-Aboriginal land use, erosion processes and flooding; sites will be located in all topographic units with site densities expected to be 10 percent higher in the northern section of the Plain because of the greater concentrations of stone resources in that area; 50 percent of all sites will be found within 50 metres of a water source with sites tending to be more frequent around permanent water sources and that sites may also occur in relatively high frequencies on or near stone resources.

Smith's (1989b) study of the Liverpool release areas tended to confirm this site location model in that almost 75 percent of sites were found in association with a permanent water source and over 60 percent of sites were within 50 metres of water. In that study Smith concluded that sites in the Liverpool area were most likely to occur on creek flat topography and this tendency increased significantly in the vicinity of stream confluences.

McDonald (1992) subsequently raised the caution that Smith's study had focused on surface sites and on creeklines and creekbanks and had thus inadvertently introduced bias into the survey results. Kohen's (1986) site location model is also based on surface sites only and is subject to similar caution, particularly since subsequent excavations on the Cumberland Plain have demonstrated that surface sites generally substantially under-represent subsurface deposits (McDonald and Rich, 1993; Rich and McDonald, 1995).

The Sydney Second Airport Proposal Draft EIS (Navin Officer Heritage Consultants, 1997; PPK Environment & Infrastructure, 1997) added a further 110 sites to the regional database of 654 Aboriginal archaeological sites.

4. Physical Attributes of the Study Area

4.1 Landform Categories

Consistent with the selection of the northern lowland portion of the Cumberland Plain as the most applicable regional division for the study area, the extent of this assessment has been limited to the area of the Plain presented on the Penrith 1:100,000 map sheet. This provides a convenient and practical subset for data searches and mirrors the extent of regional enquiry established by McDonald for the ADI site assessment situated 14 kilometres further downstream on South Creek (McDonald, 1997).

The study area encompasses three of five broad landscape divisions proposed by McDonald (1997:24-26) in her categorisation of the 1,551 square kilometre regional area she defines as the Cumberland Plain. McDonald's categories include; Volcanic Vents, Shale Lowlands, Shale Uplands, High Terraces and Low Terraces/Floodplains. The category of Volcanic Vents is not represented in the study area. Shale Lowlands is equivalent to the Berkshire Park soil landscape. Shale Uplands is equivalent to the Luddenham soil landscape. High terraces are not represented within the study area. The Low terraces/floodplains category is equivalent to the South Creek soil landscape.

4.2 Hydrology

The study area is characterised by upper catchment contexts in which the only perennial streamline is the waters of Badgerys Creek. The majority of the study area is situated within the upper catchment of Badgerys Creek which is itself a major tributary of South Creek, one of the main fluvial corridors draining the central Cumberland Plain. The watershed between Badgerys Creek and the Nepean River catchments transects the western third of the study area and is approximated by the existing line of The Northern Road. The watershed is significant in terms of the hydrology of the Plain, but provides an unimposing topographic feature as a broad and low gradient ridgeline.

In the south-eastern corner of the study area a small portion of the lower reaches of the Thompson Creek catchment occurs prior to its confluence with South Creek, approximately 500 metres east of the study area boundary. Small sections of the upper catchment of the immediate South Creek catchment also occur along the eastern margin of the study area. Along the northern margin, the upper catchments of Cosgrove, Oaky and an unnamed tributary of Badgerys Creeks occur.

4.3 Soils

In the study area soils are predominantly clay loams of the Cumberland association, with an area of the Menangle association near the middle of the study area, and an area of Mulgoa association alluvium near the western edge (Kinhill Stearns, 1985).

4.4 Vegetation

The original vegetation of most of the Cumberland Plain was an open eucalypt woodland in which the trees were widely spaced and the ground cover dominated by grasses (Perry, 1963). Reconstruction of the vegetation structure at c.1780 indicates that the study area would have been vegetated with a Eucalypt woodland of medium height. Trees achieved between 10 and 30 percent canopy coverage over an understorey of tufted and tussocky grasses and *gramineae* (Carnahan and AUSLIG, 1989a). Most of the original native vegetation has been cleared from the study area and vegetation cover over much of the area now comprises predominantly thick pasture grasses with scattered Eucalypts and exotic trees, shrubs and weeds. Currently the study area has only remnant patches of this original vegetation and the majority of lands have suffered an estimated loss of between 60 and 90 percent of their original vegetative cover (Carnahan and AUSLIG, 1989b). Few old growth Eucalypts remain in the area.

4.5 Land Use

The study area has primarily been used for agricultural purposes, including cropping, market gardening and grazing, since the early 1800s. The area is still used for farming, although a number of farms have been abandoned and some buildings demolished since Commonwealth acquisition of land in the 1980s. Subdivision into small rural residential lots has occurred over a significant proportion of the study area. Land use in the area today includes cattle and sheep grazing, chicken farms, horse breeding properties and training tracks, the Royal Australian Air Force Bringelly Remote Receiving Station, Brickworks and small allotment rural residential properties and associated infrastructure. All of these activities have the potential to disturb and/or destroy Aboriginal sites. Land clearance and repeated ploughing and cropping will have destroyed most scarred trees and impacted artefact scatters at least to a depth of the plough zone (c.25-30 centimetres). Ploughing both mixes the contents of the upper soil profile vertically, and spreads artefactual material horizontally, making artefact scatters more dispersed and larger in area (Knoerl and Versaggi, 1984; McManamon, 1984).

5. Archaeological Potential of the Study Area

5.1 Areas of Identified Archaeological Potential

Previous archaeological investigations have contributed significantly to an understanding of the Cumberland Plain regional resource, however the nature of cultural resource management studies and the limited quantity of research based projects means that only a very small part of the region has been systematically surveyed.

Nevertheless, there are several potential avenues for the estimation of cumulative impacts incurred by developments. The impact of non-Aboriginal land use has been noted to significantly reduce archaeological potential in some areas, to the degree that it can be employed as a valid criterion against which archaeological potential may be assessed. Areas of archaeological potential also appear to be related to the character of stream courses within an area. Subsequently areas of alluvial deposition may also be considered potentially significant (Navin Officer Heritage Consultants, 1997). The relationship between particular geomorphic units and the occurrence of archaeological materials is also showing promise as a means of elucidating areas of archaeological potential (McDonald, 1997). Areas of high archaeological potential were indicated in the analysis of survey results for the airport option areas (PPK Environment & Infrastructure, 1997). These included stream corridor environments, areas of alluvial deposition and remnant woodland areas, features that were largely coincident in their occurrence within the study area.

All of these approaches enable landscape based prediction of site occurrence based upon the identification of repetitive characteristics drawn from analysis of the known record. They do not however, address the underlying pattern of cultural adaptation leading to formation of the archaeological record, and their limitations in this regard must be borne in mind. Until more thoughtful and comprehensive archaeological investigations are undertaken, landscape or pattern recognition (AMBS, 1997) analyses present the only feasible means of approach.

5.2 Land Use Impact as an Indication of Archaeological Potential

McDonald (1997) categorised her ADI field area according to the severity of land use impact and its potential effect upon archaeological materials. Her four categories were housing/urban areas, small farms, larger farms/cleared land and timbered lands. She considered that the impact of housing and small scale farming activities upon the archaeological record was severe, and that site survival in such areas was unlikely (McDonald, 1997:24). The latter two categories, larger farms/cleared land and timbered lands, were considered to have moderate to high potential to contain lesser and/or undisturbed archaeological materials respectively.

The study area may also be considered in similar terms (refer to *Table 1, Attachment 2*). Figures 10.10 and 17.1 of the Draft EIS (PPK Environment & Infrastructure, 1997) show the division of land uses and remnant woodland areas present in the study area, respectively. A variety of land uses are shown in Figure 10.10 including agriculture-livestock, agriculture-cropping, rural/residential, commercial and open space. They are depicted in Photograph 1 of the Draft EIS. The aerial photograph may be correlated with Figure 10.10 and reveals that the areas designated agriculture-livestock, agriculture-cropping which may otherwise be equivalent to the 'larger farms/cleared' land category of McDonald (1997) appear to have suffered considerable disturbance in the form of clearance, ploughing, grading etc. The rural residential component equivalent to the 'small farms' category has similarly been severely impacted. The areas designated open space on Figure 10.10 are clearly not similar to the category of 'open space' (cleared only) referred to by McDonald (1997), being clearly built upon and otherwise disturbed in the aerial view ('open space' along The Northern Road for example). Wooded areas are not exclusively depicted upon the land use map (Figure 10.10) but instead are included as part of the other categories.

The areas of remnant Grey Box Woodland and River Flat Forest formation among open fields and along stream courses (Draft EIS Figure 17.1 and Photograph 1) appear to represent the only areas with high potential for less and undisturbed and hence potentially significant archaeological materials. The major land use division of the study area for this assessment is thus the distinction between these remnant wooded areas and the remaining area.

The wooded areas are subsequently the initial focus for analysis to determine the potential cumulative loss of archaeological materials represented by their destruction within the Badgerys Creek airport options, as compared to the known and surviving resource (baseline) of the Cumberland Plain (as defined by McDonald, 1997).

The areal extent of these wooded formations, their representation within each airport option, and within each geomorphic unit, was calculated from Figure 17.1 in the Draft EIS (refer *Table 2, Attachment 2*).

Table 1 (refer *Attachment 2*) adopts McDonald's (1997:11) definition of the wider Cumberland Plain region as that area lying between the Hawkesbury-Nepean River and Longitude 151 degrees East, covering approximately 1,551 square kilometres.

McDonald (1997:25-6) calculates that of this original area, an area of 724 square kilometres (or 46 percent of the region) has retained archaeological potential. Of this area 325 square kilometres is composed of Shale Lowlands (Berkshire Park soil landscape equivalent), 119 square kilometres is composed of Shale Uplands (Luddenham soil landscape equivalent), 74 square kilometres is composed of high terraces (no equivalent in study area) and 206 square kilometres is composed of low terraces/floodplains (South Creek Soil Landscape equivalent).

5.2.1 Cumulative Impact Upon Archaeologically Sensitive Land Use Categories

Calculation of wooded areas within each geomorphic category for the Badgerys Creek airport options indicates that when all Options (A, B and C) are combined, 1.8 square kilometres (0.55 percent) of the surviving Shale Lowlands (Berkshire Park soil landscape equivalent) with archaeological potential would be threatened, 0.5 square kilometres (0.42 percent) of the surviving Shale Uplands (Luddenham soil landscape equivalent) with archaeological potential would be threatened and 1.1 square kilometres (0.53 percent) of the surviving low terraces/floodplains (South Creek Soil Landscape equivalent) with archaeological potential would be threatened.

Similar calculations for Option A indicate that 1.03 square kilometres (0.31 percent) of the surviving Shale Lowlands (Berkshire Park soil landscape equivalent) with archaeological potential would be threatened, 0 square kilometres (0 percent) of the surviving Shale Uplands (Luddenham soil landscape equivalent) with archaeological potential would be threatened and 0.97 square kilometres (0.47 percent) of the surviving low terraces/floodplains (South Creek Soil Landscape equivalent) with archaeological potential would be threatened.

Calculations for Option B indicate that 1.8 square kilometres (0.55 percent) of the surviving Shale Lowlands (Berkshire Park soil landscape equivalent) with archaeological potential would be threatened, 0.5 square kilometres (0.42 percent) of the surviving Shale Uplands (Luddenham soil landscape equivalent) with archaeological potential would be threatened and 1.1 square kilometres (0.53 percent) of the surviving low terraces/floodplains (South Creek Soil Landscape equivalent) with archaeological potential would be threatened.

Calculations for Option C indicate that 1.85 square kilometres (0.56 percent) of the surviving Shale Lowlands (Berkshire Park soil landscape equivalent) with archaeological potential is threatened, 0.25 square kilometres (0.20 percent) of the surviving Shale Uplands (Luddenham soil landscape equivalent) with archaeological potential would be threatened and 1.01 square kilometres (0.49 percent) of the surviving Low Terraces/Floodplains (South Creek Soil Landscape equivalent) with archaeological potential would be threatened.

In terms of total loss of archaeological potential as represented by the destruction of undisturbed landscape areas the airport options could be ranked as follows (see *Tables 1* and *3* in *Attachment 2*):

- most loss is Option B with 3.4 square kilometres of high potential lands representing an additional 0.46 percent loss of the potential surviving regional resource and increasing regional cumulative loss to 47.13 percent;
- second most loss is Option C with 3.1 square kilometres of high potential lands representing an additional 0.43 percent loss of the potential surviving regional resource and increasing regional cumulative loss to 47.10 percent; and
- least loss is Option A with 2.0 square kilometres of high potential lands representing an additional 0.276 percent loss of the potential surviving regional resource and increasing regional cumulative loss to 46.95 percent.

5.3 Stream Order Analysis as an Indication of Archaeological Potential

McDonald's (1997) model of archaeological potential in landscapes also explored the influence of drainage regimes and their provision of reliable and permanent water sources as attractants for Aboriginal occupation and hence site formation. McDonald (1997:56-57) suggested that a direct co-relationship exists between archaeological potential and the character of drainage systems within an area. As stream order increases, its reliability in terms of provision of still or flowing water sources also increases, and as a result, so does its potential for association with more intense occupation leading to the formation of more complex, denser and potentially more significant (from a scientific perspective) archaeological sites.

Of particular importance, and as a product of this general trend, McDonald (1997) also predicted that creek junctions or confluences which she termed 'nodes', come to represent activity foci, and as a result the complexity of surrounding occupation activity (and hence archaeological evidence) increases. The degree of increase is predicted to be directly proportional to the stream order of the contributive watercourses. Within this landscape model ridgetop locations are predicted to accrue limited occupation evidence resultant of more transitory activities. The location of specifically attractive resources such as stone sources is also predicted to exert an additional strong influence upon the density and complexity of associated occupation evidence.

Considering the range of annual precipitation (700 to 900 millimetres) in the Cumberland Plain region it was estimated that the junction of second and third order streams crossed a critical threshold in terms of provision of a reliable water supply (McDonald 1997:20). In her consideration of the Cumberland Plain region McDonald (1997:23) estimates that prior to any non-Aboriginal land use disturbance (that is, circa 1788) there would have been approximately 600 nodes of second order stream and 400 nodes of streams of third order or greater. Thus according to the model there may have been over 1,000 locations which, by virtue of associated water supply, may have constituted identifiable foci for Aboriginal occupation.

Stream order analysis for the study area was extrapolated from the Penrith 9030-3-N and Prospect 9030-II-N 1:25000 topographic maps and is summarised in *Table 4* in

Attachment 2. Streams in the study area range from first to fifth order. Stream nodes are second, third and fourth order.

Option A contains 83 first order, 22 second order, 8 third order and 1 fourth order stream. It contains 23 second order nodes and 6 third order nodes.

Option B contains 152 first order, 39 second order, 10 third order and 1 fourth order stream. It contains 36 second order nodes and 9 third order nodes.

Option C contains 122 first order, 33 second order, 1 third order, 1 fourth order and 1 fifth order stream. It contains 33 second order nodes and 2 third order nodes.

By ranking each option from 1 to 3 for each category of stream and node order a score was obtained to indicate relative degrees of potential archaeological significance if the drainage regime was in pristine order. The scores suggest that Option B would contain the most archaeological potential, Option C the second most potential and Option A the least archaeological potential.

5.3.1 Cumulative Impact Upon Stream Order Indicated Archaeological Potential

Comparison with the original Cumberland Plain regional resource as calculated by McDonald (1997:23) suggests that Option A contains approximately 3.8 percent of second order nodes, Option B approximately 6 percent and Option C 5.5 percent. Option A contains 1.5 percent of nodes of third order or higher, Option B contains 2.25 percent of streams of third order or higher, and Option C contains 2 percent of streams of third order or higher.

An estimate of what these figures represent in terms of cumulative impact is harder to arrive at, since there is no analysis of the integrity of all stream confluences present in the Cumberland Plain region. McDonald (1997:55) surmises that between 300 and 500 second order nodes, and between 150 and 250 third order nodes are likely to have survived the impacts of post 1788 land use.

However, if stream confluence survival may be correlated with general patterns of land use impact (estimated by McDonald to be in the order of 54 percent overall land use disturbance) then it could be estimated that perhaps 50 to 60 percent of 'streamscapes' have suffered similar fates. Taking the less conservative estimate of 60 percent would suggest that approximately 240 second order stream nodes and 160 third order and higher stream nodes represent the surviving resource.

Cumulative impact in terms of destruction of these entities, in the case that they were all in pristine condition, for Badgerys Creek airport options would then be as follows:

- Option A would constitute an additional 9.5 percent impact upon the potential resource associated with second order stream nodes. It would constitute an additional 5 percent impact upon the potential resource associated with third or higher order stream nodes;

- Option B would constitute an additional 15 percent impact upon the potential resource associated with second order stream nodes. It would constitute an additional 7.5 percent impact upon the potential resource associated with third or higher order stream nodes; and
- Option C would constitute an additional 13.75 percent impact upon the potential resource associated with second order stream nodes. It would constitute an additional 6.6 percent impact upon the potential resource associated with third or higher order stream nodes.

Examination of topographic maps for the Badgerys Creek area reveals that a considerable number of nodes have been impacted by the construction of dams. Of the 43 second order nodes present in the area 15 have dams constructed over them, and of the 14 third order or higher nodes, seven have had dams constructed over them. This reduces the cumulative impact of the Second Sydney Airport proposal somewhat.

This means that the construction of Option A would result in the destruction of 17 second order nodes (an additional seven percent cumulative impact) and four third or higher order nodes (an additional 2.5 percent cumulative impact). Construction of Option B would destroy 21 Second Order Nodes (an additional 8 percent cumulative impact) and two third or higher order nodes (an additional 1.8 percent cumulative impact). Construction of Option C would destroy 23 second order nodes (an additional 9.5 percent cumulative impact) and two third or higher order nodes (an additional 0.6 percent cumulative impact).

5.4 The Known Archaeological Resource.

A total of 654 Aboriginal archaeological sites had been recorded within the Cumberland Plain region (refer *Table* 5 in *Attachment 2*) (McDonald, 1997:37). The majority (53.6 percent) are situated on the Shale Uplands and Lowlands (McDonald, 1997:50). Sites on low terraces/floodplains account for 29.5 percent of the total and the remaining 16.8 percent occur on high terraces. As McDonald pointed out in her 1997 report it is difficult to equate 'sites recorded' with concepts of 'surviving resource', since there are no consistent records maintained as to the survival of the resource after recording. Some sites may have been subject to Consent to Destroy applications but there is little documented follow up as to whether all or part of a site was actually destroyed.

The Draft EIS for the Sydney Second Airport Proposal (PPK Environment & Infrastructure, 1997) added 110 sites (15 lying outside the area of the airport options) to that regional database making a total of 764 sites for the Cumberland Plain region. *Table* 6 in *Attachment 2* shows the composition of new sites recorded in the study area.

5.4.1 Cumulative Impact of the Proposal upon the Known Archaeological Resource

All airport options combined would result in the destruction of 96 archaeological sites (refer *Table 7* in *Attachment 2*), comprising 7 scarred trees, 48 open artefact scatters and 41 isolated finds. Their destruction would constitute a cumulative impact of 12.56 percent of the known archaeological resource. Specifically all options combined would account for the destruction of 32 percent of known scarred trees, 7.5 percent of open artefact scatters, and 12.5 percent of all lithic sites (inclusive of isolated finds).

Option A would result in the destruction of 7.8 percent (60 sites) of the known archaeological resource, 23 percent of known scarred trees, 3.9 percent of open artefact scatters and 7.4 percent of all lithic sites (inclusive of isolated finds).

Option B would result in the destruction of 10.99 percent (84 sites) of the known archaeological resource, 32 percent of known scarred trees, 5.76 percent of open artefact scatters and 10.98 percent of all lithic sites (inclusive of isolated finds).

Option C would result in the destruction of 12.3 percent (94 sites) of the known archaeological resource, 32 5 of known scarred trees, 7.32 percent of open artefact scatters and 12.41 percent of all lithic sites (inclusive of isolated finds).

5.5 The Predicted Archaeological Resource

Some indication of the potential archaeological resource present in a region may be drawn from comparison of site yields per unit area surveyed (refer *Table 8* in *Attachment 2*). *Table 9* in *Attachment 2* presents data extrapolated from the survey coverage, sample size and site recovery data from the survey area

The data enables an estimate to be made of total archaeological resources present, or originally present in the survey, based upon analogy with actual findings. It predicts that there are probably 230 sites in total throughout the combined airport option areas (95 were recorded). Option A is predicted to contain 126 sites and/or isolated finds. Option B is predicted to contain 190 sites or isolated finds. Option C is predicted to contain 201 sites or isolated finds. These predictive totals would increase the regional database to 884 sites.

5.5.1 Cumulative Impact of the Proposal with Reference to the Predicted Regional Resource

Development of the combined airport options would potentially account for a 26 percent reduction in aggregate known and predicted sites. Development of Option A would result in destruction of 14.25 percent of all sites. Development of Option B would result in the destruction of 21.5 percent of the regional resource. Development of Option C would result in the destruction of 23 percent of the regional archaeological resource.

Within Option A, a total of one site or isolated find is predicted to occur in the Shale Uplands (Luddenham soil landscape), 88 sites/isolated finds are predicted to occur within the Shale Lowlands (Berkshire Park soil landscape) and 37 sites/isolated finds are predicted to occur in the Quaternary Floodplains (South Creek soil landscape).

Within Option B, 5 sites or isolated finds are predicted to occur in the Shale Uplands (Luddenham soil landscape), 78 sites/isolated finds are predicted to occur within the Shale Lowlands (Berkshire Park soil landscape) and 42 sites/isolated finds are predicted to occur in the Quaternary Floodplains (South Creek soil landscape).

Within Option C, five sites or isolated finds are predicted to occur in the Shale Uplands (Luddenham soil landscape), 79 sites/isolated finds are predicted to occur within the Shale Lowlands (Berkshire Park soil landscape) and 50 sites/isolated finds are predicted to occur in the Quaternary Floodplains (South Creek soil landscape).

6. Qualifications to Archaeological Potential Estimates

At face value the actual and predicted figures suggest that the development of any of the airport options would result in a significant impact to the archaeological resource of the Cumberland Plain. However figures which relate to known archaeological resources must be seen in their relative context. Overall, only a very small proportion of the Cumberland Plain has been subject to comprehensive field survey. In 1989 a consultant estimated that less than 0.5 percent of the Cumberland Plain had been systematically surveyed and a total of 386 sites were then on record (McDonald, 1997:29).

Thus the known record in fact relates to a much smaller geographic area than might be initially surmised from consideration of a 1,551 square kilometre regional area. In order to more accurately assess the potential archaeological loss resulting from the development of the Sydney Second Airport the possible predicted total archaeological resource present within the Cumberland Plain requires discussion.

By way of spurious example, if 0.5 percent of the region produced 386 sites, then 100 percent of the region might have produced 77,200 sites. If land use since 1788 has resulted in an approximately 60 percent reduction in archaeological resources then 46,320 of these ought still to have survived. Therefore a more realistic regional baseline ought to be 46,320 instead of 884 predicted sites. This would suggest the existence of approximately one site per three hectares as an average. If this was the case, then the cumulative impact of any proposed developments would then be reduced by an order of magnitude. Whilst such figures are meaningless in suggesting where such a corpus of sites might be situated within the region, they still provide an indication of the order of magnitude of the regional archaeological potential as yet unrealised by systematic and comprehensive survey.

The preceding example highlights the need for an overarching regional survey in the Cumberland Plain which would enable a more realistic approximation of the archaeological baseline. Nevertheless it is still apparent that the previous analyses of the airport options are suggestive of considerable cumulative impact upon particular categories of archaeological resource. The ostensibly higher percentages of cumulative impact may be explained by the particular circumstances of different site types. The loss of between five and seven scarred trees for example stands to reduce the regional resource by between 23 and 32 percent. The limited number of these site types on record may be partly due to the lack of regional survey coverage rather than rarity per se. However further information ought be sought as to the real status of this site type in the Cumberland Plain prior to their destruction. A comparative sample area targeting remnant wooded areas in the Cumberland Plain should indicate whether the recorded low numbers are simply a product of sample bias.

A further qualification could be introduced concerning the concepts of site significance (Australia ICOMOS, 1987). This analysis has deliberately avoided attaching significance values to any of the archaeological sites discussed since the various types of values under which significance may be assessed would not necessarily be consistent. For example, the concept of Aboriginal cultural significance may accrue to sites regardless of any perceived scientific or other value. However if scientific values were considered it ought to be noted that *Technical Paper No. 11* for the Draft EIS (Navin Officer Heritage Consultants, 1997) ascribed predominantly low scientific value to the majority of sites recorded in the study area due to considerations of size, condition and regional commonality.

In addition the status of the trees as definitively Aboriginal sites also requires further analysis. *Technical Paper No. 11* clearly outlined the methodological difficulties associated with the identification of these sites and the requirement for further substantiation (Navin Officer Heritage Consultants, 1997).

7. Conclusions

7.1 Estimated Sum Cumulative Impact of the Proposal on the Archaeological Resource

The cumulative impact of the proposed development of the Sydney Second Airport is in most cases proportional to the actual loss of the landform units involved in the study area, except where land use impacts have operated differentially between the option areas (refer *Table 10* in *Attachment 2*). Option A consistently presents as incurring the least cumulative impact, Option B the second least and Option C consistently incurs the greatest levels of cumulative impact.

Consideration of the known database reveals what otherwise might be interpreted as alarming trends, in comparison to the predictive models based upon land use disturbance and stream order analysis. In some cases the loss of sites is far higher than what would be predicted given the size of the study area. This is explicable in terms of the limitations of the existing regional database and lack of large area comprehensive survey areas. In some cases there are additional considerations centred on site provenance. In the study area, the recorded scarred trees were not originally accorded with a high degree of confidence for an Aboriginal origin (Navin Officer Heritage Consultants, 1997).

Table 10 in *Attachment 2* also includes a speculative calculation of the cumulative impact with regard to a predicted surviving archaeological resource, rather than the known entity, which suggests the possibility of cumulative impact being an order of magnitude less than otherwise indicated. Before such figures could be used as support for the proposal however, the onus would be on the proponent to instigate quality regional archaeological investigations in areas other than Badgerys Creek by which their reality may become more obvious.

Mitigation of the cumulative impact may also be approached from the perspective of regional trade-offs. For instance better conserved (that is, areas with less land use impact) examples of the landforms and site complexes present in Badgerys Creek occur outside of the study area. Landforms such as aggrading alluvial contexts which would be considered to have high archaeological potential are the landforms that are well preserved in other areas of the South Creek catchment. Long term protection of such landscapes would be a more practical approach than the conservation of the degraded resource contained within the Badgerys Creek area.

The longer term cumulative impacts set in motion by the development of the Sydney Second Airport within the region, in tandem with anticipated urban expansion and other land use changes within the wider region and within the Sydney Basin overall call for such alternative measures to be seriously considered.

7.2 Future Cumulative Impacts

This refers to those impacts likely to arise in the future as further developments occur which are necessitated or encouraged by the proposed Sydney Second Airport. Future cumulative impacts have not been considered in this assessment. Those identified in the Draft EIS (PPK Environment & Infrastructure, 1997 27-10-14) which may potentially affect cultural heritage resources include:

- local and regional planning effects - increased population resulting in increased visitation to sites, increased requirement for cultural heritage awareness and education, increased vandalism and incidental site destruction;
- land use changes and urban developments - the development of new businesses, relocation of others in proximity to the new airport. Associated developments including new water supplies and sewerage services. Changes in land use leading to increased clearance and ground disturbance. New powerlines, telecommunications linkages etc.;

- land transport access proposals - new road and rail links and utility services. Upgraded roads immediately surrounding the airport (Elizabeth Drive, Bringelly Road and The Northern Road) have been identified; and
- changes to the noise environment and air and water quality may have indirect impacts upon cultural heritage, particularly where aesthetics, interpretation and ability to appreciate through visitation constitute part of the significance of the resource.

8. Authorship and Acknowledgments

This investigation was project managed by Navin Officer Heritage Consultants. The report was co-written by Jan Klaver and Kelvin Officer. Jo McDonald kindly provided comparative materials referred to in the report.

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Attachment 1

Site Definitions

Attachment 1: Site Definitions

Isolated Finds

An isolated find is a single stone artefact, not located within a rock shelter, and which occurs without any associated evidence of Aboriginal occupation within a radius of 60 metres. Isolated finds may be indicative of the random loss or deliberate discard of a single artefact, the remnant of a now dispersed and disturbed artefact scatter or an otherwise obscured or sub-surface artefact scatter. Except in the case of the latter, isolated finds are considered to be constituent components of a background scatter present within any particular landform. Archaeologists often make a distinction between an isolated find and a site because an isolated find cannot normally be reliably related to a place or focus of past activity.

Background Scatter

Background scatter, or off-site archaeological remains refers to artefacts which cannot be justifiably related to a place or focus of past activity (except for the net accumulation of single artefact losses). Background scatters are a temporally unrelated accumulation of artefacts across a large area and will vary in density according to the type and frequency of past occupation within that landscape. A background scatter can be defined as artefactual material where association between artefacts can only be described using large scale and inclusive temporal and spatial categories of past occupation.

Sites

A site is defined as any material evidence of past Aboriginal activity which remains within a context or place which can be reliably related to that activity.

The range of potential site types include: open artefact scatters, rock shelter sites including occupation deposits and/or rock art, grinding groove sites and scarred trees.

Scarred Trees

These are trees from which pieces of bark have been removed for any of a range of purposes in Aboriginal land use and where a characteristic negative or scar remains. Each tree is normally considered to be a separate site. The identification of a scar as Aboriginal in origin is dependent on a set of inter-related interpretive criteria (Beesley, 1989; Simmons, 1977).

Open Artefact Scatters

These are Aboriginal occupation sites which occur on land surfaces unprotected by rock overhangs and may be distinguished by the presence of flaked stone materials and occasionally occupation deposit including economic and food remains and campfire debris.

Attachment 2

Tables

Attachment 2: Tables

Table 1: Archaeological Potential as Indicated by Land Use Impacts

												Timbered Lands and Open Space				Timbered and Open Space Percentage of Lands Potentially Lost Due to Airport Compared to Land Category Throughout Cumberland Plain				Remaining lands of Low Potential	
Land Category	Total Area km^2	% Component of Cumberland Plain	Area Left with Archaeological Potential	Housing $\%/km^2$	Small Farms $\%/km^2$	Housing and Small Farms Sum km^2	Open Space	Timbered land	Open Space and Wooded Sum	Badgerys Creek All Options	As % of total land system within Cumberland Plain	All Options	Option A	Option B	Option C	Option A	Option B	Option C	All Options	Area km^2	All Options
Volcanic Vents	6	0.4																			
Shale Lowlands (Berkshire Park Soils)	835	54	325	26.1 /404	7/109	513	17 /269	4/59	328	29.68	3.5	1.8	1.03	1.8	1.8	0.316	0.55	0.55	0.55	27.88	5.78
Shale Uplands (Luddenham)	195	13	119	4/62	1/14	76	5/74	3/45	119	1.83	0.938	0.5	0	0.5	0.25	0	0.42	0.21	0.42	1.33	2.4
High Terraces	225	14	74	4/61	6/90	151	0.42/7	4.2 /67	74	0	0	0	0	0	0	0	0	0	0	0	0
Low Terraces and Floodplains (South Creek Soils)	290	19	206	3/67	1/7	84	12 /180	2/26	206	2.3	0.79	1.1	0.97	1.1	1.01	0.47	0.53	0.49	0.53	1.2	2.725
Total	**1551**	**100**	**724**	**594/37**	**230/15**		**530/34.5**	**13 /197**	**928**	**33.81**	**5.228**	**0.34**	**2.0**	**3.4**	**3.1**	**0.27**	**0.46**	**0.43**	**0.46**	**30.41**	
													200ha	340ha	310ha						

Table 4 **Steam Order Analysis for the Airport Options**

	Pristine Environment							Post 1788 Land Use		
	Stream Order					Nodes		Nodes		
	1	2	3	4	5	2	≥3	2	≥3	Relative Ranking of Cumulative Impact
Option A										
Total	83	22	8	1	0	23	6	17	4	
Ranking 1 to 3	2	3	2	1	2	3	3	3	1	Equal
Option B										
Total	152	39	10	1	0	36	9	21	3	
Ranking 1 to 3	1	1	1	1	2	1	1	2	2	Equal
Option C										
Total	122	33	10	1	1	33	8	23	2	
Ranking 1 to 3	3	2	1	1	1	2	2	1	3	Equal

Table 5 **Sites Recorded in Geomorphic Units Within the Cumberland Plain Region Compared with Predicted Totals for the Badgerys Creek Area**

Geomorphic Category	% of Cumberland Plain	No. of Recorded Sites	% of Recorded Sites	% of Badgerys Creek	Predicted No. of Sites
Volcanic Vents	0.4% (neg)	0			
Shale Lowlands	5.4%	see below	see below	88%	175.1
Shale Uplands	13%	see below	see below	5%	4.6
Combined Shale Uplands and Lowlands		351 Combined	53.6% Combined	93%	180
Tertiary Terraces	14%	110	16.8%	0	0
Floodplains	19%	193	29.5%	7%	50.4

Table 6 **Site and Isolated Find Recovery per Geomorphic Unit in Airport Options**

	All Options		Option A		Option B		Option C	
	IF	Sites	IF	Sites	IF	Sites	IF	Sites
Luddenham	1	0	1	0	1	0	1	0
South Creek	11	21	9	11	11	16	11	21
Berkshire Park	29	34	20	17	28	23	28	33

Table 10 Summary of Cumulative Impact of Airport Options

Type of Impact	Option A	Option B	Option C
High Potential Lands/Land Use	0.276%	0.46%	0.43%
Second/Third Order Intact Stream Nodes	7% / 2.5%	8% / 1.8%	9.5% / 0.6%
Loss of Recorded Sites	8.5%	11.98%	13.4%
Loss of Predicted Archaeological Resource Relative to Region	14.25%	21.5%	23%
Ranking	3	2	1

Appendix H1

Methodology Adopted to Establish Land Transport Demand

Appendix H1

Methodology Adopted to Establish Land Transport Demand

1. Introduction

To assess land transport demand associated with the Second Sydney Airport, traffic models were developed for the years 2006 and 2016 considering a range of different scenarios. This involved a combination of different travel forecasts for airport patronage and operational workforce.

The modelled traffic on the roads is divided into two components. The first is base traffic volumes and these are generated as a result of Sydney's population, employment and workforce location.

The other component is that directly generated by the airport. Components of this traffic are:

- airport employment;
- passengers; and
- meeters and greeters.

2. Sydney Land Use Projections

Land use scenarios are used to present a picture of how Sydney might look in the future, in terms of the extent, timing and distribution of population, workforce residency and employment location.

Land use forecasting is an uncertain process, given the nature of Sydney's complex and changing urban society. For the purpose of assessing major infrastructure projects, such as the Second Sydney Airport proposal, it is necessary to define a number of land use scenarios within which the actual land use might lie at a given point in time. The land use forecasts used in the Draft EIS were developed in the following manner:

- base land use data was assembled from the *1991 Census of Population and Housing* (Australian Bureau of Statistics, 1991) using collector districts and subsequently aggregated to travel zones, of which there are 756 in the Sydney region;
- population forecasts for the Sydney region, based on *Population Projections, Sydney Region Local Government Areas 1991-2021, 1995 Revision* (Department of Urban Affairs and Planning, 1995a) were identified;
- potential urban development areas were identified using *Sydney Residential Land Urban Development Program, The 1995/96-1999/2000 Program* (Department of Urban Affairs and Planning, 1995b). This included urban development on key sites such as the ADI site at St Marys;
- the population was distributed within the Sydney region using a dwelling stock approach, based on assumptions about dwelling commencements in both urban release and established areas, vacancy rates, occupancy rates and replacement rates; and
- the workforce and employment levels were then estimated, based on assumptions about participation rates, unemployment rates, industry structure and employment locations.

Two future land use scenarios were developed, as described in Chapter 10 of the Draft EIS, to reflect possible land use patterns that might occur due to the influences of the Badgerys Creek airport options. Additionally, a "do nothing" scenario for the purposes of defining a base case for traffic modelling was developed to reflect the land use pattern if no new airport was developed. Each scenario was assessed for 2006 and 2016. Population projections for each scenario are listed in *Table H1.1*.

Table H1.1: Sydney Population Projections

	Sydney Metropolitan Region	Sydney Outer Region	Total Sydney
1996	3,424,450	366,100	3,790,550
Do Nothing			
2006	3,715,250	409,850	4,125,150
2016	3,919,500	436,200	4,355,700
Option C			
2006	3,715,250	409,850	4,125,150
2016	3,920,950	434,800	4,355,700

Source: PPK Environment & Infrastructure, 1997

Based on the above, it is possible, using the traffic model, to estimate the likely distribution of trips across the modelled network and identify those roads which might experience congestion in future years.

It must be emphasised that the modelling did include the impact of traffic growth occurring within potential urban villages surrounding a rail link to the proposed airport. The Draft EIS estimates of village population in 2016 have been adopted for traffic modelling purposes, that is, 12,000 people in Bringelly or Rossmore and 14,000 in Edmondson Park. It should be noted that the model did not distinguish between an urban village located at Rossmore or Bringelly. This is because at the regional context at which the traffic impacts were being assessed the nominated village locations would not alter the predicted impact on the region's roads. Consequently, the resultant impacts on the region's roads from population growth occurring in the urban villages was considered as part of the Draft EIS traffic assessment. (The forecast traffic volumes and levels of service for the modelled airport options was included in Appendix I of *Technical Paper No. 13*.)

3. Travel Forecasts

3.1 Air Traffic Forecasts

The following scenarios were adopted for the evaluation of the impact of a Second Sydney Airport on the surface transport infrastructure:

- 2006: the first scenario is based on *Air Traffic Forecast 2* which assumes 10 million air passengers at Second Sydney Airport; and
- 2016: the second scenario is based on *Air Traffic Forecast 3* which assumes about 30 million air passengers at Second Sydney Airport.

Chapter 4 of this Supplement indicates that the air traffic forecasts used in the Draft EIS are conservatively high. The revised forecasts are based on trends in passenger and aircraft movements occurring since publication of the Draft EIS and accordingly suggest the total forecast vehicles trips estimated in the Draft EIS may not occur to some time after 2006 and 2016.

3.2 Future Airport Workforce

Forecasts of future employment growth was assembled from a number of sources relating to employment patterns and trends in Sydney. A forecasting model was developed using base employment data from a recent study of Sydney Airport (Institute of Transport Studies, 1996).

Future direct employment estimates for the two Sydney airports in the Draft EIS were based on current levels of employment and future passenger projections which were then discounted by a productivity forecast. With the application of new technology to airports and the probable advent of larger aircraft, it is likely that passenger demand and employment levels would not grow at the same rate. Past trends in productivity improvement for the air and space transport sector have been

References

Australian Bureau of Statistics (1991), *CDATA91 - Census 1991*, Australian Bureau of Statistics, Canberra.

Department of Urban Affairs and Planning (1995a), *Population Projections, Sydney Region Local Government Areas 1991-2021, 1995 Revision*, Department of Urban Affairs and Planning, Sydney.

Department of Urban Affairs and Planning (1995b), *Sydney Residential Land Urban Development Program, The 1995/96 - 1999/2000 Program*, Department of Urban Affairs and Planning, Sydney.

Institute of Transport Studies (1996), *Report on the Economic Significance of Sydney International Airport*, prepared for Federal Airports Corporation, Canberra.

Masson & Wilson (1996), *Sydney Airport Ground Access Study Update*, prepared for Federal Airports Corporation, Canberra.

PPK Environment & Infrastructure (1997), *Second Sydney Airport Draft Environmental Impact Statement*, prepared for Department of Transport and Regional Development, Canberra.

Appendix H2

Analysis of the Effects of Road Traffic Demand Management

Appendix H2

Analysis of the Effects of Road Traffic Demand Management

1. Background to Road Transport Demand Management

The NSW Government has made a significant commitment to develop and implement a comprehensive long term plan to protect and improve air quality across NSW. In *Action for Air - The NSW Government's 25 Year Air Quality Management Plan* (Environment Protection Authority, 1998) the Government has committed to a two phased program in relation to:

- firstly, to achieve a zero growth in per capita vehicle kilometres travelled by 2011; and
- secondly, to achieve zero growth in total vehicle kilometres travelled by the year 2021.

These targets have been adopted in *Action for Transport 2010: Sydney Region* (Department of Transport, 1998). The vehicle kilometres travelled target will require a reduction of about 9% in per capita vehicle kilometres travelled in the decade 2011-2021. To achieve these targets, the projected vehicle kilometres travelled in 2011 and 2021 would need to be reduced by about five and 12 percent respectively.

The impacts of achieving these targets on the estimated road network improvements associated with a Second Sydney Airport have been assessed. Some important assumptions have been made related to the adopted target:

- to achieve these targets, which are assumed to represent daily travel, it would be reasonable to assume that a higher reduction would need to be achieved during the peak periods; therefore a 20 percent reduction was applied to the total unconstrained vehicle kilometres travelled in the year 2016;
- the assessment only applies to background (non-Second Sydney Airport) traffic - the impact of travel demand management measures on traffic generated by the Second Sydney Airport has already been considered in the Draft EIS;

- the reduction in travel demand applies equally to all trips in the Sydney area; and
- travel demand management measures would only reduce trip making rates and not the distribution (start and end) of trips.

A major reason for adopting a target for travel demand management is to reduce the need for new road construction. However, it has been assumed that the list of currently committed road projects, used in the Draft EIS evaluation, would still be required. The evaluation conducted as part of the Draft EIS showed that there is a strong need for the listed projects and it is likely that, even if the 20 percent reduction in vehicle kilometres travelled is achieved, the road projects would proceed.

The target reduction in vehicle kilometres travelled was evaluated by reducing trip demand in 2016 Badgerys Creek model scenarios by 20 percent. Although this method does not guarantee vehicle kilometres travelled would reduce exactly by the targeted amount, the results showed very close approximation. It should be noted that applying a 20 percent reduction in vehicle trip demand would not guarantee a corresponding reduction in traffic volumes on all roads. Output from the model exercise showed that traffic levels were more likely to reduce on sub-arterial/arterial roads than on freeways.

Reducing demand on freeways would attract traffic from alternative routes. For example, the Hume Highway and the M5 Motorway offer alternative routes through Sydney's south-west corridor. The M5 Motorway is quicker if there is no congestion but during peak periods traffic may use the Hume Highway as an alternative route. Reducing travel demand by 20 percent in the corridor led to predicted reductions in traffic volumes of up to 30 percent on the Hume Highway but only about 5 percent on the M5 Motorway. Overall congestion is less, so more traffic is likely to use the M5 Motorway.

Table H2.1 shows the daily traffic volumes on major roads with reduced vehicle kilometres travelled.

Table H2.1: Major Roads Future Daily Traffic Volumes (2016)

	Base Case (No Airport)[1]			With Second Sydney Airport Forecast[1]		
Location Description	**No Demand Management**	**Reduced Vehicle Kilometres Travelled**	**Percentage Decrease**	**No Demand Management**	**Reduced Vehicle Kilometres Travelled**	**Percentage Decrease**
Badgerys Creek Airport to Elizabeth Drive	n/a	n/a	n/a	61,361	61,361	n/a
Badgerys Creek Airport to The Northern Road	n/a	n/a	n/a	20,226	20,226	n/a
Bringelly Road east of The Northern Road	6,370	4,110	-35%	29,456	21,225	-28%
Bringelly Road west of Cowpasture Road	18,711	14,625	-22%	31,755	30,451	-4%

Location Description	Base Case (No Airport)[1]			With Second Sydney Airport Forecast[1]		
	No Demand Management	Reduced Vehicle Kilometres Travelled	Percentage Decrease	No Demand Management	Reduced Vehicle Kilometres Travelled	Percentage Decrease
Camden Valley Way west of South Western Freeway	19,805	17,407	-12%	29,666	28,050	-5%
Cowpasture Road south of Hoxton Park Road	14,421	10,026	-30%	21,642	15,068	-30%
Deepfields Road west of Camden Valley Way	5,448	4,156	-24%	8,380	5,829	-30%
Denham Court Road east of Camden Valley Way	9,755	6,882	-29%	15,683	12,969	-17%
Devonshire Road south of Elizabeth Drive	5,691	4,225	-26%	11,255	15,364	37%
Elizabeth Drive west of Wallgrove Road	20,339	12,930	-36%	37,422	36,295	-3%
Elizabeth Drive west of Luddenham Road	13,009	8,646	-34%	18,838	15,514	-18%
Elizabeth Drive west of Mamre Road	17,511	12,617	-28%	43,598	41,694	-4%
Erskine Park Road south of M4 Motorway	22,209	17,626	-21%	26,826	20,477	-24%
Fifteenth Avenue west of Cowpasture Road	5,067	3,290	-35%	9,119	7,838	-14%
Luddenham Road north of Elizabeth Drive	4,583	2,516	-45%	55,003	45,399	-17%
M4 Motorway at Nepean River	80,882	64,064	-21%	82,787	65,980	-20%
M4 Motorway east of Erskine Park Road	123,600	111,602	-10%	160,967	143,319	-11%
M4 Motorway east of Wallgrove Road	131,171	118,504	-10%	160,027	145,799	-9%
M4 Motorway east of Northern Road	102,849	90,602	-12%	100,125	90,925	-9%
M5 Motorway east of Moorebank Avenue	106,196	88,732	-16%	119,506	103,622	-13%
Mamre Road south of M4 Motorway	26,826	19,462	-27%	68,612	65,230	-5%
Mamre Road north of Elizabeth Drive	9,944	5,005	-50%	8,745	7,580	-13%
Mulgoa Road north of Park Avenue	8,779	7,167	-18%	11,609	8,805	-24%
Mulgoa Road south of M4 Motorway	6,591	4,825	-27%	6,441	5,102	-21%

References

Department of Transport (1998), *Action for Transport 2010: An Integrated Transport Plan for Sydney*, Department of Transport, Sydney.

Environment Protection Authority (1998), *Action for Air: The NSW Government's 25 Year Air Quality Management Plan*, Environment Protection Authority, Sydney.

Appendix H3

Analysis of Road Traffic Impacts Assuming No Rail Link

Appendix H3

Analysis of Road Traffic Impacts Assuming No Rail Link

1. Methodology

The total peak hourly trips to and from the Second Sydney Airport with and without a rail link were estimated, as described in the methodology outlined in *Appendix H1*. Previously, only the with rail link estimates were modelled. The estimates of trips to and from the Second Sydney Airport estimated previously were used to determine the increase in vehicle trips experienced at Second Sydney Airport without a rail link for 2006 and 2016. This increase in trips was assumed to have a similar distribution of trips to the with rail scenario and was distributed accordingly.

The additional trips arising from the lack of provision of a rail link were added to the trip tables used in the Draft EIS and the network models re-run for the AM and PM peak periods in 2006 and 2016. Traffic volumes on selected road links are provided in summary *Tables H3.1* and *H3.2*.

Table H3.1: Future Traffic Volumes on Major Approach Routes to Badgerys Creek: 2006 Average Daily Traffic (No Airport Rail Link)

Approach Route	Base 2006	Draft EIS		No Rail 2006	
		Forecast 2 2006	Percentage Increase	Forecast 2 2006	Percentage Increase
Bringelly Road, east of The Northern Road	6,193	15,362	148%	15,285	147%
Bringelly Road, west of Cowpasture Road	23,179	29,169	26%	29,319	26%
Camden Valley Way, west of South Western Freeway	18,781	22,705	21%	22,024	17%
Cowpasture Road, south of Hoxton Park Road	15,268	16,229	6%	16,381	7%
Deepfields Road, west of Camden Valley Way	4,767	6,083	28%	6,256	31%
Denham Court Road, east of Camden Valley Way	7,427	9,596	29%	11,254	52%
Devonshire Road, south of Elizabeth Drive	5,425	10,042	85%	10,839	100%
Elizabeth Drive, west of Wallgrove Road	23,153	30,225	31%	31,313	35%
Elizabeth Drive, west of Luddenham Road	13,275	18,561	40%	19,058	44%
Elizabeth Drive, west of Mamre Road	14,440	26,561	84%	27,149	88%
Erskine Park Road, south of M4 Motorway	21,251	22,775	7%	23,086	9%

Approach Route	Base 2006	Draft EIS: Forecast 2 2006	Draft EIS: Percentage Increase	No Rail 2006: Forecast 2 2006	No Rail 2006: Percentage Increase
Fifteenth Avenue, west of Cowpasture Road	4,802	7,364	53%	8,473	76%
Luddenham Road, north of Elizabeth Drive	7,076	24,529	247%	27,322	286%
M4 Motorway, at Nepean River	71,429	72,121	1%	72,225	1%
M4 Motorway, east of Erskine Park Road	125,860	140,226	11%	140,185	11%
M4 Motorway, east of Wallgrove Road	127,953	141,600	11%	143,175	12%
M4 Motorway, east of The Northern Road	70,182	69,489	-1%	70,240	0%
Mamre Road, south of M4 Motorway	33,602	46,807	39%	47,396	41%
Mamre Road, north of Elizabeth Drive	16,969	15,925	-6%	15,715	-7%
Mulgoa Road, north of Park Avenue	6,853	7,036	3%	7,089	3%
Mulgoa Road, south of M4 Motorway	4,675	5,067	8%	4,560	-2%
Raby Road, west of Campbelltown Road	24,650	24,879	1%	25,172	2%
The Northern Road, at Lowes Creek	15,394	19,256	25%	18,949	23%
The Northern Road, north of Bringelly Road	17,882	28,974	62%	29,397	64%
The Northern Road, south of M4 Motorway	23,167	26,191	13%	27,045	17%
Western Sydney Orbital, south of Elizabeth Drive	37,815	36,973	-2%	37,434	-1%

Table H3.2: Future Traffic Volumes on Major Approach Routes to Badgerys Creek: 2016 Average Daily Traffic (No Airport Rail Link)

Approach Route	Base 2016	Draft EIS: Forecast 3 2016	Draft EIS: Percentage Increase	No Rail 2016: Forecast 3 2016	No Rail 2016: Percentage Increase
Bringelly Road, east of The Northern Road	6,370	29,456	362%	31,638	397%
Bringelly Road, west of Cowpasture Road	18,711	31,755	70%	33,971	82%
Camden Valley Way, west of South Western Freeway	19,808	29,666	50%	31,709	60%
Cowpasture Road, south of Hoxton Park Road	14,421	21,642	50%	22,650	57%
Deepfields Road, west of Camden Valley Way	5,448	8,380	54%	7,872	44%
Denham Court Road, east of Camden Valley Way	9,755	15,683	61%	17,921	84%
Devonshire Road, south of Elizabeth Drive	5,691	11,255	98%	18,723	229%
Elizabeth Drive, west of Wallgrove Road	20,339	37,422	84%	41,912	106%
Elizabeth Drive, west of Luddenham Road	13,009	18,838	45%	23,155	78%

Approach Route	Base 2016	Draft EIS Fore-cast 3 2016	Draft EIS Percen-tage Increase	No Rail 2016 Fore-cast 3 2016	No Rail 2016 Percen-tage Increase
Elizabeth Drive, west of Mamre Road	17,511	43,598	149%	46,726	167%
Erskine Park Road, south of M4 Motorway	22,209	26,826	21%	27,473	24%
Fifteenth Avenue, west of Cowpasture Road	5,067	9,119	80%	12,813	153%
Luddenham Road, north of Elizabeth Drive	4,583	55,003	1100%	59,193	1192%
M4 Motorway, at Nepean River	80,882	82,787	2%	83,006	3%
M4 Motorway, east of Erskine Park Road	123,600	160,967	30%	160,025	29%
M4 Motorway, east of Wallgrove Road	131,171	160,027	22%	161,118	23%
M4 Motorway, east of The Northern Road	102,849	100,125	-3%	103,207	0%
M5 Motorway, east of Moorebank Avenue	106,196	119,506	13%	123,546	16%
Mamre Road, south of M4 Motorway	26,826	68,612	156%	72,860	172%
Mamre Road, north of Elizabeth Drive	9,944	8,745	-12%	10,987	10%
Mulgoa Road, north of Park Avenue	8,779	11,609	32%	11,361	29%
Mulgoa Road, south of M4 Motorway	6,591	6,441	-2%	6,430	-2%
Raby Road, west of Campbelltown Road	29,570	28,652	-3%	27,505	-7%
The Northern Road, at Lowes Creek	16,539	24,010	45%	22,838	38%
The Northern Road, north of Bringelly Road	18,667	47,847	156%	44,838	140%
The Northern Road, south of M4 Motorway	22,578	32,194	43%	32,575	44%
Western Sydney Orbital, south of M4 Motorway	85,430	87,958	3%	85,984	1%
Western Sydney Orbital, south of Elizabeth Drive	70,875	75,365	6%	76,057	7%
Western Sydney Orbital, north of Elizabeth Drive	67,181	65,923	-2%	65,461	-3%

2. Results

It is important to note that the impact of additional airport trips is not the same on different parts of the surrounding road network as both airport and background traffic redistributes to take into account the effects of congestion. While most roads experience an increase in traffic some actually experience a decrease which is indicative of higher congestion somewhere else in the network that traffic formerly using the road is now avoiding.

The results for 2006 show only minor changes to predicted traffic volumes on key links around the Badgerys Creek site. From a modelling perspective these changes are not particularly significant and the conclusions made in the Draft EIS report with regards to traffic impacts and required road network improvements in 2006 are unchanged.

The results for 2016 show more significant increases in traffic volumes on some road links:

- the majority of road links show relatively small increases in traffic volumes (less than 10 percent) with some actually showing decreases;
- traffic volumes increase quite markedly on the route to the south west that uses Devonshire Road, Fifteenth Avenue and Denham Court Road; and
- traffic volumes on Elizabeth Drive near the airport (west of Luddenham Road) increase by over 20 percent;

Having not modelled the impacts of road network improvements identified in the Draft EIS as being required for both base (no airport) and Second Sydney Airport cases it is difficult to estimate the specific impacts of no rail link on required road network improvements. However, it can certainly be concluded that the lack of a rail link would have the following general impacts, particularly by 2016:

- the need for identified road network improvements would be intensified;
- even with identified road network improvements the additional traffic generated by the lack of a rail link would result in worse traffic conditions including increased travel times, and increased environmental impacts - such impacts will be on both airport and background traffic; and
- additional road network improvements to those previously identified may be required - for example, substantial improvements may be required to roads such as Devonshire Road and Fifteenth Avenue.

Appendix H4

Analysis of Construction Traffic

Appendix H4

Analysis of Construction Traffic

1. Construction Traffic

Information obtained from the Second Sydney Airport Planners (1997) was used to establish the likely traffic generation due to construction activity, particularly of heavy vehicles. The expected time frame for the construction of each airport option is described in Draft EIS *Technical Paper No. 13.* Night work was part of construction planning.

Construction traffic would mainly consist of workforce vehicles and heavy vehicles carrying quarry products and building materials. The forecast daily and peak hour vehicular traffic, generated by the construction activities for the stage one and master plan, is shown in *Table H4.1*.

Table H4.1: Traffic Generated During Construction of Airport Option B or C[1]

		Daily Traffic[2]			AM Peak[3]		PM Peak[4]	
Staging	**Employees**	**Car**	**Truck**	**Total**	**In**	**Out**	**In**	**Out**
Stage 1	1,460	2,700	700	3,400	800	200	200	800
Master Plan	2,080	3,800	900	4,700	1,100	300	300	1,100

Notes:
1. Traffic generated by Option A would be marginally less.
2. Two-way traffic volumes to and from the airport sites.
3. Total cars and trucks.
4. Figures rounded to nearest 100.

The most likely approach routes to the airport site at Badgerys Creek for construction traffic have been identified in *Technical Paper No. 13*, for both the workforce and the transport of construction materials, and detailed in *Table H4.2*. It is anticipated that the majority of the materials would reach the site by road from the south.

Traffic volumes along The Northern Road and Elizabeth Drive would experience the largest increase as a result of construction traffic. The section of The Northern Road, between Elizabeth Drive and Adams Road, the possible access to the airport site during construction, would need to be widened to a four lane carriageway. Whilst other approach roads, such as Bringelly Road and Wallgrove Road, would also be affected by construction traffic, they would continue to operate at acceptable levels of service.

Table H4.2: Peak Hour Construction Traffic Along Major Routes to Badgerys Creek Site

			AM Peak Period								PM Peak Period							
	Percentage Distribution		Arrival				Departure				Arrival				Departure			
Approach Routes	Car	Truck	Car	Truck	Total	PCU[1]	Car	Truck	Total	PCU[1]	Car	Truck	Total	PCU[1]	Car	Truck	Total	PCU[1]
Stage 1																		
Wallgrove Road/Elizabeth Drive/The Northern Road	21%	10%	159	2	161	164	40	2	42	45	40	2	42	45	159	2	161	164
Elizabeth Drive (east of Wallgrove Road)/The Northern Road	39%	0%	291	0	291	291	73	0	73	73	73	0	73	73	291	0	291	291
Bringelly Road/The Northern Road (south of airport sites)	18%	80%	134	16	150	174	32	16	48	72	13	16	48	72	134	16	150	174
The Northern Road, south of Bringelly Road	7%	5%	55	1	56	58	14	1	15	17	14	1	15	17	55	1	56	58
The Northern Road, north of Elizabeth Drive	9%	5%	69	1	70	72	17	1	18	20	17	1	18	20	69	1	70	72
Mamre Road/Luddenham Road/Elizabeth Drive/The Northern Road	5%	0%	34	0	34	34	9	0	9	9	9	0	9	9	34	0	34	34
Total	**100%**	**100%**	**742**	**20**	**762**	**793**	**185**	**20**	**205**	**236**	**185**	**20**	**205**	**236**	**742**	**20**	**762**	**793**
Masterplan																		
Wallgrove Road/Elizabeth Drive/The Northern Road	21%	10%	227	2	229	232	57	2	59	62	57	2	59	62	227	2	229	232
Elizabeth Drive (east of Wallgrove Road)/The Northern Road	39%	0%	414	0	414	414	105	0	105	105	105	0	105	105	414	0	414	414
Bringelly Road/The Northern Road (south of airport sites)	18%	80%	192	16	208	232	46	16	62	86	46	16	62	86	192	16	208	232
The Northern Road, south of Bringelly Road	7%	5%	78	1	79	81	19	1	20	22	19	1	20	22	78	1	79	81
The Northern Road, north of Elizabeth Drive	9%	5%	99	1	100	102	25	1	26	28	25	1	26	28	99	1	100	102
Mamre Road/Luddenham Road/Elizabeth Drive/The Northern Road	5%	0%	49	0	49	49	12	0	12	12	12	0	12	12	49	0	49	49
Total	**100%**	**100%**	**1059**	**20**	**1079**	**1110**	**264**	**20**	**284**	**315**	**264**	**20**	**284**	**315**	**1059**	**20**	**1079**	**1110**

Note: 1. PCU - Passenger Car Equivalent Units (1 truck = 2.5 cars).

2. Intersection Operation

Twelve intersections were identified for impact analysis of construction traffic on the local road network; their locations and existing traffic control are included in *Table H4.3*. Existing turning volumes at these intersections were obtained from the Base Road Network Model developed to assess the traffic impact of an airport at Badgerys Creek. At locations where actual counts were available, the modelled peak hour volumes were generally higher; thus the following assessment is based on a worst case scenario.

The traffic volumes likely to be generated by construction activities associated with the Airport were assigned to the intersections. The intersections were then assessed using the Intersection Analysis Program INTANAL V3.15. The evaluation of the operation of these intersections was based on guidelines included in *Technical Paper No. 13*. The average delays of vehicles, which represent the main parameter for the assessment of intersections, are summarised in *Table H4.3* for the following scenarios:

- base case condition;
- with peak Stage 1 construction activities; and
- at peak Master Plan construction activities.

The existing unsignalised intersections of Elizabeth Drive with Devonshire Road, Bringelly Road with Cowpasture Road and Camden Valley Way, and The Northern Road with the access to site assumed at Adams Road would require treatment as follows:

- intersection widening and improvements for right-turning traffic at intersection of Elizabeth Drive and Devonshire Road;
- installation of traffic signals at the intersections of Bringelly Road with Cowpasture Road and Camden Valley Way (works proposed by the NSW Roads and Traffic Authority expected to be in service in 1999); and
- installation of traffic signals at The Northern Road - Adams Road intersection, providing access to the Airport site.

All other intersections are estimated to continue to operate at satisfactory levels of service.

Figure 19.5 of this Supplement details the principal routes to be used by construction traffic, existing traffic management measures and the anticipated measures that need to be installed to cope with the impact of the volume of construction traffic.

Appendix I

Operational Lighting Impacts Assessment

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Appendix I

Operational Lighting Impacts Assessment

1. Methodology

1.1 Aims and Scope of Works

This technical paper aims to achieve the following with respect to the impact of operational lighting on the proposed Second Sydney Airport:

- describe the existing surrounding topographical features of the site;
- identify and group areas of similar impacts;
- identify the existing lighting environment;
- identify a potential operational lighting environment for the proposed Second Sydney Airport;
- assess potential impacts of the lighting;
- identify variations to the impacts created by the three runway layout options and different Airport operational procedures; and
- propose mitigative measures to reduce potential lighting impacts.

The applicability of a number of techniques was considered during this study. There were five phases in the procedure. The existing environment was assessed in terms of its topography and lighting environment. An inspection of a similar facility was carried out to identify likely operational lighting patterns and impacts. Views into the site have been considered and representative viewpoints have been selected. An analysis of the proposed operating conditions and runway options was then undertaken. The level of impact was then assessed and mitigative measures proposed to reduce potential impacts.

1.2 Information Sources

Much of the information used was gathered from the Draft EIS. Particularly reference was made to:

- Summary of the Draft Environmental Impact Statement; and
- Draft EIS Volume 1;

- Part C The Proposals;
  - Chapter 8 Airport Planing;
  - Chapter 9 Airport Operations;
- Part F Physical and Biological Impacts;
  - Chapter 14 Methodology;
- Part G Social and Environmental Impacts;
  - Chapter 23 Visual and Landscape; and
- Technical Paper No. 14 Visual and Landscape.

For information regarding planning and design of the proposed Second Sydney Airport, reference was made to *Second Sydney Airport Planning and Design* (Second Sydney Airport Planners, 1997a).

Topographical data was obtained from the following 1:25,000 scale topographical maps issued by the Central Mapping Authority of New South Wales:

- Camden 9029-4-N;
- Campbelltown 9029-1-N;
- Liverpool 9030-2-S;
- Penrith 9030-3-N;
- Prospect 9030-2-N;
- Riverstone 9030-1-S;
- Springwood 9030-4-S; and
- Warragamba 9030-3-S.

1.3 Site Investigations

Site investigations for this technical paper were carried out on 29 October 1998. The airport sites were assessed by vehicle on existing roads. Surrounding areas were investigated to establish viewing locations ("viewpoints") from which the airport lighting may be visible at night. Topographical maps and aerial photographs were examined to identify outlying areas with potential lighting impacts.

Locations determined to be representative of potential impacts were then visited at night and analysis report sheets were prepared. Significant look out positions and major roads were accessed at night searching for further areas of potential impact.

A site investigation and assessment of lighting impacts was carried out at Melbourne Airport on 22 October, 1988 to assess the potential operational lighting requirements and their impact *(see Attachment 1)*.

2. Existing Environment

2.1 The Site

2.1.1 Generally

The sites of the proposed Second Sydney Airport options are located in western Sydney, within the local government area of Liverpool City Council. The site is part of the larger South Creek valley of which Badgerys Creek is a tributary. The Nepean River is approximately 12 kilometres to the west and the Blue Mountains National Park and Warragamba Dam another six to eight kilometres further west. The town centre of Penrith is approximately 12 kilometres to the north of Badgerys Creek. The site falls within the broad geographical region of the Cumberland Plain. The site and its surroundings are essentially open pasture lands and rural residential areas.

2.1.2 Topography

The sites of the proposed Second Sydney Airport options are located in a transitional landscape zone between the relatively flat Cumberland Plain and the foot slopes that rise to the Blue Mountains. There is approximately 40 metres range in elevation within the site: from a high point close to The Northern Road of approximately 107 metres to a low point along Badgerys Creek of approximately 70 metres.

The topography of the airport sites are gently undulating with broad rounded crests and ridges (RL 100-300 metres). The major ridgelines occur along The Northern Road and perpendicular to it, in the western part of the site. These ridges offer views into the site and beyond. Other viewing points into the site exist to the north and east of the site. Long distance views to the site also exist to the north and east of the site. Long distance views to the site also exist from the foothills of the Blue Mountains. The lower and flatter parts of the site occur in the eastern portion around Badgerys and Thompsons Creek. Slopes are predominantly five percent or less with some slopes five to 10 percent and a very small percentage 10 to 20 percent (Bannerman et al 1990).

As the viewer moves away from the site potential viewing locations are created by the surrounding topography.

To the east significant topographical features are limited. Within five kilometres of the site the topography falls away and viewing opportunities are limited. Between five and 10 kilometres the topography rises to Mount Vernon (RL 110) *(Figure I.1a - transect No. 1)*, Cecil Park Reservoir (RL 160) and Melville (RL 160). Beyond 10 kilometres the topography falls away again until gradually rising towards the coast around North Parramatta and the Hills District.

To the north significant topographical features are even more limited. Approximately two kilometres north of the site is Blackford Hill (RL 102) *(Figure*

I.1a - transect No. 2). Beyond this feature are the relatively low undulating hills of the Cumberland Plain extending North to Wiseman's Ferry.

To the south within five kilometres of the site the topography falls and rises slowly to levels of RL 100 – RL 110 along Greendale Road and RL 100 – RL 105 along Dwyer Road Bringelly. Between five and 10 kilometres the topography undulates with high points at the Sugarloaf (RL 115) Newstead (RL 138) and the Birling at (RL 158) *(Figure I.1a - transect No. 3)*.

Beyond 10 kilometres potential viewing points exist at Cobbity Hill (RL 188), Mount Annan (RL 180) and Badgery Hill (RL 195). Some of these features are located within the "potential growth area" identified in Chapter 10 of the Draft EIS.

The most significant potential background impacts are to the south west, west and north west.

To the south west the topography undulates and rarely rises above RL 100 until the Nepean River. South west of the Nepean River, the Blue Mountains escarpment rises to Silverdale (RL 200) *(Figure I.1b - transect No. 4)* and Werombi (RL 210) both at distances of approximately 12 kilometres. Beyond 12 kilometres there are the relatively inaccessible Crown Reserve areas in the parish of Werriberri.

Within 4 kilometres to the north west the topography rises slightly to the town of Luddenham and then undulates to rise again to Mount Henry (RL 190) *(Figure I.1b - transect No. 5)*, at a distance of approximately 10 kilometres.

Beyond 10 kilometres the next significant feature is the Lapstone Monocline. This provides extensive views over the entire Cumberland Plain and Sydney Basin Regions. Mount Elizabeth at Lapstone commands a superb view of the site from RL 200 *(Figure I.1b - transect No. 6)*. Beyond Lapstone the topography continues to rise up the Blue Mountains Escarpment with potential long distance viewing sites at distances beyond 15 kilometres and elevations in excess of RL 350.

To the west within five kilometres the topography undulates with selected elevated locations along Greendale Road, the most prominent at Elizabeth Farm No. 2 (RL 100). The topography then falls into the Nepean River Basin and rises approximately 10 kilometres from the site to the township and surrounds of Warragamba. Warragamba covers an extensive area with topographical features such as Sunrise Hill (RL 172) and various locations along the escarpment facing east, which vary from RL 150 – RL 170. Beyond 15 kilometres is the Blue Mountains National Park and hence access and potential viewing locations are relatively limited.

2.2 Night Light Environment

2.2.1 Airport Sites

The existing night lighting environment of the sites is predominantly rural in character. The site is dark and most surrounding topographical features are also unlit. Random spotting of street, security and residential lights occurs on and around the site. On the surrounding roads lighting is insignificant except at major intersections.

2.2.2 Surrounding Areas

The nearest significant light source is the string of high pressure sodium lights along the Northern Road at Luddenham (three kilometres). These lights are visible from elevated positions at distances exceeding 15 kilometres due to the dark surrounds and the distinctive colour and form of the lights.

When viewed from surrounding elevated positions, within five kilometres, the site appears dark and is generally seen against a dark background. From locations between five and 10 kilometres the background changes to include a greater number of light sources.

When viewed from the south, the lights of Western Sydney and Penrith form a distant background. From the west, depending on the elevation of the viewer, the lights of residential areas from Prospect to Liverpool form a background.

From the east and north at distances less than 10 kilometres the background is dark. From the north west at high elevations such as Mount Henry, the site appears dark within the framework of the lights of several intervening towns such as Wallacia, Mulgoa and Luddenham. From Lapstone the lighting of the bulk of the Cumberland Plain is obvious. The site is a distant middle ground dark element with a background of twinkling lights from Parramatta to Campbelltown and foreground elements of higher contrast at Wallacia and Emu Plains.

2.2.3 Visual Sensitivity

Within the airport sites and surround areas, most of the light sources are static. Generally distance is sufficient to overcome any disability or discomfort glare caused by the existing sources. This however is a subjective assessment and different viewers will have different sensitivity to the array of light sources within the visual catchment. When viewed at distances of less than a few hundred metres unshielded high powered sources have the potential to cause discomfort glare or disability glare. This is best understood when driving at night. It is therefore obvious that shielding and direction of light sources plays a critical role.

Beyond 500 metres from the airport sites, the potential for disability and discomfort glare drops relative to the increased distance and the relative intensity of surrounding light sources. Once a light source becomes part of a random pattern we perceive the visual quality to increase. As the random pattern becomes more extensive the visual quality rises resulting in highly attractive night lighting effects when towns are viewed from elevated positions at night.

Changes to the random pattern are obvious. Colour becomes an important element in the pattern and colour variation becomes visible.

At a distance less than eight to 10 kilometres movement of lights is a significant element. If the movement is slow and regular the effect is minimal. If however the movement is rapid, flashing or has variations in colour or intensity the movement is obvious and can be seen at great distances from the source, particularly with a dark background.

An assessment of the relative impact and sensitivity of the flashing high intensity coloured Tower Identification light at different distances was made at Melbourne Airport *(see Attachment 1)*.

It is not possible to assess the sensitivity of specific locations without an individual assessment of each site. Due to the vegetation and topography locations only short distances apart may experience vastly different impacts. For this reason the assessment of impact is carried out at a location which is representative of the higher impacts for the surrounding area.

2.3 Viewpoints

For the purpose of environmental assessment *Technical Paper No. 2* divided areas potentially affected into 'Community Assessment Areas'. These areas have been used as a basis for selection of potential viewing points which are representative of the view from locations with a similar elevation and distance from the proposed Second Sydney Airport.

Viewing locations or 'viewpoints' were selected initially using topographical information. Field surveys were then used to confirm whether these locations had a direct line of sight into the airport sites and checked for actual potential site visibility. The viewpoints are generally representative however views can vary greatly with small changes to vegetation or elevation. Intervening vegetation and topography can vary significantly for viewpoints only short distances apart. Viewpoints are generally assessed from the nearest public place, road or public open space.

Viewpoints of the proposed airport site, their altitude (Australian Height Datum), relative height to airport facilities and approximate distance to the facilities are listed in *Table I.1* and shown on *Figure I.2*. The average height of the airport facilities will vary depending on the selected option. However for the purpose of this assessment an average height of RL 85 has been selected for the base level of the infrastructure and runways.

Table I.1: Potential Viewpoints into the Airport Sites

View-points	Location	Height (metres above sea level)	Relative Elevation (metres)	Distance to Centre of Airport Sites (kilometres)
1	The Northern Road, Badgerys Creek	100 to 105	+ 20	3
2	Elizabeth Drive, Badgerys Creek	65 to 90	-20 to -5	2.5
3	Badgerys Creek, Road Badgerys Creek	60 to 75	-15 to -10	1.5
4	Lawson Road, Badgerys Creek	60 to 65	-20 to -15	3.5
5	Cecil Park Communication Tower	140	+ 55	10
6	Mount Vernon Road	105	+ 20	9
7	Blackford Hill, Hill View	100	+ 15	4
8	Dwyer Road, Bringelly	105	+ 20	3
9	Silverdale	235	+ 150	12.5
10	Warragamba	100 to 140	+15 to +60	10
11	Mount Henry, Hillcrest	190	+ 105	11.5
12	Lapstone Tower, Lapstone	200	+ 115	16

3. Anticipated Operational and Lighting Environment

3.1 General

The lighting environment for the Second Sydney Airport has not been designed at this time. It is however possible to estimate the type and style of fittings likely to be used by comparison to the existing environment at Melbourne Airport.

Current master plans indicate landing lights for all three options at both ends of the runways (refer Figures 9.6, 9.10 and 9.16 of the Draft EIS). The complete distribution of landing lights at both ends of each runway would not be implemented until the construction of the proposal to master plan stage was complete. A preferred low visibility landing option approaching from one direction is likely to be selected for Stage 1 development. However *Airport Operation 3* (noise sharing) could require landings from all directions in all conditions. The assessments are therefore based on this worst case.

3.2 Badgerys Creek Option A

Option A comprises two parallel runways running in a north east to south west direction approximately 1,600 metres apart. The northern most runway is approximately 3,000 metres long and the southern most runway 4,000 metres long. The terminal, control tower and apron reserve areas are located between the runways. The associated airport support facilities and services such as fuel storage, freight terminals and maintenance areas are located at the north eastern and south western ends.

3.3 Badgerys Creek Option B

Badgerys Creek Option B comprises two parallel runways running in a north east to south west direction approximately 4,000 metres long and 2,200 metres apart with a cross runway, approximately 2,500 metres long running in a north west to south east direction across the western portion of the parallel runways. As with Option A the terminal, control tower and apron reserve areas are located between the two parallel runways, the associated airport support facilities and services are also located between the runway at the north eastern and south western ends.

3.4 Badgerys Creek Option C

Badgerys Creek Option C comprises two parallel runways running in a north to south direction approximately 4,000 metres long and 2,200 metres apart with a cross runway, approximately 2,500 metres long running in an east to west direction across the western portion of the parallel runways. As with Option A and B the terminal, control tower and apron reserve areas are located between the two parallel runways, the associated airport support facilities and services are also located between the runways at the northern and southern ends.

3.5 Surrounds

The relocation of surrounding roads and the upgrading and construction of new roads and infrastructure will create changes to the surrounding lighting environment. Road lighting would increase along major access routes and car movements would also increase relative to usage.

It is anticipated that general site and road lighting in the vicinity of the Airport will be well shielded to prevent light spill and probably be high pressure Sodium vapours similar to the lights at Luddenham. Over time it is anticipated that other uses will develop around the site.

3.6 Airport Lighting

The lighting requirements of the airport will vary from general area lighting to specific task lighting. The lighting environment will be strictly controlled and monitored to create safe conditions for aircraft using the facilities. This will require a high level of design and maintenance of fittings and shielding.

Adjacent infrastructure is likely to consist of a Control Tower (16 to 20 metres high) Domestic and International Terminals (16 to 20 metres high), car parking, cargo handling facilities and associated airport infrastructure.

Appropriate shielding of fittings is critical to aircraft safety. As a result the direct light spill from the airport is likely to be minimised. This reduces the possibility of glare from the facility when viewed from outside the airport perimeter.

Based on the inspection of Melbourne Airport it is likely the Second Sydney Airport will have a variety of light fittings with various properties and purposes. It is possible to group these as follows:

Table I.2: Predicted Operational Lighting System for the Second Sydney Airport

Light Type	Location	Direction[1]	Intensity[2]	Angle[3]
Infrastructure Lights	Buildings and Work Areas	Shielded Down	500 candela	not applicable
General Runway lights	Edge of all runways	Omni-directional	100 candela	3^0
High Intensity Approach lights	Up to 900m out from landing runway	Uni-directional	20,000 candela	6^0
High intensity sideline lights	Side of landing runway	Uni-directional	5,000 candela	10^0
High intensity identification strobe lighting	Glide zone within airport perimeter	Uni-directional	200,000 candela	5^0
Tower identification light (TIL) alt. Green/white	Top of control tower	Rotating omni-directional	100,000 candela	360^0
Taxi runway and Pavement lights	Pavements	Uni-directional	200 candela	not applicable
Warning lights and General signage	Various	Omni-directional	Various	not applicable

Notes:
1. Omni-directional light transmits in all directions. Uni-directional light transmits in one direction
2. Candela standard unit of light intensity.
3. Angle of light direction measured in a vertical plane

As with all airport lighting shielding for safety purposes is critical and it is anticipated that shielding will be equal to or better than the cut off angles achieved at Melbourne Airport.

The directional nature of many fittings reduces impacts. A significant factor is the shielding of high intensity fittings below the minimum glide angle of three degrees.

This is the lowest entry angle to the glide zone. Operational requirements for other impacts such as noise or obstacle limitations will probably require steeper glide angles. The Draft EIS states that the minimum glide angle for a B747-400 is approximately 12 degrees average over 16 kilometre range. This may allow shielding of directional high intensity fittings at greater angles than those noted.

4. Assessment of Lighting Impacts

4.1 General

Potential lighting impacts for each option have been identified following detailed consideration of the various master plan drawings. The information provided in these documents is of a broad scale conceptual planning nature. Consequently the potential impacts are identified and described in a similar level of detail. More detailed assessments of impacts can be made when detailed development plans are prepared.

Potential impacts are described for the operational phase of the airport development. The estimated construction time for the airport is five years for the 'stage one' development phase and six years to achieve the ultimate master plan configuration.

In addition to the impacts described for each option there will also be a number of additional impacts that are related to the construction process but are not part of the finished development, which are common to all options. These aspects are the construction compounds, car parking areas, materials stockpile areas, erosion and sediment control procedures and the like.

As there is no information in relation to the location and extent of these various elements an assessment of any impact they may have is not possible. Nevertheless, given the scale and extent of the airport development it could be considered that these various construction related activities would not cause any significant additional impact. All fittings in used during construction should be appropriately shielded. Most of those items could be located in areas that form part of the ultimate development, for example construction road access and car parking could be located on the designed entry road alignment and car park areas.

It is not possible to assess the sensitivity of specific locations without an individual assessment of each site. Due to the vegetation and topography, locations only short distances apart may experience vastly different impacts. For this reason the assessment of impact is carried out at a location which is representative of the higher impacts for the surrounding area.

4.2 Lighting Impacts

4.2.1 General

As noted in *Attachment 1*, the various light fittings have significantly different impacts. The runway lights, taxi area and pavement lights have low intensity levels and result in negligible effects when viewed from beyond the perimeter of the airport. These can be discounted in any assessment of the impact of the facility on the night environment.

4.2.2 Infrastructure Lights (IF Lights)

The infrastructure lighting will generally be well shielded. This creates effects, which will vary with distance from the facility. As a foreground element the infrastructure lighting will be dominant as an element even when viewed with strong lighting in the background. The orange colour of the halides may mark the facility as different from much of the surrounding lighting, which is likely to be predominantly white. As distance increases the dominance of the infrastructure lights would decrease and at a distance of approximately five to seven kilometres the lights will blend into the background.

Conversely the skyglow created by the infrastructure lighting is unlikely to be apparent within one kilometre of the edge of the facility. At this distance the observer is within the zone of the skyglow and the skyglow is not contrasted against a dark background.

4.2.3 Skyglow

Skyglow may be defined as the direct or reflected light from a facility that illuminates the sky above the facility and reduces the viewer's ability to see the night sky. As the observer moves further from the facility the effect of the skyglow will increase as the skyglow becomes obvious against the darkened sky. The effect will be greatest between three and 10 kilometres from the airport sites and will be increased by the contrast with a dark background such as the Blue Mountains National Park. This of course would vary depending on the height and density of the cloud cover. Skyglow is likely to be less obvious when viewed from the elevated locations to the west because of the backdrop of the Parramatta central business district and suburban skyglow.

Given that the available meteorological data is related only to low lying cloud an exact assessment of the regularity of the appearance of skyglow cannot be made. It is however reasonable to assume from the inspection of Melbourne Airport that skyglow will occur even with high cloud cover at around 800 metres.

Skyglow will affect far more viewers than the direct lighting effects. It is reasonable to assume that all areas within a radius of 15 kilometres will be affected by skyglow to some degree depending on the height and density of the cloud cover.

Viewer sensitivity may become a factor in the early stages of the development. The skyglow is unlikely to exceed that created by a town centre such as Penrith. It is unlikely that any complaints have been registered with Department of Urban Affairs and Planning or the Local Councils during the development of Penrith or the surrounding suburbs over the last 10 years. However concerns over the general effects of the proposed airport may highlight this issue as an undesirable impact.

4.2.4 High Intensity Lights (HI Lights)

All the high intensity runway approach, sideline and strobe lights are unidirectional and well shielded. The shielding angles vary, however all are shielded below 3° elevation.

All lights in this group would be adjustable in six steps to allow for various landing conditions. The highest levels are used only for approaches in extremely poor conditions and then only as the aircraft approaches. These lights have the potential to have significant impacts if the viewer is located within the unshielded viewing area. Generally these high intensity lights will be imperceptible beyond one kilometre from the source if the viewer is outside the shielded area. An assessment of all the potential viewing points indicates that all fall below the three degree (1:20) screening angle relative to the lowest high intensity light fittings.

4.2.5 Tower Identification Light (TI Light)

Located at the top of the tower, this light would be omni-directional and operate as a rotating flashing unit alternating green and white signals. The intensity would be approximately 100,000 candela. This light is deliberately not screened as it is an all weather reference and identification point for aircraft navigation. Within five kilometres of the airport site Tower Identification Light would be intrusive. Between five and 10 kilometres the Tower Identification Light would be highly visible and more intrusive at greater elevations or where the light is against a dark background. Beyond 10 kilometres the Tower Identification Light would still be visible but distance would reduce the general effect and the resulting impact would be low to moderate. The potential operational lighting impacts at viewpoints identified in *Table I.1* are summarised in *Table I.3*.

4.3 Assessment of Impacts at Viewpoints

The following table takes account of changes due to distance from the runway, alignment and relative level. It is anticipated that the proposed airport options would not create significantly different lighting effects. The impact ratings are a result of the factors outlined in *Sections 4.2.2* to *4.2.5*. Each viewpoint was assessed for impact relative within each group with ratings scaled negligible (N), low (L), moderate (M), high (H), very high (VH).

Table I.3 Summary of Impacts of Viewpoints[1]

View-points	Location	Infrastructure Lights	Skyglow	High Intensity Lights	Tower Identification Light
1	Northern Road	H	M	L	VH
2	Elizabeth Drive	H	L	N	H
3	Badgerys Creek Rd	VH	N	N	H
4	Lawson Road	H	M	N	H
5	Cecil Park Communication Tower	L	M	L	H
6	Mount Vernon Rd	L	M	N	H
7	Blackford Hill, adj. Hill View	M	M	L	H
8	Bringelly, Corner Findley and Dwyer	M	M	L	H
9	Silverdale	L	L	N	M
10	Warragamba	L	L	N	M
11	Mount Henry, Hillcrest	L	L	N	M
12	Lapstone, Lapstone Tower	N	L	N	L

Notes: 1. Abbreviations:
VH = Very High
H = High
M = Moderate
L = Low
N = Negligible

4.4 Summary of Impacts

The light impacts for each airport option for the construction and operational phases would be similar. The viewpoints selected are among the most impacted in each general area. Many potential viewers are screened by the existing vegetation and topography.

From the assessments at each viewpoint it is reasonable to conclude that:

- the infrastructure lights will create moderate to high impacts within approximately five kilometres of the facility;
- skyglow will have generally moderate impacts between three and 10 kilometres from the facility, particularly when looking west and south-west;
- high intensity lights would have low to negligible impacts only when the viewer is elevated at above three degrees and almost in a direct line from the source. No potential viewing points lie in this zone; and

- the tower identification light poses the greatest impact due to its high intensity, colour and movement. Unless it is suitably screened, it will have high to very high impacts at distances up to 10 kilometres.

4.5 Environmental Management

The impacts of lighting at the second Sydney Airport will primarily be created by the lights from the infrastructure and the tower identification lights. The lighting impacts for each option for the construction and operational phases appear to be similar at this level of planning The infrastructure lights have potential to create sky glow due to reflections from illuminated surfaces and direct lighting glare at distances less than two to three kilometres. These effects can be reduced to acceptable levels with suitable light shielding. The appropriate methods are:

- avoid direct lighting of light coloured surfaces such as white concrete and metal finishes;
- select colours which are light absorbing; and
- erect fittings on high towers to spread luminance evenly and shield fittings carefully to avoid lateral glare.

The tower identification light could also be shielded. Generally this fitting is unshielded as installed at Melbourne Airport. However no apparent or identifiable reason exists that prevents the tower identification light from being shielded below three degrees. This screening would eliminate a significant impact.

In summary suitable screening of the infrastructure lights and tower identification light would eliminate disability glare, reduce discomfort glare to acceptable levels and therefore overcome the significant lighting impacts.

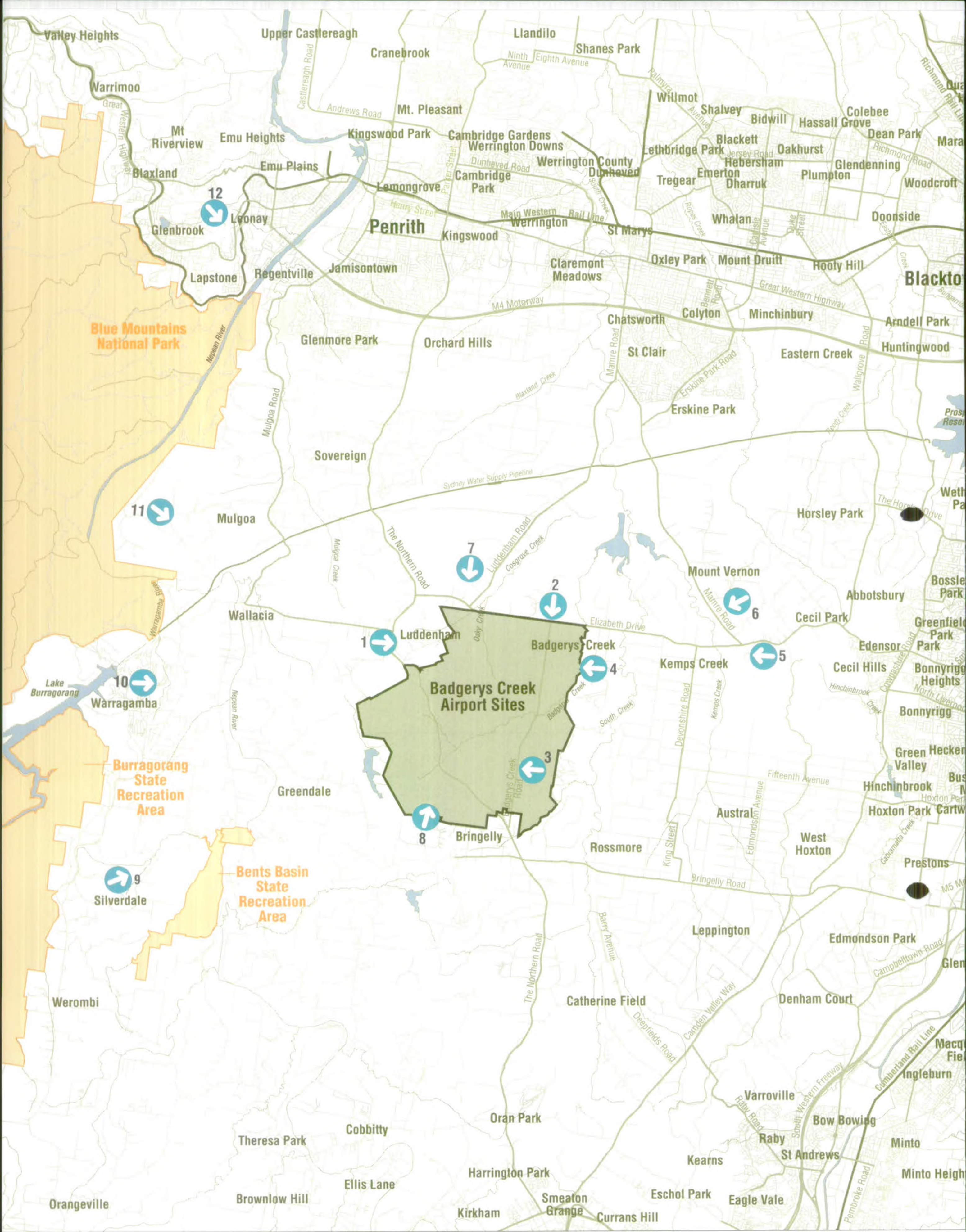
Glossary

Candela	The candela is the standard unit of measurement of luminous intensity.
Glare	When there is an excessively large contrast in the field of view the visual phenomenon of glare will be produced. Nearly always the contrast is produced by light sources being much brighter than their background.
Luminous Intensity	Luminous intensity is the measure of luminous flux which is emitted in the particular direction from a light source.
Discomfort Glare	Discomfort glare is created when glare occurs but is of insufficient contrast to create a direct impairment of the view of the object.
Disability Glare	Disability glare is created when the glare condition produces a direct impairment of ability to see the object.
Intrusive	Impact of an object which is so discordant with its surroundings that it becomes dominant in the visual field. Lighting impacts above moderate could generally be considered intrusive.
Transect	A transverse section taken through the topography which is usually exaggerated in the visual scale.
Foreground	Visual field usually within 500 metres to 800 metres of the viewer depending on weather conditions.
Close Middle Ground	Visual field usually between 800 metres and three kilometres of the viewer depending on weather conditions.
Distant Middle Ground	Visual field generally between three kilometres and eight kilometres of the viewer depending on weather conditions.
Back Ground	The visual field beyond eight kilometres from the viewer depending on weather conditions.
Skyglow	The direct or reflected light from the facility which lights the sky above the facility and reduces the viewers ability to see the night sky.

References

Second Sydney Airport Planners (1997), *Second Sydney Airport Planning and Design*, prepared for the Department of Transport and Regional Development, Canberra.

Figures



View Points

1	Northern Road	7	Blackford Hill, Hill Road
2	Elizabeth Drive	8	Bringelly, Dwyer Road
3	Badgerys Creek Road (Option A and B only)	9	Silverdale
4	Lawson Road	10	Warragamba
5	Cecil Park Communications Tower	11	Mount Henry, Hillcrest
6	Mount Vernon Road	12	Lapstone, Lapstone Tower

Figure I.2

Locations in the Area with Views Into the Airport Sites

Attachment 1

Review of Lighting and Environment - Melbourne Airport

Within the 10 to 15 kilometre radius the City of Melbourne and its suburbs are located to the east and south. To the north east and north west respectively are the towns of Craigieburn and Sunbury.

3. Existing Regional Lighting Environment

The regional lighting environment of the City of Melbourne is clearly displayed from a vantage viewpoint similar to Gellibrand Hill which is located 3.5 kilometres north east of the airport.

The greater concentration of light and associated skyglow of tall buildings at a distance of 10 to 15 kilometres stand out due to their contrast with the dark background of Port Phillip Bay.

To the north, north east, west and north west the suburbs and major roads radiate out from the Central Business District. Closer to the centre lighting is more intense. Further out lighting becomes less concentrated. As the outer suburbs are reached the concentration of light sources reduces. As in all cities lighting effects vary greatly due to height, size and particularly intensity of the sources.

The main concerns with the lighting environment would be glare and intensity. When viewed from elevated locations, panoramic views of the lights at night are generally considered to enhance the view.

4. Local Lighting Environment

The lighting environment immediately surrounding Melbourne Airport varies due to the intensity of development and the adjacent topography.

Between five and 10 kilometres to the north and west lighting is restricted to major roads, rural residential allotments and specific use areas such as Calder Raceway.

Within 5 kilometres of Melbourne Airport to the north west and south are several national parks and recreation areas such as golf courses. These appear as large dark areas with random elements of security lighting. To the east are the main airport facilities such as hotels and car parks, which visually connect to the adjacent suburban areas of Westmeadows and Tullamarine.

Outside a 10 kilometre radius of the airport lighting to the north and west is sparse with the exception of local concentrations of the towns of Sunbury and Diggers Rest. To the east and south respectively are the suburbs and the Melbourne Central Business District which are intensely lit.

Melbourne Airport is well lit. When viewed from within two to three kilometres the lights of the facilities are equivalent to those of the surrounding suburbs, however depending on the viewing location, the runway lighting is relatively subdued.

5. Viewpoints

Viewpoints of the airport with AHD (Australian Height Datum), relative height to the airport facilities and distance from the facilities are listed in *Table 5.1*:

Table 5.1: Viewing Locations

View-point	Location	Altitude	Relative Elevation	Distance to Airport
1	Sunbury Road, 1 kilometre west of Oaklands junction	RL 130	+ 10 m	2.5km
2	Gellibrand Hill, Trig Station	RL 200	+ 80 m	3.5km
3	Oaklands Road, 4 kilometres north of Oaklands Junction	RL 190	+ 70 m	6.0km
4	Craigieburn Road, 560 metres south of Crowe Hill	RL 260	+ 140 m	9.0km
5	Calder Highway, 500 metres south east of Diggers Rest Road	RL 180	+ 60m	10km
6	Toolern Road, 400 metres east of Mount Kororoit	RL 200	+ 80m	15km

6. Existing Infrastructure and Operational Environment

Melbourne Airport consists of a pair of intersecting runways. The main runway 16-34 runs North South and the secondary runway 09-27 crosses east to west. The preferred operating environment is for landings on runway 16 north to south and take offs on runway 09 from east to west. As a result of this and the prevailing weather conditions landing lights are faced north on runway 16 towards Oakland Road.

Adjacent infrastructure consists of a Control Tower (16-20 metres high) Domestic and International Terminals (16-20 metres high), car parking, cargo handling facilities and associated airport infrastructure.

7. Airport Lighting Environment and Fittings

The lighting requirements of the airport are varied from general area lighting to specific task lighting. The lighting environment is strictly controlled and monitored to create safe conditions for aircraft using the facilities. This requires a high level of design and maintenance of fittings and shielding.

Appropriate shielding of fittings is critical to aircraft safety. As a result the direct light spill from the airport is minimised. This reduces the possibility of discomfort glare from the facility when viewed from outside the airport perimeter.

The airport has a variety of light fittings with various properties and purposes, as shown in *Table 7.1*:

Table 7.1: Lighting Types Used at Melbourne Airport

Light type	Location	Direction	Intensity	Angle
Infrastructure Lights	Buildings and Work Areas	Shielded Down	500 candela	N/A
General Runway lights	Edge of all runways	Omni directional	100 candela	3 degrees
High Intensity Approach lights	Up to 900m out from landing runway	Uni directional	20,000 candela	6 degrees + or -5 degrees
High intensity sideline lights	Side of landing runway	Uni directional	5,000 candela	10 degrees + or- 7.5 degrees
High intensity identification strobe lighting	Glide zone within airport perimeter	Uni directional	200,000 candela	5 degrees + or -20 degrees
Tower identification light (TIL) alt. Green/ white	Top of control tower	Rotating omnidirectional	100,000 candela	360 degrees

Light type	Location	Direction	Intensity	Angle
Taxi runway and Pavement lights	Pavements	unidirectional	200 candela	N/A
Warning lights and General signage	Various	Omnidirectional	Various	N/A

8. Lighting Impacts

8.1 General

The various light fittings have significantly different impacts. The runway lights, taxi area and pavement lights have low intensity levels and result in negligible effects when viewed from beyond the perimeter of the airport. These can be discounted in any assessment of the impact of the facility on the night environment.

8.2 Infrastructure Lights

The infrastructure lighting is generally well shielded with the exception of some advertising signage. This creates effects, which will vary with distance from the facility. As a foreground element the infrastructure lighting is dominant as an element even when viewed with the lights of the CBD in the background. The orange colour of the halides marks the facility as different from much of the surrounding lighting, which is white. As distance increases the dominance of the infrastructure lights decreases and at a distance of approximately five to seven kilometres the lights blend into the background.

8.3 Skyglow

Conversely the skyglow created by the infrastructure lighting is not apparent within one kilometre of the centre of the facility. At this distance the observer is within the zone of the skyglow and the skyglow is not contrasted against a dark background.

As the observer moves further from the facility the effect of the skyglow increases as the skyglow becomes obvious against the darkened sky. The effect seems greatest between six to 10 kilometres from the source and is increased by the contrast with a dark background such as the national park.

8.4 High Intensity Lights

All the high intensity runway approach, sideline and strobe lights are unidirectional and well shielded. The shielding angles vary, however all fittings are shielded below three degree elevation.

All lights in this group are adjustable in six steps to allow for various landing conditions. The highest levels are used only for approaches in extremely poor conditions and then only as the aircraft approaches. These lights have the potential to have significant impacts if the viewer is located within the viewing direction. However the likelihood of this occurring is very low as it would also place the viewer in the glide path of the incoming aircraft. The inspection of Melbourne Airport did not reveal a location where this occurred. Generally these high intensity lights were imperceptible beyond one kilometre from the source.

8.5 Tower Identification Light

Located at the top of the tower, this light is omni-directional and operates as a rotating flashing unit alternating green and white signals. The intensity is approximately 100,000 candela. At distances less than five kilometres the tower identification light is intrusive. Between five and 10 kilometres the tower identification light is highly visible and more intrusive at greater elevations or where the light is against a dark background. Beyond 10 kilometres the tower identification light is still visible but distance reduces the general effect and the resulting impact is low to moderate.

9. Assessment of Impacts at Viewpoints

To gain a relative understanding of the impacts of each lighting type or effect they have been ranked from the selected viewpoints. Each viewpoint was assessed for impact relative to each group with ratings scaled nil, low, moderate, high, very high. The results of the assessment are summarised in *Table 9.1*.

Table 9.1: Summary of Impacts at Viewpoints

View-point	Location	Infrastructure Lights	Skyglow	High Intensity Light
1	Sunbury Road	High	Low	Mod
2	Gellibrand Hill	High	Mod	Low
3	Oaklands Road	Mod	High	Nil
4	Craigieburn Road	Low	High	Nil
5	Calder Highway	Low	Low	Nil
6	Mount Kororoit	Nil	Low	Nil

Appendix J1

Benefit Cost Study of a Second Sydney Airport at Badgerys Creek

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Appendix J1

Benefit Cost Study of a Second Sydney Airport at Badgerys Creek

Executive Summary

This study was undertaken with the aim of measuring, to the extent possible, the benefits and costs of the proposed Second Sydney Airport at Badgerys Creek. The study drew to a large extent on information gathered in the preparation of the Draft EIS.

A wide range of the impacts of the proposed airport identified in the Draft EIS were able to be incorporated in the benefit cost analysis, including the economic cost to the community of having insufficient airport capacity for Sydney, the cost of constructing the airport and associated infrastructure, the likely operational revenues and costs, the health and noise impacts on the local community and the risks associated with potential air crashes.

The key impacts which were not able to be monetised and thereby incorporated in the analysis were the effects on Aboriginal cultural heritage, the effects on the habitat of species of plant and animal of significance to the locality, potential reductions in water quality, impacts on other Sydney Basin airports, impact on non-Aboriginal cultural heritage, loss of amenity in National Parks due to aircraft over-flight, and visual and landscape impacts.

A factor in commissioning this study was criticism of the Draft EIS that a formal benefit cost study of the proposed airport was not undertaken.

The key factor influencing the benefit cost study is the cost of not having sufficient airport capacity in future years. This cost (representing the major economic benefits of investing in the proposed airport) depends on three key factors:

- the future demand for air transport to and from Sydney;
- the future capacity of KSA; and
- the price elasticity of demand for air travel.

Using the preferred values for each of these variables and taking into account both the financial and broader economic benefits and costs, it was found that the proposed investment was a profitable investment for the Australian economy. In 1996 dollars the present value of the benefits of developing the airport are estimated to be some $7.9 billion, against costs of $3.6 billion (essentially the costs of construction for the airport and associated infrastructure). Therefore, the Net Present Value of the investment is estimated to be about $4.3 billion. This also corresponds to an Internal Rate of Return of 12.5 percent and a Benefit Cost Ratio of 2.2.

However, most of the economic benefits of the proposed airport do not accrue to the potential owners of the airport. Given current air movement charges at KSA and likely revenue yields from commercial activities at the proposed airport, it is likely that a potential buyer would require an initial subsidy of some $1.2 billion in order to construct and operate the airport to a capacity of 10 million passengers per year. Alternatively, aircraft charges would need to increase by $19 per passenger movement (relative to those currently made at KSA) to avoid the need to subsidise a potential operator to construct the airport. Also, unless it were possible for the airport operator to increase charges, the proposed second Sydney airport would only become financially viable once passenger and flight utilisation approaches maximum capacity.

The results of both the economic and financial assessments must be qualified because of uncertainties about the accuracy of some of the key inputs, including future pricing policies for the airport, the cost estimates and future demand for the airport. In the case of the economic assessment, it has also not been possible to quantify some of the environmental costs because of methodological difficulties and the lack of some key data.

1. Objective of the Study

The objective of this study is to provide, in so far as is practicable, a comprehensive, logical and internally consistent assessment of the economic impact of a Second Sydney Airport at Badgerys Creek. The economic impact is assessed at the local region, for the Sydney region, New South Wales and for the Australian economy as a whole. The likely returns to a potential operator of SSA are also considered.

The construction of a second major airport for Sydney has been mooted for more than 50 years, with various sites suggested and then discarded for various reasons. An airport of the scale envisaged represents a major investment of public funds and has the potential to impose a wide range of costs on communities proximate to the development. Conversely, it is likely that Sydney and the broader community would suffer significant economic costs if there were insufficient airport capacity for international and domestic air transport needs. Therefore, it is important that any decision to construct a major second Sydney airport is taken having regard to both the potential costs and benefits that are likely to be involved.

This study draws on the information gathered in the preparation of the Draft Environmental Impact Statement: SSA Proposal (Draft EIS)[1] and additional information where possible and relevant, to prepare a comparison of the benefits and costs of the proposed SSA.

2. Background to the Study

2.1 Draft EIS

PPK Environment and Infrastructure Pty Ltd (PPK) was appointed by the Department of Transport and Regional Development, Canberra in September 1996 to examine the potential environmental impacts of both the Badgerys Creek and Holsworthy airport proposals, based on Guidelines released in November 1996.[2] In September 1997, after studies had been substantially completed in the assessment of these two sites, the Government decided to exclude the Holsworthy Military Area from further consideration. New Guidelines were then prepared for the Draft EIS,

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1 Draft Environmental Impact Statement: Sydney Second Airport Proposal. (Draft EIS) Prepared by PPK Environment & Infrastructure for the Commonwealth Department of Transport and Regional Development. Concord West, NSW: PPK Environment & Infrastructure, 1997. 2v.

2 Draft EIS, v. 1, p. 2-5.

however apart from removal of references to the Holsworthy Military Area, they remained substantially the same.[3]

SMEC Australia Pty Ltd was appointed as the independent auditor of the EIS process by the Minister for the Environment in November 1996.[4] ACIL operates as its sub-consultant for the economic analysis.

The Draft EIS, assessing the three Badgerys Creek possibilities, was prepared by PPK, and specialist sub-consultants retained by PPK, and published in December 1997.[5]

Corporate Economics Australia was a sub-contractor to PPK in the preparation of the Draft EIS, preparing material published within Technical Paper 15.[6]

2.2 Criticisms of the Economic Analysis in the Draft EIS

The major criticisms of the Draft EIS related to the fact that it did not attempt a cost benefit analysis. The main comments on the economic analysis contained in the Draft EIS were the following:

- the absence of a do nothing option;
- the methodology used is not capable of establishing the net economic effect of the proposal;
- the costing analysis does not take impacts on the broad community (including costs of environmental impacts) into account;
- all relevant costs and benefits have not been included; and
- insufficient account taken in the regional assessment of general equilibrium impacts and impacts for NSW as a whole.

The Department of Transport and Regional Services commissioned further work on the economic aspects of the proposed airport in preparation for the Final EIS

2.3 Need for Further Analysis

The need for further analysis flows from the need to respond to the criticisms raised of the Draft EIS.

A particular criticism of the economic analysis was the lack of a detailed cost benefit analysis. A further important criticism was the lack of any detailed consideration of

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3 Draft EIS, v.1, pp. 3-1 to 3-2.

4 Draft EIS, v.1, p. 2-1.

5 Draft EIS, v.1, p. 2-5.

6 Draft EIS, Technical Paper 15.

the "do nothing" option. Several of the other criticisms relate closely to these two fundamental matters.

This study is intended to specifically address the main criticism by undertaking a benefit cost analysis of the character proposed by the Auditor. As part of this study the issue of the "do nothing" option becomes of prime importance as such an option provides the conceptual point of reference for an assessment of the cost of not having sufficient airport capacity in future years.

This study is concerned with the question of "should a major airport be constructed at Badgerys Creek". The issue of the "do nothing" option becomes fundamental as the prime alternative or counter factual reference point for the analysis.

3. Benefit Cost Analysis – In Concept

3.1 Conceptual Framework

Benefit cost analysis is a technique for systemically estimating the economic efficiency impact of public policies. It has particular relevance to studying the efficiency impacts of alternative capital expenditures by governments. Benefit cost analysis can take into account direct costs and benefits, economic externalities (including environmental impacts) and discounting for the impacts of risk and time.

The application of benefit cost analysis has been formally incorporated into the decision making process for airport investment decisions within the United States for many years, although it is acknowledged as being more difficult for second airports.[7]

3.2 Process

Cost benefit analysis involves four main steps:

- identifying relevant impacts;
- monetising impacts;

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[7] Federal Aviation Administration, *Economic Analysis of Investment and Regulatory Decisions – Revised Guide*, Washington DC USA, January 1998.

- discounting for time and risk; and
- calculating summary statistics.

3.3 The Base Case

Benefit Cost analysis is essentially a method of comparing the economic desirability of alternative actions. In the example of the SSA, the analysis has no meaning unless the proposal is put against an alternative. In this study, the "Base Case" is defined as the "do nothing" alternative with air transport volumes for the Sydney region limited to the maximum capacity of KSA.

However, the maximum passenger capacity of KSA is unlikely to be a fixed figure. Calculating the future capacity of a major airport such as KSA requires judgements concerning the capacity of the physical infrastructure (such as runways, terminals and transport access), the capacity of the airspace management system, the effect of measures to mitigate environmental impacts (including Government policies on noise sharing, the curfew and hourly movement caps), pricing and access arrangements, and the strategic and business decisions of the major users of the airport. The complex interaction of these elements and their potential to change over time underlines the difficulty in clearly defining the capacity of KSA if a second Sydney airport were not built.

In addition, it should be noted that the base case has as its central feature the continued expansion of KSA until well into the next century. Much of this expansion is already taking place or has been planned. This expansion involves significant additional expenditure at KSA and is a matter which is only indirectly relevant to this study. Much of the current expansion is necessary to deal with projected increases in demand which will most likely occur prior to any potential second Sydney airport becoming available. Decisions about whether the expansion of KSA represents a profitable use of capital need to be taken against the returns available from KSA. Placing an artificial constraint on the operating capacity of KSA is unlikely to represent optimal policy and, therefore, it is assumed that capacity at KSA will continue to expand in line with either of the two capacity scenarios set out in a subsequent section of this report.

The indicative analysis of the cost of not constructing a SSA presented in Technical Paper 15 to the Draft EIS was based on a maximum capacity at KSA of 30 million passengers per annum.[8] In this study the issue of the maximum capacity of KSA was extensively discussed with Department of Transport and Regional Services and, following these discussions, advice was received from Department of Transport and Regional Services in relation to the likely maximum capacity of KSA and how the maximum capacity may increase over time.[9] The maximum capacity of KSA used in this study to define the "do nothing" option is consistent with the advice received from Department of Transport and Regional Services and higher than the maximum

8 Draft EIS, Working Paper 15, page A-22.

9 Second Sydney Airport Proposal – Supplement to the Draft EIS, Chapter 4.

assumed in the Draft EIS. It should be noted, however, that these projections of maximum capacity embody considerations about the range of factors identified above which constrain the potential capacity of KSA, including the continuation of certain Government policies (especially the curfew and the maximum number of flight movements per hour) and modest increases in the number of passengers per aircraft movement (0.8 percent per annum).

The various technical and policy constraints on the capacity of KSA are potentially capable of being eased by technological developments. Larger and quieter aircraft and improved aircraft movement management systems could incrementally change the maximum capacity of KSA. However, forecasting technological change and changes in Government policy are difficult and, for the purposes of this study, it is assumed that current policies in relation to the curfew at KSA and the limitation of 80 movements per hour are maintained.

3.4 Limitations

The key limitation of the benefit cost technique (and any other form of quantitative assessment) is the difficulty with quantifying all relevant benefits and costs. Some benefits and costs are almost impossible to quantify. It is important that those which cannot be measured in monetary terms are nevertheless identified so that decision makers can make a qualitative assessment of their importance.

It is also difficult to take into account distributional impacts of alternative investments. For example, high income travellers and businesses not located immediately adjacent to the airport are likely to benefit from the airport while relatively lower income local residents will bear a disproportionate share of the costs.

3.5 General Equilibrium Effects

The impact of an economic change (including a major airport development) may have wide-ranging impacts throughout an economy. General Equilibrium effects are the net impacts of an economic change once it has had all its reinforcing and offsetting impact throughout the economy. There is a wide range of indirect and generally offsetting effects throughout an economy which result from any economic shock. For example, an increase in wages will tend to increase inflation (offsetting the initial increase in purchasing power of wage earners) and reduce industry competitiveness against other economies. Also, a constraint on the expansion of one industry is likely to limit the growth of industries supplying inputs to the first industry, but free resources for use by other industries allowing them to expand. It is therefore important to look at the broad range of industry interactions and economic linkages rather than only at, in this case, the air transport industry.

Of particular relevance in this study is the economy-wide economic impact of not allowing a second Sydney airport to be developed. Consider the quite plausible possibility that the level of national investment is unaffected by the construction of SSA and alternative investments would absorb the available funds for investment if SSA were not constructed. If the alternative investments had a similar rate of return as SSA, then income and employment for the national economy may well not vary whether SSA were built or not. The maximum annual expenditure on the construction of SSA is some $0.7 billion (1996 dollars) or some 0.15 percent of GDP and as such represents only 0.7 percent of current annual capital expenditure. Also, as identifying all or a reasonable sample of alternative investments is beyond the scope of this study, it is impossible to know whether the development of SSA would increase or reduce national income or employment.

An important general equilibrium effect not captured by a partial equilibrium analysis is potential crowding out of the benefits of investment by a real exchange rate or balance of trade effect. That is, the apparent economic gain from the investment may be largely offset by other economic activities becoming less competitive.

Also, the expansion of an industry in one region may see the same industry or even apparently unrelated industries decline in other regions. If general equilibrium effects are ignored, the gross benefits of a major investment will usually be understated and gross costs also understated from an economy-wide perspective. The net impact of all General Equilibrium impacts not captured in a conventional benefit cost analysis may be positive or negative.

The application of General Equilibrium modelling to the assessment of public investment proposals raises a further range of issues. A recent study undertaken jointly by the NSW Treasury and The Centre for Regional Economic Analysis, University of Tasmania was directed at the economic impact of the Sydney Olympic Games and associated capital expenditures. This study identified considerable net benefits from the Sydney Olympics over and above those that could be identified by a conventional benefit-cost analysis.[10] However, if the purpose of undertaking either a General Equilibrium analysis or a benefit-cost analysis is to rank alternative uses of public funds, then it is important that comparable techniques are used for all alternative proposals. There are currently few examples of the application of General Equilibrium analysis to competing public investment alternatives and, therefore, it is difficult to know what level of return would represent the best use of public funds. Also, the underlying assumptions about the formulation and detailed specification of General Equilibrium models remains the subject of continuing debate amongst economists, leading to further uncertainty about the application of General Equilibrium models to the comparative assessment of major public investments.

A further issue is the necessity to greatly simplify the project to adequately analyse its impact within a General Equilibrium framework. The recent study of the Sydney 2000 Olympics only considers two "average" impacts being a typical year of construction and a typical year of operation. In contrast, the Benefit Cost analysis presented here considers each of some 30 years for each alternative scenario, detailed benefits and costs for each of those years, the staged construction of the airport (three stages) as demand dictates and can easily accommodate alternative assumptions about key variables.

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[10] NSW Treasury, *The Economic Impact of the Sydney Olympic Games*, TRP 97-10, Sydney, November 1997.

There is, therefore, a trade-off between the use of the traditional benefit cost analysis and General Equilibrium analysis. The former allows for the more detailed modelling of direct economic impacts, whereas the General Equilibrium approach allows the consideration of the economy wide impact of a necessarily simplified representation of an investment opportunity.

4. Benefit Cost Analysis - Definitions and Assumptions

4.1 Defining the Base Case

The Base Case is defined as the "do nothing" or "what if a second airport is not built" option. The Draft EIS generally avoided the definition of such an option except for the analysis of employment impacts and the indicative cost benefit analysis set out in Chapter 5 of Technical Paper 15 – Economics (see section 5.2 of Appendix A).

The key issue in defining the Base Case is determining the capacity of KSA. The Department of Transport and Regional Services has advised[11], having regard for the operating policies that have been implemented for KSA and likely future efficiency gains, that two scenarios in relation to the passenger capacity of KSA should be considered:

- A: a capacity level of 33.6 million passengers will be reached in 2006-07; or
- B: a capacity level of 37.6 million passengers will be reached in 2010-11.

Scenario A assumes a continuation of current trends in aircraft size and loading, and that the percentage of slots allocated to regional, domestic and international aircraft remains unchanged. Scenario B assumes significant consolidation of regional/domestic services over time (for example, through regional hubbing and the use of larger aircraft into KSA).

However, these capacity limits are likely to further expand over time, even if only due to the likely steady increase in the number of passengers per aircraft movement. This increase is likely to result from both the adoption of larger aircraft by airlines and the further rationalisation of light aircraft movements at KSA. For example, the latest forecasts prepared by Department of Transport and Regional Services[12] indicate a projected average annual 0.8 percent increase in the number of passengers

[11] Second Sydney Airport Proposal – Supplement to the Draft EIS.

[12] ibid.

per aircraft movement over the period 2010-11 to 2021-22. This ongoing increase in the capacity of KSA is assumed to operate from the years 2006-07 and 2010-11 respectively for each of the scenarios. Implicitly it is thereby assumed that the other forms of efficiency gain at the airport have been exhausted.

A further factor which would impinge upon the economic benefits of constructing SSA is that not all of the projected excess demand would transfer to SSA. The location of SSA is geographically distant from those parts of Sydney where most demand for air transport is generated (mainly from residents of the eastern and northern suburbs) and transport access time and costs would be substantially greater. Following consultations with Department of Transport and Regional Services, it has been assumed that of the excess demand from KSA 90 percent of international, 75 percent of domestic and 60 percent of regional passengers would be willing to travel from SSA. The balance of the excess demand is assumed to not travel by air as a result of the lack of airport capacity.

The capacity limits and projected demand for aircraft services to the year 2021-22 are set out in *Table J1.1*. It is assumed that only the excess demand or shortfall in capacity is available for flight activity at the proposed SSA. Under Scenario A, there is no likely demand for the SSA prior to 2007-08 with demand increasing steadily to 14.1 million passengers by 2021-22. Under Scenario B, there is no likely demand for the SSA prior to 2011-12 with demand increasing steadily to 9.1 million passengers by 2021-22.

The benefit cost analysis presented in this report is undertaken over a notional 25 year period of operation of SSA (starting at whatever point the demand forecasts and capacity constraints dictate) and therefore demand forecasts well beyond 2021-22 are required. For the purpose of the analysis, the level of demand and capacity are each projected forward at the rate of increase indicated for the final year shown in *Table J1.1*.

The forecasts of KSA capacity and the growth in demand for air travel in the Sydney basin are crucial in determining the potential benefits of the proposed SSA. The lower the capacity of KSA and the higher the future demand for air transport, the greater is the economic benefit of developing SSA.

As noted above, forecasting the future capacity of KSA in any particular year is problematic. Each of the two scenarios is used as alternatives in the benefit cost analysis.

Table J1.1: Forecast Capacity and Demand for Aircraft Passenger Movements: Sydney: Base Case (millions)

Year ended 30 June	Capacity A	Capacity B	Projected Demand (actual)	Projected Shortfall A	Projected Shortfall B	Projected Demand A	Projected Demand B
1996			*21.7*				
1997			*22.5*				

Year ended 30 June	Capacity A	Capacity B	Projected Demand (actual)	Projected Shortfall A	Projected Shortfall B	Projected Demand A	Projected Demand B
1998			23.2				
1999			24.0				
2000			25.0				
2001			26.1				
2002			27.2				
2003			28.3				
2004			29.6				
2005			30.8				
2006			32.2				
2007	33.6		33.6				
2008	33.9		35.0	1.1		0.9	
2009	34.2		36.6	2.4		1.9	
2010	34.4	37.6	37.6	3.1		2.5	
2011	34.7	37.9	38.6	3.9	0.7	3.1	0.5
2012	35.0	38.2	39.6	4.6	1.4	3.7	1.1
2013	35.3	38.5	40.7	5.4	2.2	4.4	1.8
2014	35.6	38.8	41.8	6.3	3.0	5.1	2.4
2015	35.9	39.2	43.0	7.1	3.8	5.8	3.1
2016	36.2	39.5	44.2	8.0	4.7	6.5	3.8
2017	36.5	39.8	45.4	9.0	5.6	7.2	4.5
2018	36.8	40.1	46.7	9.9	6.5	8.0	5.3
2019	37.1	40.5	48.0	10.9	7.5	8.8	6.1
2020	37.4	40.8	49.3	11.9	8.5	9.7	6.9
2021	37.7	41.1	50.7	13.0	9.6	10.6	7.8
2022	38.0	41.5	52.1	14.1	10.6	11.5	8.6

The demand forecasts shown in *Table J1.1* are the "central" estimates provided by Department of Transport and Regional Services. These assume a major slowing of the growth of air transport demand from recent levels of around 7 percent per annum to around four percent for the next decade and then less than three percent per annum for the decade to 2020-21. However, it is worth noting that these forecasts are similar to those prepared by the United States Office of Aviation Policy and Plans in June 1998.[13] Within the benefit-cost analysis a sensitivity analysis

[13] Office of Aviation Policy and Plans, *FAA Long-range Aviation Forecasts Fiscal Years 2010, 2015 and 2020.* Washington DC, June 1998. p 2.

involving both higher and lower forecasts of passenger demand are used to test the sensitivity of the results to the growth in demand.

Regional results are included in the analysis for Australia, NSW, Sydney and the SLAs making up the Badgerys Creek region. Regions are distinguished by allocating the key category of benefits (the loss of consumer surplus resulting from constrained supply) in accordance with estimated use of air transport services by the residents of those regions.

The regional use of air transport services is based on data set out in the Draft EIS.[14] For the purpose of this analysis it is assumed that the benefits of air travel accrue to regions as they were each centred on the airport. That is, a departure from Sydney and an arrival from Sydney are each indicative of a benefit to a region containing the airport. In accord with these data it is assumed that the SSA would essentially benefit the residents of NSW only. The estimated regional distribution of benefits is set out in *Table J1.2*.

Table J1.2: Estimated Regional Share of the Benefits of SSA

Region	Share (percent)
Australia	100
NSW	100
Sydney	92
Badgerys Creek Region	17

How the construction of SSA and related infrastructure is to be funded has yet to be finally determined. Two broad alternatives appear likely involving either construction being funded by the Commonwealth Government or by the sale of the long-term lease of KSA with an obligation upon the purchaser to construct and operate SSA. In both cases the financial risk of construction is effectively borne by those taxpayers with potential obligations to the Commonwealth.[15]

Under the first funding scenario, risk is clearly borne by the Commonwealth and therefore the cost of construction can be fairly allocated geographically in proportion to taxpayers' liability to pay tax to the Commonwealth.

Under the second funding scenario the allocation of liability is more problematic. If the airport is assessed as financially viable in terms of meeting the purchaser's required rate of return, then the risk faced by Commonwealth taxpayers may be so

[14] Technical Paper 13 in support of Draft EIS, Appendix H.

[15] Not all of the costs are to be borne directly or indirectly by the Commonwealth as it is likely that the NSW Government will fund at least part of the road and rail access costs. The proportion of costs borne by NSW is likely to be relatively minor, however, as a substantial part of State expenditures is funded from Commonwealth taxation revenues and additional grants for these developments may be forthcoming from the Commonwealth. For these reasons the costs of the project are allocated in proportion to Commonwealth taxation liabilities only.

low as to be negligible. However, if, as the analysis presented in this report suggests, private investors regard the development of SSA as not providing an adequate expected rate of return, then the price obtained for the sale of the combined airports (inclusive of the obligation to construct SSA) may be less than if KSA were sold alone. Therefore, it is judged that Commonwealth taxpayers are fundamentally at risk in relation to the development of SSA.

The construction costs are assumed to be funded by taxpayers in proportion to the regional payment of taxation by individuals (based on ATO statistics for 1996 year).[16] Taxation statistics are presented on a regional basis by postcode. It should be noted that postcode areas do not map uniquely to SLAs thereby producing the potential for a slight bias. The approach taken was to include all postcodes which fell at least in part into the SLAs which are defined to constitute either the Sydney or Badgerys Creek Regions as defined below. The estimated regional distribution of tax liability is set out in *Table J1.3*.

Table J1.3: Estimated Regional Share of the Construction Costs of SSA

Region	Share (percent)
Australia	100
NSW	36
Sydney	24
Badgerys Creek Region	6

4.2 Defining Whose Costs and Benefits to Include

Which stakeholders have standing in the analysis? The potential operator of the proposed second Sydney airport clearly has an interest in the viability of the airport. However, the key beneficiaries (at least in the first instance) are users of air transport services. Another key group of stakeholders is the local community which bears the physical costs of being proximate to the proposed SSA (noise, congestion, pollutants, risk of crashes, etc). A further important stakeholder is the community generally, which through the Government, could bear the risk of the airport development. The benefit cost analysis is largely undertaken from the perspective of the whole community with subsidiary calculations being undertaken to identify the impact on the potential operator and regional groupings.

4.3 Industry Definitions

In this study, data limitations force use of the Input-output industry "Air Transport" as defined by the Australian Bureau of Statistics[17]. Other industries referred to will also follow the same definition source.

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[16] Australian Taxation Office, *Taxation Statistics 1995-96*, Table 11 : Individuals, Canberra, 1998.

[17] Australian Bureau of Statistics, Australian National Accounts, Input Output Tables 1992-93

4.4 Geographic Definitions

An output of this study is the regional impact of the proposed development and the analytical tool used has a maximum disaggregation of "Statistical Local Area" (SLA). The Badgerys Creek region (used for defining local impacts) is defined as comprising the SLAs of Penrith, Blacktown, Fairfield, Liverpool, Camden, Campbelltown, Baulkham Hills and Parramatta. Sydney is defined as the Statistical Division of the same name.

5. Costs

5.1 Construction Costs

Construction costs and timing are drawn from the Planning and Design Summary Report which accompanied the Draft EIS.[18] Option C is used as the basis for the cost of construction and likely timeframe thereof because this option represents the midpoint in terms of projected costs. These costs include land acquisition ($252 million), the cost of Airservices Australia's facilities ($42 million) and certain on-site aspects of railway facilities ($92 million). The construction costs included are those consistent with the staged development of SSA to a capacity of 10 million passengers per year when first coming into operation, subsequent development to a capacity of 20 million passengers per year and then full development to the "Master Plan" capacity of 30 million passengers.

For the purposes of the cost benefit study it is assumed that construction for each stage commences five years (ie year -5) prior to the year in which the projected air traffic demand dictates. That is, it is assumed that planners can forecast KSA capacity and market demand with sufficient precision that they make the airport available at the time when overflow demand eventuates. Estimated construction costs and timing are summarised in *Table J1.4*. If the airport were constructed earlier than demand suggested, then resources would have been applied to SSA for a period in which no return would be obtained.

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[18] Second Sydney Airport Planners, *Second Sydney Airport Planning and Design*, Chapter 5 and Airport Planning Pty Ltd, Second Sydney Airport – Stage 2 Development Scenario for Financial Feasibility Analysis, July 1997.

Table J1.4: Construction Costs and Timing

Year	Estimated Expenditure (1996 $ million)
Stage 1 – 10 million passengers	
-5	314
-4	220
-3	624
-2	556
-1	336
Airport opens	11
Stage 2 – 20 million passengers	
-5	73
-4	175
-3	427
-2	588
-1	328
Capacity available	2
Stage 3 – 30 million passengers	
-5	72
-4	204
-3	396
-2	338
-1	98
Capacity available	4
Total	**4,764**

Note: The total cost reported here is higher than that reported in the Draft EIS because later cost estimates have been used and the construction costs associated with a three stage construction program are also higher than a single or two stage construction program.

5.2 Cost of Associated Infrastructure

Indicative estimates of the cost of external infrastructure for SSA are set out in *Tables J1.5* and *J1.6*. These estimates are obtained from further work undertaken by Department of Transport and Regional Services.[19] It is assumed that the external infrastructure is also constructed in three stages with the railway constructed for the third stage. For each stage the external infrastructure is constructed so that it is only available at the precise time that expected passenger numbers dictate. This may involve construction commencing up to five years prior to the necessary airport

19 Second Sydney Airport Planners, *Second Sydney Airport Planning and Design*, page 5-4.

capacity being required. Because the demand estimates indicate that the full capacity of SSA will not be required during the evaluation period a total external capital expenditure of $1,126 million is taken into the benefit cost calculations over the three stages.

Table J1.5: Cost Estimates of External Infrastructure: by Type ($ million)

Infrastructure Type	Stage 1	Stage 2	Stage 3 (Master Plan)
Road[20]	550	0	0
Rail[21]	0	0	400
Water	20	11	9
Waste Water	25	6	4
Power	30	0	0
330kV Transmission Line Relocation	25	0	0
Telecommunications	10	3	2
Aviation Fuel Pipeline	25	0	0
Natural Gas Pipeline	6	0	0
Total	**691**	**20**	**415**

Table J1.6: Cost estimates of external infrastructure: by year ($ million)

Infrastructure Type	Stage 1	Stage 2	Stage 3 (Master Plan)
Year			
-5	163	6	84
-4	117	8	88
-3	115	6	84
-2	154	0	80
-1	142	0	80
Total	**691**	**20**	**415**

5.3 Operating Costs

The costs of operating SSA were derived from data provided by Department of Transport and Regional Services, which in turn was based on analysis undertaken by Department of Transport and Regional Services. The various year by year estimates

[20] No costs for the Western Sydney Orbital (WSO) have been attributed to the Airport. It has been estimated that Stages 1 and 2 of the WSO would cost $400 million and Stages 3 and 4 would cost $460 million.

[21] The rail costs refer to the development of a link from Glenfield to the airport.

of costs given estimated passenger numbers and air craft movements were subject to a statistical analysis to determine the average fixed and variable components of costs. These cost estimates were then applied to the projected passenger demand in each period to provide an estimate of the costs of operating the airport and managing the various commercial activities that would yield income to the owner/operator of SSA.

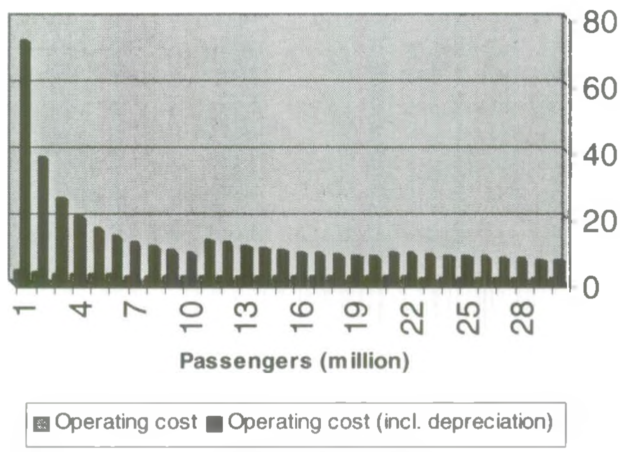
The costs included in the analysis included an estimate of the true (book) average rate of depreciation of capital investments. The rates used by class of asset are as set out in *Table J1.7*, with the basis of calculating an average rate of depreciation using an indicative mix of capital expenditures and economic lives as advised by Department of Transport and Regional Services.

Table J1.7: Estimated Rates of Depreciation

	Indicative Mix of Capital Expenditures	Assumed Economic Life (years)	Depreciation Rate
Land	1%	n.a.	0
Runways	29%	40	2.5%
Permanent building - Structure	18%	40	2.5%
Permanent building - Plant	5%	20	5.0%
Furniture & fittings	17%	50	2.0%
Site services	14%	12.5	8.0%
Lighting and visual aids	4%	30	3.3%
Roads and car parks	12%	40	2.5%
Total/Average	**100%**	**30**	**3.35%**

The estimated operating costs, with and without depreciation are illustrated in *Figure J1.1*. Excluding depreciation, operating costs per passenger are estimated to be as high as $3.80 at a throughput of one million passengers, falling to $1.65 per passenger at 30 million passengers per annum. Including depreciation and allowing for the staged development of the airport, operating costs per passenger are estimated to be some $73 per passenger at a throughput of 1 million passengers, falling to $7 per passenger at 30 million passengers per annum.

Figure J1.1: Operating Costs Per Passenger



5.4 Loss of Local Residential Amenity

The loss of amenity resulting from noise, air quality, congestion, etc is estimated from changes in housing values estimated for areas affected by KSA flight paths together with the estimated costs of noise management. Estimates included in the Draft EIS put the decline in housing values at $49 to $67 million (impact in 2016 expressed in 1996 dollars).[22] The cost of noise management including voluntary acquisition of properties and acoustical treatment is estimated to be between $21 and $44 million measured in 1996 dollars.

A value of $33 million is assumed in the analysis for the cost of noise management for SSA. It is further assumed that these costs are incurred in full at or about the time at which the SSA is commissioned, even though the magnitude of the loss of local residential amenity will increase over time as the SSA approaches its 30 million annual passenger design capacity.

5.5 Other Environmental Impacts

The key impacts which were not able to be monetised and thereby incorporated in the analysis were the effects on Aboriginal cultural heritage, the effects on the habitat of species of plant and animal of significance to the locality, potential impacts on water quality, impacts on other Sydney Basin airports, impact on non-Aboriginal cultural heritage, loss of amenity in National parks due to aircraft over-flight, and visual and landscape impacts.. It has not been possible to quantify the monetary

[22] *Proposal for a Second Sydney Airport at Badgerys Creek or Holsworthy Military Area: Property Values*. Prepared by JLW Advisory and PPK Environment & Infrastructure for the Commonwealth Department of Transport and Regional Development. Concord West, NSW: PPK Environment & Infrastructure, December 1997. (Technical Paper 4).

value of these impacts and the fact they have not been quantified needs to be kept in mind when interpreting the results of this study.

The Draft EIS found that the SSA site had already been degraded from existing land uses, limiting the value that could be placed on the remaining Aboriginal and non-Aboriginal heritage values. Similarly, the existing damage to local water quality and threats thereto from previous developments limit the value that might be placed on these factors. Finally, it is anticipated that any development of SSA would be accompanied by a comprehensive environmental management plan which would have the potential to improve environmental outcomes on the site compared to those which currently exist.

Also, if SSA were not to be constructed it is highly likely that other investments and construction activities would take place that would perhaps have similar effects in the same or other locations. Is the potential impact on Aboriginal sites or flora and fauna within the SSA site relatively adverse compared to a range of other investment alternatives? The Draft EIS only looked at the potential impact of development on particular airport sites with no attempt to ascertain whether the damage of development was relatively benign or destructive compared to other possible investments in airports or any other investment.

5.6 Health Impacts

Degradation of air quality has been estimated to have an adverse impact on the regional population through increased ozone levels, air toxics and particulates. On the assumption that each projected cancer case becomes terminal, up to 5 additional deaths might be expected each 100 years as a consequence of the regional population being exposed to the operation of SSA.

The valuation of human life within policy or project evaluation is a complex issue. A common method of valuation has been to value each life in terms of the income lost due to the shortening of life. However this approach has been criticised on theoretical grounds.[23] A better approach is the use of estimates of risk-premium which are well grounded in economic theory. The risk-premium approach measures the value of life by looking at how much people implicitly value their lives by seeing how much additional wage compensation they demand for working at riskier jobs.

Viscusi has reported 23 studies in which estimates are made of the value of human life. The estimates he cites mainly range from US$3 million to US$7 million.[24] The Federal Aviation Administration has issued a direction to organisations submitting

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[23] Weimer, D. L., and A. R. Vining, *Policy Analysis: concepts and practice*. 2nd ed. Englewood Cliffs, NJ: Prentice-Hall, 1992. p.296.

[24] Viscusi, W. K., The value of risks to life and health. *Journal of Economic Literature*, v.31, Dec 1993, pp1912-1946.

proposals for airport funding that lives lost should be valued at US$2.7 million each.[25]

Having regard to the US experience and the range stated in US$s in the references cited, a value of AUD$5 million is applied to each life projected to be lost within this report.

Also, the probabilities cited in the Draft EIS are reduced in proportion to the estimated airport traffic in each year. In this regard, it is further assumed that the probabilities set out in the Draft EIS apply to SSA operating at a capacity of 30 million passengers per year. That is if only 5 million passengers were to use SSA in a year all probabilities would be one sixth of those stated in the Draft EIS.

5.7 Loss of Displaced Existing Production

The SSA site is effectively being used only for agricultural uses and the estimate of the production foregone by virtue of constructing SSA is as set out in the Draft EIS. The Draft EIS also makes reference to the loss of access to a thermal coking coal deposit, although it would seem unlikely that this deposit would be viable to develop and this loss is therefore assumed to be zero.

5.8 Risk of Aircraft Crashing

Set out in the Draft EIS are estimates of the probability of an aircraft crashing. This probability is put at one crash per 10,000 years and a predicted fatality rate of up to 5 persons per 100 years.

The cost of an aircraft crash is put at $100 million per incident (excluding loss of life and the loss of the aircraft) and is intended to represent the adverse impact of such an event on the crash site.

As discussed above, the value of each life lost is put at $5 million.

As with the calculation of the cost of adverse health impacts, the estimated annual cost of an aircraft crash is proportional to the number of passengers estimated to use SSA relative to 30 million passengers.

5.9 Diversion of Activity from KSA

The cost of diverting activity from KSA is assumed to be zero on the basis the use of SSA will be purely voluntary with no forced diversions being placed upon airlines. Similarly the cost of additional travel time to and from SSA (relative to KSA) is also not relevant providing that airline use is not influenced by Government directives or non-economic pricing.

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[25] FAA, *Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Decisions*, Washington DC, June 1998, p.2-2.

6. Benefits

6.1 Catering for Additional Demand Growth

The central rationale for the construction of a second Sydney airport is the prospect of KSA not being able to adequately service the air transport needs of the Sydney region. As KSA approaches its maximum capacity users and operators may either suffer administrative restraints on their operations or, if airport access was not overtly managed, increased costs due to congestion. The current management of KSA involves the allocation of landing rights for scheduled flights at a maximum rate of 80 per hour. This maximum rate has been set having regard for the safe operation of the airport and, subject to unplanned occurrences, should allow operations without significant economic loss due to congestion. While a certain amount of congestion occurs during peak demand periods, this is a typical feature of most major airports. If the KSA were not managed, users would suffer directly the costs of congestion including additional operating costs from queuing planes in holding patterns before landing, aircraft departure delays and time lost by air travellers. These costs are difficult to measure.

Given current air traffic management arrangements, and the likelihood of their continuation into the future, the quantum of passenger movements available for the proposed SSA is likely to be determined by the air movement slots available for allocation (especially but not only in high demand periods) at KSA. Therefore, the issue of congestion and the magnitude of the costs of congestion at KSA are not directly relevant to the economic benefits of constructing SSA. The economic benefits of SSA relate to the economic value derived by those consumers which will use SSA and those economic activities which will obtain additional benefits. If travellers choose to suffer congestion costs at KSA while SSA was available, this has the effect of reducing the patronage of SSA (an impact taken into account), but the cost to that traveller of congestion at KSA is not relevant to the economic value of SSA.

The magnitude of the benefit of constructing SSA is therefore measured as the obverse of the cost of constraining air transport to Sydney to the defined limit of KSA (as specified in the two capacity scenarios) after allowing for that proportion of displaced travellers which will be expected not to fly because they are unwilling to travel to SSA.

It should be noted that the economic cost of not constructing SSA is not equal to the number of potential passengers diverted multiplied by the average expenditure on air transport by those displaced passengers. The economic cost to the community is equal to a lower amount, recognising that consumers will choose alternative goods or services to consume (in respect of which they will obtain a lower level of satisfaction. Alternatively, displaced passengers may achieve their travel or transport objectives by other means, albeit not as efficiently as they would have had they been able to depart or arrive through KSA.

From an economic perspective the economic cost of consumers not being able to travel in their preferred manner, is measured as the loss of consumer surplus.[26] That is, the economic loss resulting from restricting supply to the projected limited capacity of KSA, year by year, as compared to the projected demand for air transport services.

A conceptual illustration of the impact of the economic cost of the constraint to air transport capacity is set out in *Figure 2*.[27] The key assumptions of the representation are that:

- the current price of air travel (P_0) embodies a cost for the use of airport facilities that is indicative of the long run average cost (LRAC) of operating a major airport in the Sydney basin;
- the LRAC is identical for KSA and SSA and that the operator sets prices at each equal to the LRAC;
- the LRAC remains unchanged in real terms in all future periods;
- the LRAC curve is flat over the relevant range of utilisation;
- the demand curve is linear over the relevant range of quantities and prices analysed; and
- expansion of demand for air transport results essentially from higher per capita incomes and a trend to greater use of air transport and can be represented by a horizontal shift in the demand curve.

For example, at time 0, demand for air transport is represented by the demand schedule D_0. If the supply of air transport is limited to quantity Q_0 at that time, then demand is fully satisfied at price P_0. Now consider a situation where demand expands (a future time period) such that the demand schedule becomes D_1. Unless capacity is increased prices will rise from P_0 to P_1. The economic loss faced by consumers as a result of not expanding (in this case) the airport capacity is measured by the additional amount each one of those consumers would have been willing to pay for air transport services over and above the initial price P_0.

It is assumed that both KSA and SSA will be owned by the same party and the single operator will set access prices no higher at SSA than KSA. The assumption is, in part, based on the requirements set out in the airport sale legislation which embodies

26 Consumer surplus is the difference between what a consumer actually pays for an item and the price the consumer would have been willing to pay. Adding the surpluses realised by all consumers in a market yields a measure of the *consumer surplus* for that market.

27 The Consultant and the Auditor did not fully agree on the method by which the estimates of the loss of consumer surplus were calculated. The Auditor suggested a more complex approach which, if adopted, would have resulted in greater economic benefits being attributed to the proposed Second Sydney Airport. The Consultant is of the view that the Auditor's suggested approach would overstate the potential economic benefits of the proposed Second Sydney Airport.

the principle of the sale of both airports to a single operator.[28] As operators have stated their preference to keep all their operations at KSA for as long as possible[29], it is unlikely that users of SSA will be faced with higher prices. In other words, the implicit supply schedule is a horizontal line equivalent to the price level at any point in time.

The dollar value of the economic loss resulting from not constructing the airport is the area of the triangle identified in *Figure J1.2* as "Loss of consumer surplus". The area can be measured from the length of its horizontal base (that is, the difference between potential demand and the maximum capacity of KSA) and the height of the triangle which is equal to the expected price change resulting from the supply constraint.

The price change resulting from a change in quantity is measured by what economists term the "elasticity of demand"[30]. The elasticity of demand for air transport services has been measured in a number of studies with little consensus. In a recent study of the elasticity of demand for international travel the Bureau of Transport and Communications Economics found a wide range of estimates depending on the destinations involved as illustrated in *Table J1.8*.[31]

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[28] Airports Act 1996.

[29] See submissions to the Draft EIS by both Qantas and Ansett.

[30] The elasticity of demand can be defined as the change in demand resulting from a one unit change in the price of the product offered to consumers.

[31] Bureau of Transport and Communications Economics, *Demand Elasticities for Air Travel to and from Australia*, Canberra, December 1995. (Working Paper 20)

Figure J1.2: Impact of Constrained Supply on Consumer

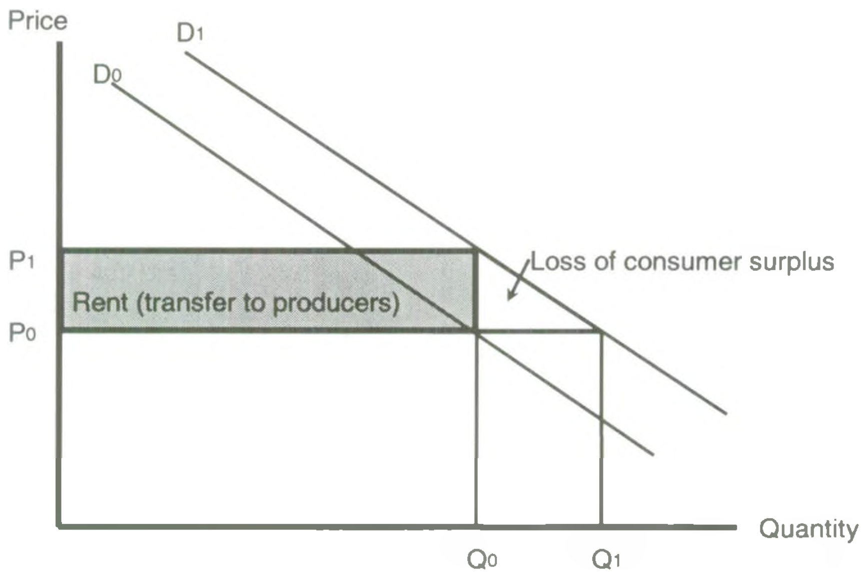

Table J1.8: Estimates of Airfare Demand Elasticities for Leisure and Business Travel to and from Australia

	Leisure travel		Business travel	
Economy	**Foreign Arrivals**	**Australian Departures**	**Foreign Arrivals**	**Australian Departures**
Germany	-1.23	-0.50	-0.55	–
Italy	-0.56	-0.29	*	-0.19
UK	-1.79	-0.14	-0.21	-0.20
Japan	-0.79	-1.16	-0.24	–
Korea	-0.50	-1.14	-0.20	-0.40
Taiwan	-0.83	-1.19	–	*
Indonesia	-1.46	-0.48	-0.62	-0.01
Malaysia	-0.78	-0.95	–	-0.29
Singapore	-1.86	-0.54	-0.22	-0.12
Fiji	-0.80	-0.53	*	*
New Zealand	-0.68	-0.23	-0.16	-0.34
USA	-1.85	-0.64	-0.45	–

Note: Travel demand equations were estimated using quarterly data from March 1986 to June 1994.
The BTCE could not estimate statistically robust models for these economies.
Variable was omitted from the model as it added no further explanatory power.

Source: Adapted from BTCE (1995).

It should be noted that the estimates of elasticity set out in *Table J1.8* vary greatly between markets and are also subject to statistical uncertainty. For example, the estimated elasticities for Australian leisure departures vary between –0.23 and -1.19. For foreign leisure arrivals the estimated elasticities vary between –0.5 and -1.86. The elasticity of demand for business travel is generally less price elastic ranging between –0.01 to –0.4 for departures and between –0.16 to –0.62 for arrivals.

In the more recent Draft Report on International Air Services, the Productivity Commission concluded that the demand for air travel was strongly elastic in respect of income (a 1 percent increase in national income leading to a 2 percent increase in the demand for air travel) but that it is generally somewhat less elastic with respect to fares.[32] The relative importance of higher incomes on the growth of air travel found by the Productivity Commission is consistent with the assumption made earlier that the growth in demand for air travel will largely result from shifts in the demand schedule due to higher real incomes rather than from falls in the real price of air travel.

No recent published estimates of the elasticity of demand for domestic users of air transport in Australia have been identified.

Given the wide range of elasticity estimates found by BTCE for each market, it is likely that the price elasticity of the aggregate demand schedule for the demand for air transport is characterised by a higher level of responsiveness to price at the margin. That is, business travellers would be relatively more willing to pay higher prices for travel. In contrast, the marginal leisure traveller would be the most likely to be displaced by a constraint on the airport capacity of Sydney. If it is travellers with a high elasticity of demand for air travel which are being displaced, this means that the economic cost of a constraint on capacity is correspondingly low for any given level of constraint. However, as the level of air travel services from SSA increases it is likely that the average elasticity of demand exhibited by those travellers which would travel via SSA will fall.

For the purposes of the benefit cost analysis, a range of elasticities of demand with respect to price has been used. The three alternatives used are -0.4, -0.8 and -1.2. This range encompasses almost all of the estimates obtained by BTCE in their study of the demand for international air travel. The base elasticity value used for the presentation of summary results in this study was –0.8, but it should be stressed that the correctness of this magnitude remains uncertain.

A key factor in calculating the loss of consumer surplus is the average price of air travel. The appropriate price to use should include an appropriate weighting of domestic and international services and with due allowance for discounts, etc. The approach taken in this study has been to use the average passenger yield achieved by Qantas, calculated from data published in Qantas' 1997 Annual Report. The average (one way) fare thereby obtained was $328.13, as shown in *Table J1.9*.

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32 Productivity Commission, *International Air Services – Draft Report*, p. 19.

Table J1.9: Calculation of the Average One-way Fare - Qantas[33]

Item	
Yield per revenue passenger kilometre	$0.1056
Revenue passenger kilometres flown ('000)	58,619,000
Passengers movements ('000)	18,865
Average fare per passenger movement	$328.13

The estimated benefits of having the proposed SSA have both an industry and household component. However the method of estimating these does not permit their disaggregation.

The estimation of the costs of not having sufficient airport capacity has focussed on passengers rather than freight. While air freight is becoming increasingly important, it is largely a by-product of passenger services and is generally priced on a marginal cost basis. For example, more than 90 per cent of Australian international air freight is carried in the belly-holds of passenger aircraft.[34] Therefore, no significant bias from the results is expected from the focus on passengers as the basis for measuring the benefits of constructing the SSA.

6.2 Operating Revenue

Estimates of the likely revenue from operating SSA were derived from data provided by Department of Transport and Regional Services, which in turn was based on analysis undertaken by Department of Transport and Regional Services. The various year by year estimates of revenues given estimated passenger numbers and aircraft movements were subject to a statistical analysis to determine the average fixed and variable components of revenues. These revenue estimates were then applied to the projected passenger demand in each period to provide an estimate of the revenues from operating the airport and managing the various commercial activities that would yield income to the owner/operator of SSA.

The estimated operating revenues per passenger are estimated to vary between $16 and $17 over the relevant range of passenger throughput.

6.3 Use of Airport Transport Links by Badgerys Creek Region Residents

The Draft EIS provided detailed forecasts of the likely demand for and use of road and rail facilities by employees, travellers and meeter/greeters at SSA. In relation to road, the Draft EIS forecasts suggest that the airport specific road works would not provide significant net benefits to local residents. In relation to rail, the Draft EIS

[33] Qantas, Annual Report 1998

[34] Productivity Commission p. 101

Appendix K1

Literature Review Relating to Sulphur Dioxide Health Effects

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Appendix K1

Literature Review Relating to Sulphur Dioxide Health Effects

1. Background

Sulphur dioxide is an irritant gas released into the atmosphere as a result of combustion of sulphurous fossil fuels. Since most Australian coal does not contain high levels of sulphur, this form of pollution has not been a major problem in Australia as it has been in parts of Europe and North America.

Experimental studies have shown that people with asthma may develop symptoms and decreases in lung function when exposed, during exercise, to sulphur dioxide concentrations in the range 0.25 to 0.5 parts per million (reviewed in Sandstron et al, 1995). No effects are seen in healthy, non-asthmatic subjects at levels up to 1.0 parts per million (Schachter et al, 1984). There is marked variability among patients with asthma in their sensitivity to sulphur dioxide (Horstman et al, 1986). The effect is enhanced by prior exposure to ozone (Koenig et al, 1990). The intensity of symptoms induced by performing moderate exercise during exposure to sulphur dioxide at concentrations > 0.5 parts per million may be greater than that experienced during episodes triggered by more strenuous exercise in clean air (Gong et cal, 1995). Symptoms and bronchoconstriction may occur after exposure to sulphur dioxide 1.0 parts per million, during exercise, for as little as two minutes (Horstman et al, 1988). There is evidence that a substantial minority of patients with asthma may experience bronchoconstriction after brief exposure, during moderate exercise, to sulphur dioxide concentrations in the range 0.6 to 1.0 parts per million (NSW Environment Protection Authority, 1994). However, the effect reverses quickly with rest, even if exposure to sulphur dioxide continues (Hackney et al, 1984).

A systematic review has been conducted of the literature to quantify the adverse health effects of exposure to atmospheric sulphur dioxide.

2. Methods

The computerised bibliographic databases Medline and Embase, for the period 1966 and 1998, were searched using the following Medical Subject Heading (MeSH) key words: sulphur dioxide, health, lung function, symptoms, admission and mortality. Bibliographies from the initially retrieved articles were searched to identify further relevant reports.

Papers were accepted for inclusion in the meta-analysis if they met the following criteria:

- they were primary studies, not re-analyses or reviews;
- the study design was a case-control, cohort, or cross-sectional study, using individual level exposure and health outcome information;
- lung function, symptoms, hospital admission or mortality were measured as outcomes;
- exposure to sulphur dioxide was measured; and
- a summary odds ratio (OR), beta coefficient or percentage change were cited together with an estimate of variance or standard error.

The key features of included studies are listed in *Tables K1.1* to *K1.4*.

Data was abstracted by a single reviewer. Odds ratios or regression coefficients relating a given change in maximum hourly sulphur dioxide level to daily rates of mortality, hospital admission, and/or symptom prevalence were abstracted. Where several coefficients or odds ratios were cited for a single outcome (usually for differing lags between exposure and outcome) the highest odds ratio or coefficient was selected for inclusion. Ninety five percent confidence intervals (95% CI) were either abstracted directly from the original papers or calculated by the standard approximation to a normal distribution on a logarithmic scale. Where the regression coefficient was cited in the paper, this was converted to an odds ratios and ninety-five percent confidence interval by taking the exponential of the coefficient. {The Poisson regression is on the log scale, that is, odds ratio = exp (coefficient), and the 95% confidence interval = exp(coefficient +/- 1.96 X SE).}

Since the studies cited odds ratios for different increments of sulphur dioxide, we recalculated these based on a common increment of ten parts per billion (10 parts per billion). This was achieved by transforming back to the regression coefficient. For example, in one study it was estimated that the odds ratio for symptoms was 1.244 for an sulphur dioxide increment of 40 parts per billion. The calculated odds ratio for a 10 parts per billion increment in sulphur dioxide is exp(Ln 1.244/40 x 10), which is 1.06.

Table K1.1: Mortality

Author	Year	Country	Health Outcome	Relative Risk	Age (yr)	SO_2 Level	SO_2 Increment	Adjusted Confounders
Ballester, 1996 (APHEA)	1991-3	Valencia, Spain	Total mortality	1.0007(0.99-1.001)[lag:2days]	All	39.94 ug/m^3	1 ug/m^3	season, temperature, humidity, trends,
			Respiratory mortality	0.99(0.99-1.00), "	All	(All year)		day of week, holiday, flu
			Cardiovascular mortality	1.00(0.99-1.00), "	All			
Vigotti, 1996 (APHEA)	1980-9	Milan, Italy	Respiratory hospital admissions	1.09(1.01-1.17)[lag:0-3days]	15-64	117.7 ug/m^3	125 ug/m^3	season, temperature, humidity, trends,
				1.07(0.99-1.15), "	>64	(All year)		day of week, holiday, flu
			Mortality due to respiratory diseases	1.16(1.05-1.29)[lag:0-1day]	All			
Sunyer, 1996 (APHEA)	1985-91	Barcelona	Respiratory mortality	1.244(1.039-1.49)	All	36.4ug/m^3	100 ug/m^3	season, temperature, humidity, trends,
		Spain	Total mortality	1.127(1.068-1.189)		(summer)		day of week, holiday, flu
				1.145(1.063-1.232)				
Anderson, 1996	1987-92	London, UK	Respiratory mortality	1.02(0.99-1.05) [lag:1day]	All	32.2 ug/m^3	28 ug/m^3	"
			Total mortality	1.01(0.99-1.02), "		(All year)		
			Cardiovascular mortality	1.00(0.99-1.02), "				
Dockery, 1993	1979-89	USA	Cause of death (all)	1.26(1.08-1.47)	25-74	9.67 ppb	22.4 ppb	smoking, gender, occup
				[mortality rate ratio]				exposure to dust, gases,
Mackenbach, 1993	1979-87	Holland	Cause of death (all)	-0.0001(SE 0.00005)	All	18 ug/m^3	1 ug/m^3	season, temperature,
			CVS death	-0.00006(0.00007)				humidity, weekday,
			respiratory death	-0.00033(0.00019)				incidence of 'flu, trend
Touloumi, 1994	1984-8	Athens, Greece	estimated decrease in mortality/	0.062(SE 0.01),p=0.0001[a] [lag:1day]	All	44.92 ug/m^3	4.49 ug/m^3	season, temperature, humidity, trends,
			10% drop in pollutant (SO_2)					day of week, holiday
			" [after adjust for smoke, CO]	0.042(SE0.014),p=0.003[a] [lag:1day]				

APHEA: A European approach using epidemiologic time series data

a = health outcome reported in beta coefficient and SE

Table K1.1: Mortality (Continued)

Author	Year	Country	Health Outcome	Relative Risk	Age (yr)	SO_2 level	SO_2 increment	Adjusted confounders
Spix, 1996 (APHEA)	1975-85	Cologne, Germany	daily mortality	1.04(RR)	All	66 ug/m^3	20 ug/m^3	trend,season,influenza,
				0.0221(0.0099)[b e]				day of week & holidays,
								temperature
Zmirou, 1996 (APHEA)	1985-90	Lyon, France	Total minis external causes	1.06(1.02-1.09)	all	46.76 ug/m^3	50 ug/m^3	trend, seasonality,
			respiratory deaths	1.05(1.02-1.09)				temperature, humidity,
			CVS deaths	1.08(1.03-1.12)[e]				influenza, days of week
Wojtyniak, 1996	1977-90	Cracow, Poland	CVS death	0.05(0.02-0.087)[a,e]	all	47.45 ug/m^3	100 ug/m^3	trend, seasonality,
(APHEA)		Lodz	CVS death	0.017(-0.009-0.04)[a,e]				temperature, humidity,
		Poznan	CVS death	0.002(-0.0144-0.018)[a c]				influenza, day of week
		Wroclaw	CVS death	-0.013(-0.029-0.004)[a,e]				
		Cracow	respiratory death	-0.06(-0.16-0.04)[a,c]				
		Lodz	respiratory death	-0.04(-0.12-0.039)[a,c]				
		Poznan	respiratory death	-0.02(-0.07-0.03)[a,d]				
		Wroclaw	respiratory death	0.024(-0.03-0.07)[a,c]				
Simpson, 1997	1987-93	Brisbane, Australia	resp mortality(winter)	0.0452(0.113)[b]	all	4.5 ppb	8 ppb	long term trend, season, 'flu epidemics, day of week, holidays, temp. and humidity
Moolgavkar, 1995	1974-84	Ohio, USA	Total mortality	1.072(0.978-1.181)	all	28.8 ppb	100 ppb	season, temp., humidity
Moolgavkar, 1995	1973-88	Philadelphia, USA	Daily mortality	1.142(1.085-1.199)	all	18.9 ppb	100 ppb	temp., trend, season
Krzyzanowski, 1991/92 (APHEA)	1977-89	Cracow, Poland	resp mortality(/100 ug/m^3)	0.16(0.05)[b]	all	74.1 ug/m^3	100 ug/m^3	years, months, Sunday
			CVS mortality(/100 ug/m^3)	0.91(0.18)[b]				

a = health outcome reported in beta coefficient and 95% CI

b = health outcome reported in beta coefficient and SE

c= lag:0-1day

d= lag:0-2 days

APHEA: A European approach using epidemiologic time series data

e= lag:0-3 days

f= expose to 24hr level SO_2

Table K1.1: Mortality (Continued)

Author	Year	Country	Health Outcome	Relative Risk	Age (yr)	SO_2 level	SO_2 Increment	Adjusted confounders
Dab, 1996 (APHEA)	1987-92	Paris, France	admission for resp cause /100ug/m[3]	1.042(1.005-1.08)[c]	all	29.7 ug/m[3]	100 ug/m[3]	trend, seasonality,
			admission for COPD "	1.099(1.023-1.18)[c]				temperature, humidity,
			admission for asthma "	1.07(1.004-1.141)[c]				influenza, day of week
			resp death "	1.082(0.97-1.026)[c]				
				0.029(0.01653)[b]				
Bacharova, 1996 (APHEA)	1987-91	Bratislava, Slovak Rep.	death from CVS cause	0.986(0.94-1.00)[c]	all	23.79 ug/m[3]	100 ug/m[3]	trend, seasonality, temp, humidity, influenza
			total mortality "	0.978(0.96-0.99)[c]				day of week
								year, weekend
Saldiva, 1995	1990-1	Sao Paulo, Brazil	total mortality: SO_2 ppb(x7.5)	3.98(1.71)[b]	>65	6.5 ppb	7.5 ppb	temperature, humidity, seasonality, month of year
			[SO^2 only]					day of week
			total mortality: SO_2 ppb(x7.5)	-1.43(2.39)[b]				
			[adjusted for other pollutants]					

a = health outcome reported in beta coefficient and 95% CI

b = health outcome reported in beta coefficient and SE

c= expose to 24hr level SO_2

APHEA: A European approach using epidemiologic time series data

Table K1.2: Hospital Admission

Author	Year	Country	Health Outcome	Relative Risk	Age(yr)	SO_2 level	SO_2 Increment	Adjusted confounders
Ponce de Leon, 1996 (APHEA)	1987-92	London, UK	Respiratory hospital admissions	0.9986(0.9862-1.0111) [lag=1day]	All	32.2 ug/m^3 (All year)	29 ug/m^3	trend, season, epidemics, day of week, holidays
								temp, humidity
Vigotti, 1996 (APHEA)	1980-9	Milan, Italy	Respiratory hospital admissions	1.09(1.01-1.17)	15-64	117.7 ug/m^3	125 ug/m^3	trend, season, epidemics, day of week, holidays
			[lag:0-3days]	1.07(0.99-1.15)	>64	(All year)		temp & humidity
Castellsague, 1995	1985-9	Barcelona, Spain	Emergency admission for asthma in summer	1.052(0.98-1.129)	>14	40.8 ug/m^3	25 ug/m^3	trend, season, epidemics, day of week, holidays
								temperature & humidity
Schwartz, 1995	1988-90	New Haven, USA	respiratory admissions	1.04(1.06-1.02)[d]	All	78 ug/m^3	50 ug/m^3	PM_{10}
			respiratory admissions	1.06(1.01-1.12)[d]		44 ug/m^3	50 ug/m^3	-
Walters, 1994	1988-90	Birmingham, UK	weekly admissions, respiratory diseases, autumn	1.59(0.91-2.27)[a]	All	39.1 ug/m^3	100 ug/m^3	temperature, pressure, humidity
			winter	0.63(0.25-1.01)[a]				
Schouten, 1996 (APHEA)	1977-89	Rotterdam, Holland	respiratory diseases, summer	1.07(0.999-1.146),[lag:2day]	All	40 ug/m^3	100 ug/m^3	trend, season, epidemics, day of week, holidays
		Amsterdam	winter	1.028(1.008-1.048),*		28 ug/m^3		temperature & humidity
Romieu, 1995	1990	Mexico	emergency visits for asthma	1.05(0.99-1.11)[b]	<16	0.07 ppm	50 ppb	day of week, period, temperature, ozone level
Dab, 1996 (APHEA)	1987-92	Paris, France	admission for resp cause	1.042(1.005-1.08)[c]	All	29.7 ug/m^3	100 ug/m^3	trend, seasonality,
			admission for COPD	1.099(1.023-1.18)[c]				temperature, humidity,
			admission for asthma	1.07(1.004-1.141)[c]				influenza, day of week

a = health outcome reported in beta coefficient and 95% CI

b = health outcome reported in rate ratio; the study only lasted for 6 months

c = health outcome related to 24 hr level of SO^2

d=SO2 concentration 2 days before admission

APHEA: A European approach using epidemiologic time series data

Table K1.3: Prevalence of Respiratory Symptoms

Author	Year	Country	Health Outcome	Relative Risk	Age(yr)	SO_2 level	SO_2 Increment	Adjusted confounders
Higgins, 1995	199?	Halton, UK	Wheeze (48 hr lag)	1.24 (1.06-1.45)	18-82	117 ug/m^3	10 ug/m^3	-
Schwartz, 1994	1984-88	USA	Lower respiratory symptoms	1.28(1.13-1.46)[g]	grade2 -grade5	82 ppb	10 ppb	previous day's temp, day of the week, and city of residence
Harre[c], 1997	1994	NZ	Wheeze	0.99(0.78-1.26)	55-83	<25 ug/m^3	4.58 ug/m^3	temperature, wind speed, day of study, effects of CO, NO_2,PM_{10}
			Chest symptoms	0.95(0.8-1.13)				
Segala, 1998	1992	Paris, France	prevalence episodes of asthma[d]	1.71(1.15-2.53)[h]	7-15	22 ug/m^3	50 ug/m^3	weekdays, weekend, time trend, temperature, humidity
			prevalence episodes of RTI[d]	2.09(1.05-4.15)[i]				
			prevalence episodes of asthma[e]	1.41(0.86-2.3)[j]				
			prevalence episodes of wheeze[e]	1.31(0.89-2.15)[j]				

a = health outcome reported in beta coefficient and SE
b = health outcome reported in beta coefficient(x1000) and SE
c = all subjects had COPD
d = health outcome of 43 subjects with mild asthma
e = health outcome of 41 subjects with moderate asthma
f = The study sample composed of 1025 wheezy subjects and 4285 normal subjects

g= lag:1day
h=lag:0 day
i=lag:3 day
j=lag:4 day

Table K1.4: Lung Function

Author	Year	Country	Health Outcome	Relative Risk	Age	SO_2 level	SO_2 Increment	Adjusted confounders
Harre[a], 1997	1994	NZ	change in PEFR (mane)	0.05%(-0.15-0.26)	55-83	<25 ug/m^3	4.58 ug/m^3	temperature, wind speed,
			change in PEFR (evening)	-0.06%(-0.23-0.11)				day of study, effects of
								CO, NO_2,PM_{10}
Segala[b], 1998	1992	Paris, France	PEF variability (%ug/m^3)	0.038(SE 0.02)	7-15	22 ug/m^3	50 ug/m^3	weekdays, weekend,
				[lag:3 days]				time trend, temperature,
								humidity
Peters[c], 1997	1990-92	Erfurt, Germany	%Change inPEF measurement			128.5 ug/m^3	128 ug/m^3	trend, temperature,
		Weimar	" in adult	-0.28%(-0.72-0.16)	32-80			humidity
		Sokolov, Czech Rep	" in children	-0.9%(-1.35 - -0.46)	7-15			

a= Study sample composed of 40 subjects with COPD

b=Study composed of all 21 subjects with mild asthma; RR is a combined results of the 3 cities and related to 5-day mean of SO_2; outcome estimate was reported in regression coefficient and SE

c=Study sample composed of 112 non-smoking adult and 163 children with diagnosed asthma

The formal statistical part of the meta-analysis, the estimation of the pooled odds ratios, was performed using the DerSimonian-Laird method (DerSimonian and Laird, 1986). The random effects model was used because we intend to generalise our results to the population. Briefly, this method involves taking a weighted average of the log odds ratio from each study, with the weight assigned to each log odds ratio proportional to the inverse of its variance. The variance was made up of the variance calculated within each study and the variability in log odds ratios among studies is also incorporated. In the presence of substantial inter-study variability (heterogeneity), this method produces wider confidence intervals than a simple inverse-variance weighted average. For each summary odds ratio, a $\chi 2$ with k-1 (k = number of studies) degrees of freedom was computed under the null hypothesis of homogeneity across studies. A significant value of $\chi 2$ indicated differences among the combined studies in the strength of association between sulphur dioxide and health outcomes.

3. Results

The papers from which data were extracted are summarised in *Tables K1.1* to *K1.4*. The results of meta-analysis are summarised in *Table K1.5*. (Dockery et al, 1993; Anderson et al, 1996; Ballester et al, 1996; Sunyer et al, 1996; Vigotti et al, 1996) (Mackenback et al, 1993; Touloumi et al, 1994; Spix and Wichmann, 1996; Zmirou et al, 1996) (Moolgavkar et al, 1995; Wojtyniak and Piekorski, 1996; Simpson et al, 1997) (Krzyzanowski and Wojtyniak, 1991/92; Salvida et al, 1995; Bacharova et al, 1996; Dab et al, 1996) (Castellsague et al, 1995; Schwartz, 1995; Ponce de Leon et al, 1996) (Walters et al, 1994; Higgins et al, 1995; Romieu et al, 1995; Schouten et al, 1996) (Schwartz et al, 1994; Harre et al, 1997; Peters et al, 1997; Segala et al, 1998).

Table K1.5: The Impact of Sulphur Dioxide on Health: A Meta-Analysis

Health outcome	Relative Risk	95% Confidence Interval
Total mortality	1.0146*	(1.0047-1.0247)
Respiratory mortality	1.0111	(0.9981-1.0243)
Cardiovascular mortality	1.0071*	(1.000-1.0142)
Respiratory admission	1.0171*	(1.0068-1.0275)
Asthma admission	1.0292*	(1.0000-1.0592)

*The pooled relative risk was reported in relation to a 10ppb increment in sulphur dioxide
*= $P < 0.05$

Data for mortality attributable to all causes was available from 12 published reports. There was significant heterogeneity among the estimates but, on average, there was a significant association between increased levels of sulphur dioxide and the mortality rate. The association with mortality due to respiratory causes, estimated from 10 papers did not reach statistical significance. There was a significant effect on mortality due to cardiovascular causes but the studies were heterogeneous and the effect was smaller than for all cause mortality.

Data on risk of hospitalisation for respiratory disease was available from six reports. There was significant heterogeneity but the average effect was significant. The findings with respect to admissions for asthma, based on four reports, were similar.

The studies on risk of respiratory symptoms and impaired lung function were mainly conducted in selected populations of adults or children with respiratory illness (asthma or chronic obstructive pulmonary disease). Hence the results are not numerically generalisable to the population as a whole. Furthermore, differences in outcome measures and the small number of heterogeneous studies makes it inappropriate to conduct a statistical meta-analysis. Three of the four studies have shown that people with respiratory disease are more likely to experience symptoms on days with high sulphur dioxide levels. Two of three studies did not show any relation between sulphur dioxide levels and lung function.

4. Comment

Unfortunately the epidemiological evidence is difficult to interpret due to the strong association between sulphur dioxide and particulate pollution Europe and North America, where many of these studies were conducted. The correlation between these pollutants means that it is difficult to be sure whether the observed effects are attributable to sulphur dioxide or to particulate pollution.

The epidemiological evidence shows that, over a wide range of exposure levels, particulates and/or sulphur dioxide are associated with a range of adverse health effects including increased daily mortality and hospital admission rates. At this stage these adverse effects cannot confidently be attributed to one or the other of these pollutants.

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Appendix K2

Effects of Air Pollutants on Upper Respiratory Tract and Eye Symptoms

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Appendix K2

Effect of Air Pollutants on Upper Respiratory Tract and Eye Symptoms

1. Introduction

The term upper respiratory tract refers to the breathing passages above the larynx (voice box). This includes the nose, the mouth and the throat. A wide range of physical and biological stimuli, including irritants, extremes of heat or dryness, infections and allergens, may cause discomfort in these sensitive tissues. Studies of the adverse health effects of air pollutants have tended to focus on the lungs (that is, the lower respiratory tract). However, some investigations have measured subjects' reports on upper respiratory tract and eye symptoms including sore or dry throat, runny or stuffy nose, and eye irritation. These studies have been reviewed for this report.

1.1 Method

A Medline search was conducted to find items with subject headings ["upper respiratory", "nose diseases", "eye", "cornea", "eye diseases", "eye irritation", "conjunctivitis", "rhinitis", "rhinoconjunctivitis", "exp laryngeal diseases", OR "pharyngitis"] AND subject headings ["ozone", "nitrogen dioxide", "particulate(s)", OR "sulphur dioxide"]. The resulting titles and abstracts were reviewed for relevance and data was abstracted for narrative review.

1.2 Results

1.2.1 Ozone

Among 14 healthy children who attended a summer camp in New Jersey (203 person-days of data), the prevalence of eye irritation was higher on days with ozone > 0.12ppm (27.5%) than on days with ozone < 0.08ppm (12.6%, P = 0.04). There was no significant difference between the high and low ozone days in the prevalence of runny or stuffy nose (57.5% vs 48.3%, P = 0.3) (Berry 1991). Among 62 patients with asthma or chronic obstructive pulmonary disease (COPD) in the UK, the preceding day's ozone level influenced the frequency of reporting throat (odds ratio 1.19, 95% confidence interval 1.01 to 1.40 for a 5ppb increase) and eye symptoms (odds ratio 1.22, 95% confidence interval 1.03-1.46) (Higgins et al, 1995).

In Mexico City the number of adults and children presenting to out-patient clinics with upper respiratory tract illness (sore throats, colds etc) was related to the daily ozone peak (Hernández-Garduño et al, 1997). This is a city with very high levels of ozone: hourly peaks > 0.12ppm at least 6% of the year. It was estimated that when comparing the highest ozone day to a day when ozone levels were average, the number of clinic visits would be 19% higher.

However, in contrast to these positive findings several similar investigations have failed to find any link between ozone exposure and upper respiratory tract or eye symptoms. Included among these negative investigations are a survey of children in the Netherlands before and after a high ozone smog episode (Cuijpers et al, 1995), a study of cyclists in the Netherlands (Brunekreef et al, 1994), a panel study involving 625 Swiss pre-school children (Braun-Fahrlander et al, 1992) and an eight month study of children in the US (Vedal et al, 1987).

1.2.2 NO_2

An investigation of 625 Swiss pre-school children found that parental reporting of upper respiratory tract symptoms in their young children was related to ambient NO_2 levels (odds ratio 1.23, 95% confidence interval 1.03-1.48) (Braun-Fahrlander et al, 1992). This study also showed an effect of particulates on symptoms. The effects of the two pollutants were not independent; that is, it is not clear which, if either, of these two pollutants was responsible for the symptoms in these children.

A similar problem with interpretation arises from another European study in which NO_2 and particulates were both related to symptoms. Daily NO_2 levels were associated with the frequency of presentation to hospital or a paediatrician with croup in five German cities. An increase in NO_2 from 10 to 70$\mu g/m^3$ (= 0.034ppm increase) was associated with 28% increase in croup cases (Schwartz et al, 1991). In Mexico city, daily NO_2 levels were correlated with the number of people attending out-patient clinics for respiratory illnesses (mainly sore throats and colds) (Hernández-Garduño et al, 1997).

Three other studies, one in 62 adults with asthma or chronic obstructive pulmonary disease in the UK (Higgins et al, 1995), two others in children with asthma or similar illnesses (Vedal et al, 1987; Timonen and Pekkanen, 1997), did not show any relation between NO_2 levels and upper respiratory tract symptoms.

1.2.3 SO_2

High levels of exposure to SO_2 (1.0ppm for four hours), in an experimental setting, causes mild nose and throat irritation (Kulle et al, 1986). However, brief exposure to an even higher level (4.0ppm for 10 minutes) had no effect on nasal resistance (an objective measure of a blocked nose) in subjects with rhinitis (Tam et al, 1988).

Several of the cohort studies described above have failed to show a consistent link between SO_2 levels and reporting of upper respiratory tract symptoms (Vedal et al, 1987; Braun-Fahrlander et al, 1992; Higgins et al, 1995). The findings of the Finnish study were complex but are also essentially negative (Timonen and Pekkanen1997). In a cohort of 89 asthmatic children in the Czech Republic, reporting of a runny nose was associated with SO_2 concentration over the preceding five days (odds ratio 1.07, 95% confidence interval 1.04-1.10, for a 65$\mu g/m^3$ [0.0227ppm] increase in SO_2). There was no association with current day SO_2 (Peters 1997).

1.2.4 Particulates

Schwartz has summarised the data from five cohorts of children (four from the USA (Pope et al, 1991; Pope and Dockery 1992; Schwartz et al, 1994) and one from Switzerland (Braun-Fahrlander et al, 1992)) investigating the relation between particulate pollution and upper respiratory tract symptoms. A further study, reporting the incidence of 'runny nose' in a cohort of children with asthma living in the Czech Republic, has been published more recently (Peters 1997). Taken together these studies show a small significant effect of particulate pollution on reporting of upper respiratory tract symptoms. Analysis of the six studies indicates that a 3$\mu g/m^3$ increase in PM_{10} would be associated with an odds ratio of 1.010 (95% confidence interval 1.005 to 1.015, assuming random effects model). This summary does not include the Finnish study (Timonen et al, 1997), which reported no association between PM_{10} and upper respiratory symptoms but did not include data in the published report.

There is also some evidence that days with high levels of particulate pollution may be associated with a higher frequency of seeking medical attention for upper respiratory tract problems. In five German cities, the frequency of presentations to hospital or a paediatrician with croup increased by 27% from low pollution to high pollution days (total suspended particulates 10 vs 70$\mu g/m^3$, approximately equivalent to a 40$\mu g/m^3$ difference in PM_{10}) (Schwartz et al, 1991). In Alaska, it was estimated that a 10$\mu g/m^3$ increase in PM10 was associated with 3% increase in medical visits for upper respiratory tract illnesses (Gordian et al, 1996).

1.3 Conclusion

There is consistent evidence that day-to-day variation in the level of particulate pollution is related to the daily prevalence of upper respiratory tract symptoms. However, the effect is small: a 3$\mu g/m^3$ increase in PM_{10} would be expected to cause a 1% increase in the prevalence of symptoms.

There is conflicting evidence concerning the effect of ozone, nitrogen dioxide and sulphur dioxide on upper respiratory tract and eye symptoms. For each of these pollutants there are some studies which do show an association but several other studies are negative. The reason for this inconsistency in the published data cannot be ascertained with certainty. However, it may relate to the complex mixture of pollutants to which subjects are exposed and the consequent difficulty in attributing effects to specific pollutants.

It is not possible to draw a definite conclusion about the effect of predicted, airport-associated changes in ozone, nitrogen dioxide and sulphur dioxide levels on upper respiratory tract and eye symptoms . However, based on the existing evidence it seems unlikely that they will have a major effect at, or around, existing ambient levels.

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provided forecasts that the proposed rail link would be unlikely to be fully utilised by SSA related travel and residents should therefore enjoy improved transport services compared with the base case.

It was estimated in the Draft EIS that more than 80 percent of all passengers and meeters/greeters would travel by road.[35] By 2016 between 66,000 (with rail) and 77,000 (without rail) daily vehicle trips were estimated to be generated on the assumption of 30 million passengers at SSA.[36] The estimated cost of the required road works was $470 million.[37] No additional expenditure on road upgrading is expected to be required to cope with the additional traffic flow resulting from the rail line not being built. These costs include only the construction and upgrading of roads closely associated with the SSA. However, the traffic modelling undertaken for the Draft EIS[38] indicates that essentially no additional traffic flow from the local area would be expected in the absence of SSA. Indeed, the establishment of SSA is expected to divert local traffic away from the key roads to be most affected by SSA (Elizabeth Drive, Bringelly Road and Northern Road). The magnitude of this diversion (a cost to local residents) is estimated to be insignificant and it is therefore excluded from the benefit cost study.

In the case of rail, it was estimated that the planned expansion of the rail line from Glenfield to Badgerys Creek would see daily patronage in 2006 of 1,300 airport employees and 6,000 passengers and meeters/greeters (47 percent of patronage) assuming 10 million passengers in 2006. The corresponding forecasts for 2016 were for 3,700 employees and 18,000 passengers and meeters/greeters (61 percent of patronage) assuming 30 million passengers.[39] The estimated cost of the rail line was put at between $345 and $400 million.[40] Subsequent analysis has cast some doubt on the extent to which the railway would be used by local residents, with the estimates set out in the Draft EIS now being seen as overestimates. For this reason, no benefit of the railway is ascribed to local residents.

6.4 Regional Employment Expansion

While employment impacts are important for a range of considerations, they do not represent additional benefits that should be incorporated in the benefit-cost analysis. To include both the expenditure on an item and then the wage component of that expenditure would represent double counting. Also, because of the General Equilibrium impacts discussed above , any regional gains to employment may well be offset by employment losses elsewhere if investment and, therefore, employment are diverted from one region to another as a result of developing SSA.

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35 Draft EIS, v. 1, p. 22-8

36 Draft EIS, v. 1, p. 22-11

37 Draft EIS, v. 1, p. 24-4

38 Draft EIS, Technical Paper 13 Land Transport, Table 7.6.

39 Draft EIS, v.1, p22-15

40 Draft EIS, v. 1, p. 24-4

Further work has been undertaken on the regional employment impacts of the SSA. This is outlined in Appendix J2.

7. Discounting for Risk and Time

The SSA proposal involves both costs and benefits spread over extended time periods. If there were no risk involved in the investment (all future costs and benefits were known with certainty) then an appropriate discount rate would be the long term bond rate for prime Commonwealth Government debt. However, there remain real uncertainties about the level of construction and environmental costs, and technological change could substantially reduce the estimated benefits of the proposed SSA. Therefore it is prudent to discount the values of all costs and benefits at an interest rate significantly above that evident from market yields of prime government debt.

A discount rate of 7 percent real has been adopted for the benefit cost analysis. This is the rate recommended by the Federal Aviation Administration as it is broadly consistent with the marginal opportunity cost of capital.[41] The Australian Department of Finance recommends that a project specific rate be calculated using Capital Asset Pricing Model (CAPM), or if this is not possible, a rate of 8 percent real.[42]

Based on CAPM, the discount rate is R = Rf + Beta*Rp, where Rf is risk free rate, Rp is called risk premium, and Beta is a measure of the volatility of the return of the stock relative to that of the return of the market. The current yield on 10 year Commonwealth Bonds at the time this report was being prepared was 4.74 percent per annum which can be used as Rf. If the market risk premium is, say 4 percent, and Beta is 0.6[43], then R can be calculated as 7.1 percent (4.7 percent + 4 percent*0.6).

To explore the sensitivity of the results to changes in the discount rate, results are also presented for discount rates of 4 percent and 10 percent per annum.

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41 Federal Aviation Administration, *Economic Analysis of Investment and Regulatory Decisions – Revised Guide*, Washington DC, January 1998.

42 Department of Finance, Handbook of cost benefit analysis, Canberra, 1991 pp. 56-57.

43 A Beta of 0.6 has been used based on the Beta calculated for Hills Motorway Limited (a comparable infrastructure investment) by ABN-AMRO, *Industrials Equity Working List*, 4th Quarter 1998, p. 149.

All benefits and costs are calculated over the period from 1999 to 2035 (each year is for the 12 month period ended 30 June for each year stated).

8. Calculation of Net Present Values, Cost Benefit Ratios and Internal Rates of Return

8.1 Measures of Relative Economic Worth

The three standard measures of the relative economic worth of a project or investment are Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR).

Net Present Value is the sum of the discounted project benefits less discounted project costs. Formally it can be expressed as follows:

$$NPV = \sum_{n=0}^{N} \frac{B_n - C_n}{(1+r)^n}$$

where B_n = project benefits in year n expressed in constant dollars

C_n = project costs in year n expressed in constant dollars

r = real discount rate

N = number of years that costs and/or benefits are produced

A project is potentially worthwhile (or viable) if the NPV is greater than zero; ie the total discounted value of benefits is greater than the total discounted costs. If competing projects are mutually exclusive, the project which yields the highest NPV would be chosen.

The Benefit-Cost Ratio (BCR) is the ratio of the present value of benefits to the present value of costs. In algebraic terms it can be expressed as follows:

$$BCR = \sum_{n=0}^{N} \frac{B_n}{(1+r)^n} \Big/ \sum_{n=0}^{N} \frac{C_n}{(1+r)^n}$$

Table J1.10: Part A: Summary of Indicative Costs vs Benefits Sydney Second Airport ($ million 1996 prices):

Net Present Value: $4,299
IRR: 12.5%
Benefit Cost Ratio: 2.19

		Actual values			Discounted values		
Year ended 30 June	Effective Demand (passengers per year)	Total Benefits (25 year ops)	Total Costs (25 year ops)	Net Cash Flow	Discount Factor	Benefits	Costs
1999	0.0	-	-	-	0.935	-	-
2000	0.0	-	-	-	0.873	-	-
2001	0.0	-	-	-	0.816	-	-
2002	0.0	-	-	-	0.763	-	-
2003	0.0	-	477	-477	0.713	-	340
2004	0.0	-	370	-370	0.666	-	247
2005	0.0	-	739	-739	0.623	-	460
2006	0.0	-	710	-710	0.582	-	413
2007	0.0	-	477	-477	0.544	-	260
2008	0.9	21	109	-88	0.508	11	55
2009	1.9	55	101	-46	0.475	26	48
2010	2.5	80	102	-22	0.444	35	45
2011	2.1	109	104	6	0.415	45	43
2012	3.7	144	105	39	0.388	56	41
2013	4.4	185	106	79	0.62	67	39
2014	5.4	232	108	124	0.339	78	36
2015	5.8	285	191	95	0.17	90	60
2016	6.5	346	362	-16	0.296	102	107
2017	7.2	414	568	-153	0.277	115	157
2018	8.0	492	744	-252	0.258	127	192
2019	8.8	578	496	82	0.242	140	120
2020	9.7	674	172	502	0.266	152	39
2021	10.6	780	171	609	0.211	165	36
2022	11.5	898	173	725	0.197	177	34
2023	12.4	1,027	174	853	0.184	189	32
2024	13.4	1,170	176	994	0.172	201	30
2025	14.4	1,325	338	987	0.161	213	54
2026	15.4	1,496	485	1,010	0.150	225	73

Year ended 30 June	Effective Demand (passengers per year)	Actual values: Total Benefits (25 year ops)	Actual values: Total Costs (25 year ops)	Net Cash Flow	Discounted values: Discount Factor	Discounted values: Benefits	Discounted values: Costs
2027	16.5	1,681	691	990	0.141	236	97
2028	17.6	1,884	645	1,239	0.131	247	85
2029	18.8	2,104	412	1,691	0.123	258	51
2030	20.0	2,342	241	2,102	0.115	269	28
2031	21.2	2,601	238	2,363	0.107	279	26
2032	22.5	43,994	3,664	40,330	0.100	4,409	367
Total						**7,912**	**3,615**

Key assumptions:

Key assumptions:	Elasticity of demand	-0.8
	Passenger Demand	Central
	KSA Capacity	Lower
	Discount Factor	7 percent per year

Table J1.10: Part B: Summary of Indicative Benefits SSA ($ million 1996 prices):

Year ended 30 June	Effective Demand (passengers per year)	Consumer Surplus*	Operating revenue	Total benefits (excl Terminal value)	Net Terminal Value
1999	0.0	-	-	-	-
2000	0.0	-	-	-	-
2001	0.0	-	-	-	-
2002	0.0	-	-	-	-
2003	0.0	-	-	-	-
2004	0.0	-	-	-	-
2005	0.0	-	-	-	-
2006	0.0	-	-	-	-
2007	0.0	-	-	-	-
2008	0.9	5	16	21	-
2009	1.9	23	33	55	-
2010	2.5	38	42	80	-
2011	3.1	57	52	109	-
2012	3.7	82	62	144	-
2013	4.4	112	73	185	-
2014	5.1	148	84	232	-
2015	5.8	190	95	285	-

Year ended 30 June	Effective Demand (passengers per year)	Consumer Surplus*	Operating revenue	Total benefits (excl Terminal value)	Net Terminal Value
2016	6.5	239	107	346	-
2017	7.2	295	119	414	-
2018	8.0	359	132	492	-
2019	8.8	432	145	578	-
2020	9.7	515	159	674	-
2021	10.6	607	173	780	-
2022	11.5	710	188	898	-
2023	12.4	825	203	1,027	-
2024	13.4	951	218	1,170	-
2025	14.4	1,091	234	1,325	-
2026	15.4	1,244	251	1,496	-
2027	16.5	1,413	268	1,681	-
2028	17.6	1,597	286	1,884	-
2029	18.8	1,799	305	2,104	-
2030	20.0	2,019	324	2,342	-
2031	21.2	2,258	344	2,601	-
2032	22.5	2,517	364	2,881	37,726

Key assumptions:
Elasticity of demand -0.8
Passenger Demand Central
KSA Capacity Lower
Discount Factor 7 percent per year.
See Annex A for an example of the calculation of the consumer surplus estimates

Table J1.10: Part C: Summary of Indicative Costs Sydney Second Airport ($ million 1996 prices):

Year ended 30 June	Effective Demand (passengers per year)	Airport Construction (stage 1,2,3)	External Infrastructure	Health effects	Noise & local amenity	Loss of mining and agricultural production	Crash risks fatalities and other	Operating costs	Depreciation	Total costs
1999	0.0			0.00		0.00	0.00	0.0		
2000	0.0			0.00		0.00	0.00	0.0		
2001	0.0			0.00		0.00	0.00	0.0		
2002	0.0			0.00		0.00	0.00	0.0		
2003	0.0	314	163	0.00		0.00	0.00	0.0		477
2004	0.0	220	117	0.00	33	0.00	0.00	0.0		370
2005	0.0	624	115	0.00		0.00	0.00	0.0		739
2006	0.0	556	154	0.00		0.00	0.00	0.0		710

Year ended 30 June	Effective Demand (passengers per year)	Airport Construction (stage 1,2,3)	External Infrastructure	Health effects	Noise & local amenity	Loss of mining and agricultural production	Crash risks fatalities and other	Operating costs	Depreciation	Total costs
2007	0.0	336	42	0.00		0.00	0.00	0.0		477
2008	0.9	11		0.01		2.30	0.01	3.6	92	109
2009	1.9			0.02		2.30	0.03	6.3	92	101
2010	2.5			0.03		2.30	0.04	7.7	92	102
2011	3.1			0.03		2.30	0.05	9.0	92	104
2012	3.7			0.04		2.30	0.05	10.3	92	105
2013	4.4			0.05		2.30	0.06	11.7	92	106
2014	5.1			0.05		2.30	0.07	13.0	92	108
2015	5.8	73	6	0.06		2.30	0.08	14.3	95	191
2016	6.5	175	8	0.07	60	2.30	0.09	15.6	101	362
2017	7.2	427	6	0.07		2.30	0.10	17.0	115	568
2018	8.0	588		0.08		2.30	0.12	18.3	135	744
2019	8.8	328		0.09		2.30	0.13	19.7	146	496
2020	9.7	2		0.10		2.30	0.14	21.1	146	172
2021	10.6			0.11		2.30	0.15	22.6	146	171
2022	11.5			0.12		2.30	0.16	24.0	146	173
2023	12.4			0.13		2.30	0.18	25.5	146	174
2024	13.4			0.14		2.30	0.19	26.9	146	176
2025	14.4	72	84	0.15		2.30	0.21	28.5	151	338
2026	15.4	204	88	0.16		2.30	0.22	30.0	161	485
2027	16.5	396	84	0.17		2.30	0.24	31.6	177	691
2028	17.6	338	80	0.18		2.30	0.25	33.2	191	645
2029	18.8	98	80	0.19		2.30	0.27	34.8	197	412
2030	20.0	4		0.20		2.30	0.29	36.4	197	241
2031	21.2			0.22		2.30	0.30	38.1	197	238
2032	22.5			0.23		2.30	0.32	39.8	197	240

9.2 Summary Results and Sensitivities

Set out in *Table J1.11* are the key overall results for Australia, again using the preferred elasticity estimate of –0.8. Results are presented for each of the measures of relative economic worth, for each of the demand forecast scenarios (**L** – low, **C** – central and **H** – high) and each of the KSA capacity scenarios (**A** - 33.6 million passengers in 2007 and **B** – 37.6 million passengers 2011). The most likely view of the future is considered to be the central demand growth scenario (**C**) in conjunction with the lower level of maximum activity at KSA (capacity scenario **A**).

Table J1.11: Summary Results: Australia: by Demand and Capacity Scenarios

		Demand Growth		
IRR		L	C	H
KSA Capacity	A	7.3%	12.5%	16.3%
	B	7.8%	11.9%	15.6%
BCR		L	C	H
KSA Capacity	A	1.04	2.19	3.77
	B	1.09	2.06	3.51
NPV ($ million)		L	C	H
KSA Capacity	A	$122	$4,299	$12,766
	B	$189	$3,147	$9,982

Elasticity –0.8
Discount rate 7 percent

Based on the results set out in *Table J1.11*, the construction of SSA can be seen as clearly viable: IRR significantly more than the discount rate of 7 percent; BCR is clearly more than 1 (one); and the estimated NPV is positive. In each case the margin above the criteria values is large. It can also be seen that the results are highly sensitive to the level of demand growth. This should not be surprising as the net revenues from the airport and the benefits of avoiding the economic costs of Sydney having inadequate airport capacity grow more than proportionally with growth in the level of passenger demand. In fact, demand growth provides the basic rationale for considering the construction of a second airport for Sydney. If it were not for growth in demand for air transport there would be no need for additional airport capacity. However, the construction of SSA involves lumpy investments in capacity of around 10 million passengers per annum per stage. The higher the rate of growth in demand the faster it is possible to recoup the construction cost for each stage.

Set out in *Table J1.12* are further sensitivities having regard for the regional economic impact of SSA and alternative levels of elasticity of demand for air transport services. For these results the preferred central demand growth scenario (C) in conjunction with the lower level of maximum activity at KSA (capacity scenario A) have been maintained. The results are also very sensitive to the elasticity assumption. If the demand for air transport is relatively inelastic (that is if -0.4 might be seen as more appropriate) then the economic value of the project is much larger. If demand is more inelastic consumers have relatively little opportunity or desire to substitute alternative consumption for air travel and thereby suffer a relatively large loss of economic welfare by virtue of being constrained in their capacity to consume air travel. Alternatively, if demand is relatively elastic, air travellers are able to relatively easily substitute other expenditures for air transport and thereby suffer little loss of economic welfare if for some reason they are not able to consume all the air transport that they would otherwise choose to enjoy.

Table J1.12: Sensitivity of Results by Region and Elasticity

		Elasticity of Demand		
IRR		**-0.4**	**-0.8**	**-1.2**
	Australia	16.5%	12.5%	10.3%
	NSW	23.6%	19.2%	17.0%
	Sydney	26.3%	21.7%	19.4%
	BC Region	26.7%	23.9%	22.7%
BCR		**-0.4**	**-0.8**	**-1.2**
	Australia	4.02	2.19	1.58
	NSW	9.94	5.42	3.91
	Sydney	12.91	7.09	5.15
	BC Region	8.27	5.65	4.78
NPV (7%)		**-0.4**	**-0.8**	**-1.2**
($ million)	**Australia**	$10,903	$4,299	$2,098
	NSW	$13,057	$6,453	$4,252
	Sydney	$12,362	$6,317	$4,302
	BC Region	$3,144	$2,011	$1,633

The variation of outcomes among regions results from the different extent to which they bear the costs and benefits of SSA. In particular, the financial cost of establishing SSA is assumed to be borne by taxpayers in proportion to their liability to pay taxation as individuals to the Commonwealth (see page 11 for details). In contrast, the travel benefits of the airport are assumed to be borne in proportion to the place of residence of those flying (see page 11 for details). Also, the health, noise and risk costs of SSA are assumed to be fully borne by local residents. Sydney as a whole is the largest winner, gaining most of the benefits, but bearing only part of the costs. Local residents, however, do not face quite as good a trade-off between benefits and costs.

Results for the BCR and NPV are also sensitive to the chosen discount rate. These are set out in *Table J1.13* where alternative discount rates of 4 percent and 10 percent are used. The lower rate might be appropriate if the project was judged to be without significant economic risk, whereas the higher discount rate more closely approximates the level of risk that might be appropriate to a private sector commercial investment. At the higher discount rate of 10 percent, the project becomes economically non-viable only at the highest elasticity of -1.2 percent. However, at the middle and lower discount rate the project becomes viable at all of the elasticity scenarios.

Table J1.13: Sensitivity of Results by Discount Rate and Elasticity

Summary Results		Demand	C	
		KSA Capacity	A	
		Discount rate		
IRR		**4%**	**7%**	**10%**
Elasticity	**-0.4**	17.8%	16.5%	15.7%
	-0.8	14.0%	12.5%	11.6%
	-1.2	11.9%	10.3%	9.4%
BCR		**4%**	**7%**	**10%**
Elasticity	**-0.4**	7.54	4.02	2.28
	-0.8	4.07	2.19	1.26
	-1.2	2.91	1.58	0.92
NPV ($m)		**4%**	**7%**	**10%**
Elasticity	**-0.4**	$42,852	$10,903	$3,057
	-0.8	$20,110	$4,299	$618
	-1.2	$12,529	$2,098	-$195

The economic viability of SSA was also assessed on the basis that the airport was constructed is three stages, each allowing for 10 million passengers. That is Stage 1 would accommodate 10 million passengers, Stage 2 20 million, with Stage 3 bringing the airport to the "Master Plan capacity of 30 million passengers per annum. The sensitivity of the results to stopping construction at each stage is presented in *Table J1.14*. A similar IRR and BCR are achieved regardless of whether construction was constrained to Stage 1, 2 or 3. An implication is that a decision could be taken to construct a Stage 1 airport, with a strong likelihood of it being viable without necessarily making a commitment to proceed with further stages.

Table J1.14: Summary Results: Australia: by Construction Stage

	Stage of Construction		
	1	**2**	**3**
IRR	12.3%	12.7%	12.5%
	1	2	3
BCR	2.41	2.38	2.19
	1	2	3
NPV ($ million)	$3,731	$4,540	$4,299

10. Interpretation of Results

This study has aimed to measure the benefits and costs associated with the development of a second major airport for Sydney at Badgerys Creek. When interpreting the results it is important to bear in mind the limitations of the methods being applied and the limitations of the data used within the methods applied.

10.1 Methodological Limitations

The major methodological limitations involve the partial nature of cost benefit analysis. The method is partial in that it only includes the direct impact of a project (its costs and direct benefits). Major construction projects can also have wider impacts on the broader economy which also need to be taken into account. These impacts have been discussed above.

The fundamental purpose of undertaking an economic appraisal of an investment opportunity is to determine whether the potential investment is a relatively good use of the community's resources. The purpose of the appraisal is essentially comparative. In practical terms benefit cost analysis looks in detail at the proposal and then makes use of a discount rate as a point of comparison to other potential investments. The discount rate is a proxy for the minimum rate of return required of investments having regard for their particular risk profiles. In this context, the fact that a quantitative assessment of General Equilibrium effects was not undertaken need not bias the results. If, for example, the broader (General Equilibrium) economic impacts of alternative investments are similar, then no bias should result from using conventional benefit cost analysis. Alternately, if a proposed investment has a number of unique linkages to the rest of the economy, then bias might result.

In principle, the SSA proposal should have similar economic linkages to those of other major infrastructure investments in terms of the impact of the raising of capital for construction and linkages to the construction and related sectors. Differences may be possible in relation to the specific economic activities of a major airport and the benefits and costs that its operational activities might provide for various industry sectors.

As there are few studies of the broader economic impact of alternative investments available for comparison (through, for example, the use of General Equilibrium models), it is difficult to know whether any particular bias has resulted from not using such technologies for this study. Almost certainly higher absolute benefits could be obtained under reasonable assumptions, but would these be higher in relative terms?

The key benefit of undertaking an analysis of the SSA proposal is that it forces a detailed consideration of the facts and the placing of these facts into a consistent framework. The assumptions underlying the numbers are thereby laid bare for scrutiny.

10.2 Data Limitations

To undertake this study it has been necessary to look into the future and estimate figures on a number of important variables which cannot be known with certainty. While the study has benefited from drawing on a major EIS which looked in great detail at all aspects of the SSA proposal, the task nevertheless involved forecasting up to nearly four decades into the future.

Forecasting is difficult at the best of times and the uncertainty associated with forecasting demand for air transport, changes in air transport technology, capacity of KSA and the like should not be understated. Calculating the future capacity of a major airport such as KSA requires judgements concerning the capacity of the physical infrastructure (such as runways, terminals and transport access), the capacity of the airspace management system, the effect of measures to mitigate environmental impacts (including Government policies on noise sharing, the curfew and hourly movement caps), pricing and access arrangements, and the strategic and business decisions of the major users of the airport. The complex interaction of these elements and their potential to change over time underlines the difficulty in clearly defining the capacity of KSA if a second Sydney airport were not built. Also, forecasting the cost of constructing a major project many years into the future has also been known to have been inaccurate.

From the sensitivity analysis reported in the preceding section it can be seen that modest changes in the forecast assumptions (especially the rate of growth in the demand for air transport) can have a major impact on the viability of the proposed SSA development.

10.3 Excluded Factors

It should also be stressed that a number of costs in the form of environmental and social impacts have not been quantified. In particular, effects on Aboriginal cultural heritage, the effects on the habitat of species of plant and animal of significance to the locality, potential reductions in water quality, impacts on other Sydney Basin airports, impact on non-Aboriginal cultural heritage, loss of amenity in National Parks due to aircraft over-flight and visual and landscape impacts. It is also likely that the disruption to many local residents may vary widely from person to person and these particular impacts are impossible to accurately measure in monetary terms.

However, to put the missing factors into perspective, they would need to have a collective cost of some $4.3 billion in discounted present values or an average annual cost of more than $300 million per annum before their existence would cause the NPV of the project to become negative.

In addition, it should be noted that the do nothing option has as its central feature the expansion of KSA until well into the next decade. This expansion will involve significant additional expenditure at KSA, which has yet to be quantified and has not been included in this analysis.

On the other side of the ledger, many local businesses would be expected to benefit from the development of SSA and these benefits have not been included in the calculations. However, as noted above many of these benefits to local businesses are likely to have been at the expense of other businesses which may have benefited if the same funding had been expended elsewhere.

11. Conclusion

The SSA proposal represents a major investment of public funds of the order of $5 billion in 1996 prices. This level of expenditure could also contribute in a major way towards satisfying other economic and social needs. The cost of not being able to fully satisfy the demand of travellers is also potentially very large. It is, therefore, important that a decision to proceed with the SSA should only be taken with due consideration.

Under a set of plausible assumptions SSA clearly achieves the minimum criteria necessary to be regarded as a viable investment for the Government. That is, a positive NPV is obtained for a discount rate of 7% per annum. However, this conclusion must be qualified to the extent that the outcome is sensitive to assumptions about the growth of demand for air transport, the future capacity of KSA and the elasticity of demand for air transport.

Also, the risk that construction costs might escalate should also be borne in mind.

A further consideration is that not all benefits and costs which bear upon the economic viability of the proposed SSA are able to be readily quantified. These impacts need to be assessed separately in a qualitative way as part of any decision to proceed with construction of the proposed SSA.

Annex A: Example of Consumer Surplus Calculation

This Annex provides an example of a consumer surplus calculation as an aid in the interpretation of the figures presented in *Table J1.10* part B. Readers should also refer to *Figure J1.1* for a graphical representation of the concept of consumer surplus.

Table A1: Consumer Surplus Calculation Example: 2020 as per Table J1.10 - Part B

A	Effective passenger demand	9.68 million
B	KSA capacity	37.36 million
C	Capacity impact if no SSA	-26% = A/B
D	Average airfare	$328.13
E	Price elasticity of demand	-0.8
F	Implied change in airfare	$106.31 = C/E*D
G	Loss of consumer surplus	$514.81 million = A*F/2

The consumer surplus for each time period is calculated as the area of the triangle identified in Figure 1. Set out in *Table A1* are data for 2020 from *Table J1.10* Part B.

The base of the triangle is equivalent to the estimated effective passenger demand for SSA in 2020 of 9.68 million passenger movements.

The height of the triangle is calculated from the change in price, which can be calculated from the effective passenger demand and the price elasticity of demand. The restriction of demand by not constructing SSA in 2020 is equal to 26 percent of the estimated capacity of KSA in that year. Using the assumed price elasticity of demand of –0.8 the expected change in the average airfare is obtained by dividing the change available capacity (-26 percent) by the elasticity (-0.8) and multiplying the resultant percentage change by the average airfare ($328.13). It is thereby estimated that the lack of forecast SSA capacity in 2020 would increase the average airfare by $106.31.

The area of the triangle is therefore 9.68 million multiplied by $106.31 or $515 million as set out in *Table J1.10* part B.

Appendix J2

Regional Employment Impacts of a Second Sydney Airport at Badgerys Creek

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Appendix J2

Regional Employment Impacts of a Second Sydney Airport at Badgerys Creek

1. Objective of the Study

The objective of this study is to provide estimates of the impact on employment of a Second Sydney Airport (SSA) at Badgerys Creek. A related objective is to reconcile a number of alternative estimates of the likely employment impact of the proposed SSA.

This study draws on the information gathered in the preparation of the Draft Environmental Impact Statement: Second Sydney Airport Proposal (Draft EIS)[1], fresh estimates by the Consultant and additional information where possible and relevant.

2. Background to the Study

2.1 Draft EIS

PPK Environment and Infrastructure Pty Ltd (PPK) was appointed by the Department of Transport and Regional Development, Canberra in September 1996 to examine the potential environmental impacts of both the Badgerys Creek and Holsworthy airport proposals, based on Guidelines released in November 1996.[2] In September 1997, after studies had been substantially completed in the assessment of these two sites, the Government decided to exclude the Holsworthy Military Area from further consideration. New Guidelines were then prepared for the Draft EIS,

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1 Draft Environmental Impact Statement: Sydney Second Airport Proposal. (**Draft EIS**) Prepared by PPK Environment & Infrastructure for the Commonwealth Department of Transport and Regional Development. Concord West, NSW: PPK Environment & Infrastructure, 1997. 2v.

2 Draft EIS, v. 1, p. 2-5.

however apart from removal of references to the Holsworthy Military Area, they remained substantially the same.[3]

SMEC Australia Pty Ltd was appointed as the independent auditor of the EIS process by the Minister for the Environment in November 1996.[4] ACIL operates as its sub-consultant for the economic analysis.

The Draft EIS, assessing the three Badgerys Creek possibilities, was prepared by PPK, and specialist sub-consultants retained by PPK, and published in December 1997.[5]

Corporate Economics Australia (CEA) was a sub-contractor to PPK in the preparation of the Draft EIS, preparing material published within Technical Paper 15.[6] CEA provided some of the employment impact estimates presented in Technical Paper 15.

3. Previous Estimates of Employment Impacts

The Draft EIS included estimates of employment impacts of the SSA derived from work undertaken for the Federal Airports Corporation by the Institute of Transport Studies (ITS) in 1993 and 1996 and work specifically undertaken for the Draft EIS by CEA. The employment impacts estimated by PPK from the ITS studies were somewhat higher than those estimated by CEA. PPK preferred the higher estimates, referring to them as "Final Employment Forecasts".[7] CEA estimated additional regional employment resulting from the SSA at some 26,500[8] whereas the preferred estimates were around twice this level.

The Draft EIS concluded that construction of a SSA would "generate between 52,000 and 63,000 jobs in Sydney by 2016".[9] However, this estimate was relative to a situation in which no SSA was constructed and KSA was limited to a capacity of 30 million passengers per year. The actual direct and indirect employment estimated

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3 Draft EIS, v.1, pp. 3-1 to 3-2.

4 Draft EIS, v.1, p. 2-1.

5 Draft EIS, v.1, p. 2-5.

6 Draft EIS, Technical Paper 15.

7 Draft EIS, Technical Paper 15, p. 6-9.

8 Draft EIS, Technical Paper 15, p. A-26.

9 Draft EIS, v.1, p. 25-14.

to be generated from the SSA was put at "between 88,000 and 107,000"[10]. Of the latter, some 44,000 to 53,000 were estimated to be direct employment related to activities at SSA.

The forecasting method for the PPK-preferred estimates involved, as the key assumptions, using a base of 34,000 jobs in 1996 "directly employed" (including employment in broadly associated economic activities) as a result of KSA and an employment multiplier of 2 (one indirect employee for every directly employed person). In contrast, the CEA estimates used regional employment in the Air and Space Industry from official ABS sources which resulted in a lower base level of employment. Both estimates used 1996 Sydney Airport employees relative to passenger numbers and forecasts of passenger demand at SSA to estimate employment at SSA in future years.

The starting point of 34,000 employees at KSA in 1996 was based on a survey conducted by ITS of 500 businesses in a number of proximate local government areas (Ashfield, Bankstown, Botany, Canterbury, Drummoyne, Hurstville, Kogarah, Leichhardt, Marrickville, Randwick, Rockdale, South Sydney and Sutherland). The results of that survey indicate total direct employment of 33,506 generated by KSA, of which nearly 23,000 were employed by the Major Airlines and General Aviation.[11] In contrast, official employment figures have total employment of 189,000 for the Sydney Airport region (defined more narrowly to include Botany, South Sydney and Rockdale) of which only 8.6% or some 16,000 are attributable to Air and Space Transport[12] (the appropriate Input/Output industry as defined by the Australian Bureau of Statistics). As employees in the Major Airlines and General Aviation should form part of employment for the Air and Space Transport industry there appears to be either a discrepancy resulting from the survey approach of the ITS (1996) study or the possibly of employment at Bankstown Airport providing a bias to estimates of employment at KSA.

A key methodological issue is whether the base for estimating the employment impact of an airport should be a narrowly defined industry such as Air and Space Transport or whether other closely related industries should also be included as part of the SSA before employment multipliers are applied. PPK chose to use a definition of airport employment as adopted in ITS (1996) which included employment in a range of related industries whether situated at KSA or elsewhere in a broadly defined geographical area[13]. CEA in contrast used as its starting point employment in the Air and Space Transport industry within a smaller number of suburbs closely proximate to KSA.

CEA took the view that its approach was more conservative and avoided the possibility of double counting. Double counting will occur to the extent that some of

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10 Draft EIS, Technical Paper 15, p. 6-10.

11 Draft EIS, v.1, p. 25-13.

12 Draft EIS, v.1, p. 25-6.

13 Draft EIS, v.1, p. 25-13

the employment at the SSA resulted from the economic linkages represented in the ABS Input/Output tables (which aim to measure the economic linkages between industries in the economy). However, the CEA approach will understate employment to the extent that additional economic activity is generated other than through the linkages embodied in the Input/Output relationships between the Air and Space Transport industry and other industries.

In summary, the explanation of the differences between the PPK-preferred estimates and those of CEA provided in the Draft EIS essentially relate to a lower base level of airport employment which results from differing estimates of the 1996 level of employment generated by KSA.

The following estimates are lower still as a result of lower estimates of the passenger traffic likely to be serviced by the SSA. The estimates of employment impact presented in the Draft EIS were on the basis of a passenger throughput of 29.3 million per annum in 2016. In contrast, the estimates presented in the following section are for an estimated throughput of 6.5 million in 2016.

4. Estimates of the Regional Employment Impacts

Within this report, results are presented of the estimated regional economic and employment impacts of the SSA proposal as compared to a base case under which industries located in the SSA region might be expected to exhibit typical growth rates. Before setting out the result, a description of CEA's Regional Economic Analysis (ERA) Model is presented.

5. The ERA Model

The ERA Model has been developed to provide a tool for regional strategic planning and analysis.

Aside from providing a detailed database for selected regions, the ERA Model can help analyse the impact of changes in industry competitiveness through, for example, infrastructure investment or the development of an industry in a particular region.

Its outputs include:

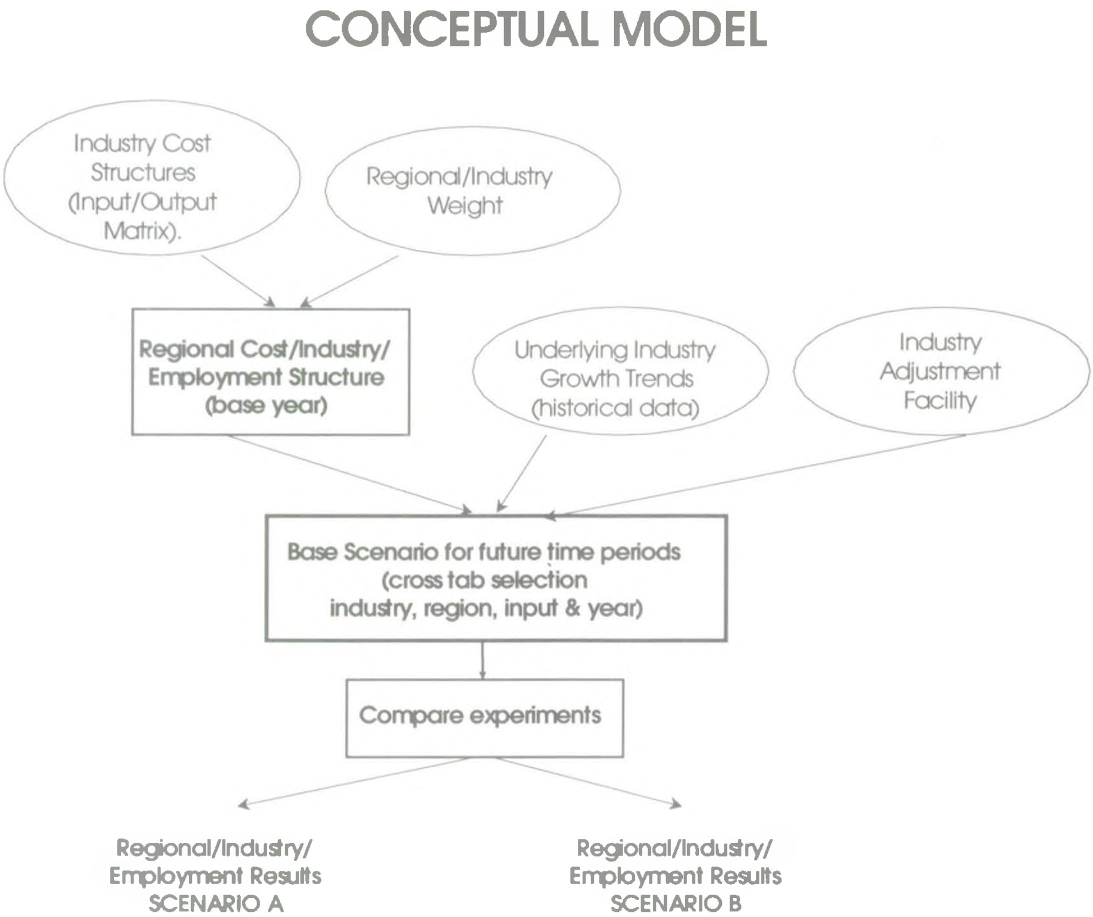
- the effect on related industries;
- the effect on employment; and
- the effect on total output.

The ERA Model comprises;

- a basic industry structure extending across 109 industry sectors;
- regional weights for each industry sector;
- growth forecasts for each 109 industries;
- an analyses facility allowing the user to specify regions, inputs, industries and year;
- an experiment facility enabling the modelling of different scenarios; and
- comparison facility to allow differences between scenarios to be compared.

A base data set is provided in the Model. This base data set provides users with a detailed picture of the characteristics of industries within regions and the pattern of their expenditures.

5.1 Conceptual Model: Flow Chart



5.2 Model Components

The conceptual framework of the analysis is set out in the chart above and each component of the structure is briefly outlined below.

5.3 Industry Cost Structures

The industry cost structure tables provide the basic input/output (I/O) relationships for each of the 109 industries defined by the ABS within its standard I/O tables. These data provide the basic cost structures for each industry and the relationship between industries.

5.4 Regional Distribution of Industry and Employment

This data table consists of each region's share of employment of each industry. Using these shares the national I/O tables can be allocated to each region included in the model.

5.5 Base Year Industry and Cost Structures

From the two preceding tables a unique industry structure is derived for each region. Each region has a unique mix of industries, although the cost structures for each of those industries remains in proportion to the cost structures in the national I/O framework. Included in the cost structures are estimates of employment, wages and profits.

5.6 Underlying Industry Growth Trends

CEA, in an independent analysis, has estimated the underlying growth rates of industries. These growth rates differ between industries, depending on the structure of their markets and their links to population growth. These estimates and how they were derived are set out in a subsequent section of this manual. These estimates are used to generate a projection, ignoring the particular impact of the infrastructure investment being investigated, or the extent to which each industry is likely to expand at the key time periods considered in the analysis (1996, 2006, 2016 and 2026).

Scenarios for Future Time Periods

For each region, the composition of industry in future time periods depends on their initial mix of industries and the growth projections for those industries.

5.7 Experimental Scenarios

Users can vary the model's base data in a wide range of ways to simulate economic and industry developments. The model allows scenarios to be compared and results to be quickly tabulated.

5.8 Results

The results are set out in *Tables J2.1* and *J2.2* which include estimates of employment impacts for 2016 and 2026 respectively. The results presented are based on the central demand growth forecast scenario (C – central); and the KSA capacity scenario (A – 34 million passengers in 2007) (these scenarios are outlined in more detail in Appendix J1).

The results should be interpreted as being the impact of the operation of the proposed SSA on the BC Region. The results include the impact of input/output linkages between industries, but these are limited to the extent that linked industries may not have a large presence in the region. Essentially input supplying industries are expected to maintain their national market share.

Employment in the Air and Space Transport industry in the BC Region is estimated to grow to around 6,400 in 2016 and 11,615 in 2026. If the SSA were not constructed, the underlying employment in the industry would be expected to be only 350 and 400 respectively.

Total employment attributable to the SSA's operations is much larger than the increase in employment in the Air and Space Transport industry. In 2016 the total employment generated is estimated to be some 10,100 and by 2026 the estimate is 18,600. These are estimated to represent increases in regional employment of 2% and 3% respectively.

The key industries to benefit are Accommodation, cafes , restaurants; Services to transport; Communication services; Wholesale trade; Legal, accounting, marketing; Aircraft; and Plastic Products.

Table J2.1: Employment Impacts Badgerys Creek Region 2016

Industry Code	Industry	Base	With Airport	% change	Change
0101	Sheep	14	14	0.0%	0
0102	Grains	2	2	0.0%	0
0103	Beef cattle	135	135	0.0%	0
0104	Dairy cattle	651	651	0.0%	0
0105	Pigs	65	65	0.0%	0
0106	Poultry	646	646	0.0%	0
0107	Other agriculture	1,735	1,754	1.1%	19
0200	Services to agriculture; hunting and trapping	75	75	0.0%	0
0300	Forestry and logging	60	60	0.0%	0
0400	Commercial fishing	14	14	0.0%	0
1100	Coal; oil and gas	506	506	0.0%	0
1302	Non-ferrous metal ores	141	141	0.0%	0
1400	Other mining	717	717	0.0%	0
1500	Services to mining	146	146	0.0%	0
2101	Meat and meat products	2,984	2,984	0.0%	0
2102	Dairy products	690	690	0.1%	1
2103	Fruit and vegetable products	233	233	0.0%	0
2104	Oils and fats	61	61	0.0%	0
2105	Flour mill products and cereal	438	438	0.0%	0

Industry Code	Industry	Base	With Airport	% change	Change
2106	Bakery products	2,524	2,524	0.0%	0
2107	Confectionery	618	618	0.0%	0
2108	Other food products	1,392	1,393	0.1%	2
2109	Soft drinks, cordials and syrups	439	439	0.0%	0
2111	Wine and spirits	75	75	0.0%	0
2112	Tobacco products	463	463	0.0%	0
2202	Textile fibres, yarns and woven fabrics	644	644	0.0%	0
2203	Textile products	316	318	0.7%	2
2204	Knitting mill products	120	120	0.0%	0
2205	Clothing	1,508	1,510	0.2%	2
2206	Footwear	175	175	0.0%	0
2207	Leather and leather products	119	119	0.0%	0
2301	Sawmill products	125	125	0.0%	0
2302	Plywood, veneer and fabricated	338	338	0.0%	0
2303	Other wood products	3,266	3,278	0.4%	13
2304	Pulp, paper and paper board	675	682	1.1%	7
2305	Paper board containers; paper bags and sacks	774	809	4.6%	36
2306	Other paper products	325	325	0.0%	0
2401	Printing and services to print	3,800	3,816	0.4%	16
2402	Publishing; recorded media and publishing	2,201	2,201	0.0%	1
2501	Petroleum and coal products	598	712	19.0%	114
2502	Fertilisers	169	169	0.0%	0
2503	Other basic chemicals	504	504	0.0%	0
2504	Paints	881	881	0.0%	0
2505	Medicinal and pharmaceutical products; pesticides	6,930	6,930	0.0%	0
2506	Soap and other detergents	843	843	0.0%	0
2507	Cosmetics and toiletry preparations	675	675	0.0%	0
2508	Other chemical products	864	864	0.0%	0
2509	Rubber products	1,309	1,310	0.1%	1
2510	Plastic products	5,097	5,404	6.0%	306
2601	Glass and glass products	724	724	0.0%	0
2602	Ceramic products	3,198	3,198	0.0%	0

Industry Code	Industry	Base	With Airport	% change	Change
2603	Cement and lime	226	226	0.0%	0
2604	Concrete slurry	423	423	0.0%	0
2605	Plaster and other concrete products	2,167	2,167	0.0%	0
2606	Other non-metallic mineral products	349	349	0.0%	0
2701	Iron and steel	2,218	2,218	0.0%	0
2702	Basic non-ferrous metal and products	4,587	4,587	0.0%	0
2703	Structural metal products	4,132	4,132	0.0%	0
2704	Sheet metal products	2,261	2,261	0.0%	0
2705	Fabricated metal products	5,992	6,021	0.5%	28
2801	Motor vehicles and parts; other transport equipment	3,346	3,346	0.0%	0
2802	Ships and boats	42	42	0.0%	0
2803	Railway equipment	188	188	0.0%	0
2804	Aircraft	201	414	105.7%	213
2805	Photographic and scientific equipment	1,063	1,064	0.0%	0
2806	Electronic equipment	3,086	3,087	0.0%	0
2807	Household appliances	763	763	0.0%	0
2808	Other electrical equipment	5,194	5,203	0.2%	9
2809	Agricultural machinery	84	84	0.0%	0
2810	Mining and construction machinery, lifting and material handling equipment	2,608	2,608	0.0%	0
2811	Other machinery and equipment	3,555	3,555	0.0%	0
2901	Prefabricated buildings	287	287	0.0%	0
2902	Furniture	7,133	7,133	0.0%	0
2903	Other manufacturing	1,697	1,706	0.6%	10
3601	Electricity supply	2,486	2,492	0.3%	6
3602	Gas supply	92	92	0.2%	0
3701	Water supply; sewerage and drainage services	2,350	2,350	0.0%	0
4101	Residential building construction	11,567	11,567	0.0%	0
4102	Other construction	56,505	56,566	0.1%	62
4501	Wholesale trade	47,170	47,817	1.4%	647
5101	Retail trade	57,117	57,117	0.0%	0

Industry Code	Industry	Base	With Airport	% change	Change
5401	Mechanical repairs	6,842	6,848	0.1%	6
5402	Other repairs	5,806	5,870	1.1%	64
5701	Accommodation, cafes and restaurants	23,667	24,546	3.7%	879
6101	Road transport	14,706	14,863	1.1%	158
6201	Rail, pipeline and other transport	1,838	1,842	0.2%	4
6301	Water transport	48	48	0.3%	0
6401	Air and space transport	348	6,433	1,750.0%	6,086
6601	Services to transport; storage	2,766	3,209	16.0%	443
7101	Communication services	17,160	17,399	1.4%	239
7301	Banking	6,502	6,561	0.9%	59
7302	Non-bank finance	2,194	2,214	0.9%	20
7303	Financial asset investors	1,537	1,537	0.0%	0
7401	Insurance	2,871	2,872	0.0%	0
7501	Services to finance, investment and insurance	1,899	1,900	0.0%	1
7702	Other property services	6,090	6,119	0.5%	29
7801	Scientific research, technical and computer services	8,333	8,440	1.3%	107
7802	Legal, accounting, marketing and business management services	11,706	12,047	2.9%	341
7803	Other business services	14,680	14,816	0.9%	137
8101	Government administration	11,068	11,068	0.0%	0
8201	Defence	3,568	3,568	0.0%	0
8401	Education	25,615	25,616	0.0%	1
8601	Health services	32,123	32,123	0.0%	0
8701	Community services	7,089	7,089	0.0%	0
9101	Motion picture, radio and television services	1,729	1,740	0.7%	12
9201	Libraries, museums and the arts	663	663	0.1%	1
9301	Sport, gambling and recreation	5,928	5,930	0.0%	2
9501	Personal services	9,682	9,701	0.2%	19
9601	Other services	6,688	6,689	0.0%	1
	Total	**513,032**	**523,135**	**2.0%**	**10,102**

Table J2.2: Employment Impacts Badgerys Creek Region 2026

Industry Code	Industry	Base	With Airport	% change	Change
0101	Sheep	12	12	0.0%	0
0102	Grains	2	2	0.0%	0
0103	Beef cattle	139	139	0.0%	0
0104	Dairy cattle	704	704	0.0%	0
0105	Pigs	61	61	0.0%	0
0106	Poultry	604	604	0.0%	0
0107	Other agriculture	1,696	1,727	1.8%	31
0200	Services to agriculture; hunting and trapping	70	70	0.0%	0
0300	Forestry and logging	63	63	0.0%	0
0400	Commercial fishing	13	13	0.0%	0
1100	Coal; oil and gas	525	525	0.0%	0
1302	Non-ferrous metal ores	163	163	0.0%	0
1400	Other mining	798	798	0.0%	0
1500	Services to mining	169	169	0.0%	0
2101	Meat and meat products	3,092	3,092	0.0%	0
2102	Dairy products	745	747	0.2%	2
2103	Fruit and vegetable products	246	246	0.0%	0
2104	Oils and fats	62	62	0.0%	0
2105	Flour mill products and cereal	428	428	0.0%	0
2106	Bakery products	2,587	2,587	0.0%	0
2107	Confectionery	654	654	0.0%	0
2108	Other food products	1,504	1,507	0.2%	3
2109	Soft drinks, cordials and syrups	486	486	0.0%	0
2111	Wine and spirits	81	81	0.0%	0
2112	Tobacco products	409	409	0.0%	0
2202	Textile fibres, yarns and woven fabrics	616	616	0.0%	0
2203	Textile products	288	292	1.2%	3
2204	Knitting mill products	109	109	0.0%	0
2205	Clothing	1,282	1,285	0.3%	3
2206	Footwear	151	151	0.0%	0
2207	Leather and leather products	125	125	0.0%	0
2301	Sawmill products	132	132	0.0%	0

Industry Code	Industry	Base	With Airport	% change	Change
2302	Plywood, veneer and fabricated	363	363	0.0%	0
2303	Other wood products	3,494	3,517	0.7%	23
2304	Pulp, paper and paper board	673	685	1.8%	12
2305	Paper board containers; paper bags and sacks	837	902	7.8%	65
2306	Other paper products	350	350	0.0%	0
2401	Printing and services to print	3,936	3,963	0.7%	27
2402	Publishing; recorded media and publishing	2,340	2,341	0.1%	1
2501	Petroleum and coal products	645	851	31.9%	206
2502	Fertilisers	183	183	0.0%	0
2503	Other basic chemicals	463	463	0.0%	0
2504	Paints	961	961	0.0%	0
2505	Medicinal and pharmaceutical products; pesticides	8,455	8,455	0.0%	0
2506	Soap and other detergents	899	899	0.0%	0
2507	Cosmetics and toiletry preparations	712	712	0.0%	0
2508	Other chemical products	946	946	0.0%	0
2509	Rubber products	1,316	1,318	0.1%	2
2510	Plastic products	5,141	5,659	10.1%	518
2601	Glass and glass products	767	767	0.0%	0
2602	Ceramic products	3,360	3,360	0.0%	0
2603	Cement and lime	246	246	0.0%	0
2604	Concrete slurry	466	466	0.0%	0
2605	Plaster and other concrete products	2,347	2,347	0.0%	0
2606	Other non-metallic mineral products	374	374	0.0%	0
2701	Iron and steel	2,424	2,424	0.0%	0
2702	Basic non-ferrous metal and products	5,103	5,103	0.0%	0
2703	Structural metal products	4,440	4,440	0.0%	0
2704	Sheet metal products	2,487	2,487	0.0%	0
2705	Fabricated metal products	6,372	6,423	0.8%	51
2801	Motor vehicles and parts; other transport equipment	3,252	3,252	0.0%	0
2802	Ships and boats	43	43	0.0%	0

Industry Code	Industry	Base	With Airport	% change	Change
2803	Railway equipment	192	192	0.0%	0
2804	Aircraft	205	569	177.3%	364
2805	Photographic and scientific equipment	1,123	1,123	0.0%	0
2806	Electronic equipment	3,267	3,267	0.0%	1
2807	Household appliances	791	791	0.0%	0
2808	Other electrical equipment	5,588	5,605	0.3%	16
2809	Agricultural machinery	89	89	0.0%	0
2810	Mining and construction machinery, lifting and material handling equipment	2,911	2,911	0.0%	0
2811	Other machinery and equipment	3,854	3,854	0.0%	0
2901	Prefabricated buildings	303	303	0.0%	0
2902	Furniture	7,458	7,458	0.0%	0
2903	Other manufacturing	1,796	1,813	1.0%	17
3601	Electricity supply	2,411	2,421	0.4%	10
3602	Gas supply	99	100	0.3%	0
3701	Water supply; sewerage and drainage services	2,480	2,480	0.0%	0
4101	Residential building construction	12,411	12,411	0.0%	0
4102	Other construction	68,844	68,970	0.2%	126
4501	Wholesale trade	50,540	51,702	2.3%	1,162
5101	Retail trade	59,858	59,858	0.0%	0
5401	Mechanical repairs	7,258	7,269	0.1%	10
5402	Other repairs	6,160	6,274	1.9%	114
5701	Accommodation, cafes and restaurants	28,117	29,866	6.2%	1,750
6101	Road transport	15,528	15,807	1.8%	279
6201	Rail, pipeline and other transport	1,950	1,957	0.4%	7
6301	Water transport	43	44	0.6%	0
6401	Air and space transport	394	11,615	2,850.0%	11,221
6601	Services to transport; storage	2,957	3,750	26.8%	793
7101	Communication services	20,631	21,112	2.3%	482
7301	Banking	6,718	6,820	1.5%	102
7302	Non-bank finance	2,267	2,302	1.5%	34
7303	Financial asset investors	2,148	2,147	0.0%	-1
7401	Insurance	3,182	3,183	0.0%	1

Industry Code	Industry	Base	With Airport	% change	Change
7501	Services to finance, investment and insurance	1,943	1,944	0.1%	1
7702	Other property services	6,081	6,130	0.8%	49
7801	Scientific research, technical and computer services	9,235	9,434	2.2%	199
7802	Legal, accounting, marketing and business management services	12,816	13,442	4.9%	627
7803	Other business services	16,117	16,368	1.6%	252
8101	Government administration	10,389	10,389	0.0%	0
8201	Defence	3,588	3,588	0.0%	0
8401	Education	26,329	26,330	0.0%	1
8601	Health services	34,743	34,743	0.0%	0
8701	Community services	7,485	7,485	0.0%	0
9101	Motion picture, radio and television services	1,838	1,859	1.1%	21
9201	Libraries, museums and the arts	679	681	0.2%	2
9301	Sport, gambling and recreation	6,762	6,765	0.0%	3
9501	Personal services	10,423	10,458	0.3%	35
9601	Other services	7,149	7,151	3.3%	1
	Total	**558,561**	**577,189**	**3.3%**	**18,627**

Appendix K3

Quantifiable Air Quality-Related Health Impacts

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Appendix K3
Quantifiable Air Quality-Related Health Impacts

1. Introduction

Section 15.6.4 of the Draft EIS, Chapter 9 of *Technical Paper No. 6* and Appendix F of *Technical Paper No. 6* provide the results of an analysis undertaken to quantify the air quality-related health impacts of the Second Sydney Airport proposal. This analysis, whilst acknowledging the limitations in the methodology used, provided quantifiable rates for hospitalisation and mortality resulting from increased levels of ozone and particulates that would be caused by the Second Sydney Airport. An estimation of the increased lifetime risk of cancer as a result of predicted air toxic emissions from the airport was also provided.

Chapter 11 of this Supplement contains details of further air quality modelling carried out using new data obtained from the NSW Environment Protection Authority and the Bureau of Meteorology. Quantifiable health impacts based on the revised air quality modelling, which includes the impacts of vehicular traffic to and from the airport, have been re-calculated. In addition, based on further research undertaken for this Supplement, the health effects of sulphur dioxide emissions have also been calculated.

The EIS has adopted two complementary strategies for assessing the health impact of predicted changes in air quality attributable to the Second Sydney Airport. The first is to estimate the expected frequency of exceedances of air quality guidelines (Commonwealth of Australia. National Environment Protection Council (Ambient Air Quality) Measure. Canberra: AGPS, 1998). The advantage of this approach is that it is based on reference to well established threshold levels derived from a consensus of experts. However, it has limited value for the purposes of assessing the health impact of airport-associated changes in air quality. Air quality guidelines are designed as a basis for assessing the outcome of measures to control pollution sources. They are established on the basis of a variety of inputs of which health effects is only one. Ecological, economic, social and political factors also influence the setting of air quality guidelines. The other limitation of air quality guidelines is that they do not allow any quantification of health effects. In reality adverse health effects occur in proportion to the level of exposure to pollutants; they do not begin and end at the threshold level chosen for the air quality guideline.

For these reasons the EIS has sought to quantify the health impacts of air quality changes by estimating the relation between pollution levels and various adverse health effects directly from published evidence on this subject. This Appendix summarises the methods and results of this analysis.

2. Methodology

There are two ways in which changes in air quality attributable to the airport may have an impact on illness within the affected community:

- long-term exposure to increased levels of pollutants may have a cumulative adverse effect on health leading to more chronic illness in the affected community. This would be expected to cause more symptoms of illness, more hospitalisations due to severe episodes, and a greater rate of premature mortality due to specific chronic diseases within the affected community; and
- short-term increases in pollutants may have an immediate, but short-lived (that is, acute), effect on health within the community. This would be expected to cause higher rates of symptoms, hospitalisations and deaths on the days when pollution levels were high.

This report provides a limited level of quantification of the impacts of projected changes in air quality predominantly in terms of the second (acute effects) mechanism. The long-term effects have not been quantified because of uncertainty about whether there are long-term effects, and also due to the absence of any data which would allow them to be quantified. The increased risk of cancer associated with exposure to air toxics is a quantifiable long-term health effect. This impact has been modelled separately based on the application of published risk thresholds.

Some data on long-term health effects of specific pollutants are presented in Appendix F of *Technical Paper No. 6* (Sections 5.4, 6.4 and 7.4) and in *Chapter 23* of the Supplement (*Section 23.2*). While some investigations have shown that people living in communities with high levels of exposure to particulates have more problems with bronchitis than less polluted communities, others have shown that there is less asthma and allergy among people living in heavily polluted eastern European cities than in less polluted western European cities. The interpretation of these data is hampered by the fact that they are derived from comparison among small numbers of communities which are likely to differ in many respects (for example, socio-economic status, employment, smoking prevalence, and diet) apart from pollution exposure. This makes it difficult to be certain that observed differences in illness between communities are, in fact, attributable to differences in pollution levels. In summary, its is not known whether small changes in air quality have any long-term impact on health.

There are several sources of information on the short-term impact of changes in air quality on illness. Information on the effect of ozone, and to a limited extent, sulphur dioxide and nitrogen dioxide, on symptoms and objective measures of lung problems is available from two types of investigation:

- exposure chamber studies, in which volunteers breath various concentrations of specific pollutants for a limited time (one to six hours) and the effects are recorded; and

- panel studies, in which subjects record symptoms and breathing capacity each day and this record is compared with daily measures of ambient pollutants.

Although each of these methods has some limitations on interpretation, the combined information has allowed a number of quantitative conclusions to be drawn about the anticipated impact of increases in pollutants on respiratory symptoms and breathing capacity. These are summarised below.

Numerous studies have examined the relation between pollution levels on a given day and the number of people who die or are hospitalised on that day (or the following few days). These studies have been comprehensively reviewed in Appendix F of *Technical Paper No. 6*, *Appendix K1* of this Supplement, *Chapter 23* of this Supplement and below in this Appendix. Combining information from these studies has resulted in answers to the following questions for specific pollutants:

- is there consistent evidence that changes in pollution levels, within the range anticipated after the Second Sydney Airport, will influence hospitalisation or death rates on a given day? and
- if there is more consistent evidence, what is the magnitude of the relation between levels of air pollution and rates of hospitalisation or death on a given day?

These data were used to assess the likely impact of airport-associated changes in air quality on rates of hospitalisation and death. However, the interpretation of these data for this purpose is problematic and it is critically important that this interpretation be made in the context of the exact meaning of the original data. The data are derived from counts of hospitalisations and deaths on single days. It is not known, however, what would have happened, over the following days, weeks or months, to the affected person if the pollution levels had been lower on that particular day. In other words, it is possible that some or all of the extra hospitalisations and deaths on high pollution days would have occurred anyway over the next short period, irrespective of the pollution levels. This scenario is supported by the observation that the elderly and those with pre-existing heart or lung disease are most at risk for these events. On the other hand, it is also possible that some or all of the extra hospitalisations would not have occurred at all and the deaths would not have occurred for many years, if the high pollution event had not happened. Unfortunately, there is no method of analysis which allows these two alternative explanations to be tested. Clearly, the truth lies somewhere between these two ends of the spectrum of possibilities. The interpretation of the findings needs to take both these possible scenarios into account.

The total impact expected changes in specific pollutants was estimated from the data described above using the following method:

1. The daily prevalence of key health outcomes was estimated from published data as follows

   - respiratory symptoms (cough) = 3 percent daily prevalence'
   - hospitalisations for respiratory disease = 4.26/100,000/day (NSW); and

- deaths from all causes = 2.02/100,000/day (NSW).

2. The effect on daily symptom prevalence, hospitalisation rate and death rate of

   - 0.01 part per million increase in ozone;
   - 3 $\mu g/m^3$, 6 $\mu g/m^3$ and 9 $\mu g/m^3$ increase in PM_{10} (an index of particulate exposure); and
   - 0.005, 0.01 and 0.02 parts per million increase in sulphur dioxide

   was estimated from the research reviewed, as described above.

   These levels of increase in pollutant levels were selected for assessing health impacts on the basis of the populations contours of exposure. For ozone and sulphur dioxide they include the maximum increase that is predicted to occur.

   Risk estimates for nitrogen dioxide were not calculated because the literature review did not conclude that risks could be quantified in the range of exposures anticipated in association with the Second Sydney Airport (Chapter 6 of Appendix F of *Technical Paper No. 6*, updated in *Chapter 23* of this Supplement.)

3. The absolute increase in the daily prevalence of asthma symptoms, hospitalisations for respiratory disease and deaths from all causes expected to occur in association with the changes in pollution listed under (2) were calculated by multiplying the prevalence in (1) by the proportional increases in (2).

4. The effect of the Second Sydney Airport on the pollution exposure of communities surrounding the airport was expressed as the number of people who would be expected to be exposed to the increases of pollutant levels listed in (2) and the number of days per year this would be expected to occur. Multiplying the number of persons by the number of days yielded the number of person-days of increased pollution exposure.

5. The numbers of extra people affected by asthma symptoms, hospitalisations for respiratory disease and deaths from all causes on any given day which could be attributed to increases in air pollution associated with the Second Sydney Airport was calculated by multiplying the number of person-days of increased pollution exposure (from (4)) by the expected absolute increases in prevalence (from (3)).

These calculations result in an estimate of the number of persons per year who would be expected to:

- experience asthma symptoms on one additional day;
- be hospitalised one or more days earlier than otherwise; or

- die one or more days earlier than otherwise,

due to increases in air pollution associated with the Second Sydney Airport.

These estimates give a guide to the likely impact on health of changes in air quality associated with the Second Sydney Airport. It is important they are interpreted as described above and that the following sources of uncertainty about the data are acknowledged:

- there is uncertainty in the estimates of the extent of the air quality changes;
- long-term adverse impacts of air pollutants have not been taken into account. This is because it is uncertain whether long-term adverse impacts exist in the range of exposure levels under consideration. Furthermore, there are no data on which to base a quantitative estimate of these effects if they do exist;
- the estimates of the acute health effects of short-term changes in pollution are derived from a summary of a range of conflicting research results. The summary measures need to be treated with caution;
- the analysis used here assumes that changes in daily rates of symptoms, hospitalisations and deaths, which were observed in association with spontaneous fluctuations in pollution levels, can be extrapolated to airport-induced increases in pollution. This assumption has never been tested; and
- from a public health perspective it is difficult to judge the importance of the predicted changes in the absence of any information about how premature the deaths are (that is, how many days, months or years of life are lost) and whether the additional hospitalisations are ones which would have occurred anyway and, if so, how premature they are.

3. Ozone

Ozone is an insoluble gas which means it can exert effects throughout the airways from the mouth to the periphery of the lung. As a highly reactive chemical with potent oxidant activity, it produces direct and indirect toxic effects on cell constituents.

There are few domestic indoor sources of ozone. Furthermore, ozone which enters the house from outdoors is quickly inactivated by chemical reaction with household surfaces. Hence ozone is predominantly an outdoor pollutant.

3.1 Air Quality Goal

The current Australian air quality goals for ozone are ten parts per hundred million for one hour average and eight parts per hundred million for four hour average. These were incorporated into the recently published National Environment Protection Measure for Air Quality (National Environment Protection Council, 1998).

3.2 Summary of Conclusions from Review of Published Literature (see Appendix F1 of Technical Paper No. 6 and Chapter 23 of the Supplement)

Exposure of ozone causes a short-term reduction in lung function, the extent of which is related to the ozone concentration, the duration of exposure and the level of activity or exercise being undertaken. In many cases, reduction in lung function is not accompanied by any symptoms, but some people (more commonly adults rather than children) experience chest discomfort or difficulty in taking a deep breath. Individuals vary in their sensitivity to ozone but the elderly and those with pre-existing respiratory diseases (including asthma) are not more susceptible than others. Those whose work or recreation entails outdoor physical activity are most likely to be affected by ozone exposure.

It was estimated that a 0.01 part per million increase in ozone concentration on a given day would result, on that day or the following day, in a:

- 1.7 percent reduction in forced expiratory volume in one second, a measure of breathing capacity relevant to airway diseases such as asthma;
- 1.4 percent increase in the risk of hospitalisation for respiratory disease one or more days earlier than otherwise expected ; and
- 1.0 percent increase in the risk of death one or more days earlier than otherwise expected.

It should be noted that much of evidence on risk of hospitalisation and risk of death is conflicting and the impact of ozone on these health outcomes must be considered uncertain.

Table K3.1 summarises the predicted numbers of people who would be exposed to increases in ozone levels beyond one part per hundred million (0.01 ppm), during high ozone events (refer *Figure 11.8* of this Supplement). It should be noted that the area of affectation depicted in *Figure 11.8* of *Chapter 11* of this Supplement represents the cumulative area of affectation arising from 25 ozone events per year over one part per hundred million. The actual area of affectation for any individual ozone event would be approximately 20 percent of this area, as depicted in *Figure 11.9* of *Chapter 11*. Therefore, the 25 days per year indicated in *Table K3.1* represents a worst-case estimate.

Table K3.1: Estimated Person Days Exposure to 0.01 Parts Per Million Increase in Maximum One Hour Ozone Concentration (Airport Operating at 30 Million Passengers Per Year)

Airport Option	Number of Days per Year[1]	2016 Population Affected	Person Days Exposure/Year (2016)
Option A	25 (6)[2]	6,100 (8,000)	152,500 (48,000)
Option B	25 (6)[2]	6,100 (8,000)	152,500 (48,000)
Option C	25 (6)[2]	6,100 (8,000)	152,500 (48,000)

Notes: 1. Number of days per year with increments greater than or equal to 0.01 parts per million ozone.
2. Numbers in brackets are estimated provided in the Draft EIS based on original air quality modelling.

3.3 Estimation of Effects of Predicted Changes in Ozone on Breathing Capacity, Hospitalisations for Respiratory Disease and Deaths

It was estimated that a 0.01 part per million increase in level of exposure to ozone would result in a 1.7 percent decrease in lung function. This change is at least three fold less than is likely to be perceived by an individual and hence would not be regarded a clinically significant

The impact of predicted changes in levels of exposure to ozone on hospital admissions for respiratory disease and on deaths, as shown in *Tables K3.2* and *K3.3*, was calculated by the method described in *Section 2* of this Appendix using the estimates for person-days of exposure to a 0.01 parts per million increase in ozone and the summary risk estimates described above.

Table K3.2: Projected Annual Number of Additional Hospital Admissions for Respiratory Disease One or More Days Earlier than Expected which are Attributable to Increased Levels of Ozone

Option A	0.092 (0.024)
Option B	0.092 (0.024)
Option C	0.092 (0.026)

Note: 1. Numbers in brackets are estimates provided in the Draft EIS based on original air quality modelling.

Table K3.3: Projected Annual Number of Deaths One or More Days Earlier than Expected which are Attributable to Increased Levels of Ozone.

Option A	0.031 (0.009)[1]
Option B	0.031 (0.009)
Option C	0.031 (0.01)

Note: 1. Numbers in brackets are estimates provided in the Draft EIS based on original air quality modelling.

In summary, it is estimated that after the Second Sydney Airport reaches an operating level of 30 million passengers a year, ozone pollution associated with its operation would lead to:

- on average, no clinically relevant change in lung function;
- the potential for one person to be hospitalised one or more days earlier than otherwise expected about each 12 years; and
- the potential for one person to die one or more days earlier than otherwise expected about each 33 years.

4. Particulates

Particulate pollution is a heterogeneous mixture of everything in the air which is not a gas. Only those particles which are small enough to enter the lungs are clinically important. Particles with a mass median aerodynamic diameter greater than ten microns are filtered out by the upper respiratory tract. Smaller particles enter the lungs.

4.1 Air Quality Goal

The standard for inhalable particulate levels for Australia, adopted in the recently published National Environment Protection Measure for Air Quality, is a 24 hour average level of 50 micrograms per cubic metre with exceedences allowed on five days per year (to cope with bush fires and back burning).

4.2 Summary of Conclusions from Review of Published Literature (see Appendix F1 of *Technical Paper No. 6* and Chapter 23 of the Supplement)

Increased exposure to particulates is associated with increased symptoms and decreased lung function. This has been most clearly shown in children and the effect is more marked in children with pre-existing respiratory disease such as asthma.

There are few published data which allow a quantitative estimate of the effect of changes in particulate pollution on respiratory symptoms. Based on data from one study the Technical Paper estimated that a three micrograms per cubic metre increase in PM_{10} pollution would be expected to be associated with a 2.4 percent higher prevalence of cough on those days compared to other days. A six and nine microgram per cubic metre increase in PM_{10} pollution would be expected to be associated with a 4.9 percent and 7.4 percent higher prevalence, respectively.

A recent systematic review of data from five cohort studies of children with asthma has found that an increase of three, six and nine micrograms per cubic metre in inhalable particulates less than 10μm (PM_{10}) is associated with a 0.8, 1.61 and 2.42 percent increase, respectively, in risk of sustaining a clinically important (10 percent) reduction in lung function measured as peak expiratory flow (refer this Supplement, *Section 23.2*).

Despite some inconsistencies in the data it is highly likely that particulate pollution is associated with an increase in the rate of hospital admission for respiratory disease. It is estimated that a three, six and nine microgram per cubic metre increase in particulates (measured as PM_{10}) is associated with a 0.46, 0.93 and 1.39 percent increase, respectively, in hospital admissions for respiratory disease occurring one or more days earlier than otherwise expected.

Day to day variation in particulate levels is also correlated with variation in daily death rates. The correlation is strongest for deaths in elderly and deaths due to cardiac and respiratory diseases. It is estimated that on a given day, a three, six and nine microgram per cubic metre increase in particulate exposure is associated with a 0.18, 0.36 and 0.54 percent increase, respectively, in deaths occurring one or more days earlier than otherwise expected.

Table K3.4 shows the frequency with which various populations would be exposed to a three, six and nine microgram per cubic metre increase in PM_{10} particulate pollution due to the projected changes in air quality attributable to the Second Sydney Airport. These levels of exposure are shown in *Figures K3.1* to *K3.3*. By assuming members of each group were exposed on three (one to five days), 12 (five to 20 days), 35 (20 to 50 days) and 70 (more than 50 days) days per year, respectively, approximate person-days of exposure to a three micrograms per cubic metre increase in PM_{10} particulate pollution were calculated for each site option. These are shown in *Table K3.5*.

Table K3.4: Populations Projected to be Exposed to a Greater than 3 Micrograms per Cubic Metre Increase in 24 Hour PM_{10} by Number of Occasions per Year (Airport Operating at 30 Million Passengers Per Year)

	Population Affected[1]			
Airport Option	**1 to 5 Days per Year (3)**	**5 to 20 Days per Year (12)**	**20 to 50 Days per Year (35)**	**> 50 Days per Year (70)**
Option A				
3 $\mu g/m^3$	158,000 (4,800)[2]	7,400 (2,000)[2]	600 (900)[2]	600 (600)[2]
6 $\mu g/m^3$	10,300	1,000	400	100
9 $\mu g/m^3$	2,000	700	100	-
Option B				
3 $\mu g/m^3$	117,600 (5,200)[2]	10,100 (1,900)[2]	800 (1,000)[2]	200 (300)[2]

Airport Option	Population Affected[1]			
	1 to 5 Days per Year (3)	5 to 20 Days per Year (12)	20 to 50 Days per Year (35)	> 50 Days per Year (70)
6 $\mu g/m^1$	11,500	1,200	100	-
9 $\mu g/m^3$	3,700	200	-	-
Option C				
3 $\mu g/m^3$	157,100 (6,600)[2]	7,800 (3,000)[2]	1,500 (1,200)[2]	100 (300)[2]
6 $\mu g/m^3$	11,100	1,400	-	-
9 $\mu g/m^3$	3,500	200	-	-

Notes: 1. Based on population projections for 2016.
2. Numbers in brackets are estimates provided in the Draft EIS based on original air quality modelling.

Table K3.5: Person-Days Projected for a Greater than 3 Micrograms per Cubic Metre Increase in 24 Hour PM_{10} (Airport Operating at 30 Million Passengers Per Year)

Airport Options	Person Days[1]
Option A	
3 $\mu g/m^3$	626,000 (111,900)[2]
6 $\mu g/m^3$	64,000
9 $\mu g/m^3$	18,000
Option B	
3 $\mu g/m^3$	516,000 (94,400)[2]
6 $\mu g/m^3$	52,400
9 $\mu g/m^3$	13,500
Option C	
3 $\mu g/m^3$	624,500 (118,800)[2]
6 $\mu g/m^3$	50,000
9 $\mu g/m^3$	13,000

Notes: 1. Based on population projections for 2016.
2. Numbers in brackets are estimates provided in the Draft EIS based on original air quality modelling.

4.3 Estimation of Effects of Predicted Changes in Particulates (PM_{10}) on Cough Symptoms, Lung Function, Hospitalisation for Respiratory Disease and Deaths

The impact of predicted changes in levels of exposure to particulates on daily prevalence of cough, on hospital admissions for respiratory disease and on deaths was calculated by the method described in *Section 2* of this Appendix using the estimates for person-days of exposure to a three, six and nine microgram per cubic metre increase in PM_{10} and the summary risk estimates described above. Calculations of additional person days coughing per year, additional hospitalisation for respiratory disease per year and deaths per year one or more days earlier than expected are presented in *Tables K3.6, K3.7* and *K3.8* below.

Table K3.6: Number of Additional Person-Days Per Year of Reported Cough Due to Episodes of Increased PM_{10} (Airport Operating at 30 Million Passengers Per Year)

Airport Option	Person-Days Per Year of Reported Cough[1]
Option A	585 (162)[2]
Option B	479 (136)[2]
Option C	552 (172)[2]

Notes: 1. Based on population projections for 2016.
2. Numbers in brackets are estimates provided in the Draft EIS based on original air quality modelling.

Table K3.7: Projected Annual Number of Additional Hospital Admissions for Respiratory Disease One or More Days Earlier than Expected which are Attributable to Increased Levels of PM_{10} (Airport Operating at 30 Million Passengers Per Year)

Airport Option	Additional Hospital Admissions Per Year[1]
Option A	0.159 (0.040)[1]
Option B	0.130 (0.034)
Option C	0.151 (0.042)

Notes: 1. Based on population projections for 2016.
2. Numbers in brackets are estimates provided in the Draft EIS based on original air quality modelling.

Table K3.8: Projected Annual Number of Deaths One or More Days Earlier than Expected which are Attributable to Increased Levels of PM_{10} (Airport Operating at 30 Million Passengers Per Year)

Airport Option	Number of Deaths Per Year[1]
Option A	0.029 (0.008)[1]
Option B	0.024 (0.006)
Option C	0.028 (0.008)

Notes: 1. Based on population projections for 2016.
2. Numbers in brackets are estimates provided in the Draft EIS based on original air quality modelling

The effect of increased particulate levels on the risk of a clinically important (10 percent) decrements in lung function is only relevant to people with asthma. Based on data cited in *Chapter 23* of the Supplement it is estimated that 10 percent of the person-days of exposure to three microgram per cubic meter increases in PM_{10} would be experienced by people with asthma. The daily prevalence of clinically important decrements in lung function in people with asthma is not precisely known but, based on data in the systematic review referred to above, is probably around 12 percent. Using these data and the methods described above, the number of person-days per year of clinical important decrements in lung function attributable to particulate pollution among people with asthma in the affected area was calculated as shown in *Table K3.9*.

Table K3.9: Number of Additional Person-Days Per Year of Clinically Important Decrements in Lung Function in People with Asthma Due to Increased PM_{10} (Airport Operating at 30 Million Passengers Per Year)

Airport Option	Person-Days Per Year of Decreases in Lung Function[1]
Option A	78
Option B	64
Option C	73

Note: 1 Based on population projections for 2016.

In summary, it is estimated that after the Second Sydney Airport reaches an operating level of 30 million passengers a year, particulate pollution associated with its operation would lead to:

- between 479 and 585 additional person-days of cough each year;
- between 64 and 78 additional person-days each year of clinically-relevant

reductions in lung function in people with asthma (note that these events may be spread over few or many individuals. For example, if 100 people each experienced cough on an additional six days per year, this would amount to an additional 600 person-days of cough. If 300 people each experienced cough on an additional two days per year, this would also amount to an additional 600 person-days of cough);

- the potential for one person to be hospitalised one or more days earlier than otherwise expected about each six to eight years; and
- the potential for one person to die one or more days earlier than otherwise expected about each 34 to 42 years.

5. Sulphur Dioxide

Sulphur dioxide is an irritant gas produced by the combustion of sulphurous fossil fuels. Unlike Europe and North America, sulphur dioxide pollution is not a major problem in Australia as most of the Australian coal does not contain high levels of sulphur.

5.1 Air Quality Goal

The environmental air quality goal for sulphur dioxide, as prescribed by the NSW Environment Protection Authority, includes a maximum one hour average of 0.2 parts per million (not to be exceeded more than once per year) and a maximum annual average of 0.02 parts per million. These standards are consistent with the recently agreed National Environment Protection Measure for Air Quality (National Environment Protection Council, 1998) which provides three standards for sulphur dioxide. In addition to the maximum one hour average standard and the maximum annual standard, a maximum 24 hour average of 0.08 parts per million (not to be exceeded more than once per year) is prescribed.

5.2 Summary of Conclusions from Review of Published Literature (see Chapter 23 and Appendix K1 of the Supplement)

Inhalation of high concentrations of sulphur dioxide in a controlled experimental setting causes airway narrowing and chest tightness in patients with asthma. This is a predictable effect which is also produced by a wide range of other irritant exposures.

The health effects produced by exposure to lower levels of sulphur dioxide in ambient air have been investigated in a number of epidemiological studies. A systematic review of these studies has been conducted and is included in *Appendix K1*.

Table K1.3 in *Appendix K1* cites two European studies and a United States study which show increases in ambient sulphur dioxide concentrations are associated with an increase in respiratory symptoms in people with pre-existing lung problems (mainly asthma, chronic bronchitis and emphysema). A similar study from New Zealand however, did not show any adverse effects. Epidemiological studies measuring changes in lung function are not consistent and no definite conclusions can be drawn on this subject.

The epidemiological evidence is difficult to interpret due to the strong correlation between sulphur dioxide and particulate pollution in Europe and North America, where many of these studies were conducted. The correlation between these pollutants means that it is difficult to be sure whether the observed effects are attributable to sulphur dioxide or to particulate pollution. In summary, the epidemiological evidence shows that exposure to particulates and/or sulphur dioxide, over a wide range of exposure levels, is associated with adverse health effects including increased daily mortality and hospital admission rates. At this stage, the adverse health effects cannot be positively attributed to one or the other of these pollutants.

The data from these studies were combined to examine the level of effect on risk of hospitalisation and risk of death that might be attributable to 0.005, 0.01 and 0.02 parts per million (5, 10 and 20 parts per billion) increase in the one hour concentration of sulphur dioxide. Data on risk of symptoms and changes in lung function were also abstracted. These risk estimates, together with data on the baseline daily prevalence of these outcomes in Sydney, were used to calculate the absolute increase in daily rates of various health outcomes as indicated in *Table K3.10*.

Table K3.10: Potential Sulphur Dioxide Related Health Outcomes Based on European and United States Studies (Refer Appendix K1)[1]

	NSW Daily Rate (per 100,000 per day)	% Increase in Daily Rate			Absolute Increase in Daily Rate (per 100,000 persons per day)		
		5 ppb	10 ppb	20 ppb	5 ppb	10 ppb	20 ppb
Mortality (all causes)	2.02	0.73	1.46	2.95	0.0147	0.0296	0.0596
Hospital admissions for respiratory diseases	4.26	0.85	1.71	3.45	0.0363	0.0728	0.1469

Note: 1. The data on which these calculations are based is derived from European and North American settings where sulphur dioxide and particulates are closely related. An unknown proportion of effects attributed to sulphur dioxide would actually be due to particulate pollution. For this reason, it is likely that the estimated health impact of sulphur dioxide is over-estimated.

The dose/response results shown in *Table K3.10* are from European and United States studies which show there is a significant statistical relationship between daily fluctuations in sulphur dioxide levels and rates of death and hospital admissions. These results should be considered to be over-estimates due to the strong correlation between sulphur dioxide and particulate pollution in these countries.

Table K3.11 summarises the predicted numbers of people who would be exposed to increases in sulphur dioxide levels generated from the Second Sydney Airport operating at 30 million passengers per year beyond five, ten and twenty parts per billion, during high sulphur dioxide events. These levels of exposure are shown in *Figures K3.4* to *K3.9*.

Table K3.11: Estimated Person Days Exposure to 5, 10 and 20 Parts Per Billion Increase in Maximum One Hour Sulphur Dioxide Concentration (Airport Operating at 30 Million Passengers Per Year)

	Person-Days[1]		
Airport Option	**5 ppb**	**10 ppb**	**20 ppb**
Option A	2,848,800	176,200	0
Option B	2,822,900	167,200	0
Option C	2,736,360	157,200	0

Note: 1. Based on population projections for 2016.

Using the health outcomes indicated by the European and United States studies, the predicted changes in levels of exposure to sulphur dioxide on hospital admissions for respiratory disease and on premature deaths was calculated by the method described *Section 2* of this Appendix using the estimates for person-days of exposure to a 5, 10 and 20 parts per billion increase in sulphur dioxide and the summary risk estimates described in *Table K3.11*.

The estimates of the health impacts of sulphur dioxide suggest that approximately one additional hospital admission per year and one additional death each two years one or more days earlier than expected could be attributable to increased levels of sulphur dioxide from the operation of the Second Sydney Airport. As this data is derived from European and North American settings where sulphur dioxide and particulate pollution are closely related, an unknown proportion of effects attributed to sulphur dioxide would actually be due to particulate pollution. Furthermore, most of the impact of sulphur dioxide is attributable to a very small increase in risk experienced by a very large number of people who would be exposed to a five parts per billion increase in sulphur dioxide. It is important to note that the certainty of the estimates of effect of sulphur dioxide at this very small level of increment is low.

The above limitations of existing research, the substantially higher levels of health impacts of sulphur dioxide compared to particulates and ozone, and the prediction that emissions of sulphur dioxide generated by the Second Sydney Airport would not exceed National Environmental Protection Measure goals (refer *Section 11.4.4* of this

Supplement) indicate that the above calculated impact of sulphur dioxide is over-estimated and further research is required to develop more reliable estimates.

6. Air Toxic Health Impacts

6.1 Substances Considered for Long-Term Health Risk

California Air Pollution Control Officers Association (1993) provides a list of substances for which annual average concentrations should be calculated for assessment of cancer and chronic non-cancer risks. Substances in that list which have also been identified in the air emissions inventory for the proposed airport are listed in *Table K3.12*.

Table K3.12: Substances Considered for Long Term Health Risk

Acetaldehyde
Benzene
1, 3 - Butadiene
Formaldehyde
Gasoline vapours
Lead Compounds[1]
Polycyclic aromatic hydrocarbons including benzo(a)pyrene
Phenol
Toluene
Xylenes

Note. 1. Lead compounds were not included in the air emissions inventory because air emissions are substantially reduced due to the phase out of leaded petrol. They are discussed because lead is listed for consideration in the Guidelines for the EIS prepared by Environment Australia.

6.2 Non-Cancer Risk

Reference exposure levels for long term exposure to air pollutants have been tabulated by the California Air Pollution Control Officers Association (1993). These reference exposure levels are used as indicators of potential health effects which are not related to cancer. For average concentrations below these levels, no adverse health effects are anticipated. The potential for chronic health effects is assessed by comparing with the long-term exposure levels. The compounds listed by California Air Pollution Control Officers Association (1993) which are also identified in the *Air Emissions Inventory Report* (contained in *Technical Paper No. 6*) are listed in *Table K3.13*.

Table K3.13: Non-cancer Reference Exposure Levels - Air Pollutants

Substance	Inhalation Reference Exposure Level (micrograms per cubic metre)	References[1]
Acetaldehyde	9	IRIS[2]
Benzene	71	TLV[3]
Formaldehyde	3.6	IRIS
Lead	1.5	CAAQS[4]
Nitrogen Dioxide	470	CAAQS
Ozone	180	IRIS
Phenol	45	IRIS
Sulphur dioxide	660	DTSC[5]
Toluene	200	TLV
Xylenes	300	SPHEM[6]

Source: Table III-8 of California Air Pollution Control Officers Association's Air Toxics "Hot Spots" Program Revised 1992 Risk Assessment Guidelines published in October 1993.

Notes:
1. The references listed below are those referred to in the above publication:
2. IRIS Reference Doses from US Environment Protection Authority's Integrated Risk Information System.
3. TLV Indicates that the number is derived from an ACGIH Threshold Limit Value (TLV) which has been divided by an uncertainty factor of 420. (4.2 (to extrapolate from a 40 hour week to a 168 hour full week) times 10 (to extrapolate from healthy workers to sensitive people) times 10 (since adverse health effects are often seen at the TLVs)).
4. CAAQS California Ambient Air Quality Standard.
5. DTSC Department of Toxic Substances Control Applied Action Levels.
6. SPHEM the Superfund Public Health Evaluation Manual, 1986, pp. 149-156.

Lead is an air pollutant released from motor vehicles fuelled with leaded petrol. Poisoning occurs when blood levels of lead exceed 500 micrograms per litre. Levels as low as 100 micrograms per litre in blood have been linked with behavioural changes in children (Needleman et al 1979). By 2006, the proportion of the motor vehicle fleet which uses leaded fuels (petrol fuel vehicles manufactured prior to 1986) will be very low and as a result air emissions of lead will not be significant. By 2006 ambient lead levels will also be low compared with the Environment Protection Authority goal value of 1.5 micrograms per cubic metre. For these reasons lead air pollution resulting from airport operation will not be significant.

For each of the air toxic compounds listed in *Table K3.13*, with exception of lead and ozone, the long term increase in concentration due to operation of Sydney Second Airport was predicted using dispersion modelling. Lead was not included for the reasons discussed above and increase in long term average ozone concentration was not able to be assessed using dispersion modelling. Note that the inhalation reference dosage for ozone of 180 micrograms per cubic metre is approximately equal to nine parts per hundred million.

For each of the remaining air toxic compounds the predicted increase in average air toxic concentration was divided by the inhalation reference exposure. This gave an exposure index for each of the air toxic compounds considered. Acceptable exposure is considered to be less than an index of one. *Figures K3.10* to *K3.12* shows the modelled reference exposure dosage for each of the airport options. The combined exposure, calculated by summing the fractional exposure levels, was less than one outside the airport boundary for Airport Options B and C indicating that the non-cancer impact due to these air toxic compounds was within acceptable limits. An area immediately to the west of the boundary of Option A could potentially be exposed to air toxic compounds above desirable levels.

6.3 Cancer Risk

This section describes the results of an assessment of health impacts due to carcinogenic air toxic compounds which would be emitted as a result of the operation of the Second Sydney Airport. Emissions from aircraft, ground service vehicles, maintenance operations and passenger motor vehicles are outlined in the *Air Emissions Inventory Report* contained in *Technical Paper No. 6*. The pollutants which are addressed are:

- Acetaldehyde;
- Benzene;
- 1,3-butadiene;
- Formaldehyde; and
- Polycyclic aromatic hydrocarbons including benzo(a)pyrene.

Table K3.14 presents the lifetime inhalation cancer unit risk factors for the above compounds obtained for a range of sources (refer *Technical Paper No. 6*). The tabulated factors represent the theoretical risk of cancer over the course of an average lifetime due to a continuous inhalation exposure to a concentration of one microgram per cubic metre.

Table K3.14: Inhalation Cancer Unit Risk Factors (Lifetime Risk for Inhalation At One Microgram per Cubic Metre)

Pollutant	Inhalation Risk (per $\mu g/m^3$)
Acetaldehyde	2.2×10^{-6}
Benzene	8.3×10^{6}
1,3 Butadiene	2.8×10^{-4}
Formaldehyde	6.0×10^{-6}
Particulate matter	
Petrol vehicles	5.1×10^{-5}
Diesel vehicles	1.7×10^{-5}
Aircraft	1.7×10^{-5}

The IRIS (Integrated Risk Information System) database was consulted during the preparation of this supplement (January 1999) to review values for inhalation unit risk used in the Draft EIS. The unit risk factors adopted for benzene, butadiene and formaldehyde emissions for the Draft EIS were confirmed. A minor change to the value for acetaldehyde was noted (2.7×10^{-6} ($\mu g/m^3)^{-1}$ adopted for Draft EIS). A unit risk factor for benzene of 8.3×10^{-6} ($\mu g/m^3)^{-1}$ was adopted. This represents a reduction from the value adopted for the Draft EIS (1.3×10^{-6} ($\mu g/m^3)^{-1}$) which was taken as the largest value obtained from several literature sources. The IRIS value was adopted for the Supplement for consistency, as this is an internationally recognised source of risk assessment parameters. The values adopted in the Draft EIS for unit cancer risk for vehicle emissions remained unchanged for the Supplement.

There is considerable uncertainty in the process of unit cancer risk and a range of assessments for cancer risk from diesel particulates have been developed. The basis for assessment of the values adopted for motor vehicle particulates is described in the 'Motor Vehicle-Related Air Toxics Study' (US EPA 1993). The bulk of vehicle particulate emissions are attributed to diesel vehicles. Heam (1994) presents emissions estimates for motor vehicles in Melbourne for 2005 which show 97 percent of vehicle particulate emissions from diesel vehicles. No further information was located in relation to particulate emissions from aircraft.

Particulate emissions from diesel vehicles will be affected by introduction of more stringent motor vehicle standards likely to be imposed on new vehicles over the next ten years, consistent with the Australian Government stated policy of harmonisation with international vehicle emission standards by 2006 (FORS, 1998). The sulphur content of diesel fuel sold in Australia would be reduced to as part of this process. The reduction of sulphur content of fuel leads to reduction in particulate emissions from the entire vehicle fleet (including older vehicles). The form and timing of reductions in emissions is not known at present and these improvements in vehicle emissions have not been incorporated into the emissions estimates employed for the EIS.

The estimated cancer risk from air toxic emissions represents a worst case situation. It has been assumed that the cancer risk would apply to a person who spends 24 hour per day for their entire life (assumed 70 years) at a location near the airport.

The combined cancer risk associated with airport emissions for each of the above air toxics was estimated for each of the airport options. For each air toxic compound, dispersion modelling was carried out to predict the average increases in concentrations. The risk factors for each air toxic compound from *Table K3.14* was applied to the predicted average increase in concentration and the sum of the cancer risk for the combined exposure to the list of air toxic compounds was calculated as shown in *Table K3.15*.

Figures K3.13 to *K3.15* presents contours of the predicted increase in lifetime risk of cancer which would result from exposure to air toxic compounds from Sydney Second Airport cancer risks resulting from airport-related motor vehicle traffic have also been included in the modelling undertaken for this supplement. The level of risk is similar for each of the airport options considered, with risk factors as high as five in 10,000 predicted at the airport boundary in each case.

These risks are for a worst case situation as they would apply to a person who spent 24 hours per day for their entire life (assumed 70 years) at a location near the airport.

Table K3.15: Populations Exposed to Cancer Risks for Each of the Airport Options Operating at 30 Million Passengers Per Year

Airport Option	Risk Factor	Projected Population[1] Exposed to Risk Factor	Projected Annual Cancer Cases
Option A	1 to $2x10^{-5}$	314,200 (125,000)[2]	0.063 (0.025)
	2 to $5x10^{-5}$	46,800 (3,100)	0.023 (0.002)
	greater than $5x10^{-5}$	1,100 (1,000)	0.001 (0.001)
		Total Option A	0.087 (0.028)
Option B	1 to $2x10^{-5}$	319,800 (122,000)	0.064 (0.025)
	2 to $5x10^{-5}$	44,900 (4,000)	0.023 (0.002)
	greater than $5x10^{-5}$	900 (900)	0.000 (0.000)
		Total Option B	0.087 (0.027)
Option C	1 to $2x10^{-5}$	346,800 (109,000)	0.069 (0.003)
	2 to $5x10^{-5}$	26,800 (5,200)	0.013 (0.003)
	greater than $5x10^{-5}$	1,300 (500)	0.001 (0.000)
		Total Option C	0.084 (0.025)

Note: 1. Based on population projections for 2016.
2. Numbers in brackets are estimates provided in the Draft EIS based on original air quality modelling.

In summary it is estimated that after the Second Sydney Airport reaches an operating level of 30 million passengers a year, the emissions of air toxics associated with its operation would lead to one person contracting cancer about each 11 years.

7. Summary of Quantifiable Air Quality-Related Health Impacts

The projected increases in ozone, nitrogen dioxide, sulphur dioxide and particulate pollution associated with all the airport options are relatively small compared to total emissions in the Sydney Basin. The health effects estimates employed in this report are based on extrapolation from studies in which spontaneously occurring day-to-day variations in pollution levels were observed affecting large populations. Their use in this report relies on the assumption that interventions (such as the Second Sydney Airport) which alter pollution levels would have the same effect as that observed with day-to-day variation in pollution levels. This assumption has never been tested.

Interpretation of the data on adverse health effects must be guided by the limitations of the methods of analysis as discussed in the section of this Appendix dealing with methodology. In particular, the following considerations are important:

- there is some imprecision inherent in the methods of modelling both air quality projections and health risk assessments;
- some of the published information on adverse health effects of pollutant exposures is conflicting;
- it was not possible to model the effects of long-term exposure to pollutants. However, there is some doubt as to whether there are clinically relevant long-term effects in the range of exposures under consideration;
- the method of analysis of short-term effects of pollution on rates of hospitalisation does not provide any information on whether the additional hospitalisations on a given day represent a net increase and, if not, how much earlier than otherwise the admission occurred. Hence, the increase in hospital admissions is best described as the "number of admissions which are additional or which occur one or more days earlier than expected over the period of a year"; and
- similarly, the information on additional deaths is limited. Clearly the deaths are not actually additional (since all people are destined to die) but premature. The important issue is how premature and model cannot give this information. The increase in deaths is best described as the "number of deaths occurring one or more days earlier than expected over the period of a year".

The estimates of the health impacts of sulphur dioxide suggest that approximately one additional hospital admission per year and one additional death each two years one or more days earlier than expected could be attributable to increased levels of sulphur dioxide from the operation of the Second Sydney Airport. As this data is derived from European and North American settings where sulphur dioxide and particulate pollution are closely related, an unknown proportion of effects attributed to sulphur dioxide would actually be due to particulate pollution. Furthermore, most of the impact of sulphur dioxide is attributable to a very small increase in risk experienced by a very large number of people who would be exposed to a five parts per billion increase in sulphur dioxide. It is important to note that the certainty of the estimates of effect of sulphur dioxide at this very small level of increment is low. The above limitations of existing research, the substantially higher levels of health impacts of sulphur dioxide compared to particulates and ozone, and the prediction that emissions of sulphur dioxide generated by the Second Sydney Airport would not exceed National Environmental Protection Measure goals (refer *Section 11.4.4* of this Supplement) indicate that the above calculated impact of sulphur dioxide is over-estimated.

Overall the health impacts documented in this Appendix are higher than those stated in the Draft EIS. This is due to the use of recently available Bureau of Meteorology data revealing more frequent occurrence of poor dispersion conditions in air quality modelling and also the inclusion of airport related motor vehicle emissions in that modelling. The approach adopted for air quality modelling for this supplement provides a more conservative appraisal of air quality impacts.

A summary of quantifiable air quality related health impacts is provided in *Table K3.16*. The figures cited in the table give a quantitative guide to the likely adverse health impact of air quality changes attributable to the airport. They indicate that the probability of any serious adverse events (hospitalisations and premature deaths) attributable to air quality changes arising from the Second Sydney Airport is low. Less serious events such as episodes of coughing or episodes of decline in lung function in people with asthma are projected to occur rarely within the affected population.

Table K3.16: Revised Air Quality-Related Health Impacts of the Second Sydney Airport Operating at 30 Million Passengers Per Year

	Population Affected[1]					
	Option A		Option B		Option C	
Predicted Impact	Draft EIS Estimate	Revised Estimate	Draft EIS Estimate	Revised Estimate	Draft EIS Estimate	Revised Estimate
Short Term Health Effects of Ozone						
Deaths per year (one or more days earlier than expected)	0.009	0.031	0.009	0.031	0.009	0.031
Hospitalisation for respiratory disease per year (additional or one or more days earlier than expected)	0.024	0.092	0.024	0.092	0.026	0.092
Short Term Health Effects of Particulates Below 10 Microns in Size						
Deaths per year (one or more days earlier than expected)	0.008	0.029	0.006	0.024	0.008	0.028
Hospitalisation for respiratory disease per year (additional or one or more days earlier than expected)	0.040	0.159	0.034	0.130	0.042	0.151
Coughing (additional person-days per year)	162	585	136	479	172	552
Clinically important decrements in lung function (additional person-days per year)	-	78	-	64	-	73
Health Effects of Air Toxics						
Number of cancer cases per year	0.028	0.087	0.027	0.087	0.025	0.084

Note: 1. Based on population projections for 2016

References

California Air Pollution Control Officers Association (1993), *Air Toxics "Hot Spots" Program Revised 1992 Risk Assessment Guidelines*, October 1993

Hearne, D. (1994), "*Motor Vehicle Emissions in Melbourne: Their Environmental Impact*". Proceedings of the Clean Air Society of Australia and New Zealand Inc., 12th International Conference, October 1994.

Katatani, N.; Furushashi, N.; Ogura, S.; and Nakasugi, O. (1994), "*A Case Study for the Estimation of Human Risk by Toxic Organic Compounds*". Proceedings of the Clean Air Society of Australia and New Zealand Inc., 12th International Conference, October 1994.

Needleman, H.L., Gunnoe, C.E., Leviton, A., Reed, R., Peresie, H., Maher, C. and Barrett, P., (1979), *Deficits in Psychologic and Classroom Performance of Children with Elevated lead Levels*. New England Journal of Medicine, 300, 689-695.

Report of the Senate Select Committee on Aircraft Noise in Sydney, "*Falling on Deaf Ears:*", November 1995.

Vigyan Inc. (1993), "*Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in South-West Chicago*". Report Prepared for United States Environment Protection Agency, April 1993.

Figures

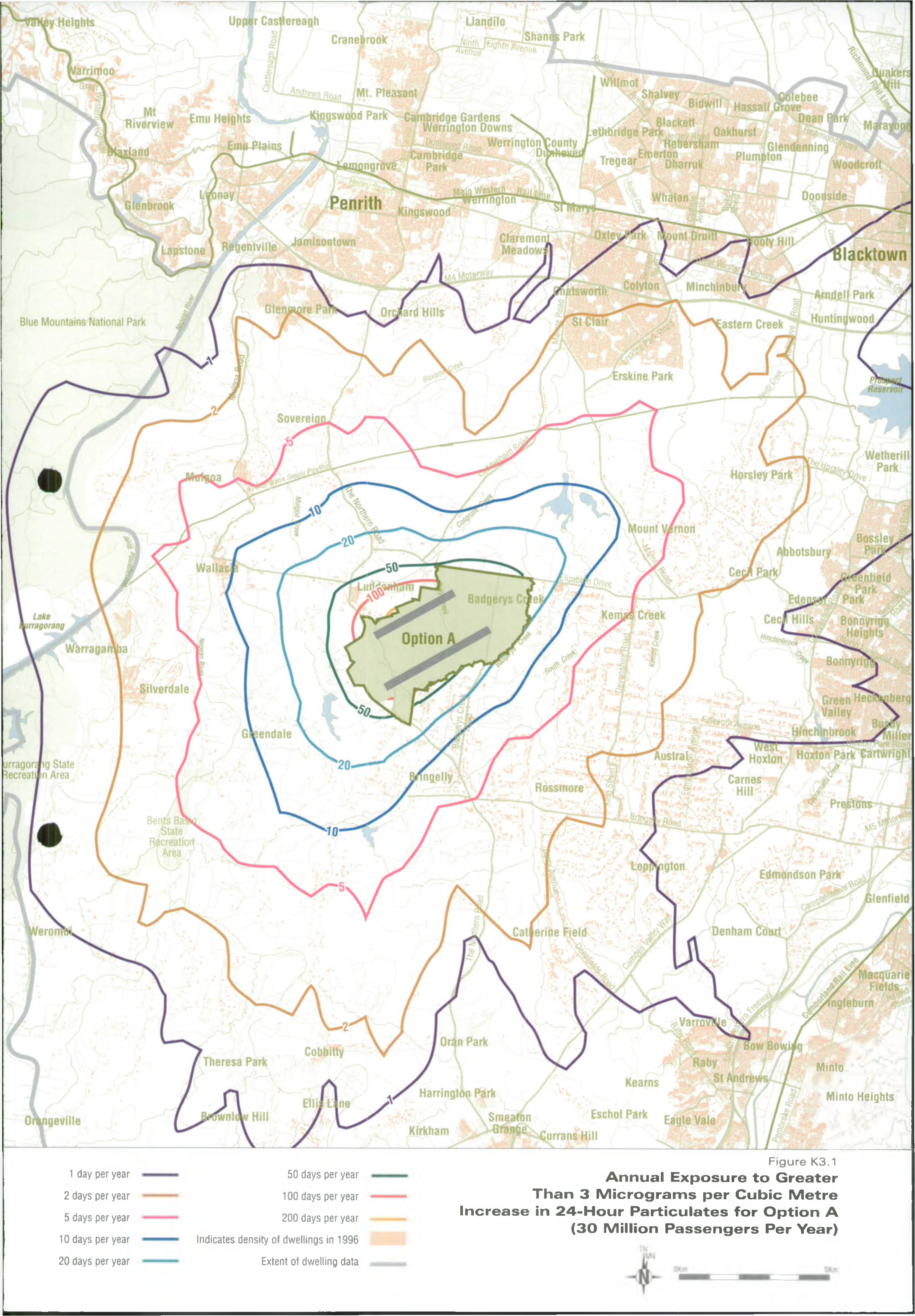
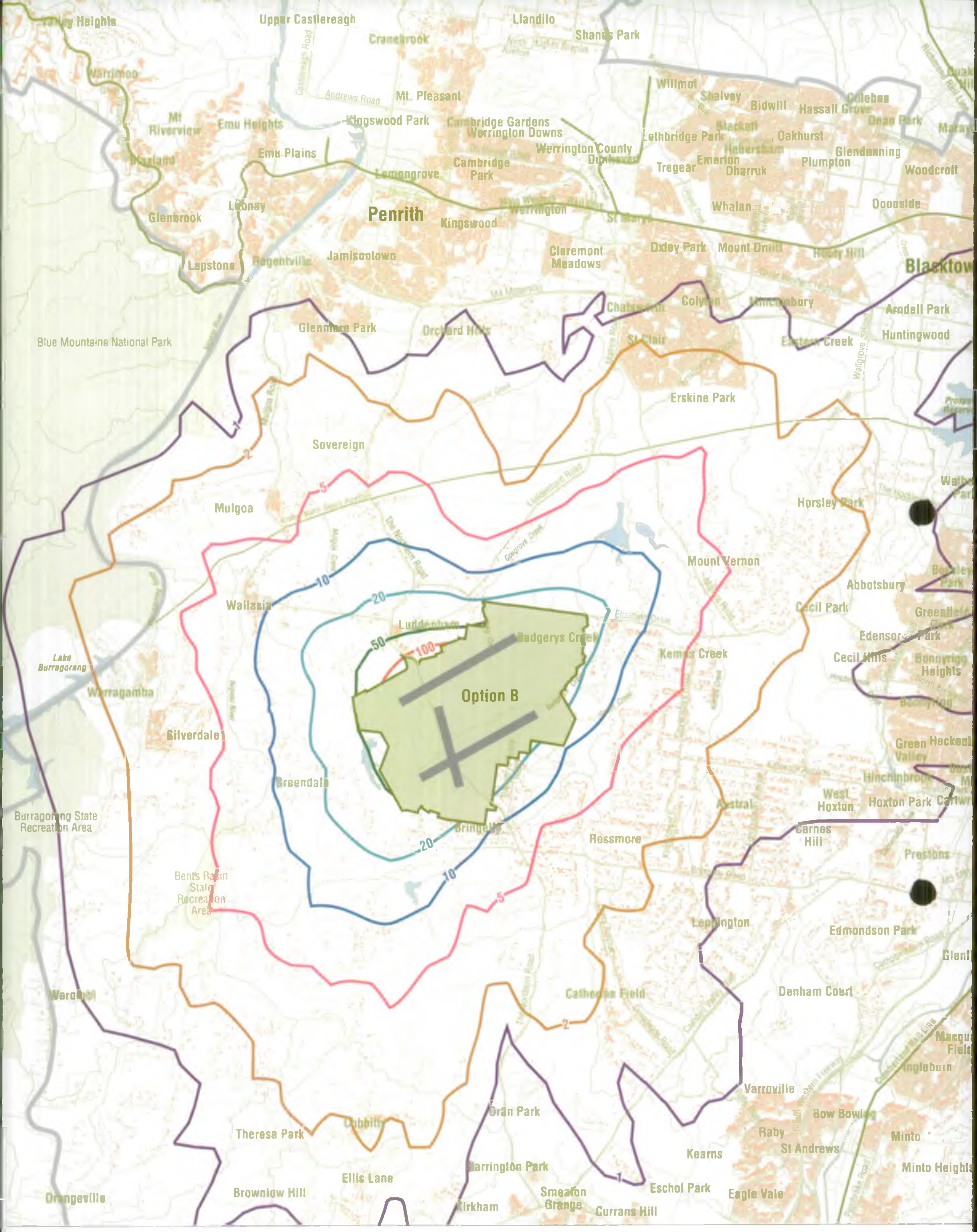


Figure K3.1

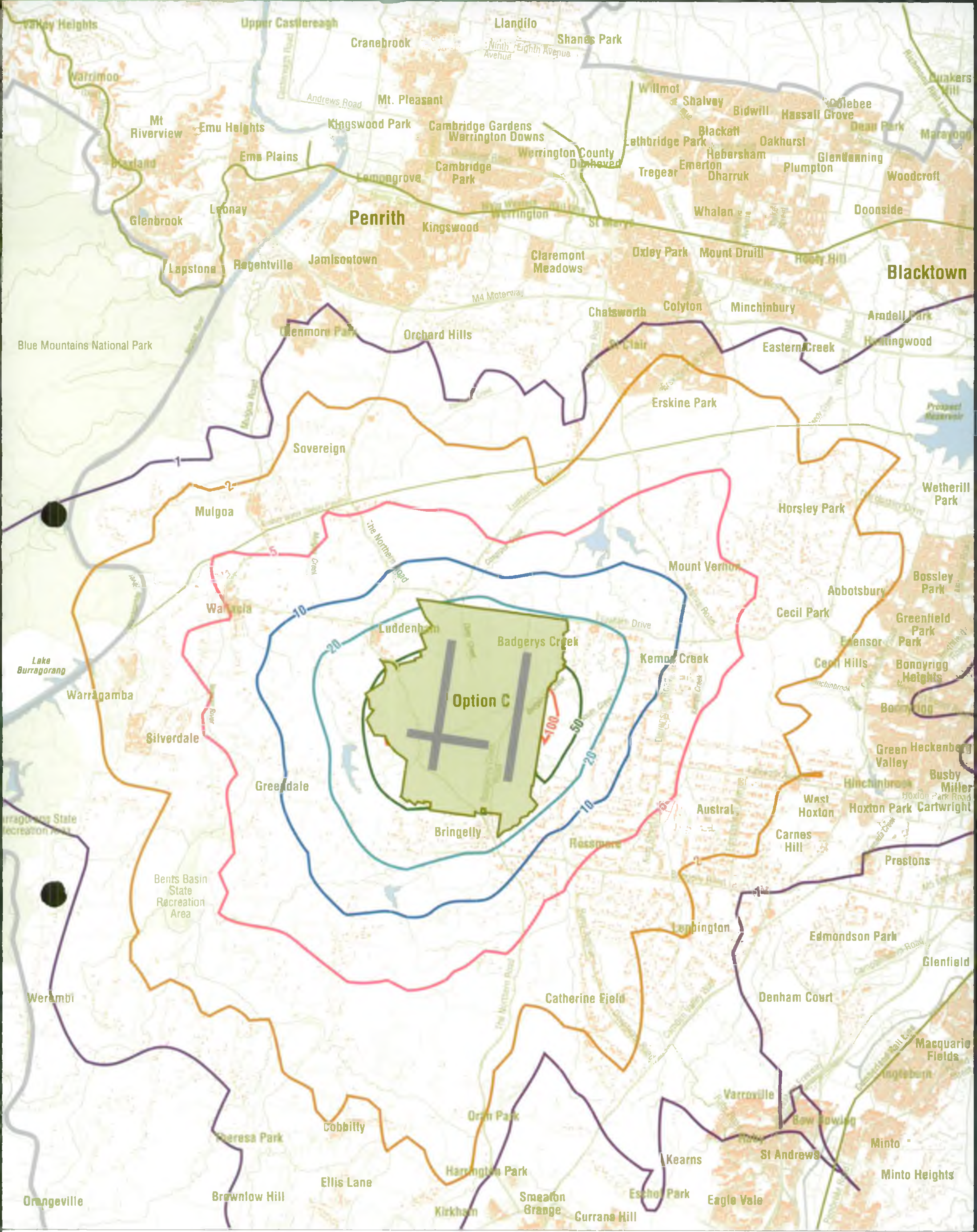
Annual Exposure to Greater Than 3 Micrograms per Cubic Metre Increase in 24-Hour Particulates for Option A (30 Million Passengers Per Year)



1 day per year	50 days per year
2 days per year	100 days per year
5 days per year	200 days per year
10 days per year	Indicates density of dwellings in 1996
20 days per year	Extent of dwelling data

Figure K3.2

Annual Exposure to Greater Than 3 Micrograms per Cubic Metre Increase in 24-Hour Particulates for Option B (30 Million Passengers Per Year)



1 day per year		50 days per year	
2 days per year		100 days per year	
5 days per year		200 days per year	
10 days per year		Indicates density of dwellings in 1996	
20 days per year		Extent of dwelling data	

Figure K3.3

Annual Exposure to Greater Than 3 Micrograms per Cubic Metre Increase in 24-Hour Particulates for Option C (30 Million Passengers Per Year)

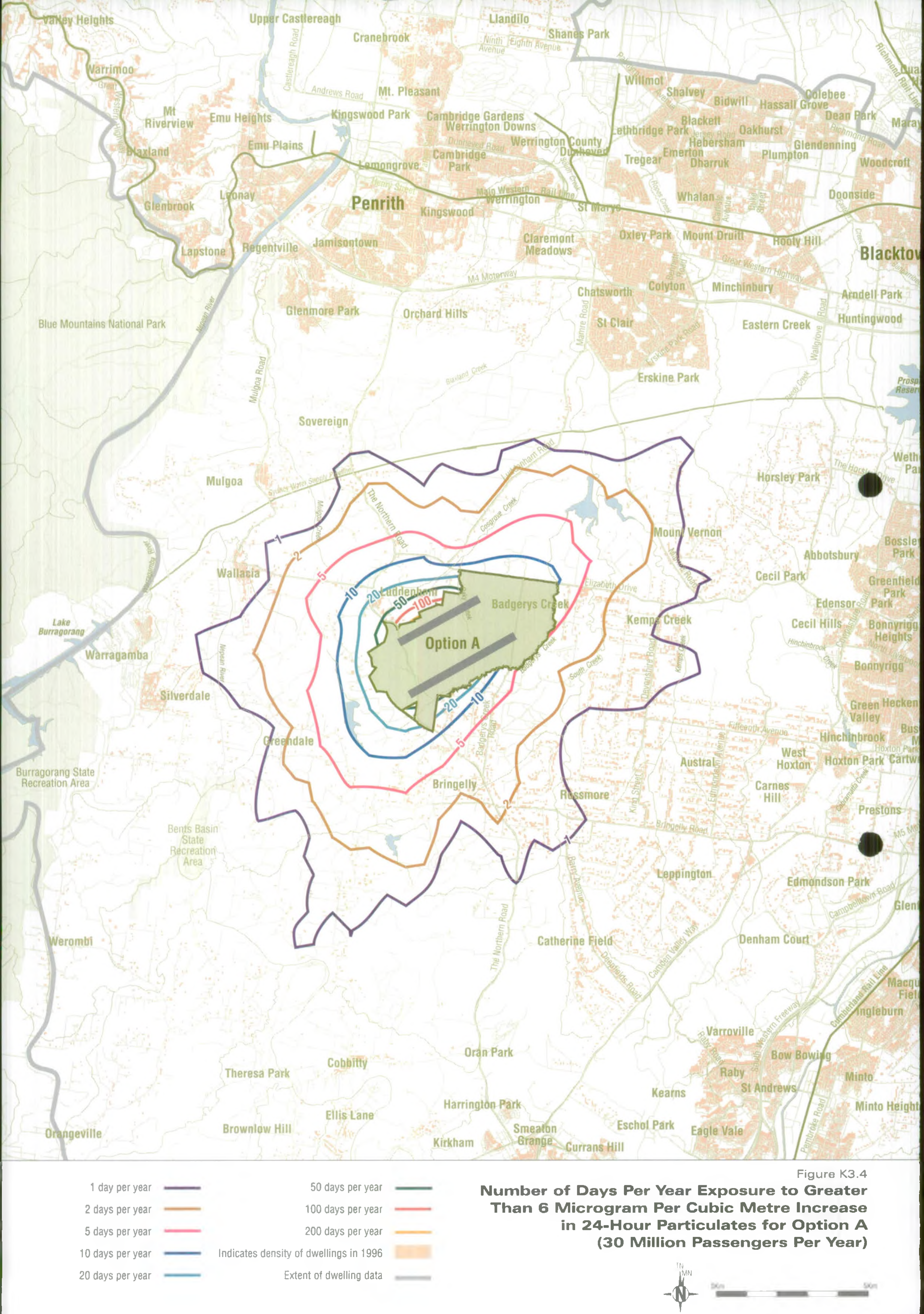


Figure K3.4

Number of Days Per Year Exposure to Greater Than 6 Microgram Per Cubic Metre Increase in 24-Hour Particulates for Option A (30 Million Passengers Per Year)

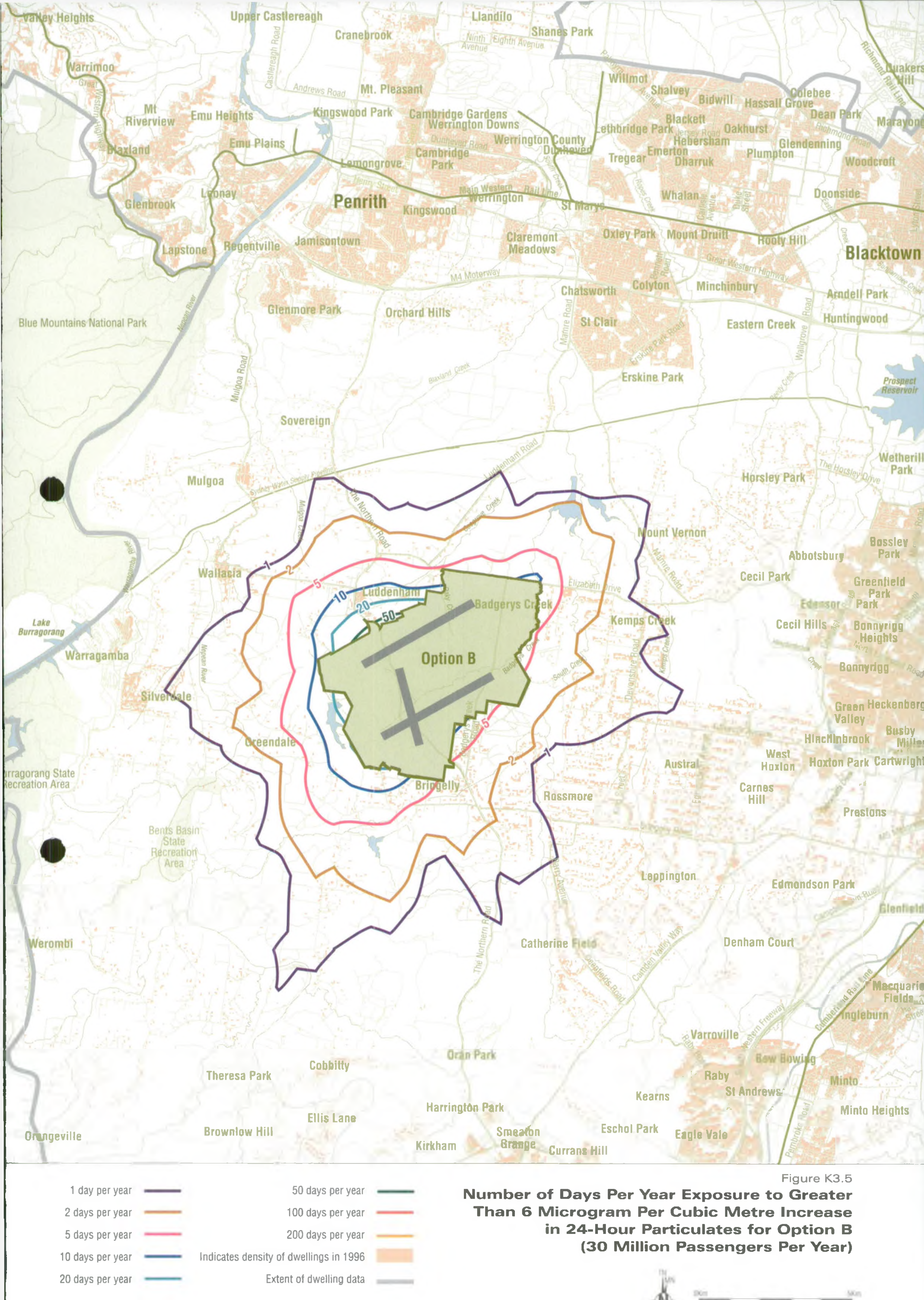
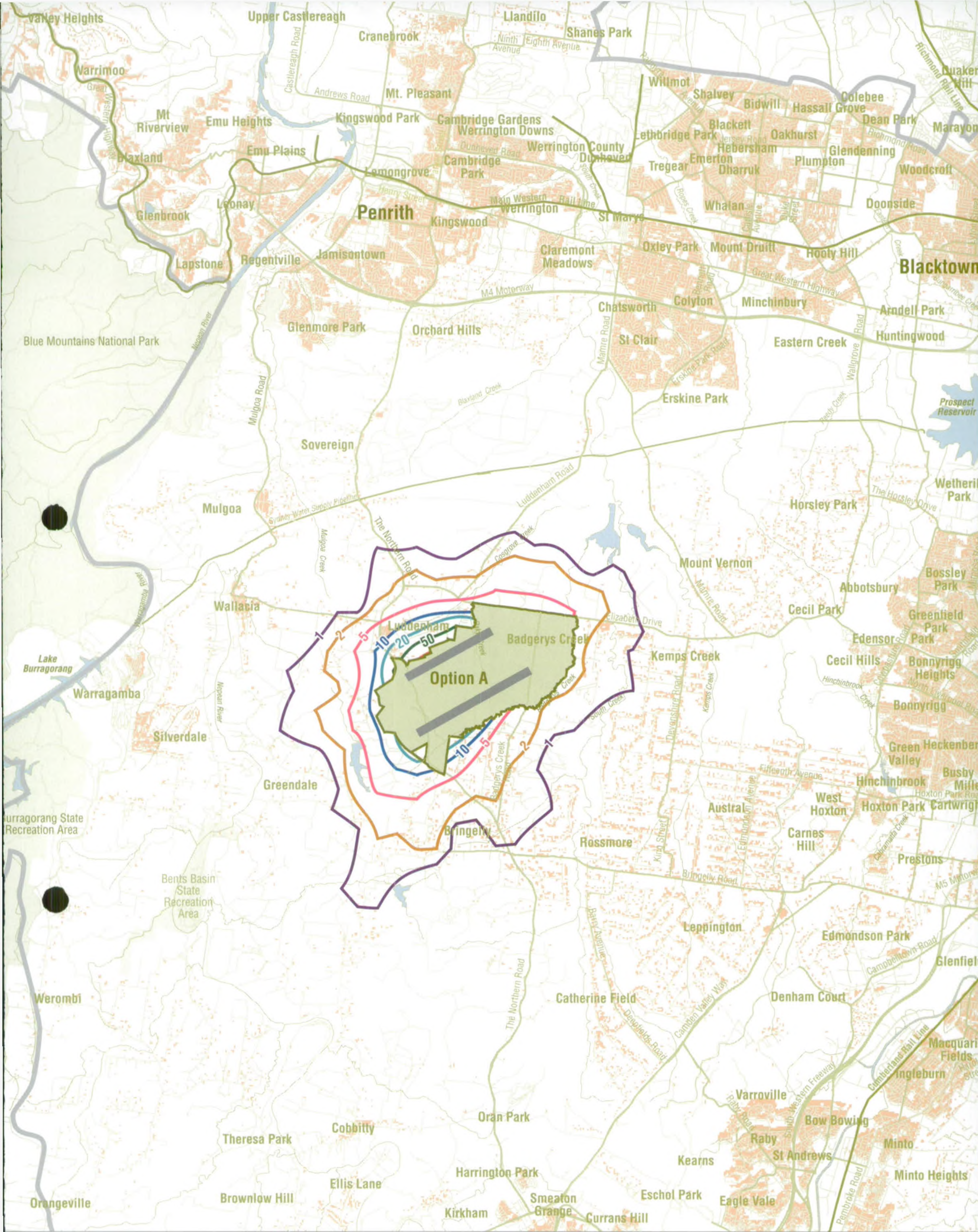


Figure K3.5

Number of Days Per Year Exposure to Greater Than 6 Microgram Per Cubic Metre Increase in 24-Hour Particulates for Option B (30 Million Passengers Per Year)

Figure K3.6

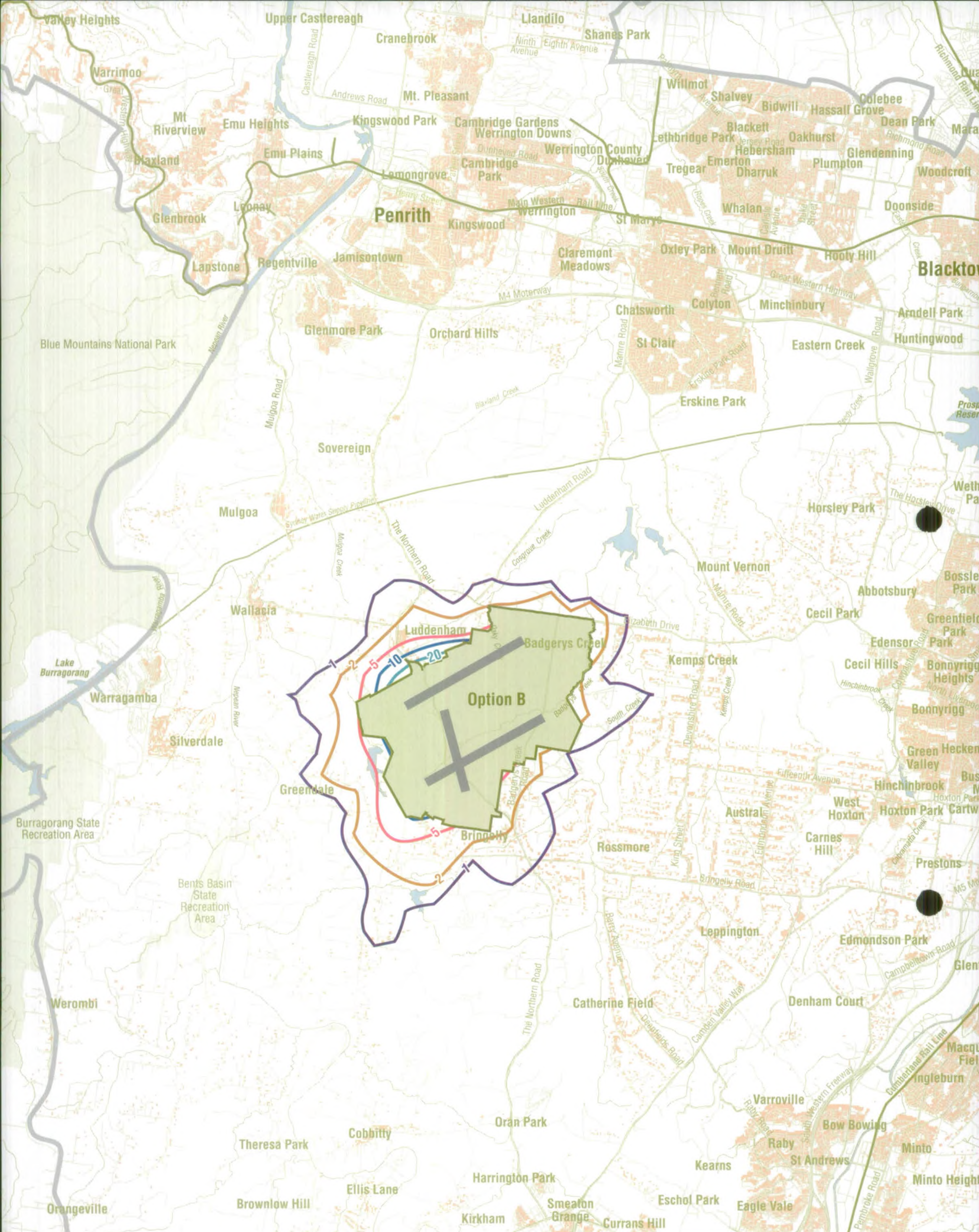
Number of Days Per Year Exposure to Greater Than 6 Microgram Per Cubic Metre Increase in 24-Hour Particulates for Option C (30 Million Passengers Per Year)



1 day per year	50 days per year
2 days per year	100 days per year
5 days per year	200 days per year
10 days per year	Indicates density of dwellings in 1996
20 days per year	Extent of dwelling data

Figure K3.7

Number of Days Per Year Exposure to Greater Than 9 Microgram Per Cubic Metre Increase in 24-Hour Particulates for Option A (30 Million Passengers Per Year)



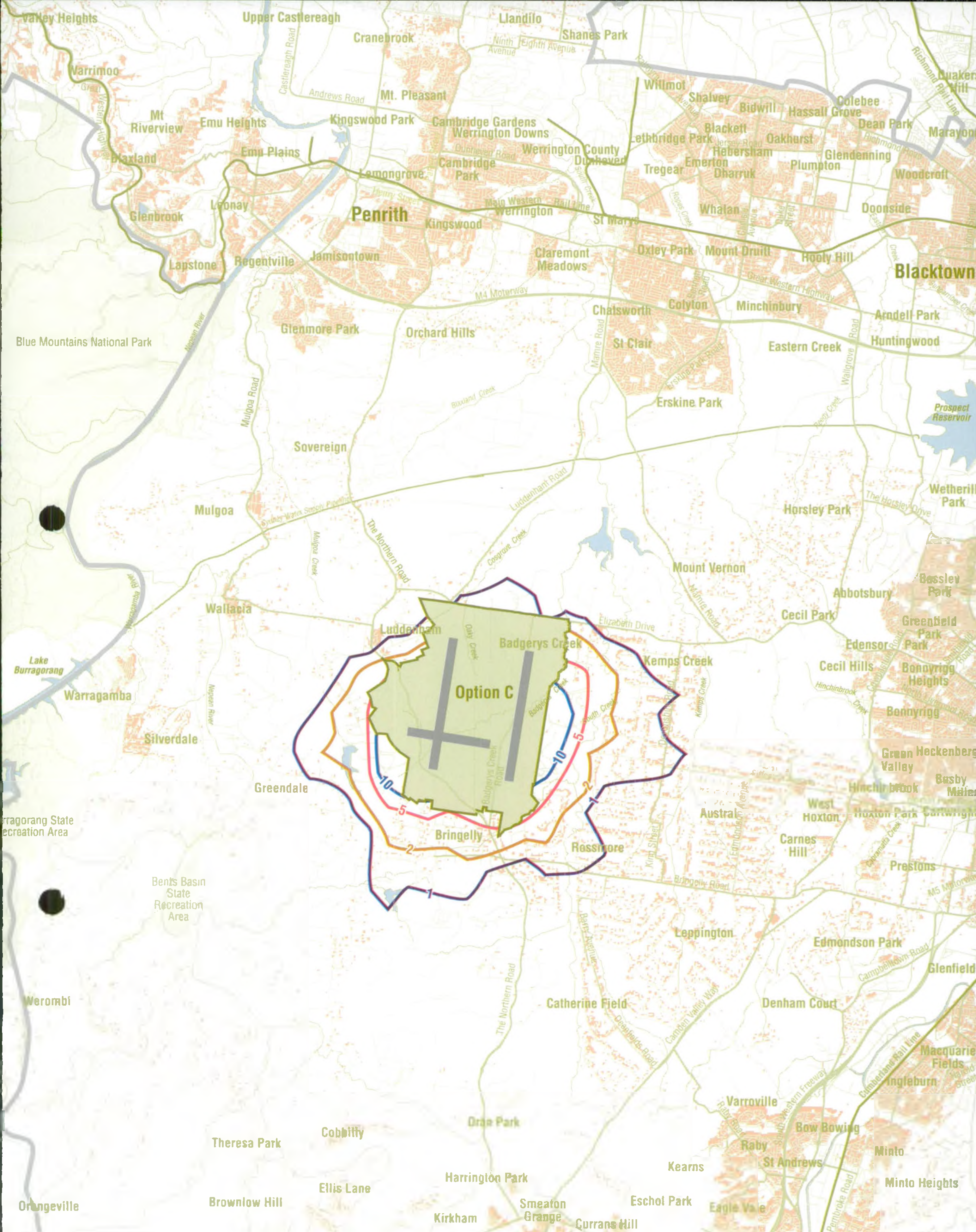
1 day per year		50 days per year	
2 days per year		100 days per year	
5 days per year		200 days per year	
10 days per year		Indicates density of dwellings in 1996	
20 days per year		Extent of dwelling data	

Figure K3.8

Number of Days Per Year Exposure to Greater Than 9 Microgram Per Cubic Metre Increase in 24-Hour Particulates for Option B (30 Million Passengers Per Year)

TN MN

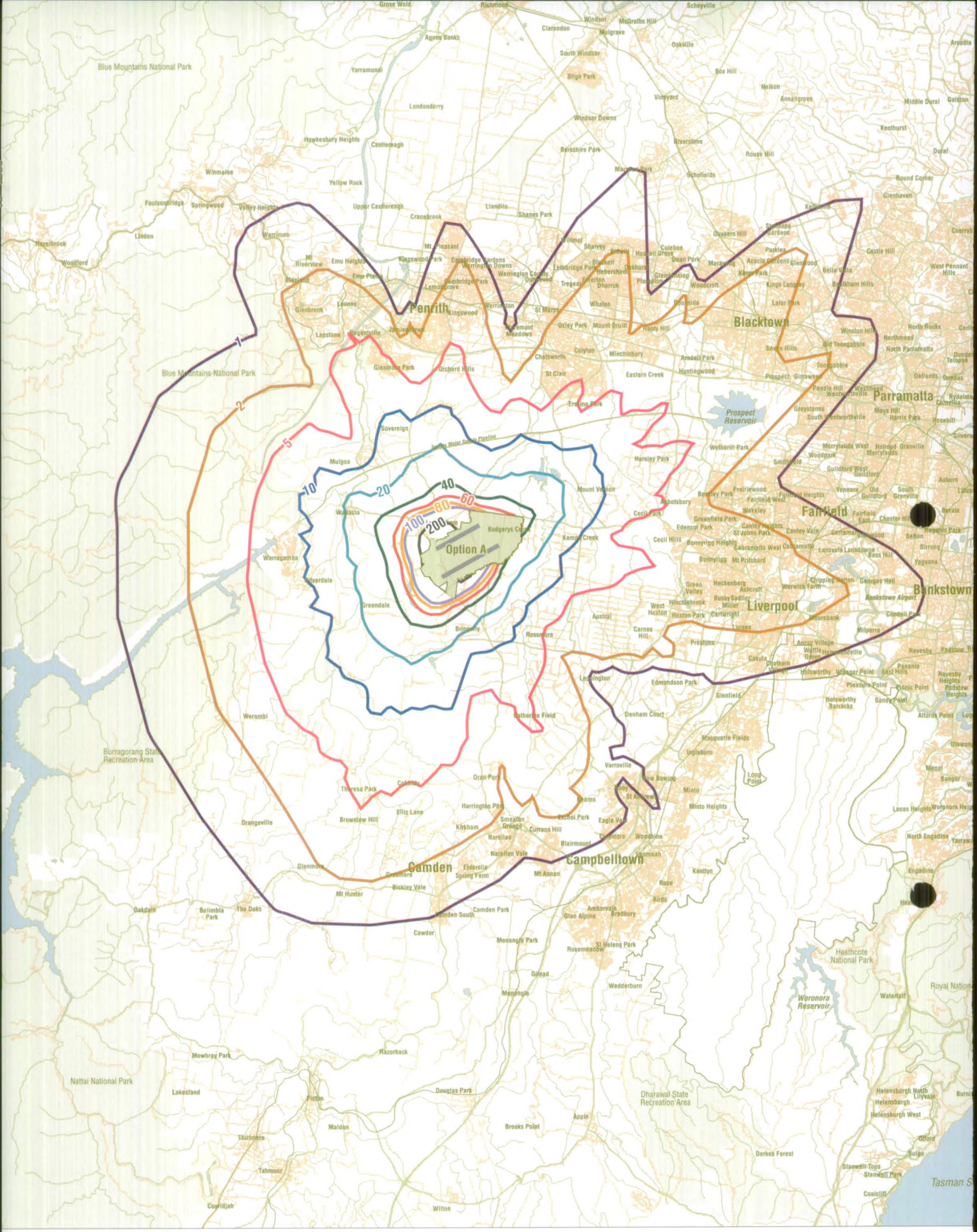
0Km 5Km



1 day per year		50 days per year	
2 days per year		100 days per year	
5 days per year		200 days per year	
10 days per year		Indicates density of dwellings in 1996	
20 days per year		Extent of dwelling data	

Figure K3.9

Number of Days Per Year Exposure to Greater Than 9 Microgram Per Cubic Metre Increase in 24-Hour Particulates for Option C (30 Million Passengers Per Year)



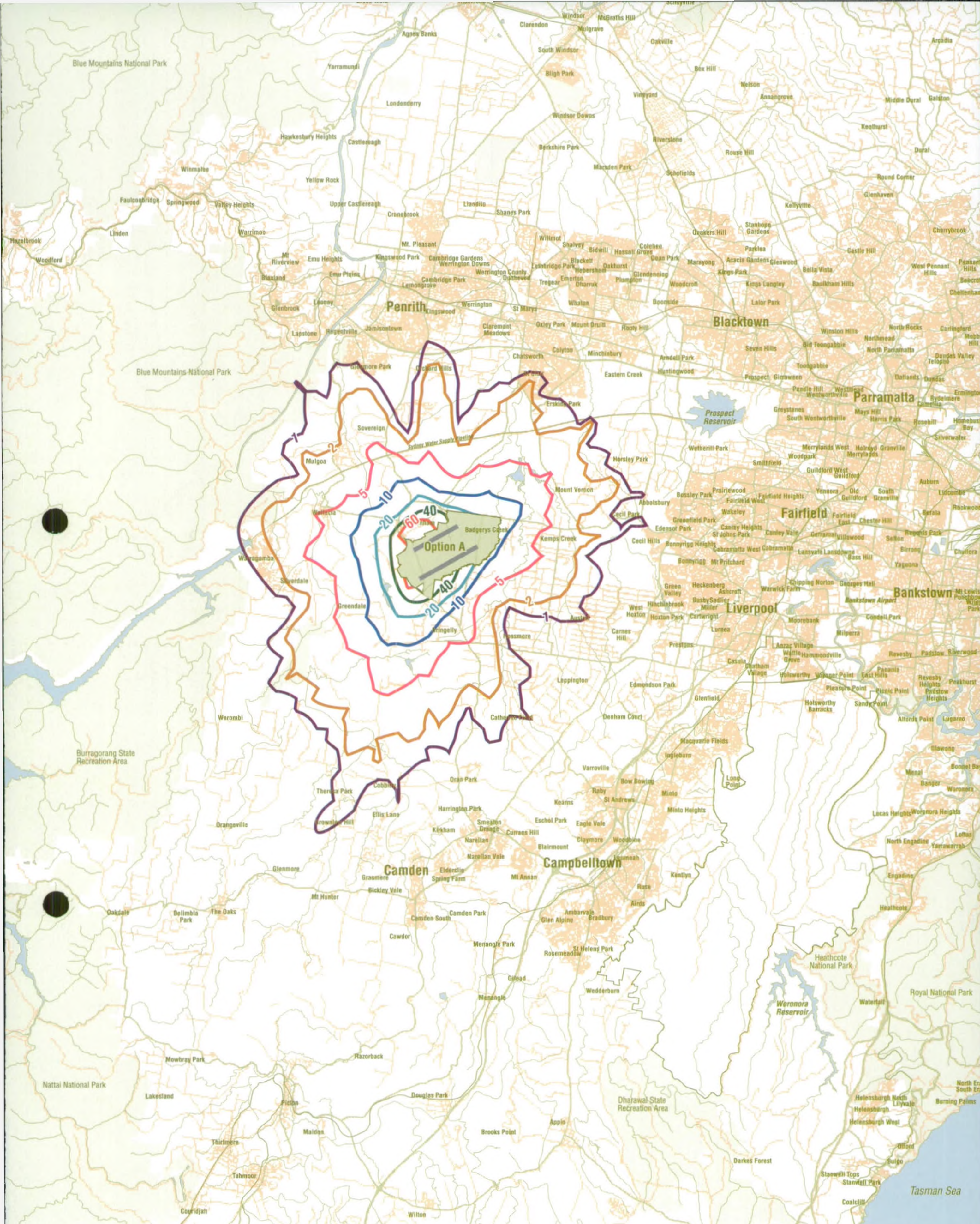
1 day per year	60 days per year
2 days per year	80 days per year
5 days per year	100 days per year
10 days per year	200 days per year
20 days per year	Urban areas (indicated by local roads)
40 day per year	

Figure K3.10

Annual Exposure to Greater Than 5 Parts Per Billion Increase in Maximum One Hour Sulphur Dioxide Concentrations for Option A (30 Million Passengers Per Year)

TN MN N

0Km 10Km

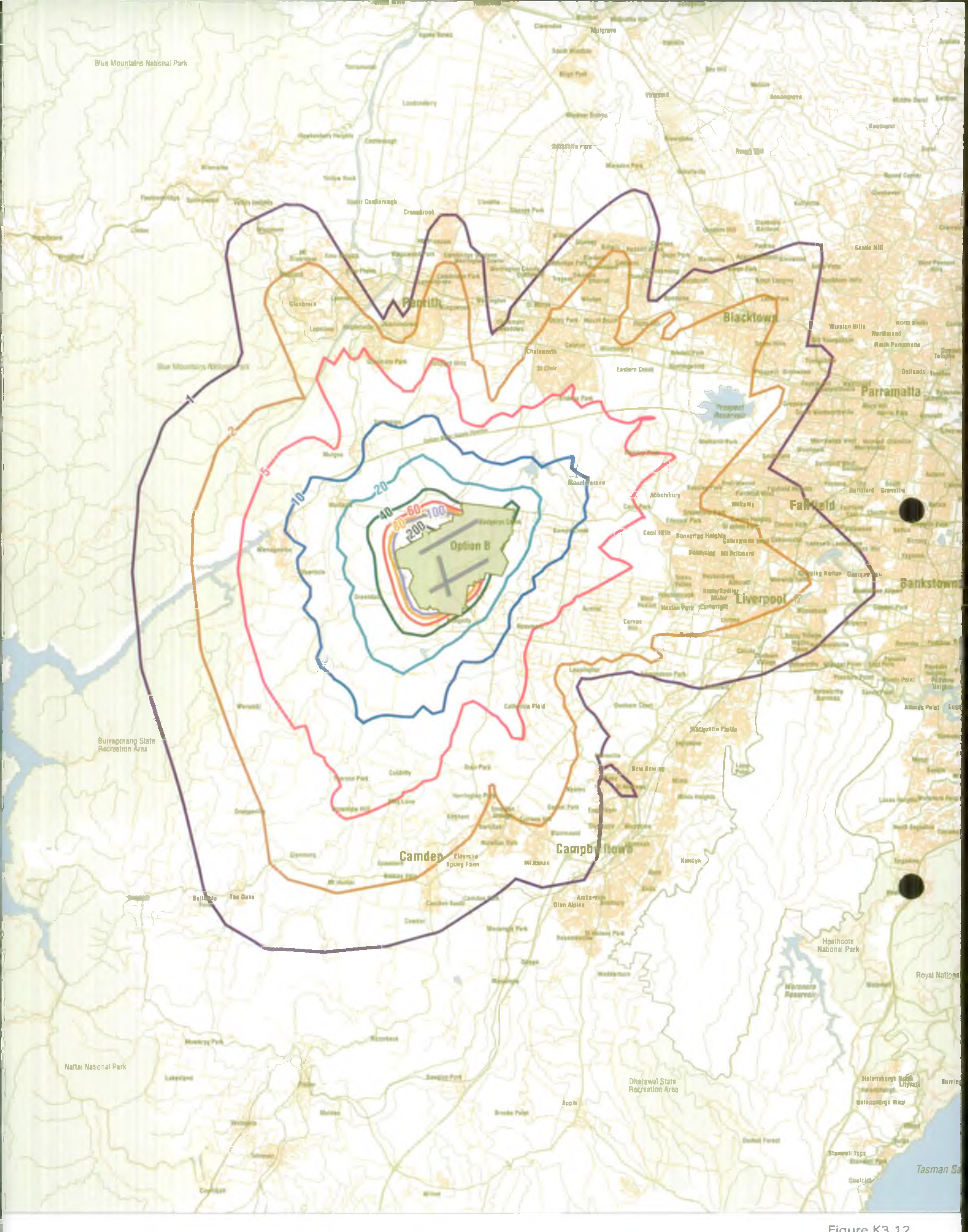


1 day per year
2 days per year
5 days per year
10 days per year
20 days per year
40 day per year
60 days per year
80 days per year
100 days per year
200 days per year
Urban areas (indicated by local roads)

Figure K3.11

Annual Exposure to Greater Than 10 Parts Per Billion Increase in Maximum One Hour Sulphur Dioxide Concentrations for Option A (30 Million Passengers Per Year)

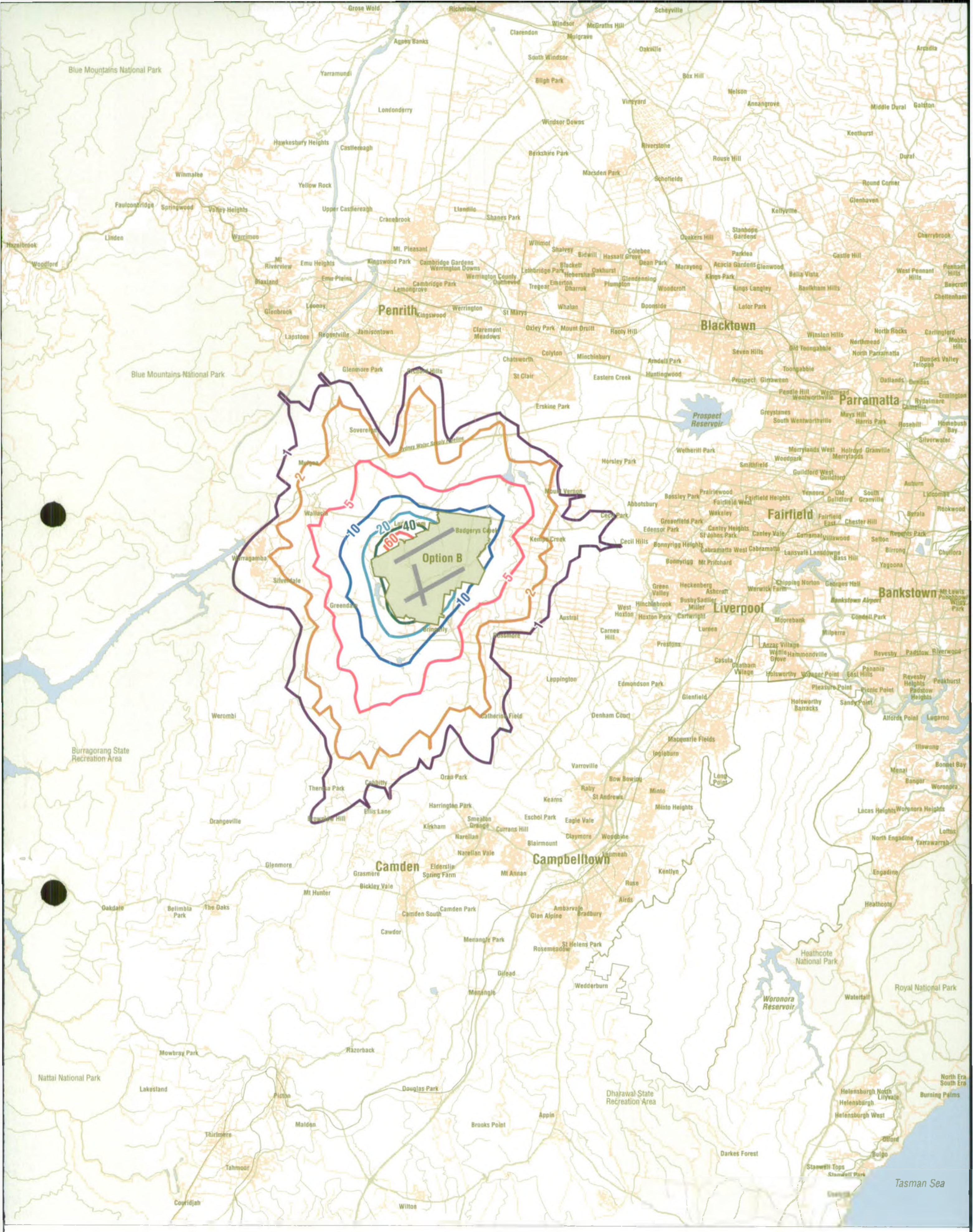
TN MN N 0Km 10Km



1 day per year
2 days per year
5 days per year
10 days per year
20 days per year
40 day per year
60 days per year
80 days per year
100 days per year
200 days per year
Urban areas (indicated by local roads)

Figure K3.12

Annual Exposure to Greater Than 5 Parts Per Billion Increase in Maximum One Hour Sulphur Dioxide Concentrations for Option B (30 Million Passengers Per Year)



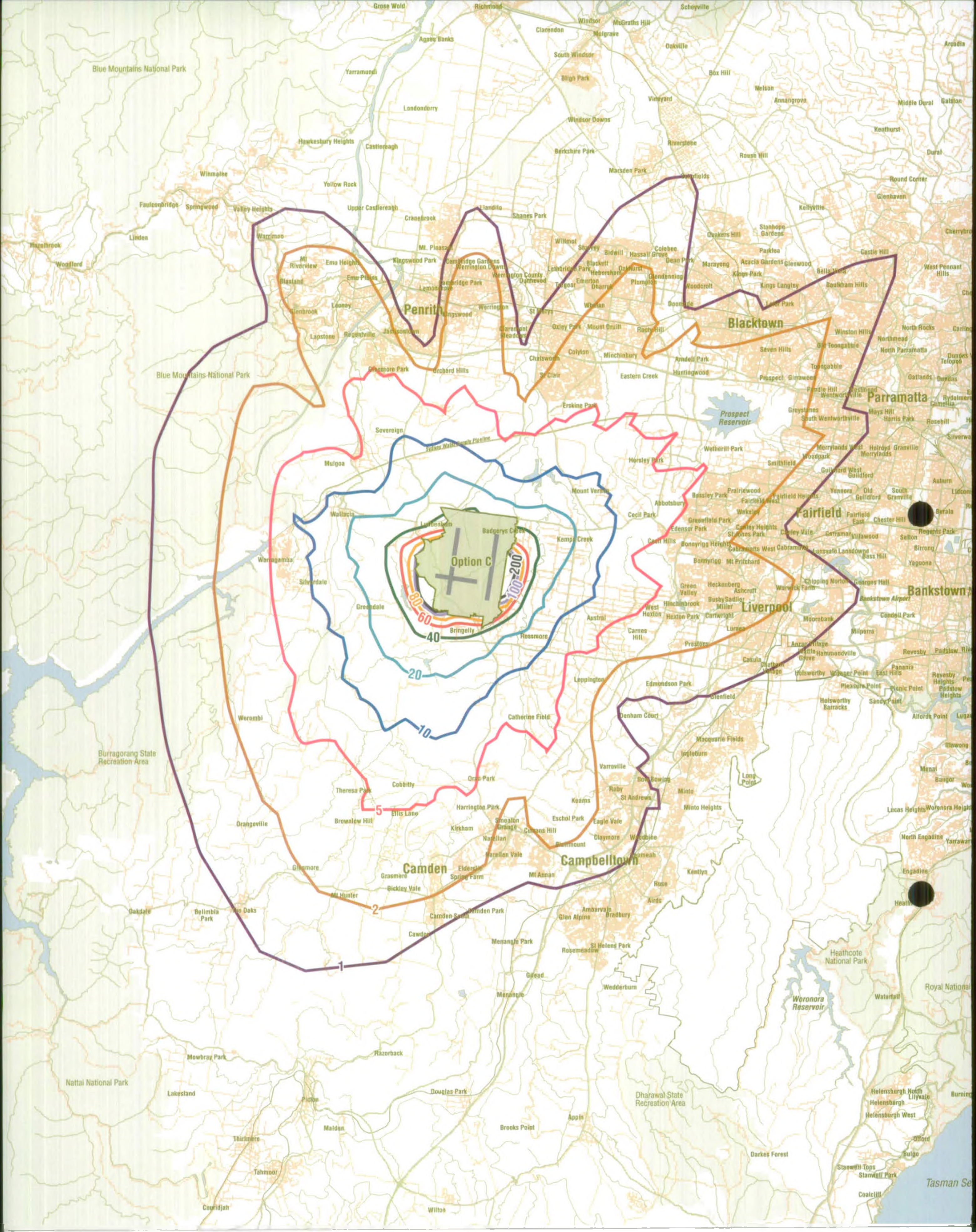
1 day per year		60 days per year	
2 days per year		80 days per year	
5 days per year		100 days per year	
10 days per year		200 days per year	
20 days per year		Urban areas (indicates by local roads)	
40 day per year			

Figure K3.13

Annual Exposure to Greater Than 10 Parts Per Billion Increase in Maximum One Hour Sulphur Dioxide Concentrations for Option B (30 Million Passengers Per Year)

TN MN

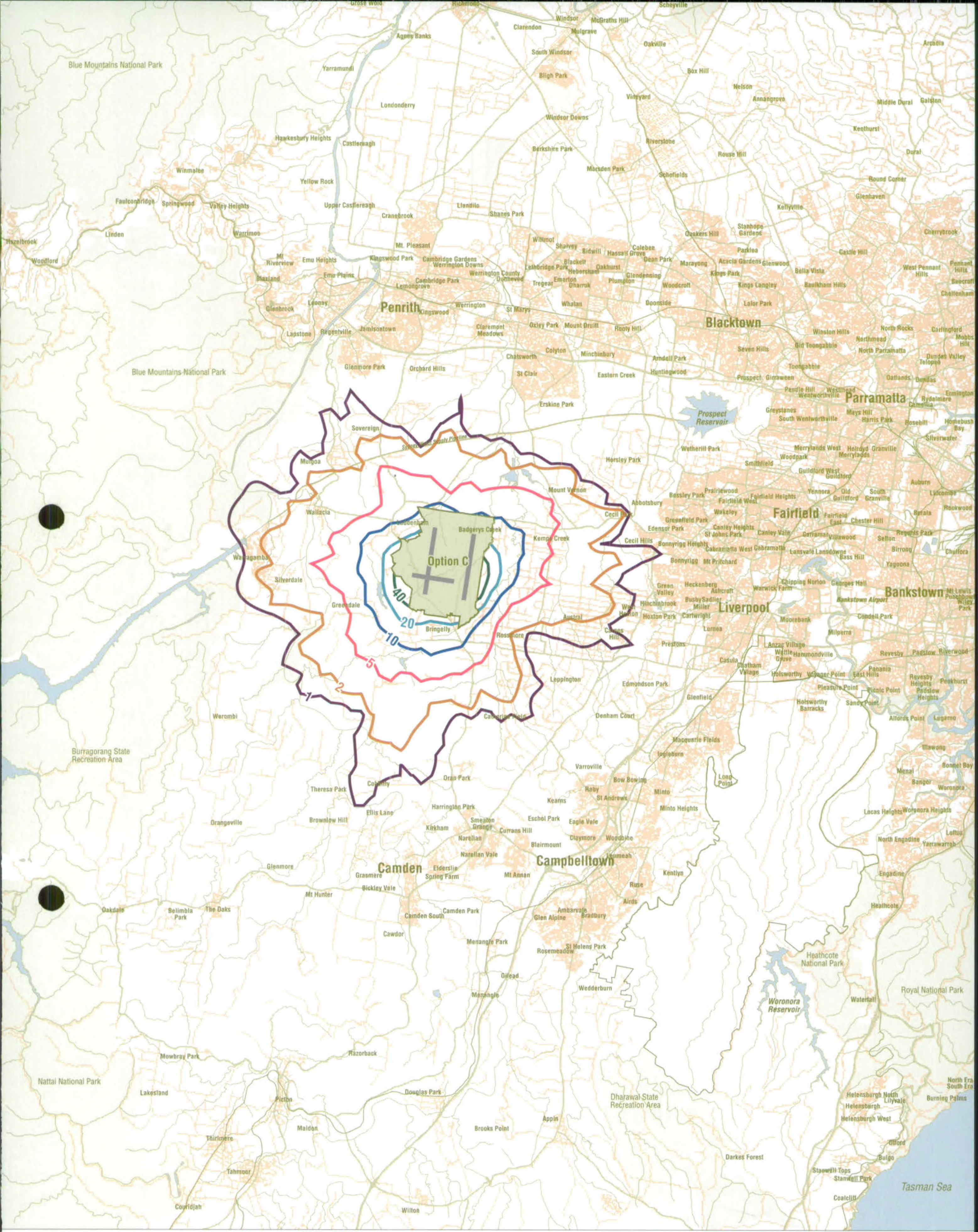
0Km 10Km



1 day per year		60 days per year	
2 days per year		80 days per year	
5 days per year		100 days per year	
10 days per year		200 days per year	
20 days per year		Urban areas (indicated by local roads)	
40 day per year			

Figure K3.14

Annual Exposure to Greater Than 5 Parts Per Billion Increase in Maximum One Hour Sulphur Dioxide Concentrations for Option C (30 Million Passengers Per Year)



1 day per year		60 days per year	
2 days per year		80 days per year	
5 days per year		100 days per year	
10 days per year		200 days per year	
20 days per year		Urban areas (indicated by local roads)	
40 day per year			

Figure K3.15

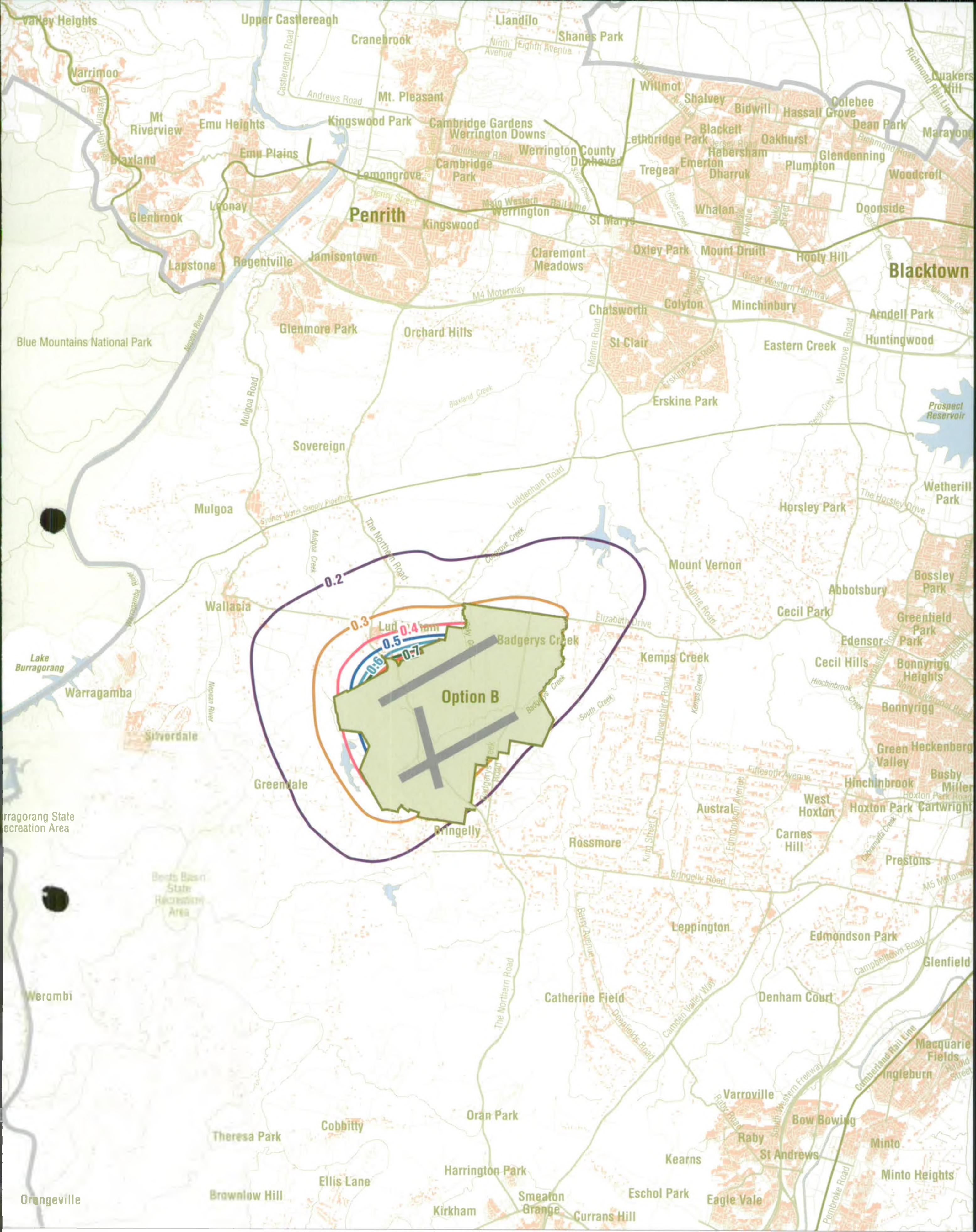
Annual Exposure to Greater Than 10 Parts Per Billion Increase in Maximum One Hour Sulphur Dioxide Concentrations for Option C (30 Million Passengers Per Year)

0Km 10Km

Air toxic reference dose index of 0.2
Air toxic reference dose index of 0.3
Air toxic reference dose index of 0.4
Air toxic reference dose index of 0.5
Air toxic reference dose index of 0.6
Air toxic reference dose index of 0.7
Air toxic reference dose index of 0.8
Air toxic reference dose index of 0.9
Air toxic reference dose index of 1.0
Indicates density of dwellings in 1996
Extent of dwelling data

Figure K3.16

Predicted Increase in Air Toxic Reference Dose Due to Lifetime Exposure to Air Toxics for Option A (30 Million Passengers Per Year)



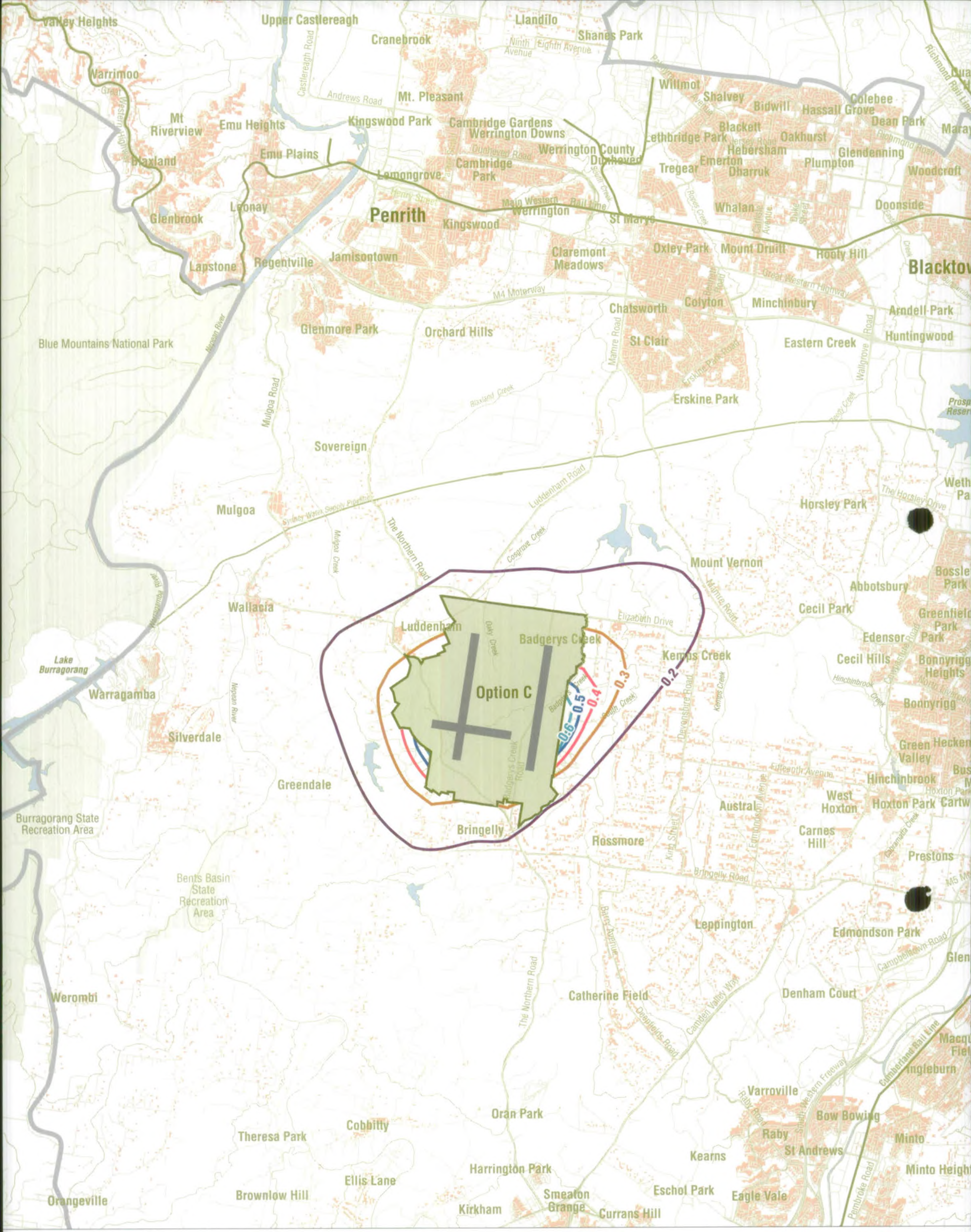
Air toxic reference dose index of 0.2
Air toxic reference dose index of 0.3
Air toxic reference dose index of 0.4
Air toxic reference dose index of 0.5
Air toxic reference dose index of 0.6
Air toxic reference dose index of 0.7
Air toxic reference dose index of 0.8
Air toxic reference dose index of 0.9
Air toxic reference dose index of 1.0
Indicates density of dwellings in 1996
Extent of dwelling data

Figure K3.17

Predicted Increase in Air Toxic Reference Dose Due to Lifetime Exposure to Air Toxics for Option B (30 Million Passengers Per Year)

TN MN N

0Km 5Km



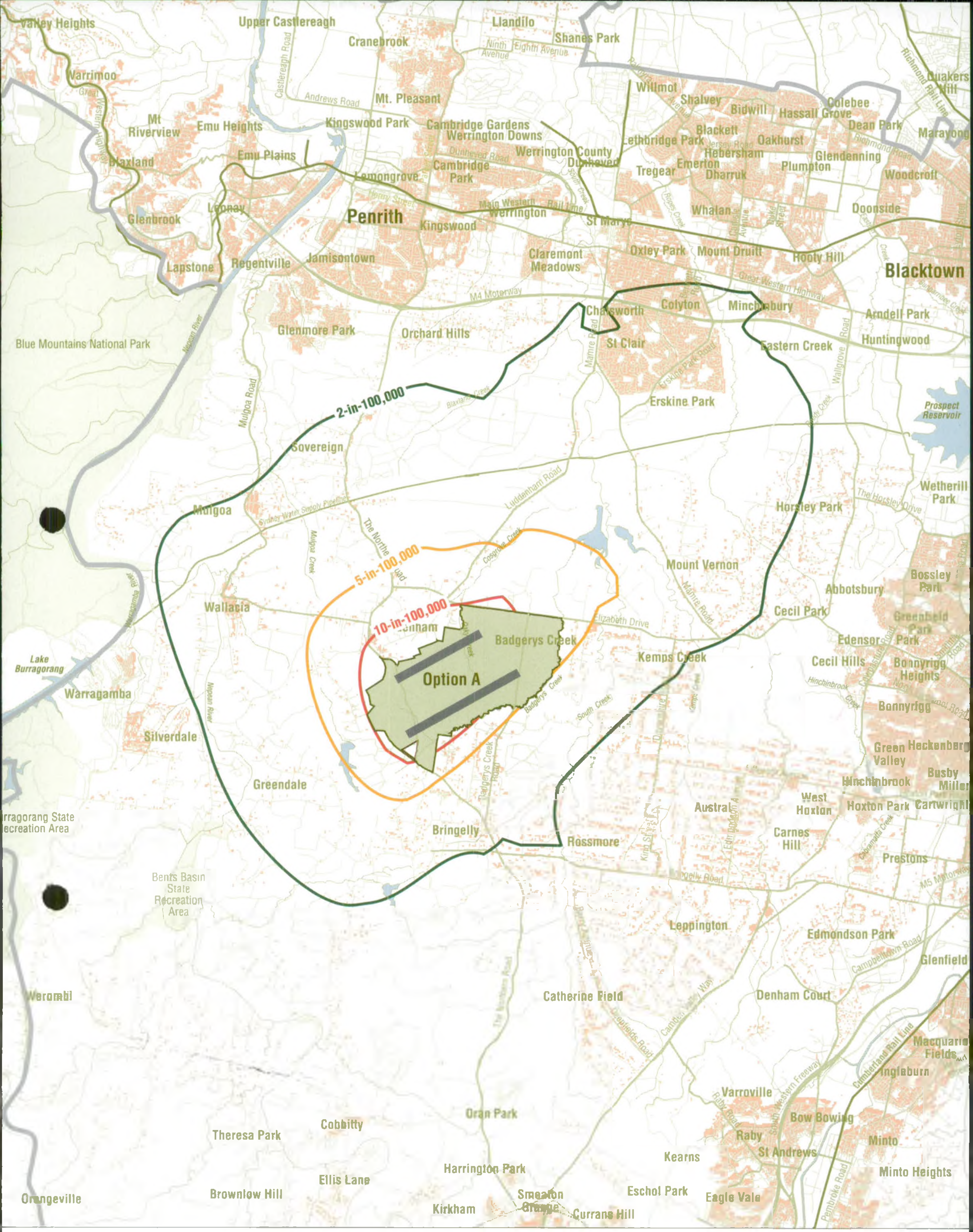
Air toxic reference dose index of 0.2
Air toxic reference dose index of 0.3
Air toxic reference dose index of 0.4
Air toxic reference dose index of 0.5
Air toxic reference dose index of 0.6
Air toxic reference dose index of 0.7
Air toxic reference dose index of 0.8
Air toxic reference dose index of 0.9
Air toxic reference dose index of 1.0
Indicates density of dwellings in 1996
Extent of dwelling data

Figure K3.18

Predicted Increase in Air Toxic Reference Dose Due to Lifetime Exposure to Air Toxics for Option C (30 Million Passengers Per Year)

TN MN

0Km 5Km



2 chances in 100,000

5 chances in 100,000

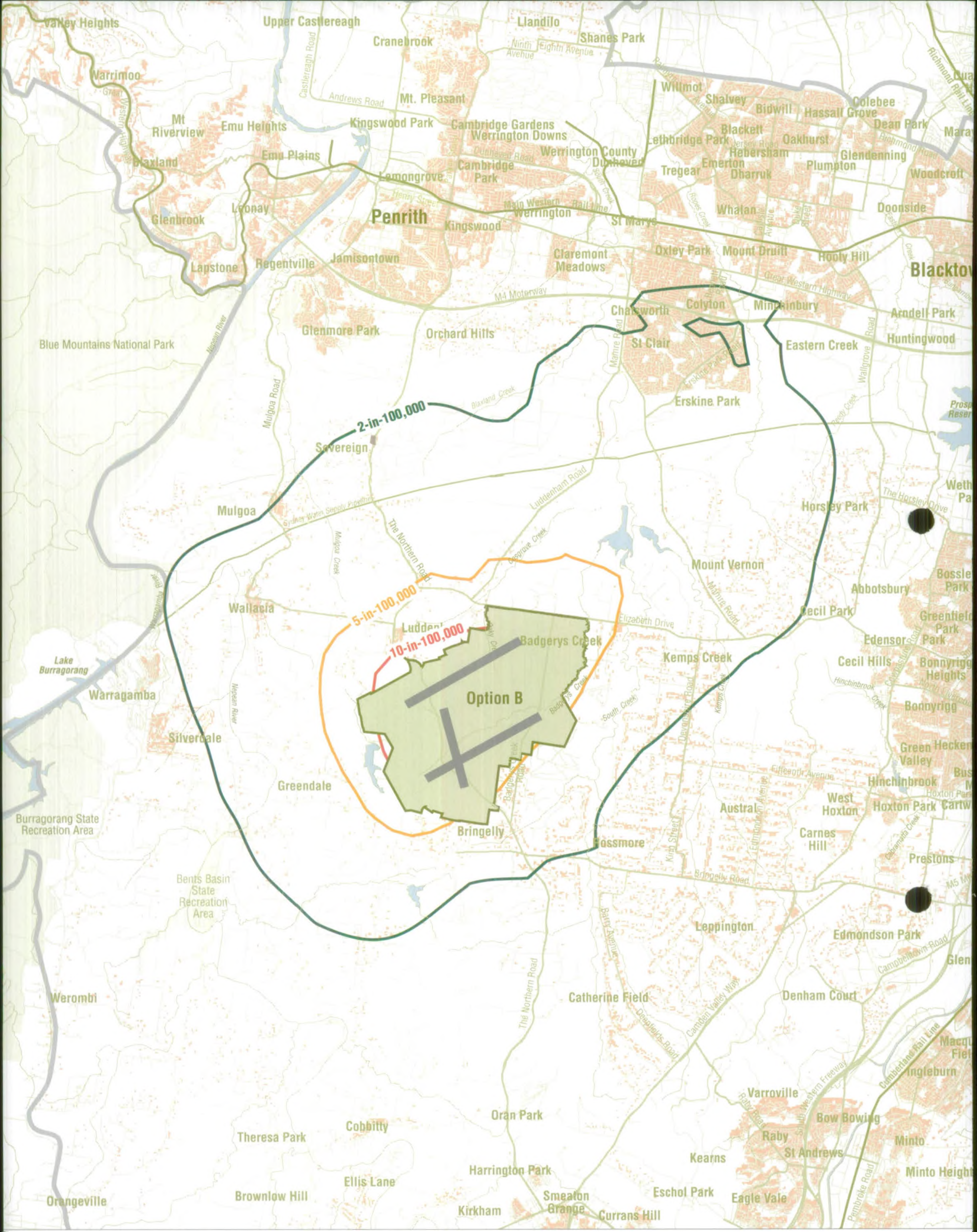
10 chances in 100,000

Indicates density of dwellings in 1996

Extent of dwelling data

Figure K3.19

Predicted Increase in Long Term Probability of Contracting Cancer Due to Lifetime (70 years) Exposure to Air Toxics for Option A (30 Million Passengers Per Year)



2 chances in 100,000

5 chances in 100,000

10 chances in 100,000

Indicates density of dwellings in 1996

Extent of dwelling data

Figure K3.20

Predicted Increase in Long Term Probability of Contracting Cancer Due to Lifetime (70 years) Exposure to Air Toxics for Option B (30 Million Passengers Per Year)

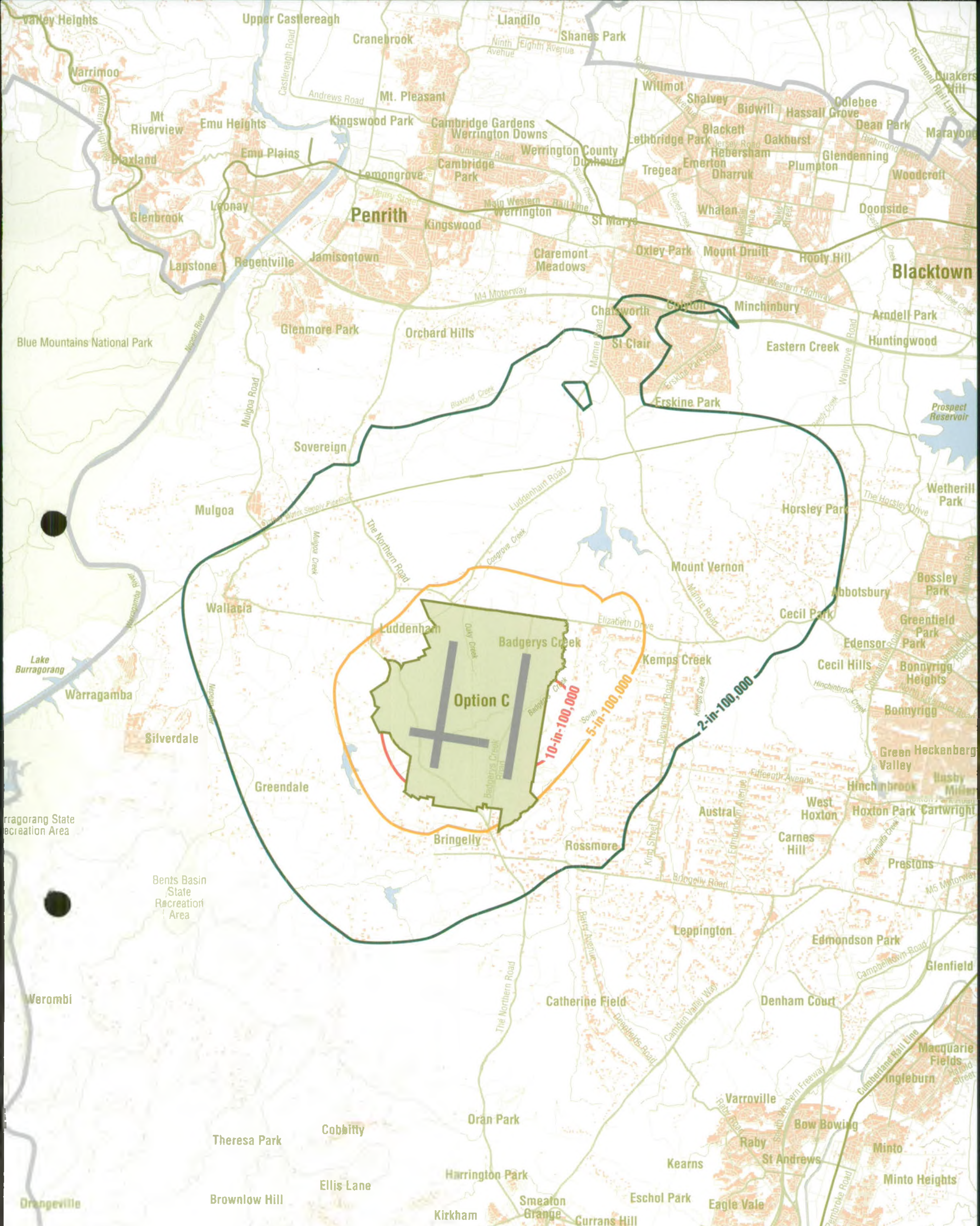


Figure K3.21

Predicted Increase in Long Term Probability of Contracting Cancer Due to Lifetime (70 years) Exposure to Air Toxics for Option C (30 Million Passengers Per Year)

2 chances in 100,000

5 chances in 100,000

10 chances in 100,000

Indicates density of dwellings in 1996

Extent of dwelling data

Appendix L

Social and Cumulative Impact Assessment Areas - Key Demographic Characteristics

Appendix L

Social and Cumulative Impact Assessment Areas - Key Demographic Characteristics

Table L.1: Age Cohort

Assessment Areas	Percentage of Age Group Category																					
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-98	99+	O/S[1] Visitor
Local Areas																						
Mulgoa/Sovereign/Wallacia	7	8	8	9	8	5	7	7	8	9	6	4	3	3	3	2	1	1	-	-	-	1
Orchard Hills	7	8	8	7	9	9	7	8	5	8	7	6	4	3	2	1	1	-	-	-	-	-
Mount Vernon/Cecil Park	6	7	7	9	11	7	7	6	7	8	6	5	4	3	3	2	1	-	-	-	-	-
Greendale	8	7	7	9	10	8	7	7	7	9	7	5	5	1	1	1	-	-	-	-	-	-
Camden Rural Lands	6	8	9	9	8	5	7	7	8	9	7	6	5	3	2	1	1	-	-	-	-	-
Warragamba/Silverdale	8	10	10	8	6	6	8	10	9	8	5	3	3	2	2	1	1	-	-	-	-	-
Badgerys Creek/Kemps Creek	8	8	9	8	8	7	8	8	8	8	6	5	3	3	2	1	-	-	-	-	-	-
Bringelly/Rossmore	7	7	8	8	9	7	6	6	8	8	7	5	4	3	2	1	1	1	-	-	-	-
Sub Regions (Local Government Areas)																						
Blacktown	9	9	8	8	8	8	8	8	7	7	5	4	3	3	2	1	1	-	-	-	-	-
Camden	9	9	8	7	8	8	9	8	8	7	5	4	3	2	2	2	1	1	-	-	-	-

Assessment Areas	Percentage of Age Group Category																					
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-98	99+	O/S[1] Visitor
Campbelltown	10	10	10	9	8	7	8	8	8	7	5	3	2	2	2	1	1	-	-	-	-	-
Fairfield	8	8	8	8	8	8	8	9	8	7	5	4	4	3	2	1	1	-	-	-	-	-
Liverpool	9	8	7	7	9	9	9	8	7	6	5	4	3	3	5	1	1	-	-	-	-	-
Penrith	9	9	9	8	8	8	8	9	8	7	5	3	2	2	2	1	1	-	-	-	-	-
Sydney Metropolitan Area																						
Sydney Metropolitan Area (45 Local Government Areas)	7	7	7	7	8	8	8	8	7	7	6	4	4	4	3	2	2	1	-	-	-	-

Source: Australian Bureau of Statistics Census of Population and Housing, 1996 Table B03
Notes: 1. O/S Indicates Overseas Visitor

Table L2: Occupation

Assessment Area	Percentage of Occupation Category						
	Managers and Administrators	Professionals and Para-Professionals[1]	Tradespersons and Related Workers	Clerical and Sales[2]	Intermediate Production and Transport Workers	Labourers and Related Workers	Others[3]
Local Areas							
Mulgoa/Sovereign/Wallacia	12	25	17	29	8	6	3
Orchard Hills	11	22	15	27	9	12	4
Mount Vernon/Cecil Park	15	17	18	27	10	10	4
Greendale	17	16	20	25	8	11	4
Camden Rural Lands	16	22	17	25	10	8	3

Assessment Area	Percentage of Occupation Category						
	Managers and Administrators	Professionals and Para-Professionals[1]	Tradespersons and Related Workers	Clerical and Sales[2]	Intermediate Production and Transport Workers	Labourers and Related Workers	Others[3]
Warragamba/Silverdale	12	23	16	29	10	7	3
Badgerys Creek/Kemps Creek	13	14	21	24	14	11	2
Bringelly/Rossmore	14	16	18	27	13	10	3
Sub Regions (Local Government Areas)							
Blacktown	5	20	15	33	13	10	3
Camden	9	26	15	31	10	6	2
Campbelltown	5	21	15	35	12	9	3
Fairfield	4	17	17	28	15	14	4
Liverpool	6	20	17	32	13	10	3
Penrith	6	22	15	34	12	8	3
Sydney Metropolitan Area							
Sydney Metropolitan Area (45 Local Government Areas)	8	31	12	31	8	7	3

Source: Australian Bureau of Statistics Census of Population and Housing, 1996 Table B20

Notes:
1. Professionals and associate professionals
2. Clerical and sales includes advanced clerical and services, intermediate clerical and sales, elementary clerical and sales
3. Other include not stated and inadequately described.

Table L3: Weekly Household Income

Assessment Areas	Percentage of Weekly Household Income Category										
	Nil/ Negative	$1 - $119	$120 - $299	$300 - $499	$500 - $699	$700 - $999	$1,000 - $1,499	$1,500 - $1,999	$2,000 and Over	Partial Income Stated	Incomes Not Stated
Local Areas											
Mulgoa/Sovereign/Wallacia	1	1	12	12	11	14	17	9	7	11	4
Orchard Hills	1	-	10	10	12	17	16	7	13	10	3
Mount Vernon/Cecil Park	1	1	11	12	11	15	17	7	8	15	3
Greendale	1	-	8	9	16	16	18	7	9	13	3
Camden Rural Lands	1	-	13	12	13	14	16	6	9	13	3
Warragamba/Silverdale	-	1	12	12	13	18	19	8	5	10	2
Badgerys Creek/Kemps Creek	-	-	8	14	17	15	17	6	5	11	6
Bringelly/Rossmore	1	1	10	13	14	15	18	8	6	12	2
Sub Regions (Local Government Areas)											
Blacktown	-	-	14	14	13	18	18	7	3	9	3
Camden	1	-	11	11	12	18	21	9	6	9	2
Campbelltown	-	-	13	14	13	19	18	7	4	9	3
Fairfield	1	1	16	16	14	17	15	5	3	10	3
Liverpool	1	1	15	14	14	17	17	6	4	9	3
Penrith	-	-	12	12	13	19	20	7	4	8	3

Assessment Areas	Percentage of Weekly Household Income Category										
	Nil/ Negative	$1 - $119	$120 - $299	$300 - $499	$500 - $699	$700 - $999	$1,000 - $1,499	$1,500 - $1,999	$2,000 and Over	Partial Income Stated	Incomes Not Stated
Sydney Metropolitan Area											
Sydney Metropolitan Area (45 Local Government Areas)	1	1	15	13	12	15	16	7	8	9	3

Source: Australian Bureau of Statistics Census of Population and Housing, 1996 Table B23

Table L4: Industry

Industry	Percentage of Assessment Areas														
	Local Areas								Sub Regions						Sydney
	Mulgoa/ Sovereign/ Wallacia	Orchard Hills	Mt Vernon/ Cecil Pk	Green -dale	Camden Rural Lands	Warra-gamba/ Silverdale	Badgerys Creek/ Kemps Ck	Bringelly/ Rossmore	Black-town	Camden	Campbell -town	Fairfield	Liverpool	Penrith	Metro. Area (45 LGAs)
Agriculture/Forestry/ Fishing	4	8	14	16	11	6	10	10	1	3	1	1	1	1	1
Mining	1	-	-	-	1	1	1	-	-	1	-	-	-	-	-
Manufacturing	13	11	13	16	13	16	15	14	18	14	18	25	19	16	13
Electricity/Gas/Water	-	-	-	1	1	2	1	1	1	1	1	1	1	1	1
Construction	12	11	14	10	12	10	13	14	7	9	7	9	8	8	6
Wholesale Trade	7	6	7	8	6	8	6	8	9	7	7	7	7	8	7
Retail Trade	15	14	16	11	13	13	12	13	13	14	14	14	13	15	13
Accommodation/Cafes/ Restaurants	4	3	2	1	3	3	2	3	3	3	3	4	3	4	4

Industry	Percentage of Assessment Areas														
	Local Areas								Sub Regions						Sydney
	Mulgoa/ Soverelgn/ Wallacia	Orchard Hills	Mt Vernon/ Cecil Pk	Green -dale	Camden Rural Lands	Warra- gamba/ Silverdale	Badgerys Creek/ Kemps Ck	Bringelly/ Rossmore	Black- town	Camden	Campbell -town	Fairfield	Liverpool	Penrith	Metro. Area (45 LGAs)
Transport/Storage	4	3	5	6	6	4	9	6	5	6	6	5	6	5	5
Communication Services	1	-	2	1	1	2	2	2	3	2	3	3	2	3	2
Finance/Insurance	2	3	3	2	3	3	2	2	5	4	5	4	4	5	6
Property Business Services	9	10	7	8	9	7	9	7	9	8	9	8	8	8	13
Government Administration/Defence	3	10	2	1	2	2	2	2	4	3	5	2	7	4	4
Education	7	4	2	5	7	7	3	3	4	8	6	3	4	5	6
Health Community Services	8	8	5	4	5	8	4	6	8	8	8	6	7	8	9
Cultural/Recreational Services	3	1	1	4	2	2	2	1	2	2	2	1	2	2	3
Personal/Other	3	3	2	2	3	4	4	3	3	4	4	3	3	4	4
Not Classifiable/Not Stated	4	3	4	4	4	4	3	4	4	3	3	5	4	3	3

Source: Australian Bureau of Statistics Census of Population and Housing, 1996 Table B20

Table L5: Labour Force Status

Assessment Areas	Percentage of Labour Force Status Category					
	Unemployed[1]	Employed[1]	Proportion of the Population Aged 15+ In the Labour Force	Proportion of the Population Aged 15+ Not In the Labour Force	Total Persons	People Aged 15+
Local Areas						
Mulgoa/Sovereign/Wallacia	5	95	70	30	3,042	2,266
Orchard Hills	4	96	68	32	1,531	1,146
Mount Vernon/Cecil Park	5	95	64	36	4,245	3,271
Greendale	6	94	71	29	776	589
Camden Rural Lands	6	94	67	33	5,860	4,439
Warragamba/Silverdale	6	94	68	32	6,082	4,267
Badgerys Creek/Kemps Creek	9	91	64	36	2,299	1,615
Bringelly/Rossmore	7	93	63	37	6,200	4,677
Sub Regions (Local Government Areas)						
Blacktown	9	91	64	36	232,219	166,323
Camden	5	95	69	31	32,107	23,377
Campbelltown	10	90	66	34	143,773	99,213
Fairfield	16	84	57	43	181,785	133,766
Liverpool	10	90	63	37	120,197	87,751
Penrith	7	93	69	31	163,122	116,679

Assessment Areas	Percentage of Labour Force Status Category					
	Unemployed[1]	Employed[1]	Proportion of the Population Aged 15+ in the Labour Force	Proportion of the Population Aged 15+ Not in the Labour Force	Total Persons	People Aged 15+
Sydney Metropolitan Area						
Sydney Metropolitan Area (45 Local Government Areas)	7	93	63	37	3,741,290	2,862,515

Source: Australian Bureau of Statistics Census of Population and Housing, 1996 Table B01
Notes: 1. Only applies to 15+ age groups

Table L6: Ethnicity

Assessment Areas	Percentage of Ethnic Group – Place of Birth						
	Australia and Oceania	UK and Ireland	Europe and USSR excluding UK and Ireland	Middle East/ North Africa/ Africa	Asia	North, Central and South America	Other[1]
Local Areas							
Mulgoa/Sovereign/Wallacia	78	8	8	1	2	-	3
Orchard Hills	72	5	14	2	2	1	5
Mount Vernon/Cecil Park	66	2	21	2	5	1	3
Greendale	80	4	10	1	1	-	4
Camden Rural Lands	74	6	12	2	3	1	3
Warragamba/Silverdale	82	7	5	-	1	1	4
Badgerys Creek/Kemps Creek	67	4	17	2	4	-	6
Bringelly/Rossmore	69	4	18	3	3	-	3

Assessment Areas	Percentage of Ethnic Group						
	Place of Birth						
	Australia and Oceania	UK and Ireland	Europe and USSR excluding UK and Ireland	Middle East/ North Africa/ Africa	Asia	North, Central and South America	Other[1]
Sub Regions (Local Government Areas)							
Blacktown	69	5	8	4	10	1	4
Camden	81	7	5	1	2	1	3
Campbelltown	75	7	4	3	5	2	4
Fairfield	45	2	13	7	26	4	4
Liverpool	65	4	11	4	9	3	4
Penrith	76	8	6	2	4	1	3
Sydney Metropolitan Area							
Sydney Metropolitan Area (45 Local Government Areas)	66	5	8	4	11	2	4

Source: Australian Bureau of Statistics Census of Population and Housing, 1996 Table B06
Notes: 1. Other includes "inadequately described", "at sea", "not stated" and "overseas visitor".

Table L7: Household Tenure and Occupancy

Assessment Areas	Percentage of Household Tenure and Occupancy						
	Occupied Dwellings						
	Fully Owned	Being Purchased	Being Purchased Rent/Buy Scheme	Rented	Rent Free or Life Tenure Scheme	Other[1]	Unoccupied Private Dwellings
Local Areas							
Mulgoa/Sovereign/Wallacia	46	30	-	16	3	4	7

Assessment Areas	Percentage of Household Tenure and Occupancy						
	Occupied Dwellings						
	Fully Owned	Being Purchased	Being Purchased Rent/Buy Scheme	Rented	Rent Free or Life Tenure Scheme	Other[1]	Unoccupied Private Dwellings
Orchard Hills	55	18	-	17	3	6	8
Mount Vernon/Cecil Park	59	11	-	21	4	5	6
Greendale	47	16	-	26	6	5	6
Camden Rural Lands	55	20	-	17	4	4	5
Warragamba/Silverdale	45	35	-	12	2	5	5
Badgerys Creek/Kemps Creek	39	13	-	36	4	8	5
Bringelly/Rossmore	56	19	1	17	3	5	4
Sub Regions (Local Government Areas)							
Blacktown	31	34	1	29	1	4	4
Camden	36	41	1	18	2	3	4
Campbelltown	27	37	1	32	1	4	4
Fairfield	42	21	1	30	1	5	4
Liverpool	31	28	1	35	1	4	5
Penrith	32	38	1	24	1	4	4
Sydney Metropolitan Area							
Sydney Metropolitan Area (45 Local Government Areas)	41	23	-	30	1	5	7

Source: Australian Bureau of Statistics Census of Population and Housing, 1996 Table B14
Notes: 1. Other includes "not stated".

Appendix M

Environmental Management Measures

Appendix M

Environmental Management Measures

1. Introduction

1.1 Purpose of this Appendix

The purpose of this Appendix is to:

- provide a summary of the environmental management measures identified in the Draft EIS and EIS Supplement, drawing together relevant information aimed at mitigating environmental impacts;
- identify a range of management measures which would be implemented during construction and operation of the Second Sydney Airport; and
- identify a range of possible management measures where the precise method of management cannot be determined at this time due to uncertainty regarding the staging of airport development or the nature of airport operation.

1.2 Environmental Issues at the Second Sydney Airport

The *Airports Act 1996* provides a comprehensive Commonwealth environmental management regime at leased Federal airports.

Environmental management of the Second Sydney Airport would also be undertaken within a broader framework which would include establishing a Regional Planning Co-ordination Body and developing a Noise Management Plan.

The environmental issues which form part of the outline of environmental management measures have been grouped into the following broad categories:

- community involvement;
- planning and land use;
- aircraft overflight noise;
- other noise;
- air quality;

- soils and water;
- flora and fauna;
- resources;
- energy;
- waste;
- hazards and risks;
- cultural heritage;
- access and traffic; and
- visual and landscape.

This Appendix presents management measures which would, or in some case possibly could, be implemented to prevent environmental harm, or where prevention is not reasonable or practicable, control or reduce potential environmental impacts associated with the construction and/or operation of the Second Sydney Airport. The following matters would be taken into consideration in determining whether a particular measure is reasonable and practicable:

- the sensitivity of the receiving environment;
- the nature of the harm that the undertaking would cause, or has the potential to cause;
- the current state of technical knowledge about preventing, or minimising, the environmental impacts of a particular undertaking; and
- the probable benefits and detriments (if any) that should be expected from the implementation of each measure.

1.3 Environmental Management of the Second Sydney Airport

The management of the on-airport environment issues would fall under the requirements of the *Airports Act 1996* and the *Airports (Environment Protection) Regulations*.

Responsibility for ensuring that the environmental management measures are carried out, including monitoring, reporting and demonstrating compliance with relevant legislation would be determined by the airport lessee company as part of its environment strategy in accordance with the *Airports Act 1996* and the *Airports (Environment Protection) Regulations 1997*. In addition an airport lessee company would be required to abide by the requirements and standards of the *Airports (Environment Protection) Regulations* during the construction and operation of a Second Sydney Airport. It is expected that during construction and operation of the airport, the airport environment officer appointed by the Department of Transport and Regional Services would ensure compliance with the *Airports Act 1996* and

Airports (Environment Protection) Regulations. In addition it is felt that an airport lessee company would appoint environmental management staff who would be responsible for developing a comprehensive environmental management plan generally consistent with the measures described in this Appendix.

2. Potential Management Measures

2.1 Community Involvement

2.1.1 Introduction

The purpose of these environmental management measures is to establish effective lines of communication with the potentially affected community with a view to providing opportunities for public involvement and participation in the planning, design, construction and operation of the Second Sydney Airport.

Communication strategies would be developed specific to the requirements and processes set out under the *Airports Act 1996* and those established by the operator of the airport. These specific management measures would respond to goals and objectives in relation to community consultation, wider communication and community relations.

The construction phase has the potential to affect the community through both direct and indirect impacts. Direct impacts would include issues such as the impact from noise and dust, while indirect impacts would include issues such as inconvenience associated with changed traffic arrangements. While construction impacts would be temporary, localised and where possible mitigated through the implementation of environmental management measures, effective communication with the local community would form an important component of the consultation process. The need for consultation would be immediate, given the high level of community interest and debate about the proposal in preceding years.

During operation of the airport the main impact on the community is likely to be aircraft overflight noise. There also may be some impacts on the local community from other operational activities such as aircraft maintenance, access and traffic management and ongoing on-site construction and repair works.

2.1.2 Proposed Management Controls - Construction Phase

Strategy 1: Develop a Consultation and Communications Strategy for the Construction Phase

Proposed Actions:

The aims of the Consultation and Communications Strategy would include, but would not be limited to:

- helping the airport lessee company reach better decisions regarding the selection of construction methods and alternatives to mitigate potential environmental impacts during construction;
- informing the community of construction activities, plans and decisions;
- providing opportunities for community involvement at a national, State and local level to broaden the information base on which decisions are made;
- establishing a community liaison forum to discuss and work towards resolving specific environmental issues relating to construction activities;
- undertaking direct consultation with the local community regarding construction activities, examining issues such as:
  - signage;
  - construction traffic management;
  - pedestrian management;
  - property access;
  - dust management and air quality;
  - noise management;
  - visual and lighting;
  - flora and fauna;
  - waste management;
  - use of chemicals/other hazardous materials;
  - cultural heritage; and
  - water quality and flooding.

Monitoring

Community issues and concerns would be monitored during construction and using methods such as:

- a procedure for recording community issues and complaints comprising a register which documents:
  - date of complaint;

  - method of communication;
  - name, address and telephone number of complainant;
  - nature of complaint;
  - response action taken and date of action; and
  - reply to complainant and date of reply;
- a telephone information line;
- a community liaison forum comprising representatives from:
  - local government;
  - NSW Agencies;
  - Commonwealth Agencies; and
  - local communities;
- discussions with councils, community groups and government authorities that liaise with the community; and
- other mechanisms which provide feedback of identified issues and concerns to the community liaison forum established as part of the Consultation and Communications Strategy.

Reporting

Regular reporting (minimum six monthly) to the community liaison forum on the achievements and outcomes of environmental management during construction including the results of the Consultation and Communications Strategy.

2.1.3 Proposed Management Measures - Operational Phase

Strategy 2: Develop a Consultation and Communications Strategy as Part of the Environment Strategy for the Ongoing Operation of the Airport

Proposed Actions

The aims of the Consultation and Communications Strategy would include, but would not be limited to:

- helping the airport lessee company reach better decisions regarding mechanisms for controlling all on-site impacts during operation in accordance with the requirements of the *Airports Act 1996* and the *Airports (Environment Protection) Regulations, 1997.* The strategy would build upon the processes and networks of communication established during the Consultation and Communications Strategy for construction activities;
- informing the community of on-ground operational activities, plans and decisions;

- providing opportunities where appropriate for community involvement at a national, State and local level to broaden the information base on which decisions are made;
- establishing a community liaison forum to discuss and work towards resolving specific environmental issues relating to on-ground operational activities; and
- undertaking consultation with airport stakeholders (such as government authorities, airport tenants and interest groups) and the community regarding operational activities, including:
  - aircraft flight paths and operations;
  - operational traffic management;
  - pedestrian management;
  - information line;
  - noise management;
  - visual and lighting;
  - flora and fauna;
  - air quality;
  - waste management;
  - use of chemicals/other hazardous materials;
  - heritage; and
  - water quality and flooding.

Monitoring

Community issues and concerns would be monitored during ongoing operation using methods such as:

- a procedure for recording community issues and complaints similar to that described in Strategy 1 above;
- a telephone information line;
- a community liaison forum comprising representatives from:
  - local government;
  - NSW Agencies;
  - Commonwealth Agencies; and
  - local communities;
- discussions with Councils, community groups and government authorities that liaise with the community; and
- other mechanisms which provide feedback of identified issues and concerns to the community liaison forum established as part of Consultation and Communications Strategy.

Reporting

Regular reporting (minimum six monthly) to the community liaison forum on the achievements and outcomes of the community consultation strategy.

2.2 Planning and Land Use

2.2.1 Introduction

The airport would impact on local and regional planning and land use. Population growth and distribution, the type and location, employment generating activities, services, transport and infrastructure would all be influenced by the airport.

The objective of this environmental management measure is to encourage:

- the proper management, development and conservation of the region surrounding the Second Sydney Airport;
- the promotion and coordination of the orderly and economic use and development of land surrounding the Second Sydney Airport having regard to the impact of aircraft overflight noise;
- the development of existing and future employment opportunities generated by the development to contribute to the economic and employment base of western Sydney;
- the provision and coordination of the required infrastructure to support development of the Second Sydney Airport;
- the protection of the environment, and in particular, the mitigation of the impacts of the airport and airport-related development on the quality of air and water in South Creek Valley, and the region generally; and
- the sharing of responsibility for environmental planning between Commonwealth, State and local government.

2.2.2 Proposed Management Controls - Construction and Operation

Strategy 1: Encourage Establishment of, and Participate in, a Regional Planning Co-Ordination Body

Possible Actions:

The Commonwealth does not have any legislative control over land use and planning outside the boundary of the airport site (with the exception of the *Airports (Protection of Airspace) Regulations* that allows the Commonwealth to protect prescribed airspace outside of the airport boundary). Control would continue to reside with the State Government and local governments under the *Environmental Planning and Assessment Act 1979*. In this regard the following matters would need to be considered by any regional planning coordination body established to address planning and land use issues in the region surrounding the Second Sydney Airport:

- the appropriate level of funding and involvement to be provided in support of the Regional Planning Co-Ordination Body;
- the appropriate application of land use and planning controls to development proposed in areas affected by aircraft noise in accordance with *Australian Standard 2021*;
- the possibility of incorporating a concurrence role in local, regional or State environmental planning instruments for the airport lessee company for certain types of development within areas affected by aircraft overflight noise greater than 25 ANEC;
- the appropriate mechanisms for ensuring coordinated metropolitan and regional planning, having regard to the potential interaction with the metropolitan urban development program and any urban development proposed to be located along a rail link to the airport;
- the appropriate mechanisms for ensuring airport-related infrastructure is planned and coordinated in accordance with the requirements of the various provider agencies; and
- further consideration of policies and strategies to address air and water quality issues associated with any future urban development in the region surrounding the Second Sydney Airport.

Monitoring

Minutes of meetings and actions proposed and completed would be distributed to nominated stakeholders.

Reporting

Provide regular reports to relevant Commonwealth and NSW Government Ministers and all key stakeholders.

2.3 Aircraft Overflight Noise

2.3.1 Introduction

Aircraft overflight noise is considered a major issue associated with the operation of the Second Sydney Airport, particularly its impact on residences and communities in the vicinity. Concerns regarding aircraft overflight noise includes impacts on schools and learning, the use of community halls, libraries and outdoor sporting facilities; impacts on lifestyle, communications and sleep; financial impacts through devaluation of housing prices and insulation of affected residences.

Potential noise abatement procedures which could reasonably be expected to be implemented for each airport option have been identified as part of this Supplement and resultant noise impacts analysed. While Airservices Australia have confirmed that all procedures described in *Chapter* 8 of the Supplement would be feasible in operational terms, many would involve additional costs, particularly in terms of fuel usage. In addition, most management procedures involve "trading" higher noise exposure for a small number of people against lower exposure for a much larger number. Determination of final noise abatement procedures would need to consider these issues as well as the concepts of noise sharing, respite and other related strategies.

2.3.2 Proposed Management Controls - Operation

Strategy 1: Manage the Impact of Aircraft Overflight Noise

Possible Actions:

The development of a Noise Management Plan prior to commencing airport operations to minimise aircraft noise impacts having regard to the safety and efficiency of airport operations. The Noise Management Plan would be prepared by the airport lessee company in conjunction with Airservices Australia and in accordance with a Consultation and Communications Strategy, described in *Strategy 2 - Community Involvement*, which would seek to:

- help the airport lessee company and Airservices Australia reach better decisions regarding the issue of aircraft overflight noise and the selection of methods, mechanisms and operating plans to mitigate aircraft overflight noise impacts;
- inform the community of airport operation plans and discussions;
- provide opportunities for community involvement at a national, state and local level to broaden the information base on which decisions are made; and
- establish a community liaison forum to discuss and work towards resolving issues related to the Plan.

In developing the Plan the desirability and practicability of a range of noise management measures will be examined. These include

- the determination of flight paths;
- the determination of runway use;
- the provision of periods of respite from aircraft noise;
- the management of the numbers of aircraft overflights;
- the control of the loudness of noise events;
- the management of noise at night;

- the insulation and/or acquisition of buildings exposed to the highest noise levels;
- the imposition of a noise levy to fund noise amelioration works;
- the establishment of a permanently staffed Noise Enquiry Unit at the Airport;
- the installation of a satisfactory noise and flight path monitoring system; and
- the effective use of airspace associated with the operation of civil and military aircraft from other airports.

Monitoring

A noise and flight path monitoring system would be installed.

Reporting

Results of monitoring would be provided to the community liaison forum and the regional planning co-ordination body to assist the airport lessee company and Airservices Australia in the ongoing development of the Noise Management Plan.

2.4 Other Noise

2.4.1 Introduction

Construction of the airport would involve substantial clearing, earthmoving and building works which would use heavy plant and equipment. There would be large numbers of truck and small vehicle movements. Noise modelling carried out to assess the potential impact of noise on local residents indicated that the impact of construction noise would affect up to 2,700 persons. The *Airports (Environment Protection) Regulations* specify the standard for determining noise generated on the site of the airport from construction activity.

Operation of the airport would increase vehicle movements in the region, due to passengers travelling to and from the airport and the commercial activities associated with the airport. Noise would also be generated from aircraft and airport maintenance activities and operation of auxiliary power, air conditioning and refrigeration units.

The objective of this environmental management procedure is to manage noise, other than aircraft overflight noise, in a manner which would mitigate the impact on the community.

2.4.2 Proposed Management Controls - Construction Phase

Strategy 1: Plan Construction Activities to Manage Potential Noise Impacts

Proposed Actions

Management measures would include:

- preparing a construction noise management plan for each stage of construction prior to the commencement of work on each stage; based on the detailed noise modelling results and consultation with the Community Liaison Forum. The plan would include:
  - a description of the proposed activities;
  - an examination of alternative staging or construction methods that would potentially reduce noise impact;
  - an assessment of potential noise from proposed construction activities, including consideration of noise impacts from construction vehicle movement and traffic diversions;
  - a description of specific noise mitigation treatments and time restrictions;
  - a noise monitoring program; and
  - a description of the mechanisms for community consultation and notification;
- incorporating noise attenuation measures - such as restricted working hours, noise barriers and use of natural topography to shield construction activities in the noise management plan as required; and
- programming of noisy construction activities such as any blasting, crushing and screening of materials and work near the boundaries of the site, so they occur at times of least impact.

Monitoring

Noise monitoring would be carried out prior to commencement of construction activities to determine background noise levels at noise sensitive sites.

Reporting

Each noise management plan would be made available to the public.

Strategy 2: Manage Off-Site Impacts of Noise During Construction

Proposed Actions:

Management measures would include:

- implementing the construction noise management plan. The plan would likely include the following management measures:
  - ongoing community consultation during the construction program;
  - generally restricting working hours to 7.00 am to 5.00 pm Monday to Saturday. Work on Sundays, public holidays and at night-time may be required on occasions to maintain the construction schedule. Noisy activities would be avoided during early mornings and weekends where practicable;
  - neighbouring properties advised at least 24 hours in advance of timing and expected duration of particularly noisy activities and any activities to be undertaken on Sundays, public holidays or at night-time;
  - monitoring of noise from any paving and tarmac laying activities which could operate up to 24 hours a day;
  - plant and equipment chosen for paving and tarmac laying activities to operate within commercially acceptable noise limits for the particular types of plant;
  - panels and covers of acoustically treated plant and equipment would be kept shut;
  - fixed plant and equipment located as far away as practicable from noise sensitive areas and the location selected to optimise attenuation effects from topography, natural and purpose built barriers and material stockpiles;
  - regular monitoring of all items of plant and equipment to ensure that noise emissions do not increase during the construction program. Any equipment which does not meet commercially acceptable noise limits would be replaced with quieter plant;
  - the majority of vehicle movements to and from the site made on weekdays;
  - construction traffic directed along main roads in preference to local roads. See section 2.12 "Traffic" for further details; and
  - investigation of noise mitigation measures to reduce off-site impacts for local residents if detailed noise modelling indicates exceedances of the performance criteria. These measures could include roadside noise barriers to reduce the impacts of increased traffic movements due to airport construction activities.

Monitoring

Regular monitoring of individual earthmoving equipment noise levels.

Regular monitoring of noise levels at airport boundaries and noise sensitive locations carried out for construction activities.

Reporting

A noise monitoring report would be prepared on a monthly basis and forwarded to relevant government authorities. The results of the monthly monitoring would be incorporated into a six-monthly environmental monitoring report to be made available to the public.

Regular reporting of equipment noise monitoring results. If results indicate an exceedance of the limits specified in the noise management plan, actions would be taken.

2.4.3 Proposed Management Measures - Operational Phase

Strategy 3: Manage Off-Site Impacts of Noise from Airport Activities

Proposed Actions:

Management measures would include:

- detailed noise modelling once detailed designs of the airport were completed;
- preparation of a noise management plan for the operation of the airport;
- provision and utilisation of acoustically treated facilities for engine maintenance;
- high powered ground running of aircraft engines carried out in a shielded areas away from noise sensitive locations;
- restriction of ground running and other ground equipment use to day time hours;
- investigation of the feasibility of restricting ground movements by aircraft under their own power, by towing of aircraft between the terminal and airfield; and
- refrigeration and air conditioning units would be acoustically treated and positioned on-site to reduce the off-site impacts by using natural shielding and use of buffer distances.

Monitoring

A noise monitoring program would be established to demonstrate compliance with the *Airport (Environment Protection) Regulations* limits.

Any exceedances of noise limits would be investigated and actions undertaken to address the issue.

Any complaints regarding operational noise at the airport would similarly be investigation and addressed.

Reporting

The results of noise monitoring would be reported as part of the environmental reporting undertaken for the environment strategy.

2.5 Air Quality

2.5.1 Introduction

Construction works for the proposed airport would generate dust and exhaust emissions that may result in short term localised air quality degradation if not managed appropriately.

The principal impact of construction on air quality would come from atmospheric dust generated by earthmoving activities and wind erosion of exposed surfaces. Other adverse effects such as those resulting from exhaust emissions of earthworks plant and gaseous emissions during detonation of explosives would be small by comparison. Dust modelling undertaken for the EIS has indicated that there would be the potential for dust deposition to occur beyond the boundary of the airport site in the absence of any management measures.

Sources of air pollutants generated from the operation of the airport would include aircraft exhaust, motor vehicle operation within the airport, combustion of gaseous fuels in boilers, evaporative losses from fuel storage tanks, use of surface coatings (paints and thinners), losses due to refuelling and maintenance operations and treatment of sewage. Air pollutants would include carbon monoxide, sulfur dioxide, nitrogen dioxide, particulates, hydrocarbons and odours.

This section outlines environmental management strategies and measures which aim to ameliorate the impacts of air emissions during construction and operation of the airport.

2.5.2 Proposed Management Controls - Construction

Strategy 1: Determine Local Meteorological Conditions

Proposed Actions:

Management measures would include a detailed meteorological monitoring program undertaken in conjunction with NSW Government agencies, for a minimum of 12 months prior to the commencement of airport operations.

Monitoring

Meteorological monitoring stations would measure key parameters, including:

- the vertical structure of wind;
- the temperature profile of the atmosphere;
- rainfall;
- wind speed and direction; and
- humidity.

Reporting

Reporting of monitoring results prior to commencement of detailed airport planning and design.

Strategy 2: Control Dust Emissions from Construction Activities

Proposed Actions:

Management Measures would include:

- a detailed dust management plan would be prepared prior to commencement of construction activities as part of the environment strategy. The dust management plan would likely include the following:
  - monitoring to assess weather conditions prior to and during dust generating activities to determine if conditions are suitable to proceed with these activities or if further mitigation measures are required;
  - minimising the clearance of vegetation where practicable;
  - defining trafficable areas to prevent unnecessary vehicle movement and disturbance to unsealed areas;
  - minimising dust emissions by regularly spraying all unsealed trafficable areas and working areas with a water cart, watersprays or sprinklers. Frequency of spraying would be determined based on weather conditions, erodability of soil and observation of any visible dust;
  - placing speed controls on vehicles, with roads signposted accordingly;
  - covering or treating all stockpiles with an appropriate material such as hydromulch as soon as practicable. Any temporary, untreated stockpiles would be sprayed regularly with water during windy conditions;
  - covering materials with the potential to generate dust, transported in trucks;
  - securing all truck tail gates prior to loading and after unloading materials;
  - fitting crushers and concrete mixers with dust suppression equipment;

- fitting workshop areas and site office access roads with hard surfaces. Access roads to be in use for six months or more would be sealed with bitumen or equivalent hard surface;
- utilising a mechanical road sweeping unit and water cart on-site to keep roads and traffic ways clean;
- prohibiting fires; and
- installing a wheel wash facility for use by all vehicles exiting the site during wet weather conditions.

Monitoring

Air quality monitoring stations would regularly measure criteria pollutants, including, but not limited to:

- nitrogen oxides (NO_X, NO_2 and NO);
- carbon monoxide;
- ozone;
- particulates;
- sulphur dioxide; and
- hydrocarbons.

n Other pollutants which would be monitored from stationary sources in accordance with the Airports (Environment Protection) Regulations, include:

- sulphuric acid mist and sulphur trioxide;
- acids and acid gases;
- fluorine compounds;
- chlorine and chlorine compounds;
- hydrogen sulphide;
- arsenic, cadmium, lead, mercury, nickel and nickel carbonyl; and
- gaseous emissions.

Selection of sites for air quality monitoring stations would be based on the following criteria:

- non-airport emissions should not be located between the airport and the airport monitoring station;
- major non-airport emission sources should not be located upwind of the airport;
- the site should be located so that winds carry airport emissions to the station on a relatively frequent basis;

- the site should be sufficiently distant from the runways or other individual emission sources so as to provide an indication of average emissions from the entire airport;
- the site should have mains power connected; and
- the site should be secure.

In addition the meteorological monitoring station would continue to measure key parameters, including:

- the vertical structure of wind;
- the temperature profile of the atmosphere;
- rainfall;
- wind speed and direction; and
- humidity.

The proposed monitoring program outlined above would need to be re-evaluated during the detailed design stage.

Monitoring stations would be sited in areas chosen to assess projected areas of greatest impact. Stations would also be placed in surrounding residential areas where possible. All complaints in relation to dust during construction would be recorded and investigated.

Reporting

Weekly report on airborne dust concentrations.

Monthly reports on monitoring results, revegetation on the site and any corrective action undertaken or recommended change in work practices to minimise dust emissions would be prepared.

Strategy 3: Control Vehicle Exhaust Emissions

Proposed Actions:

Management measures would include:

- vehicles, plant and equipment would be regularly serviced to ensure exhaust emissions comply with the requirements of the NSW Environment Protection Authority. Service records would be maintained; and
- site agreements, including those with sub-contractors, would contain provisions to stand down vehicles, plant or equipment which has excessively smoky exhausts.

Monitoring

Monitoring of vehicles to ensure compliance with Schedule 1 of the *Clean Air (Motor Vehicles and Motor Vehicle Fuels) Regulation 1997* would be carried out prior to its commissioning for use on-site and every six months thereafter for all vehicles, plant and equipment used on-site during construction.

Reporting

Six monthly report on monitoring of vehicle exhaust emissions any corrective action undertaken.

2.5.3 Operational Environmental Management Plan

Strategy 4: Reduce On-Ground Aircraft Emissions to Lowest Practicable Levels

Proposed Actions:

An inventory of merger emissions sources at or related to the airport would be prepared in the first year of operation for all emissions to air occurring within the airport's boundaries examining:

- aircraft engines during operation and maintenance;
- aircraft fuelling systems and fuel storage areas;
- service vehicles;
- road traffic associated with the airport;
- miscellaneous sources, such as aircraft auxiliary power units, boilers, surface preparation and coating operations and catering facilities; and
- ambient air quality.

Following development of the emissions inventory, a range of measures aimed at improving the environmental performance would be investigated, including:

- reducing of the number of aircraft engines in use during taxi and idle;
- turning off the auxiliary power unit while the aircraft are docked;
- certifying turbine powered aircraft and aircraft engines to standards relating to fuel venting, smoke emission and gaseous emissions;
- ensuring efficient use of the taxi-way system; and
- encouraging aircraft traffic control to delay engine start-up at terminal, wherever possible in the event of delays.

Note: Adoption of the above measures would be contingent on meeting acceptable safety standards and the improvements would depend on the proportion of the aircraft fleet able to adopt these measures.

Monitoring

Monitoring would be undertaken in accordance with the procedures outlined in *Strategy 2* above.

Reporting

Monthly reporting of ambient air quality.

Strategy 5: Reduce Air Emissions for Ground Support Fleet, Airport Plant and Equipment and Maintenance Activities to Lowest Practicable Levels

Proposed Actions:

Management measures would include:

- all fuel burning plant and equipment on the airport site to be regularly maintained and emission tested;
- investigate options to reduce oxides of nitrogen from heaters and boilers;
- improvement in emissions of the ground support fleet by use of low emissions engines such as those powered by electricity, LPG or CNG, where practicable and feasible;
- idling periods for ground services periods would be reduced where practicable by switching off when not in use;
- minimise the use of auxiliary power generation units through use of terminal based facilities such as centralised ground power system for both aircraft power and air conditioning where practicable and feasible;
- use of less solvent based paints, that is water based taxiway markings paint;
- recovering and recycling of chemical products; and
- all required approvals and licences for ozone depleting substances used on-site under the *Ozone Act* would be applied for and conditions complied with.

Monitoring

Emissions from ground support fleet and plant and equipment tested every six months. Ambient air monitoring at appropriate locations to ensure compliance with *Airport (Environment Protection) Regulations*.

Ambient air quality and meteorological monitoring would be undertaken in accordance with the procedures outlined in *Strategy 2* above.

Reporting

Maintenance services and results of testing of emissions would be reported every six months.

Strategy 6: Reduce Emissions from Fuelling and Fuel Storage to Lowest Practicable Levels

Proposed Actions:

Management measures would include:

- prevent and minimise the occurrence of fuel spills, through requiring tenants to train staff and provision and maintenance of appropriate equipment and supplies;
- a liquid spill manual would be prepared as part of the emergency response plan, see *Section 2.10 "Hazards and Risk"*, to reduce spill response and clean up times;
- a feasibility study for the installation of a vapour recovery system on the jet fuel storage tanks would be carried out and installed, if feasible;
- a vapour recovery unit for aircraft fuel tanks would be used for refuelling of aircraft; and
- a vapour return line would be installed for all mobile tankers for the recovery of vapours from fuel tanks.

Monitoring

Monitoring of vapour emitted from volatile organic liquids. Monitoring of volumes of fuel to calculate loss of fuel via emissions and spills.

Ambient air quality and meteorological monitoring would be undertaken in accordance with the procedures outlined in *Strategy 2* above.

Reporting

Reporting of air quality monitoring and calculations of fuel loss.

Strategy 7: Reduce Air Emissions from Vehicles On-Site

Possible Actions:

Potential management measures include:

- promote the use of public transport;

- provision of rail and shuttle bus links to and from the airport and airport terminals;
- promotion of timetables and transport links; and
- economic disincentives for airport employees who commute as single occupants of vehicles, such as increased parking rates relative to public transport costs.

Monitoring

Ambient air quality and meteorological monitoring would be undertaken in accordance with the procedures outlined in *Strategy 2* above.

Reporting

Reporting of vehicle emissions impact on air quality.

Strategy 8: Control Odour Emissions (Excluding Those From Aircraft)

Possible Actions

Potential management measures include:

- sludge handling facility and inlet works would be fully enclosed and ventilated;
- ventilated air from the sludge handling facility and inlet works would be passed through a scrubbing facility to reduce odours; and
- deodorising agents would be used as required.

Monitoring

Ambient air quality and meteorological monitoring would be undertaken in accordance with the procedures outlined in *Strategy 2* above.

Recording of any odour complaints.

Reporting

Any complaints received to be investigated and actioned.

Complaints and any actions taken reported.

2.6 Soils and Water

2.6.1 Introduction

The topography of the site varies from flat terrace tops to low hills. Three soil types have been identified on the site and all three have moderate to high erosion potential.

Although the airport has the potential to improve the regional water quality in the long term in the short term earthworks and land clearance associated with construction of the airport has the potential to result in soil erosion and sedimentation of nearby water ways.

Badgerys, South, Cosgrove and Oaky Creeks are located on or downstream of the site of the airport options. The existing water quality of these creeks is considered to range from poor to moderate. The poor to moderate water quality in these creeks is likely due to a number of factors including agricultural activities in the region. Badgerys and South Creek both have the potential to be subject to increased flooding as a result of the development of the site. The groundwater is currently considered too saline for most practical uses.

The development of the airport site would involve the modification of approximately five kilometres of stream for Option A and 10 kilometres for Options B and C. Modifications would involve infilling, redirection and channelisation of sections of creeks on the site.

The aims of these management measures are to maintain or improve the existing water quality, prevent flooding, protect groundwater, promote water conservation and reduce the risks of impact to the aquatic and riparian flora and fauna during construction and operation of the airport.

2.6.2 Proposed Management Controls - Preconstruction Phase

Strategy 1: Adopt Management Principles in Design and Construction Plans to Manage Stormwater and Soil Erosion

Proposed Actions:

Management measures would include:

- design stormwater drainage systems to reduce the velocity of stormwater run-off;
- direct all stormwater run-off to water pollution control ponds or detention basins;

- train construction personnel, including contractors, on the importance of erosion control measures;
- identify highly erodable soil and avoid activities involving disturbance of these areas where possible. Where avoidance is not possible, plan additional control measures for these identified areas;
- ensure finished slopes do not exceed one in four;
- identify locations where instream works are required and determine temporary stream diversion paths, if required;
- design secondary containment, such as bunds, for fuel and chemical storage areas to retain up to 110 percent of the total tank or drum storage capacity. See *Section 25.4.11 "Hazards and Risk" Strategy 1* for further spill prevention and control measures; and
- design flame traps to retain fuel spills on tarmac areas.

Monitoring

Monitor suspended solids concentration in stormwater run-off from the site prior to commencement of works.

Reporting

Reporting of monitoring results.

Strategy 2: Incorporate Management Measures in Design and Construction Plans to Manage Off-Site Impacts on Water Quality and Flooding

Proposed Actions:

Management measures would include:

- design water pollution control ponds to retain sediments and nutrients;
- design detention basins so that peak flow rates would not exceed preconstruction flows;
- review flood modelling prior to commencement of design and construction activities; and
- carry out flood investigations if modelling indicates a potential flooding issue. Investigations to consider impacts of any proposed mitigation works on upstream and downstream flooding impacts.

Monitoring

A water monitoring program would be designed and implemented prior to construction works to further establish baseline water characteristics.

Carry out biological assessment of Badgerys Creek downstream of the site prior to commencement of construction activities. Assessment to provide direct measurement of any impacts to the ecosystem during construction.

Reporting

Reporting of water quality monitoring program and biological assessment prior to commencement of construction works.

Strategy 3: Incorporate Management Measures in Design and Construction Plans to Manage Groundwater Impacts

Proposed Actions:

Management measures would include:

- investigate the need to install further groundwater monitoring bores; and
- installation of monitoring bores around fuel storage facilities to ensure the integrity of the containment measures.

Monitoring

Monthly groundwater samples and water levels to be taken at least 12 months prior to commencement of construction works.

Reporting

Reporting of groundwater monitoring results.

2.6.3 Proposed Management Controls - Construction Phase

Strategy 4: Manage Construction Impacts on Stormwater

Proposed Actions:

Management measures would include:

- stabilise banks of temporary creek diversion channels with suitable materials to minimise scouring and erosion;

- inspect temporary creek diversion channels weekly and after rainfall events, to check the integrity and effectiveness of the controls used to stabilise and minimise scouring and erosion of banks. Maintain or improve controls as soon as practicable, if required;
- construct temporary silt retention structures immediately downstream of creek works to prevent sedimentation if a creek cannot be diverted for instream works;
- stabilise and revegetate creek banks, if required, on completion of instream works;
- keep clearance of vegetation to a minimum, particularly along waterways;
- stabilise areas that have been disturbed and are not in use with an appropriate cover where practicable until recommencement of works or permanent revegetation can be carried out.;
- treat (for example, hydromulch) or grass material, as soon as practical, if not in use;
- place overburden stockpile of surplus material from Option B Stage 1 works in its final location for further stages and treat (for example, hydromulch) or grass, as soon as practical;
- locate material, overburden and topsoil stockpiles on level ground away from drainage lines and creeks; install diversion drains upslope and sediment filter fencing; and install catch drains downslope of stockpiles;
- construct temporary erosion and sedimentation control structures, such as diversion banks, where appropriate along existing drainage lines and around the perimeter of the site to collect run-off from cleared areas, including the construction-site and any access tracks;
- divert stormwater upslope of construction-sites around the site using diversion or catch drains;
- erect silt traps, gross pollutant traps and erosion control fencing where appropriate along construction-site boundaries and drainage lines;
- retain sediment fencing in areas downslope of work by sandbags or other suitable material to ensure fencing remains securely in place;
- control run-off from exposed areas by contour and diversion drains and direct to the water pollution control ponds;
- reduce run-off velocities where possible by minimising the length and steepness of slopes, construction of channels with gentle gradients and by providing linings to steeper channels;
- provide drainage outlets with energy dissipaters where appropriate to minimise water velocity and erosion;

- inspect erosion and sediment controls on a weekly basis and immediately following any rainfall events. Sediment would be cleared regularly and reused on-site or disposed of in an appropriate manner;
- maintain erosion and sediment control facilities as required;
- control access to the construction-site and keep vehicles and machinery to well defined haul roads within the construction area;
- install a wheel wash facility and require all vehicles exiting the site to use the wheel wash during wet weather;
- locate any fuel and chemical storage, fuelling and servicing of construction plant, equipment and vehicles away from drainage lines and creeks on designated hardstand areas with impermeable bunds or earthen bunds on impervious treated ground;
- ensure fixed plant installations are separately bunded and regularly inspected. Bunds would drain to a oil separator, prior to discharge to the stormwater system. Oil separators would be inspected and cleaned regularly and any hydrocarbons disposed of via a sludge tanker; and
- bund all fuel and chemical storage's and fixed plant installation as designed in Strategy 1.

Monitoring

A water monitoring program would be developed and implemented to detect any off-site impact arising from construction activities on down stream water quality. The program would include monitoring of water quality upstream and down stream of the construction-site during dry weather (depending on stream flows) and during rainfall events. The program would aim to capture at approximately 12 events per year. A rainfall event would constitute greater than ten millimetres of rain in the preceding 24 hours. Monitoring would include peak flow rates, cumulative discharge, suspended solids, total phosphorus, total nitrogen, salinity, faecal coliforms, oils and grease, polyaromatic hydrocarbons, total petroleum hydrocarbons, volatile organic compounds and heavy metals.

Total flow volumes, peak flow rates and water quality of stormwater flows would be monitored at the inlet and discharge points of detention basins and water quality control ponds.

Results would be compared against baseline results collected prior to construction works commencing.

Carry out biological assessment of Badgerys Creek downstream of the site during construction activities. Assessment to provide direct measurement of any impacts to the ecosystem during construction.

Reporting

Monthly reporting of water quality monitoring results. Results would be reviewed against the water quality standards in the Airports (Environment Protection) Regulations and any exceedance would be investigated and actions taken to mitigate against further pollution.

Strategy 5: Manage Off-Site Impacts of Water Quality and Flooding

Proposed Actions:

Management measures would include:

- construct all permanent detention basins and water quality control ponds before commencement of other major construction activities within the catchment of the detention basin or pond;
- incorporate use of the existing detention basin in the stormwater control system, if practicable;
- test stormwater treated in the water pollution control ponds or other control devices for suspended solids levels prior to discharge. Discharge of this water would only be carried out if water quality met the requirements of the Airports (Environment Protection) Regulations;
- discharges of water from water detention basins in such a manner so not to increase preconstruction peak flow rates;
- keep water in the water pollution control ponds as low as practicable through reuse of water on-site for dust suppression and landscaping.;
- dose water pollution control ponds with flocculants to reduce turbidity and nutrient levels as required;
- regularly desludge water pollution control ponds and detention basins to maintain design capacity; and
- install and maintain surface booms on water pollution control ponds and detention basins for any escaped fuel or oil.

Monitoring

Review effectiveness of the water pollution control ponds and treatment techniques during and following rainfall events.

Total flow volumes, peak flow rates and water quality of stormwater flows would be monitored at the inlet and discharge points of detention basins and water quality control ponds.

Monitoring of the level of sediment build-up in water pollution control ponds.

Monitoring of downstream water quality and peak flow rates, see monitoring outlined in Strategy 4.

Reporting

Report on effectiveness of control measures.

Report on maintenance of sediment and erosion control measures.

Reporting of any off-site discharges to Badgerys, South or Cosgrove Creeks, from detention basins and pollution control ponds.

Strategy 6: Manage Groundwater Impacts

Proposed Actions:

Management measures would include:

- prevent and control contamination of groundwater by fuel and chemical leaks and spills. See fuel and chemical storage measures in section 25.4.11 "Hazards and Risks", Strategy 1; and
- drain any saline perched water encountered on-site to temporary evaporation basins. The dry sediments from the basins would be disposed of by mixing with site fill material.

Monitoring

Groundwater monitoring carried out in accordance with Strategy 3.

Reporting

Reporting of groundwater monitoring results.

2.6.4 Proposed Management Measures - Operational Phase

Strategy 7: Manage Operational Impacts on Stormwater and Soil Erosion

Proposed Actions:

Management measures would include:

- implement a water cycle management plan for the site, including water conservation program and a comprehensive water monitoring program;
- revegetate or stabilise disturbed areas on-site as soon as practicable;

- maintain vegetated areas;
- sweep roads clean, as required;
- restrict use of pesticides, herbicides and fertilisers;
- regularly inspect and maintain bunded areas. Any stormwater in the bunds would be pumped out and treated;
- washing of aircraft to occur in designated wash down areas;
- refuel aircraft only in designated apron areas serviced by flame traps; and
- maintain flame traps for treatment of stormwater and any fuel spills from runways and aprons.

Monitoring

Develop a water quality monitoring program in creeks downstream of the site.

Monitor sediment and pollution control devices.

Reporting

Reporting of results of water quality monitoring.

Strategy 8: Manage Off-Site Impacts on Water Quality and Flooding

Proposed Actions:

Management measures would include:

- prepare an operation and maintenance plan to maintain detention basins and water pollution control ponds. Operation and maintenance activities would include bank maintenance, periodic litter and sediment removal and monitoring of water quality indicators; and
- regularly inspect ponds, including following high flow events to check for proper functioning of all components.

Monitoring

Seasonal monitoring of a range of inflow and outflow water quality parameters and sampling occasionally the water quality within the pond.

Monitoring of water quality discharges from ponds and peak discharge rates.

Monitoring of levels of sediment build up in water pollution control ponds.

Reporting

Reporting of any discharges from the water pollution control ponds and in particular those which exceed limits prescribed in the *Airport (Environment Protection) Regulations*.

Strategy 9: Improve Water Conservation and Manage Waste Water Discharged

Proposed Actions:

Management measures would include:

- apply a charging structure for leased sites to encourage water conservation based on the principle of user pays (volumetric use);
- apply a charging structure for leased sites to encourage reductions in both volume and strength of sewage. Establish and enforce rules limiting the quantity and strength of contaminants which could be discharged;
- pre-treat high contaminant sewage prior to discharge to the sewage system;
- reduce water discharged to Badgerys Creek through reuse of effluent on-site, for site toilet flushing, air conditioning make up, garden and grass watering and possible industrial uses such as vehicle washing;
- discharge of waste water to Badgerys Creek would only occur if effluent holding ponds were at capacity;
- test water quality prior to any discharge to Badgerys Creek;
- optimise and monitor plant operation;
- provide sufficient redundancy for essential plant components;
- develop a contingency response plan; and
- investigate waste water management for Stage 2 of the airport. Options to be investigated include discharge of surplus sewage to the Sydney Water Corporation sewage system and expansion of the on-site treatment to cater for the whole of the airport development.

Monitoring

The quantity and quality of sewage inflow to the sewage treatment plant would be monitored to detect any unusual flows or unacceptable substances. Sewage from any large single contributors or potential producers of unacceptable waste would also be monitored.

Inflow of stormwater would be managed by regular inspections of the sewage collection system and flow monitoring in wet weather.

Record any precautionary discharges to Badgerys Creek.

Monitoring of on-site water use.

Reporting

Quarterly reporting of results of on-site water use.

Report details of any precautionary discharges to Badgerys Creek.

Strategy 10: Control Pollution from Aircraft on Regional Drinking Water Supplies

Proposed Actions:

Management measures would include:

- dumping of fuel only permitted in emergency situations over the ocean and in accordance with legislative requirements.

Monitoring

Records kept of any fuel dumping incidents.

Reporting

Reporting of any fuel dumping to Sydney Water.

Strategy 11: Manage Groundwater Impacts

Proposed Actions:

Management measures would include:

- regularly maintain fuel storage areas; and
- install additional monitoring bores to those established as part of the pre-construction management measures (Strategy 3) if required, around any addition fuel storage areas.

Monitoring

Sample groundwater quality and levels every six months from site bores.

Salinity testing in local creeks, refer to Strategy 7 for water monitoring program.

Reporting

Reporting of results of groundwater monitoring.

Any significant changes to groundwater quality would be investigated and actioned to prevent pollution.

2.7 Flora and Fauna

2.7.1 Introduction

The sites of the airport options are considered to be of State significance for flora and fauna based on the following attributes:

- remnants of endangered ecological community Cumberland Plain Woodland, considered to be of regional conservation significance;
- remnants of the endangered ecological community River Flat Forest, considered to be of local conservation significance;
- a population of endangered plant Pultenaea parviflora that is considered to have regional significance; and
- a population of threatened Cumberland Plain Large Land Snail considered to be of State conservation significance.

Management of flora and fauna during construction and operation of the airport would be based on the goals of ecologically sustainable development and the conservation of biological diversity. The aims of flora and fauna management would be to :

- mitigate the cumulative impacts of the proposal on regional biodiversity;
- reduce impacts on threatened species, populations and ecological communities;
- reduce the potential for bird and bat strike; and
- protect and enhance habitat for threatened species, populations and ecological communities wherever possible.

2.7.2 Proposed Management Controls - Preconstruction

Strategy 1: Preserve and Manage Ecologically Endangered Communities such as Cumberland Plain Woodland and River Flat Forest

Proposed Actions:

Management measures would include:

- investigating potential areas for retention and/or rehabilitation of ecologically endangered communities within the airport site;

- retaining and managing identified vegetation within the sites of the airport options;
- Investigating off-site areas suitable for conservation of compensatory habitat for ecologically endangered communities. Priorities for identification of off-site conservation ares would include:
    - Commonwealth-owned land (or Crown Land);
    - sites identified as "core biodiversity" area for Cumberland Plain Woodland and River Flat Forest by National Parks and Wildlife Service (1997);
    - sites that represent a comparable ecosystem to that which exists on the airport sites and have equivalent or better value as wildlife habitat; and
    - sites that contain equivalent or similar areas of Cumberland Plain Woodland and River Flat Forest to that which exist on the airport sites minimising the clearance of vegetation where practicable;
- identifying significant stands of remnant vegetation within government-owned land, investigate the feasibility of designating this land for conservation purposes and zoning the land accordingly. Areas could be conserved by entering into voluntary conservation agreements with the National Parks and Wildlife Service, or by creating Commonwealth conservation reserves. Degraded areas within these sites would be rehabilitated through bush regeneration programs;
- investigating areas adjacent to the site which would be potentially most affected by airport operations and could be purchased and managed for conservation;
- developing and implementing a revegetation and regeneration plan prior to construction of the airport for preconstruction, construction and operational phases;
- collecting seeds and propagative material of threatened species during preconstruction; and
- determining the regeneration potential of vegetation to be retained on-site and control weeds.

Monitoring

See monitoring for Strategy 5.

Reporting

Reporting of areas, on-site and off-site, identified with potential for protection and preservation.

Strategy 2: Conservation of *Pultenaea parviflora*

Proposed Actions:

Management measures would include:

- continue the conservation program currently in progress at Mount Annan Botanic Gardens; and
- assess the feasibility of introducing the species into off-site conservation areas in consultation with the Mount Annan Botanic Gardens.

Monitoring

Monitoring would aim to measure the success of the ex-situ conservation program being undertaken by Mount Annan Botanic Gardens. This would involve regular inspections of the health of re-introduced populations in on-site and off-site conservation areas. Monitoring would be undertaken by a botanist from the Mount Annan Botanic Gardens as part of the conservation program.

Reporting

Reporting on the success of the conservation program.

Strategy 3: Conservation of Cumberland Plain Large Land Snail

Proposed Actions:

Management measures would include:

- minimising habitat removal and fragmentation by careful reconsideration of the siting of proposed transport and services corridors;
- retention of Cumberland Plain Woodland remnants containing suitable habitat for *Meridolum corneovirens* wherever possible;
- regeneration of existing and potential *Meridolum corneovirens* habitat within the airport sites;
- relocation of populations of *Meridolum corneovirens*, preferable to on-site conservation areas or to nearby off-site conservation areas;
- creation of an off-site conservation area containing a viable population or suitable habitat for the species, such as Cumberland Plain Woodland; and
- following the identification of suitable off-site habitat, translocation of a sample population with the airport sites would be trialed. Translocation would aim to establish the genetic material of the impacted population in an off-site conservation area.

Note: Conservation of the Cumberland Plain Large Land Snail would be ensured through protection and in some cases enhancement of existing remnant Cumberland Plain Woodland. See Strategies 5 and 7.

Monitoring

Specific relocation and monitoring strategies for the Cumberland Plain Large Land Snail would be prepared prior to the proposed relocation activities. Monitoring programs would aim to determine the distribution, abundance, breeding status and general health of these populations prior to, and following, translocation to provide baseline data for future assessments. This would allow the success of relocation to be assessed in subsequent years. The populations would continue to be monitored for an appropriate time following translocation to ensure they survive and reproduce successfully.

Reporting

Reporting on the success of the relocation strategy.

Strategy 4: Preservation of Bat Population

Proposed Actions:

Management measures would include:

- undertaking relocation of the bat populations of *Chalinolobus gouldi* (Goulds Wattled Bat) and *Mormopterus sp* 1 at Badgerys Creek Community Hall prior to construction of the airport; and
- consulting with National Parks and Wildlife Service to determine suitable relocation-sites for the populations.

Monitoring

Specific relocation and monitoring strategies for the bat populations would be prepared prior to the proposed relocation activities. Monitoring programs would aim to determine the distribution, abundance, breeding status and general health of these populations prior to, and following, translocation to provide baseline data for future assessments. This would allow the success of relocation to be assessed in subsequent years. The populations would continue to be monitored for an appropriate time following translocation to ensure they survive and reproduce successfully.

Reporting

Reporting on the success of the relocation strategy.

2.7.3 Proposed Management Controls - Construction

Strategy 5: Preserve and Manage Ecologically Endangered Communities such as Cumberland Plain Woodland and River Flat Forest

Proposed Actions:

Management measures would include:

- continue to identify significant stands of remnant vegetation within government-owned land, designated for conservation and zoned accordingly during the construction phase of the airport. Areas could be conserved by entering into voluntary conservation agreements with the National Parks and Wildlife Service, or by creating Commonwealth conservation reserves;
- determine the regeneration potential of vegetation to be retained on-site and control weeds. Continue ongoing management of on-site vegetation throughout the construction of the airport;
- implement a regeneration and revegetation plan which would outline an appropriate strategy for vegetation management;
- implement bush regeneration and revegetation programs to improve and maintain the condition of Cumberland Plain Woodland and River Flat Forest remnants; and
- undertake progressive revegetation of new sections of creeks for erosion and sedimentation control. Appropriate management, including weed control, and suitable species for planting would be outlined in the regeneration and revegetation plan. Revegetation programs would use local native seed and stock wherever possible.

Monitoring

A program of monitoring of endangered ecological communities protected in on-site conservation areas would be incorporated into the revegetation and regeneration plan. Monitoring would aim to measure changes in ecosystem health in Cumberland Plan Woodland and River Flat Forest remnants in on-site and off-site areas resulting from regeneration activities. Monitoring of any area reserved for compensatory habitat should be undertaken to document the status of the weed species present, the condition of the remnant and the regeneration of native species. In particular, transplanting to, or seeding of, an off-site conservation area should be monitored to determine the effectiveness of the strategy.

Site assessments would be conducted regularly by a qualified bush regenerator or botanist to measure indicators of community health such as:

- distribution and abundance of weed species;

- disturbance, such as clearing, grazing, fire and feral animal;
- condition of native vegetation;
- diversity and abundance of native and exotic species; and
- presence of native flora and fauna habitats.

Reporting

Reporting on the results of the monitoring program.

Strategy 6: Conservation of *Pultenaea parviflora*

Proposed Actions:

Management measures would include:

- utilise seed and stock produced by the conservation program in on-site conservation areas and in landscaping; and
- consulting with the Mount Annan Botanic Gardens during preparation of the landscaping concept in order to ensure the success of the translocation or planting of seed.

Monitoring

Monitoring would aim to measure the success of the ex-situ conservation program being undertaken by Mount Annan Botanic Gardens. This would involve regular inspections of the health of re-introduced populations in on-site and off-site conservation areas. Monitoring would be undertaken by a botanist from the Mount Annan Botanic Gardens as part of the conservation program.

Reporting

Reporting on the success of the conservation program.

2.7.4 Proposed Management Controls - Operation

Strategy 7: Preserve and Manage Ecologically Endangered Communities such as Cumberland Plain Woodland and River Flat Forest

Proposed Actions:

Management measures would include:

- ongoing management of on-site vegetation throughout the long-term operation of the airport;

- the regeneration and revegetation plan would outline an appropriate strategy for vegetation management; and
- continue bush regeneration programs to improve and maintain the condition of Cumberland Plain Woodland and River Flat Forest remnants.

Monitoring

A program of monitoring of endangered ecological communities protected in on-site and off-site conservation areas would be incorporated into the revegetation and regeneration plan. Monitoring would aim to measure changes in ecosystem health in Cumberland Plan Woodland and River Flat Forest remnants in on-site and off-site areas resulting form regeneration activities. Monitoring of any area reserved for compensatory habitat should be undertaken to document the status of the weed species present, the condition of the remnant and the regeneration of native species. In particular, transplanting to, or seeding of, an off-site conservation area should be monitored to determine the effectiveness of the strategy.

Site assessments would be conducted regularly by a qualified bush regenerator or botanist to measure indicators of community health such as:

- distribution and abundance of weed species;
- distribution, such as clearing, grazing, fire and feral animal;
- condition of native vegetation;
- diversity and abundance of native and exotic species; and
- presence of native flora and fauna habitats.

Reporting

Reporting on the results of the monitoring program.

2.8 Resources

2.8.1 Introduction

Coal and light firing clay/shale have been identified as natural resources for the site. Coal resources appear to be of lower quality than similar deposits in the region and are at a depth and thickness that makes mining difficult and costly and may require mining technology not currently used in Australia. The clay/shale has been identified as having low potential for significant economic deposits within the airport site.

Badgerys Creek is in the agricultural fringe of Sydney and contains a number of large agricultural enterprises. These enterprises play a significant part in the regional supply of agricultural produce. Agricultural industries include intensive poultry farming, grazing of beef cattle, horse studs and small scale market gardens and nurseries. Some existing agricultural operations are expected to relocate elsewhere. Potential impacts on remaining industries include dust generated from construction, and elevated noise levels.

The objective of this environmental management procedure is to minimise the impact of airport construction and operations on agricultural activities and to minimise the sterilisation of natural resources.

2.8.2 Proposed Management Controls - Construction and Operation Phase

Strategy 1: Manage Natural Resources

Proposed Actions:

Management measures would include:

- investigate the feasibility of mining surface minerals before or during airport construction.

Monitoring

Not applicable.

Reporting

Not applicable.

Strategy 2: Manage the Impacts from Construction and Operation of the Airport on Agricultural Producers in the Region

Proposed Actions:

Management measures would include:

- minimising dust impacts during construction. See *Section 25.4.5 "Air Quality"*; and
- minimising noise impacts from construction and operation of the airport. See *Section 25.4.4 "Other Noise"*.

Monitoring

Monitoring of dust and noise impacts outlined in *Sections 25.4.5* and *25.4.4* respectively would include monitoring locations at potentially affected agricultural producers.

Reporting

Reporting of impacts on agricultural producers from airport activities.

2.9 Energy

2.9.1 Introduction

Construction of the proposed airport would consume a significant amount of energy. Approximately 3,240,000 gigajoules of energy would be expended during construction of the airport to its proposed capacity. The major part of this energy would be used in earthworks.

Airport energy usage during operation has been estimated at approximately 830,000 gigajoules per annum. Lighting, refrigeration, air conditioning and vehicle usage are potentially the main consumers of energy.

The objective of these environmental management measures are to manage energy consumption, through efficient energy use and conservation principles and practices.

2.9.2 Proposed Management Controls - Construction Phase

Strategy 1: Manage Energy Usage On-Site During Construction

Proposed Actions:

Management measures would include:

- locate depots to reduce the distances travelled by site vehicles;
- store materials as close as possible to areas where they are to be used;
- plan the delivery materials so that full loads would be delivered rather than part loads;
- design and construct site offices to be energy efficient to avoid excessive heating and cooling requirements; and
- designs for the airport to take into consideration selection of intrinsically low energy materials, that is take into consideration life cycle assessment of products in terms of energy efficiency.

Monitoring

Regular energy audits of the site activities.

Review of energy usage and costs.

Reporting

Results of energy audits.

Results of energy usage and costs.

2.9.3 Proposed Management Measures - Operational Phase

Strategy 2: Manage Operational Energy Usage On-Site

Proposed Actions:

Management measures would include:

- design of airport facilities , such as buildings, would be in accordance with energy efficiency principles; and
- development of an energy management plan.

Monitoring

Monitoring of energy usage on-site and annual energy audits.

Reporting

Review of energy usage report and review of energy management plan to improve management measures.

2.10 Waste

2.10.1 Introduction

Solid and liquid wastes would be produced during construction. Solid wastes would include construction material off-cuts, soil and sand, vegetation, concrete, asphalt, putrescible waste, wood, paper, plastic and glass. Liquid wastes would include oils, sewage, contaminated fuels, paint and other chemical wastes. Solid wastes are generally disposed of to landfill while many of the liquid wastes are considered to be hazardous wastes and must be transported to an appropriate liquid waste facility for recycling or disposal.

Solid and liquid waste would also be produced during operation of the airport. Solid wastes would include quarantine waste (waste from aircraft from overseas destinations), putrescible waste, wood, paper, cardboard, plastic, glass, paints and chemical waste, used drums and machine parts and sewage sludge. Liquid wastes would include oils, sewage, contaminated fuels, paint and other chemical wastes.

The objective of these environmental management measures is to manage and dispose of waste generated during construction and operation of the airport in accordance with the preferred hierarchy of minimisation, reuse, recycling and finally disposal.

2.10.2 Proposed Management Controls- Pre-Construction Phase

Strategy 1: Avoid Producing Waste by Adopting Waste Conscious Design Principles and Planning Prior to Commencement of Construction Activities

Proposed Actions:

Management measures would include:

- order only required amount of materials needed for construction work;
- utilise standard sized timbers in design to reduce off-cut waste, where possible;
- plan for reuse of scaffolding, formwork and temporary structures; and
- carry out a detailed survey of the site to identify and locate any potentially readily re-useable or recyclable items such as concrete pipes and culverts. Incorporate these items into the designs for reuse where possible, or take off-site for reuse or recycling.

Monitoring

Checking of quantities of materials ordered against quantities planned.

Reporting

Variations in quantities of materials ordered to materials planned.

2.10.3 Proposed Management Controls- Construction Phase

Strategy 2: Encourage the Re-Use and Recycling of Excess Materials

Proposed Actions:

Management measures would include:

- print and copy documents double-sided, utilise electronic transmittal of documents, and reuse internal mail envelopes;

- store topsoil excavated during site preparation work and use in landscaping works as much as possible;
- process cleared vegetation and waste timber on-site and use in landscaping;
- harvest and sell any merchantable timber where practicable;
- recycle off specification concrete or asphalt in the on-site batching plants or utilise as general fill in bulk earthworks;
- reuse scaffolding, formwork and other temporary structures;
- arrange recycling and disposal of wastes with licensed contractors; and
- locate recycling areas throughout the site. Provide colour coded or clearly marked bins for metal, timber and glass.

Monitoring

Monthly audit of recycling opportunities, quantities and cost savings. Monthly review of quantities of waste recycled and disposed to landfill.

Regular spot checks of waste loads to ensure recyclables are not being disposed of to landfill.

Reporting

Monthly reporting of waste audits.

Strategy 3: Ensure Appropriate Storage and Disposal of Waste Materials

Proposed Actions:

Management measures would include:

- segregate hazardous wastes (including empty drums, contaminated soil and asbestos) from non-hazardous wastes and managed in accordance with relevant legislation;
- store liquid wastes (chemical, oils and greases) in an appropriately bunded area for disposal off-site by a licensed contractor;
- store food wastes in a vermin proof bin. Check waste handling areas regularly for litter and vermin;
- keep all documentation relating to waste removal and disposal on file at the main site office during construction. Documentation includes dockets for the removal and disposal of waste at a licensed facility;
- store large-scale construction waste (concrete and steel off-cuts) that cannot be contained by skips on the ground in a designated area;

- separate waste materials progressively and stockpile in designated areas at the site for collection. Secure waste disposal areas to ensure that access cannot be gained by external parties or wildlife;
- treat all site sewage by a temporary sewage treatment plant on-site or to sewer. Dispose of residual solids from the plant in an appropriately licensed landfill;
- retain on file, copies of current licences of all waste removal contractors; and
- regularly review any waste licences to ensure compliance with all conditions.

Monitoring

Monthly auditing of waste disposal practices and quantities.

Reporting

Monthly reporting of waste audits for review and action if required.

2.10.4 Proposed Management Measures - Operational Phase

Strategy 4: Maximise the Re-Use and Recycling of Waste Materials

Proposed Actions:

Management measures would include:

- prepare a waste management plan prior to commencement of operations and address opportunities and methods for minimisation of waste, recycling and reuse of waste generated by the airport;
- evaluate the feasibility of including waste minimisation requirements into contracts with domestic and international airlines;
- include waste minimisation targets in contracts with commercial and industrial tenants;
- print and copy documents double-sided, utilise electronic transmittal of documents, and reuse internal mail envelopes;
- provide separate receptacles for wastes to facilitate collection of recyclable materials;
- appoint a recycling contractor and ensure collection frequency is adequate if required;
- investigate composting of food wastes (non-quarantine), with the resulting product to be used in airport landscaping;

- benchmark the performance of the airport, in waste minimisation, against international best practice;
- store waste oils and fluids in dedicated tanks for collection by a recycling contractor; and
- return discarded machine parts to the manufacturer for collection by a scrap metal recycler.

Monitoring

Monthly audit of recycling opportunities, quantities and cost savings. Monthly review of quantities of waste recycled.

Regular spot checks of waste loads to ensure recyclables are not being disposed of to landfill.

Reporting

Reporting on reuse and recycling opportunities, quantities and savings.

Strategy 5: Ensure the Appropriate Storage and Disposal of Waste Materials

Proposed Actions:

Management measures would include:

- separate and secure quarantine waste and non-non-quarantine waste to minimise the risk of cross-contamination;
- provide a separate collection and handling system for quarantine waste;
- sterilise quarantine waste by an autoclave process or similar, prior to disposal to landfill;
- store food wastes in a vermin proof bin. Conduct regular inspections of the waste handling areas for litter and vermin;
- segregate hazardous wastes (including empty drums, rags, contaminated soil, asbestos etc) from non-hazardous wastes and managed in accordance with relevant legislation;
- store liquid wastes (chemical, oils and greases) in an appropriately bunded area and dispose of through a licensed contractor. Pre-treat washdown waters directed to the on-site sewage treatment plant or discharge to sewer under a Trade Waste Agreement;
- collect and treat all sewage on-site by the sewage treatment plant. Dispose of residual solids from the plant in an off-site sanitary landfill; and

- retain copies of current licences of all waste removal contractors and all documentation relating to waste removal and disposal on file.

Monitoring

Monthly auditing of waste disposal practices and quantities.

Reporting

Monthly reporting of results of the waste audit.

2.11 Hazards and Risks

2.11.1 Introduction

Construction and operation of the project would involve the use and handling of hazardous materials such as fuels, oils and chemicals. Hazardous materials include those termed dangerous goods, under the *Dangerous Goods Act, 1975* as well as materials which could result in environmental degradation if allowed to enter the environment.

Potential risks, hazards and environmental emergencies during the construction phase include uncontrolled spills of materials such as oil, fuel, chemicals or waste materials, bushfires and handling of contaminated soils.

Potential risks, hazards and environmental emergencies during operation of the airport include uncontrolled spills of materials, storage of dangerous goods, seismic activity, electromagnetic radiation, bird and bat strike and aircraft crash on-site and off-site into residential and industrial areas, schools and hospitals, major water and electricity infrastructure and the Defence Establishment Orchard Hills.

The objective of these environmental management measures is to ensure that appropriate measures are in place to prevent or minimise the hazards and risks and to deal with any emergency situations.

2.11.2 Proposed Management Controls - Construction Phase

Strategy 1: Ensure that Fuel and Hazardous Materials are Stored, Handled and Transported Appropriately

Proposed Actions:

Management measures would include:

- carry out a quantitative risk assessment during the design of a potential fuel pipeline to the airport;

- if a fuel pipeline to the airport is installed, incorporate safety measures, emergency plans and periodic independent audits into emergency response procedures;
- obtain appropriate licence(s) to keep dangerous goods from NSW Work Cover Authority for all dangerous goods stored on-site;
- establish a Register of Hazardous Materials which would detail the quantities, storage details and specific handling requirements for all potentially hazardous materials on-site;
- store hazardous materials in accordance with relevant dangerous goods legislation and manufacturers instructions;
- secure hazardous materials and dangerous goods storage areas and have appropriate signage displayed. Segregate incompatible materials;
- provide aboveground storage areas with appropriate secondary containment adequate to contain a major spill or leak. Design all bunded areas to contain at least 110 percent of the volume of materials stored within the area;
- provide bunded areas with roofs, and bunds with drainage valves, to enable regular emptying of any accumulated stormwater;
- clearly label contents of storage areas;
- provide mobile spill control kits containing appropriate absorbent materials, neutralising chemicals and other spill containment equipment;
- handle any spills of hazardous materials that occur on the site in accordance with procedures detailed in the emergency response plan;
- contact relevant authorities in the event of a major leak or spill outside of the airport site. Remediate as soon as practicable to the requirements of the Airport Environment Officer any soil or groundwater contamination resulting from a spill;
- collect and dispose of any spills or hazardous wastes by a licensed waste contractor. Maintain all records of waste removal on file;
- as part of induction procedures, train construction personnel in safe handling and spill clean up procedures for hazardous materials; and
- provide personal protective equipment and personnel instructed on use of safety equipment and clothing.

Monitoring

Monthly audit for compliance with legislative requirements for storage and handling of hazardous materials and licensing of dangerous goods.

Reporting:

Audit reports for storage facilities.

Strategy 2: Manage the Incidence of Bushfires On-Site

Proposed Actions:

Management measures would include:

- develop a bushfire control and management plan in conjunction with adjacent land owners and the Rural Fire Service;
- prohibit open burning of wastes;
- prohibit or confine smoking on-site to particular areas;
- design and construct sedimentation ponds to allow water from the ponds to be available for fire fighting if required;
- maintain all fire fighting equipment;
- regularly maintain vegetation around the boundary; and
- train staff in fire evacuation and prevention techniques.

Monitoring

Not applicable

Reporting

Monthly report on fire incidents, training and management.

Strategy 3: Manage Contaminated Soils

Proposed Actions:

Management measures would include:

- carry out investigations prior to construction works to determine the extent of any contaminated soils on the site;
- if contaminated soils are found on the site, as a result of the investigations carried out, develop a remedial action plan in accordance with the Airports (Environment Protection) Regulations to ensure that these soils would be handled and disposed appropriately; and
- test and validate any areas that are remediated to ensure that they meet the criteria outlined in the remedial action plan.

Monitoring

Validation testing of all areas would be undertaken after remediation is completed.

Reporting

A remedial action plan and a validation report would be produced for any areas found to be contaminated.

Strategy 4: Ensure That Appropriate Measures Have Been Taken and Procedures and Controls Implemented to Respond to Any Potential Environmental Emergency

Proposed Actions:

Management measures would include:

- develop emergency response procedures to handle any potential emergencies that could occur during the construction process;
- develop and display an emergency response table listing contact details for all relevant parties required in an environmental emergency, in appropriate locations;
- review and update emergency response procedures every six months;
- train all relevant construction personnel in emergency response procedures;
- provide appropriate safety and spill response equipment to respond to an emergency on-site and off-site; and
- appoint a safety officer.

Monitoring

Monthly review of emergency response procedures and equipment.

Reporting

Monthly report on emergency incidents, training and management.

Monthly report on review of emergency response procedures and equipment.

2.11.3 Proposed Management Measures - Operational Phase

Strategy 5: Reduce the Risks of External Factors on Aircraft Safety

Proposed Actions:

Management measures would include:

- reduce the risk of bird and bat hazards by:
  - keeping water pollution control ponds free of water plants;
  - designing landscaping on-site to minimise the habitat for bird and bat roosts; and
  - implementing planning controls for the vicinity of the airport so that in the future risk sensitive land uses would be avoided in areas where risks exceeded criteria outlined in guidelines released by NSW Department of Urban Affairs and Planning. Such controls should also prevent waste disposal or other activities that might attract birds and bats. (See *Section 25.4.2*).
- develop and adopt air traffic procedures for dealing with poor visibility, such as may be experienced in fog or heavy rain. These would be developed by Airservices Australia, in conjunction with the Civil Aviation Safety Authority;
- reduce the risk of an aircraft crash in a populated area by designing flight paths so that there is a minimum of concentrated aircraft movements over densely populated areas and major water supply infrastructure; and
- develop special co-ordination procedures between Airservices Australia and the Department of Defence to enable occasional weapons detonation in the event that the Defence Establishment Orchard Hills is not relocated.

Strategy 6: Ensure That Appropriate Measures Have Been Taken and Procedures and Controls Implemented to Respond to Any Potential Environmental Emergency

Proposed Actions:

Management Options would include:

- develop an Airport Emergency Plan which complies with Civil Aviation regulations. The plan would:
  - address emergencies that are caused by or may affect airport operations;
  - provide details of exercises to test emergency plans; and

- establish an Airport Emergency Committee, which may include agencies such as State Emergency Services, the Department of Defence and police;

- appoint an emergency services liaison officers;
- develop and implement response procedures for dealing with security related incidents such as criminal or terrorist activity. Such procedures would be jointly developed by the airport lessee company, airlines, NSW police and Commonwealth agencies;
- develop contingency plans to deal with the consequences of an aircraft crash into crucial elements of water supply and electricity infrastructure. This would be developed in cooperation with the water and electricity authorities respectively;
- develop and display in appropriate locations an emergency response table listing contact details for all relevant parties required in an environmental; and
- train all personnel in emergency response procedures.

Monitoring

Monthly review of response procedures and equipment.

Reporting

Monthly report on any emergency incidents, training and management.

Monthly report on review of emergency response procedures and equipment.

Strategy 7: Ensure Appropriate Fuel and Hazardous Material Storage, Handling and Transportation

Proposed Actions:

Management measures would include:

- obtain appropriate licence(s) to keep dangerous goods from NSW Work Cover Authority for all dangerous goods stored on-site;
- establish a Register of Hazardous Materials which would detail the quantities, storage details and specific handling requirements for all potentially hazardous materials on-site obtain Safety Data Sheets;
- store hazardous materials in accordance with relevant dangerous goods legislation and manufacturers instructions;
- secure hazardous materials and dangerous goods storage areas and have appropriate signage displayed. Segregate incompatible materials;

- provide aboveground storage areas with appropriate secondary containment adequate to contain a major spill or leak. Design all bunded areas to contain at least 110 percent of the volume of materials stored within the area;
- provide bunded areas with roofs, and bunds with drainage valves, to enable regular emptying of any accumulated stormwater;
- clearly label contents of storage areas;
- provide mobile spill control kits containing appropriate absorbent materials, neutralising chemicals and other spill containment equipment;
- handle any spills of hazardous materials that occur on the airport in accordance with procedures detailed in the emergency response plan;
- contact relevant authorities in the event of a major leak or spill outside of the airport site. Immediate remediation of any soil or groundwater contamination resulting from a spill to the requirements of the Airport Environment Officer;
- collect and dispose of any spills or hazardous wastes by a licensed waste contractor. Maintain all records of waste removal on file;
- as part of induction procedures, train relevant operational personnel in safe handling and spill clean up procedures for the hazardous materials; and
- provide personal protective equipment and personnel instructed on use of safety equipment and clothing.

Monitoring

Monthly audit for compliance with legislative requirements for storage and handling of hazardous materials and licensing of dangerous goods.

Reporting

Audit reports for storage facilities.

Strategy 8: Manage the Incidence of Bushfire On-Site

Proposed Actions:

Management measures would include:

- develop a bushfire control and management plan in conjunction with adjacent land owners and the Rural Fire Service;
- prohibit open burning of wastes at the site;
- prohibit or confine smoking on-site to particular areas;
- design and construct sedimentation ponds to allow water from the ponds to be available for fire fighting;

- maintain all fire fighting equipment;
- regularly maintain vegetation around the boundary; and
- train relevant staff in fire evacuation and prevention techniques.

Monitoring

Not applicable

Reporting

Monthly report on fire incidents, training and management.

2.12 Cultural Heritage

2.12.1 Introduction

Sites of heritage significance or value, both Aboriginal and non-Aboriginal, have been identified on the sites of the airport options.

The aim of these cultural and heritage management measures is to ensure that items of Aboriginal and non-Aboriginal significance are recognised and where possible protected or conserved during construction and operation of the airport.

2.12.2 Proposed Management Controls - Pre Construction Phase

Strategy 1: Implement Pre-Construction Programs to Ensure That Items of Aboriginal and Non-Aboriginal Heritage are Identified and Protected, Where Possible

Proposed Actions:

Everybody operating at the airport is required to comply with a general duty to ensure that sites of indigenous and heritage significance are properly protected. Management measures may include:

Aboriginal Heritage

- involve representatives of key local Aboriginal community organisations in both design and implementation of all management measures. The inclusion of Aboriginal community representatives in relevant decision making and steering committees would ensure local Aboriginal involvement;
- carry out a surface survey of the remaining unsurveyed areas of the proposed direct impact areas, prior to any construction works. The aim would be to provide an accurate, high coverage, and stratified inventory on surface

manifestations of Aboriginal sites within the proposed construction area. This would facilitate the development of appropriate research designs for subsequent sub-surface testing programs. The surface survey would also identify:

- sites or potential archaeological deposits that could be conserved in situ within the airport site; and
- sites potentially at risk due to indirect impacts such as siltation, creek bank erosion and reduced tree health.

- carry out sub-surface testing in areas of defined archaeological potential, to accurately identify the nature and distribution of the sub-surface archaeological resource. Testing would be carried out using both hand and mechanical digging and include sampling methods such as multiple shallow spade excavations, back hoe trenches, and grader scrape transects. The aim of this program would be to identify the best areas in which to conduct full scale salvage excavation;
- conduct salvage excavations in a range of locations, according to the priorities and criteria identified in the surface and sub-surface testing program. It is anticipated that the greatest focus would be on the creek corridors and sedimentary contexts below the plough line. Emphasis would be placed on large and open excavation, if sites with low levels of disturbance can be identified that warrant this approach. Deep narrow trenches may also be required to test and characterise older sedimentary facies;
- where considered appropriate by Aboriginal custodians, salvage the scarred sections of Aboriginal scarred trees after appropriate field recording. Selected examples would be the subject of a program of research with the aim of further identifying the origin and age of the scarring;
- in consultation with Aboriginal representatives and construction managers, adopt a set of strategies that define the actions required in the event that a significant site (such as a burial) is uncovered during construction works. Under the Airports (Environment Protection) Regulations an operator of an undertaking must notify the airport lessee company/airport environment officer if a previously unrecognised site of significance is discovered. This would include the following actions:
  - interrupt construction works;
  - notify any required statutory authorities;
  - obtain identification and assessment of the site by an archaeologist and suitably qualified Aboriginal representative; and
  - determine and implement an appropriate management strategy.
- implement an Aboriginal relics identification education program so that construction workers have the knowledge required to identify potential Aboriginal artefacts, relics or sites unearthed during construction.

Non-Aboriginal Heritage

- carry out archaeological assessment for all sites identified as having archaeological potential, prior to construction. Assessment would involve defining the probable nature and extent of archaeological resources, assessing their significance, determining the most appropriate archaeological management procedures and defining the boundaries for archaeological management procedures;

- carry out assessment and excavation for items judged to have high archaeological potential or rare representation within the study area;
- carry out test excavation, usually involving machine or hand excavation of a small trench, for sites where the amount of retrievable information likely to be gained from below ground remains is unknown. A site specific archaeological assessment prior to test excavation, as well as a more detailed search of historic records, would assist in determining the boundary of the area to be investigated. Test excavation would enable an archaeologist to determine whether the site merits any further action;
- in cases where sites undergo test excavation but do not warrant full archaeological excavation, carry out archaeological monitoring of the site;
- carry out archival recording for buildings and other standing structures that are to be demolished. Archival records would include all background information such as the subject of the record, why the record was made, an outline of the history and a statement of heritage significance. The record would also contain imagery of existing archival documents, black and white photography and colour slides as a minimum requirement. Measured drawings for items of regional significance would also be required. These would be handled in accordance with the standard procedures of the NSW Heritage Office. Archaeological sites would be fully recorded both graphically and photographically at the time of excavation, test excavation or monitoring;
- carry out dilapidation surveys of items to be retained near the boundary of the site before commencement of construction works, so that their condition could be regularly monitored both during construction and operation of the airport;
- prior to excavation and following recovery of artefacts, obtain advice from an experienced materials conservator in relation to cleaning, short term storage, special treatment requirements and long term storage and curation; and
- investigate opportunities for the retention of heritage items currently identified as being demolished or destroyed for the preferred airport option.

Monitoring

Not applicable

Reporting

Results of consultations, survey, subsurface testing, salvage excavations and approvals with respect to Aboriginal archaeological artefacts, relics and sites are reported as part of the environment strategy.

Results of non-Aboriginal archaeological assessments, excavations and archival recording to be regarded as part of environment strategy.

2.12.3 Proposed Management Controls - Construction Phase

Strategy 2: Protect Identified Items of Aboriginal and Non-Aboriginal Heritage Significance to be Retained or Salvaged During Construction

Proposed Actions:

Management measures would include:

Aboriginal Heritage

- implement a program of regular monitoring of indirect impacts on the site with the aim of developing and assessing the effectiveness of mitigation strategies;
- based on the results of the above monitoring program, review environmental protection measures and if necessary redesign to mitigate indirect impacts, such as for the control of water flow velocities and sediment loads into relevant drainage lines. Where necessary, fence sites and the physical environment of sites would be stabilised and reinforced if impacts are likely to be significant either during or after construction;
- if sites have been identified that can be directly conserved in situ and are significant enough to warrant conservation, then develop management plans and implement for each site. Carry out in situ site maintenance to conserve the site or artefact in its original context and configuration, restoration and stabilisation of the site. Sites adjacent to the airport that might suffer indirect impacts would also be the subject of management plans; and
- any salvage program must provide permanent, appropriate storage of salvaged materials, and this would be an important funding consideration. Care and control would be placed in the hands of local Aboriginal groups.

Non Aboriginal Heritage

- care would be taken to protect retained heritage items. This might include boarding up of some buildings or using hoardings to isolate items from activities that might damage them.

Monitoring

The protection of any Aboriginal artefacts, relics or sites identified during construction are to be monitored. Qualified archaeologists and/or representatives of Aboriginal groups would act as observers of construction activities.

Reporting

Any Aboriginal artefact, relic or site identified during construction that was not identified in the EIS, would be documented.

2.12.4 Proposed Management Measures - Operational Phase

Strategy 3: Preservation of Identified Aboriginal and Non-Aboriginal Heritage Sites Retained On-Site and Controlling Indirect Impacts Off-Site

Proposed Actions:

Management measures would include:

Aboriginal Heritage

- continue monitoring and strategy review of processes established during the construction phase for creek and bank erosion, siltation risk and scarred tree health; and
- ensure that any Aboriginal sites were found and assessed prior to the potential development of freehold land adjacent to the airport site, encourage local government organisations to ensure that development approvals are conditional on conducting adequate levels of archaeological survey assessment, and where necessary, mitigation.

Non-Aboriginal Heritage

- monitor indirect impacts on any sites to be retained or sites adjacent to the boundary of the airport site.

Monitoring

Aboriginal Heritage

- a monitoring program, including collection of baseline data, would be required to test and assess the potential effects of airborne pollutants and their possible role in rock surface instability in a regional sample of shelter pigment sites and open grinding groove and engraving sites. The study would aim to identify what impacts, if any, can be attributed to airport derived pollutants and to recommend mitigation strategies where appropriate. Sites for study would include occurrences on the nearby Burragorang Plateau.

Reporting

Results of monitoring program described above.

2.13 Access and Traffic

2.13.1 Introduction

Vehicle movements associated with the construction and operation of the airport would increase the volume of traffic in the local area.

The objective of these environmental management measures is to reduce the impact of construction and operational traffic on the regional community.

2.13.2 Proposed Management Controls - Pre-Construction Phase

Strategy 1: Reduce the Impact of Construction Traffic on the Regional Community Through Effective Planning

Proposed Actions:

Management measures would include:

- involving the local community in traffic planning decisions, keeping the community informed of the commencement and likely progress of construction works and the principal roads to be used. Consider a community liaison forum to receive feedback from community, see *Section 25.4.2* "Community Relations" Strategy 1, for further details;
- developing a comprehensive construction traffic management plan, the key features of which would include:
  - considering the timing and use of roads for construction traffic to minimise the disturbance of traffic flows, particularly during peak traffic periods, that is, 7.00 am to 9.00 am and 4.00 pm to 6.00 pm weekdays;
  - maintaining access to the site via The Northern Road, Elizabeth Drive and Adams Road;
  - consulting local councils in respect to the construction routes to be used;
  - avoiding where possible, the use of local roads as construction traffic routes;
  - developing emergency response arrangements for transportation of fuel and other dangerous goods to the site in case of an accidental spill;
- submitting traffic management schemes for comment to local councils and other relevant authorities for any temporary lane closures or road deviations;
- identifying and upgrading roads on the perimeter of the site required for construction access where required;
- providing turning bays for construction vehicles entering the site;

- erecting appropriate temporary traffic signs at intersections to direct construction traffic along the access routes; and
- consulting relevant authorities including the Roads and Traffic Authority and local councils prior to any changes to public roads.

Monitoring

A traffic survey would be conducted before construction to establish the current traffic flow characteristics.

Community feedback on traffic arrangements

Reporting

Monthly report on community feedback on traffic arrangements.

Reporting of traffic survey results.

2.13.3 Proposed Management Controls - Construction Phase

Strategy 2: Manage the Impact of Construction Traffic on the Regional Community

Proposed Actions:

Management measures would include:

- involving the community by keeping the community informed of progress of construction works and any temporary access changes to properties;
- ensuring access to affected private properties is maintained at all times;
- maintaining and upgrading access tracks to the site working area if necessary;
- erecting construction-specific traffic signs; and
- maintaining traffic signs.

Monitoring

A traffic survey would be conducted at regular intervals during construction to determine the effectiveness of traffic control mitigation measures. The results of the construction traffic study would be compared against the preconstruction results to determine if the mitigation measures are effective during construction.

Number and type of complaints received.

Reporting

Monthly report of complaints received.

Reporting of traffic survey results.

Strategy 3: Reinstate Pre-Construction Conditions

Proposed Actions:

Management measures would include:

- removing temporary road signs; and
- restoring all access routes affected by the construction to at least original condition, having regard for development of new road infrastructure.

Monitoring

A traffic survey would be conducted following construction to establish the traffic flow characteristics.

Audit of road conditions.

Reporting

Audit report of road conditions.

Reporting of traffic survey results.

2.13.4 Proposed Management Measures - Operational Phase

Strategy 4: Develop and Implement an Operational Traffic Management Plan

Proposed Actions:

The overriding principle would be, that the traffic management plan would have adequate provision for traffic access, parking and circulation within the site.

The community and local councils would be consulted.

Monitoring

A traffic survey would be carried out initially monthly and subsequently every six months after the first 12 months of operation to determine if further management measures would be required.

The results of the traffic study after construction works have been completed and 12 months after commissioning of the airport would be assessed and actions taken to restore or improve the Regional traffic conditions.

Reporting

Report results of traffic study.

2.14 Visual and Landscape

2.14.1 Introduction

Development of the Second Sydney Airport would involve substantial modification to the landscape and visual quality of the sites of the airport options. The existing rural visual character would be replaced with a built-up commercial-industrial landscape. Significant vegetation remnants would be permanently removed from the airport sites.

Operation of the airport would lead to indirect adverse impacts on the visual quality of the proposed Greater Blue Mountains World Heritage area and areas around the airport site or under flight paths, through the occurrence of aircraft flying overhead. Operational lighting impacts are expected to be significant in areas close to the airport sites, depending on the position of the viewer relative to high intensity lights and the sensitivity of the viewer.

The objective of these environmental management measures is to mitigate the visual and landscape impacts during construction and operation of the airport.

2.14.2 Proposed Management Controls - Construction Phase

Strategy 1: Manage the Impact of Construction Activities on Visual Amenity Through Effective Site Planning

Proposed Actions:

Management measures would include:

- developing a landscaping plan for the site detailing locations and types of plants to be established during landscaping works. These plans would have due consideration for remnant vegetation as detailed in Section 2.7.3 "Flora and Fauna";
- planning construction works to screen the entire core of the site during construction;

- determining the extent and coverage of re-profiling and shaping in peripheral areas running out to the boundaries in the context of overall airport planning and design, with the aim to creating profiles compatible with existing topography;
- installing site lighting to illuminate only the construction-site and reduce light spill;
- installing temporary fencing and screening where appropriate around construction and waste handling areas for security and visual screening;
- ensuring that permanent security fencing is set back substantially from the boundary so that it is not visible from any point along road edges; and
- implement revegetation work in conjunction with peripheral earthworks as soon as practical.

Monitoring

Undertaking visual inspections to determine the effectiveness of control measures.

Monitor number of complaints received regarding visual amenity and ensure that waste areas and lighting are well maintained.

Reporting

Monthly report on effectiveness of control measures and complaints.

Strategy 2: Remove Temporary Structures

Proposed Actions:

Management measures would include:

- remove temporary lighting when construction completed;
- remove temporary diversion structures and signs when construction in work area completed;
- remove temporary fencing when no longer required; and
- remove all waste materials from construction-sites.

Monitoring

Not applicable.

Reporting

Complaints from community regarding aesthetics and amenity.

Appendix N

Errata

Appendix N
Errata

Table 22.8 Future Traffic Volumes on Key Approach Roads to Second Sydney Airport in Chapter 22 of the Draft EIS contained a formatting error. The error is corrected in the revised table below.

Table 22.8 Future Traffic Volumes[1] on Key Approach Roads to Second Sydney Airport (Average Daily Traffic)

Location Description	Without Airport 2006	With Airport (Forecast 2) 2006	% Increase	Without Airport 2016	With Airport (Forecast 3) 2016	% Increase
Airport Entrance (Elizabeth Drive)	n/a	24,600	n/a	n/a	61,400	n/a
Airport Entrance (The Northern Road)	n/a	8,800	n/a	n/a	20,200	n/a
Bringelly Road west of Cowpasture Road	23,200	29,200	26%	18,700	31,800	70%
Elizabeth Drive west of Wallgrove Road	23,200	30,200	30%	20,300	37,400	84%
Elizabeth Drive west of Mamre Road	14,400	26,600	85%	17,500	43,600	149%
Luddenham Road north of Elizabeth Drive	7,100	24,500	245%	4,600	55,000	1100%
M4 Motorway east of Wallgrove Road	128,000	141,600	11%	131,200	160,000	22%
Mamre Road south of M4 Motorway	33,600	46,800	39%	26,800	68,600	156%
The Northern Road north of Bringelly Road	17,900	29,000	62%	18,700	47,800	156%
M5 Motorway east of Moorebank Avenue	80,900	85,000	5%	106,200	119,500	13%
Western Sydney Orbital south of M4 Motorway	n/a	n/a	n/a	85,400	83,000	3%

Note: 1. Figures rounded to nearest 100.