EIS 612 Vol 2

AB019353

Environmental impact statement for an aluminium smelter at

Tomago, N.S.W.

TOMAGO ALUMINIUM
Company Pty Limited

Environmental Impact Statement for an Aluminium Smelter at Tomago, NSW

Volume 2
Appendices

Prepared by
James B Croft & Associates, Newcastle

TOMAGO
Aluminium Company Pty. Limited

Environmental Impact Statement for an Aluminium Smelter at Tomago, N.S.W.

Volume 2
APPENDICES

TOMAGO ALUMINIUM COMPANY PTY. LTD.
3rd. FLOOR, 4 O'CONNELL ST. SYDNEY
Phone: (02) 221 2333

TOMAGO OFFICE,
TOMAGO, N.S.W. 2322
Phone: (049) 648411

James B. Croft & Associates
Suite 7, Corona Building
275 A Hunter St. Newcastle
N. S.W. 2300
Phone: (049) 261828

Contents

VOLUME 2

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

interaction with natural chemicals in existing soils pp 33-34

LIST OF TABLES

LIST OF TABLES (cont'd)

Appendix 1

PROJECT TEAM FOR ENVIRONMENTAL INVESTIGATIONS

APPENDIX 1

PROJECT TEAM FOR ENVIRONMENTAL INVESTIGATIONS AND LIST OF AUTHORITIES CONSULTED

The following members of staff of James B. Croft and Associates had responsibilities for aspects of the project:-

J.B. Croft, B.E., Ph.D. (N.S.W.)	Management of the study, planning and co-ordination of the investigations and report writing.
M.Taylor, B.E. (N'cle.)	Engineering investigations; mathematical modelling; design of safeguards, report writing; supervision and planning.
K.W. Perry, B.Sc. (N.S.W.) B.Arch. (W.A.)	Social and planning aspects of study; visual aspects and landscaping designs; supervision of drafting staff.
V. Smith, B.Sc. (Hons.) (N'cle.) M.Sc. (N.S.W.)	Co-ordinator "existing environment" studies, geological, hydrogeological and economic aspects; interaction analyses; and report writing.
R. Fawkes, B.Sc. (Griffith,Bris.) Prim.Met.Cert. (Qld.)	Supervision of laboratory staff in provision of data for air, water and noise pollution investigations.
F. Helleman, B.E. (Metall.)(Melb.)	Engineering investigations, report writing.
G. Bartrim, B.Sc. Dip.Ed. (U.N.E.)	Flora, fauna and ecological studies.
A. Martin, B.Sc. (U.N.E.)	Ecological studies; agricultural land use.
L. Paslawskyj, B.Sc. (N'cle.)	Geographical and social aspects.
P. Ray, B.E. (Swin., Vic.)	Hydrological aspects; design of safeguards.
P. Jonas, B.Sc. (Griffith, Bris.)	Air, water and noise pollution studies.
R. Hutchison, B.Sc. (N'cle.)	Chemical analysis.
M. Berg, Chem.Cert. (M'bank Tech. N.S.W.)	Chemical analysis.
K. Lilly, B.Sc. (N.S.W.)	Mathematical modelling.

G. Matthews, B.E. (N'cle.) — Mathematical modelling.

Several staff members of the major companies which formed the consortium were responsible for the description of the proposal and the provision of background data as to objectives and planning.

Aluminium Pechiney Australia Pty. Limited:

X. Nosten	Managing Director, Permanent Delegate of Pechiney Ugine Kuhlmann Group in Australia

Aluminium Pechiney, France:

M. Laparra	Project General Manager
P. Bourgeois	Smelter Project Officer
H. Castro	Chief of Transport Services
Y. Lallemant	Chief Environmental Officer
P. Thaure	Assistant Manager Aluminium Division
W. Janson, B.Sc.	Technical Superintendent, Eastalco Aluminium Company

CSR Limited and Gove Alumina Limited (GAL):

G. Fortescue	General Manager GAL
R.L. Muller	Senior Project Engineer
L. Thomas	Project Industrial and Personnel Manager
B.M. Munday	Manager Environment and Occupational Health, CSR
W. MacMillan	Technical Manager - Aluminium
G.T. Cleland	Senior Engineer
I.P. Willington	Environmental Officer, CSR
C. Walters	Courtaulds (Australia) Limited
G. Lock	Economist

The officers of the following government departments and statutory authorities are thanked for their assistance:

Commonwealth Government:

Department of Science and the Environment

Bureau of Meteorology

Australian Bureau of Statistics

Department of Employment and Youth Affairs

New South Wales Government:

- Premiers Department
- Department of Environment and Planning
- State Pollution Control Commission
- Department of Mineral Resources
- National Parks and Wildlife Service
- Royal Botanic Gardens (Herbarium)
- State Fisheries
- Department of Main Roads
- Department of Public Works
- Health Commission of New South Wales
- Electricity Commission of New South Wales

Local Government and Statutory Authorities:

- Port Stephens Shire Council
- Newcastle City Council
- Hunter District Water Board

Dr. Pengelly, Faculty of Medicine, University of Newcastle.

Appendix 2

DETAILED EVALUATION OF ALTERNATIVE SITES

APPENDIX 2

DETAILED EVALUATION OF ALTERNATIVE SITES

A2.1 DESCRIPTION OF THE SITES

Sites 1 and 2 - Wyong

Two adjoining sites in the Wyong area were initially investigated by the Company in early 1979. Both sites were located south of Tuggerah adjacent to the Main Northern Railway, and near the Pacific Highway. The distance to Sydney by road for both sites was 90 km, and to Newcastle, 70 km, while by rail the distance from the Port of Newcastle was 80 km.

Both sites were located adjacent to the area initially proposed for the Tuggerah Power Station. Although this project is no longer proceeding, the two sites were close to a future power source, the new Eraring Power Station, expected to be operational in 1985.

Gas, water and electricity were, or would be, available in the near future, and the sites were located close to the Gosford-Wyong growth area which could provide the manpower required.

Both sites, although relatively flat and cleared, showed evidence of flooding. The sites were located adjacent to Ourimbah Creek which is known to flood regularly in its lower reaches after periods of heavy, continuous rain. The sites were waterlogged in areas and filling would have been required to raise the ground to a suitable flood-free elevation. Site 1 was also traversed by a proposed freeway which divided the land, and consequently for these reasons the sites were considered unsuitable for the smelter.

Site 3 - Muswellbrook

The site was located 5 km east of Muswellbrook, adjacent to the Main Northern Railway and 125 km from Newcastle. Two alternative orientations for the proposed smelter were examined on either side of a 330 kV branch line serving Ayrfield No. 3 Colliery.

Road access to the site from the New England Highway was by a rough track which passed under the railway and both the track and railway crossing required upgrading. Natural gas would be available in the near future, but a water supply would have to be established.

The land was reasonably level and only partly undulating. Foundations appeared to be suitable.

The site was owned by R.W. Miller & Co. Pty. Limited who purchased the property for the protection of their coal reserves. This fact, combined with the access difficulties, resulted in the site not being retained as an alternative.

Site 6 - Greta

A site immediately south of Greta was investigated on the recommendation of the Industrial Development Unit of the Premier's Department. The site was adjacent to the Main Northern Railway and within 1 km of the New England Highway.

On investigation, the site was found to be undulating and considerable earthworks would have been required to prepare the land for the proposed smelter. The land was also owned by the Commonwealth Defence Department and was not considered to be a suitable site.

Sites 7, 8 and 9 - Lochinvar

Three sites were examined in the Lochinvar area, approximately 45 km from the Port of Newcastle. All the sites were located in an area considered by the State Government for possible future industrial development adjacent to the Main Northern Railway Line. Rail siding facilities would have been possible.

A water supply was available, but would have required several kilometres of pipeline plus amplification of the existing system. Natural gas was expected to be available in the future. No sewerage facilities were available on these sites and some form of sewage treatment would have been required.

All sites were relatively close to the industrial area of Newcastle which could have provided the necessary manpower.

Site 8 was situated between the New England Highway and the Main Northern Railway, adjacent to the eastern boundary of the Bradmill textiles factory. The site was located in an area already extensively utilised by light industry. A railway spur was provided to the industrial area but was not used. The site was flat and cleared. Although foundations appeared suitable, the site was partly waterlogged and would be inundated after periods of rain.

Site 9 was located on the eastern side of the Bradmill textiles factory, and within 2 km of the town of Rutherford. Although possessing similar characteristics as Site 8, the area was smaller and more undulating. Maitland City Council was not in favour of heavy industrial development in this area.

These three sites were not considered suitable smelter sites, not only because of the factors described above, but because of their close proximity to the proposed Alumax aluminium smelter at Farley.

Sites 10 and 11 - Cessnock/Kurri Kurri

Two sites recommended by the Industrial Development Unit in the Cessnock - Kurri Kurri area were examined. Site 10, located at Neath was not considered suitable because of the hilly terrain, while Site 11 at Heddon Greta was considered too close to the existing Alcan smelter at Kurri Kurri to warrant further investigation.

Site 12 - Tomago (A)

This is the preferred site of the Company for locating the proposed smelter and was subjected to a detailed environmental investigation prior to final selection. The findings of the study are presented in *AppendixA2.4* where detailed locational and environmental factors are discussed. The site was originally considered because of its proximity to the Port of Newcastle and existing infrastructure availability.

Site 13 - Tomago (B)

The site was located on the southern side of Tomago Road between the Hunter River and Fullerton Cove. Although conveniently located to the Port of Newcastle, the site was low lying and flood prone. A levee bank and considerable filling would have been required to raise the site to an acceptable height above highest flood levels. Such earthworks could have impeded the natural flow of flood waters in this area. For these reasons, the site was not considered a suitable alternative.

Site 14 - Williamtown

This site was one of three that was subjected to a detailed environmental investigation.

Factors leading to the site being considered were its close proximity to the Port of Newcastle, area availability and flat topography. The site is discussed in more detail in *Appendix A2.3*.

Site 15 - Fullerton Cove

A site on the western side of the Nelson Bay - Stockton road, between the road and Fullerton Cove was investigated by the Company. The characteristics of this site were similar to Site 13 in that the land was low lying, waterlogged and flood liable. Considerable filling would have been required to raise the land above flood level and these costs were considered prohibitive.

Site 16 - Cardiff

A site within an industrial zone near Cardiff, in the southern suburbs of Newcastle, was originally proposed by a real estate agent through the Industrial Development Unit. The site was 20 km from the Port of Newcastle, undulating and close to residential areas and hence considered unsuitable as a smelter site.

Site 17 - Kooragang Island

The eastern side of Kooragang Island was the first area to be considered by the Company for the siting of the proposed smelter. Originally recommended in an Investment Brief prepared by the Industrial Development Unit, the site was subjected to a detailed investigation and is discussed in detail in *Appendix A2.2*.

A2.2 KOORAGANG SITE

A2.2.1 Locational Factors

This site occupied most of the northeast corner of the Kooragang Island Industrial Estate in the City of Newcastle, as shown on *Figure 4.2*.

Kooragang Island is part of a network of islands in the estuary of the Hunter River which have been progressively reclaimed over a period of years using material dredged from the two adjacent river channels. Reclamation and development work commenced in the southern and south-eastern sections of the estate with the provision of the wharf facilities known as Rotten Row and the development of road and rail access. Several small industries are now established in the area with further potential for heavy industries and bulk materials handling facilities based on the use of Newcastle Harbour, which is in the process of further deepening, and on the available infrastructure.

The site was 1.5 km by sealed road from the port at Rotten Row and was adjacent to the railway provided to the industrial estate. Water supply and power were available in the vicinity of the site, although extensions and upgrading would have been required. The provision of a sewage treatment plant would also have been necessary. The site was in the vicinity of the proposed natural gas pipeline terminus connecting Sydney and Newcastle, which is expected to be operational within two years. Heavy and light engineering works, supplies of construction materials and a supply of skilled labour were readily available to the site.

A2.2.2 Environmental Factors

The results of the detailed environmental assessment of this site, and the Williamtown and Tomago sites, were presented in a document used internally by the Company in determining the optimum plant site *(James B. Croft and Associates, 1979)*. This document provided detailed information on the sites which is summarised below for the Kooragang site.

Foundation Conditions

The Kooragang site has been partly reclaimed using dredge spoil from the bed of the Hunter River. The area was 1 to 2 m above high water and was relatively flat. Additional filling would have been required to raise the site to a flood-free level of 3.8 m above datum. Piling to bedrock may have been necessary for some major loads.

Flora and Fauna

The site was mainly grassed or bare with only small areas of natural vegetation. It adjoined the proposed Kooragang Island Nature Reserve to the north which is characterised by Mangrove stands varying from Closed Forest to Open Woodland, Salt Flats, and Salt Meadows on higher ground.

No clearing of any consequence would have been required on the actual smelter site.

Microclimate

The Kooragang site experienced wind turbulences since it is under the influence of sea breezes and localised breezes generated from the surrounding areas of water. Southerly and southwesterly winds move emissions from surrounding industries onto the site. Westerly and northwesterly winds would have dispersed emissions from the site in the direction of Fern Bay and Stockton, respectively.

Coal Resources

Economic coal occurs beneath Kooragang Island at depth below a thick cover of unconsolidated sediments. There are no short-term plans to mine the coal and, because of the extent of industrial development and the problems of mining beneath unconsolidated sediments, any extraction of coal would be likely to be confined to the deeper coal horizons and unlikely to cause any surface subsidence problems.

Agricultural Use

There was no agricultural land use in the vicinity of the site.

Special Uses

Special uses in the area included the Stockton Hospital for the Intellectually Handicapped, Fort Wallace which is a Department of Defence installation and the Stockton Rifle Range. Outside this area, the Hunter District Water Board has a sewage treatment plant located on Stockton peninsula adjacent to Fort Wallace. The additional effect that a smelter would have had on emission levels measured near the hospital may have led to an impact on this use. Other uses would not have been affected.

Urban Use

The settlement of Fern Bay was within close proximity of the site. More distant settlements were North Stockton, Stockton, Mayfield and Carrington being 2.5 to 4 km from the site.

Moderate to very high levels of fluoride in vegetation have been measured in the Stockton and Fern Bay areas and have been of concern to local residents. These levels are due to a number of fluoride producing industries in the Mayfield and Kooragang Island areas. The high background fluoride levels have resulted in damage to home-grown vegetables, garden flowers and shrubs.

An impact on residents would have been expected if the siting of a smelter at this location had resulted in an increase in the levels of fluoride above the moderate to very high levels which already existed.

Industrial Use

The site was located within an area designated for the first stage of industrial development on Kooragang Island. The area was zoned for heavy industrial use and under the control of the New South Wales Department of Public Works. The siting of a smelter on the island would have been unlikely to cause an impact on existing industry but may have restricted the entry of additional fluoride producing industries.

Sound Levels

The site had high background sound levels as a result of the adjacent heavy industrial land uses. It was expected that sound levels emitted from the smelter would not have added significantly to existing background levels.

Water Quality

Water discharges from the plant to the Hunter River would have been possible at the site subject to controls imposed by the State Pollution Control Commission.

Visual Aspects

This site was ranked as having low scenic interest due to the flat, barren appearance of the filled areas and the surrounding heavy industrial land use.

Open Space, Natural Areas and Recreation

Open space in the vicinity of the site consisted of the Hunter River, proposed nature reserves and Stockton Beach. Apart from bird watching and fishing along the north arm of the Hunter River, recreation is confined to the Stockton area. The beach, rifle range and sports ovals are the main attractions. The proposed smelter would not have affected open space areas beyond the industrial site.

Planning Proposals

Kooragang Island is zoned for heavy industry and large-scale industries are preferred on the island. The proposed Kooragang Island Nature Reserve includes the northern part of Kooragang Island and the long-term industrial future of Kooragang is uncertain.

Sociological

Residents of Stockton and Fern Bay are predominantly middle-aged and belong to an established community which co-exists with adjacent heavy industrial uses. It was expected that the siting of a smelter on Kooragang would have altered current life-styles only if increased fluoride levels occurred.

Economic

The siting of a smelter on Kooragang would have had a beneficial effect on employment opportunities and economic prosperity of the City of Newcastle. Support industries in the existing industrial areas of Mayfield, Port Waratah and Carrington would have benefited from the expansion of the industrial base that the smelter would have provided.

A2.3 WILLIAMTOWN SITE

A2.3.1 Locational Factors

The Williamtown site, shown on *Figure 4.3* , was approximately 10 km north of Newcastle and adjacent to the main road connecting Newcastle to the recreational area of Port Stephens. The site was cleared, low-lying grazing land behind the dune system of Newcastle Bight and near the Williamtown Royal Australian Air Force (RAAF) Base and civil airport.

The site was connected to the Port of Newcastle by a sealed dual carriageway for most of the route, but an upgraded intersection at Lavis Lane would have been required. No rail access was available.

Amplification and extension of the water supply to the site, and provision of sewage treatment facilities would have been required. Natural gas could have been supplied to the site with completion of the pipeline from Sydney to Newcastle, and power was available. The site was fairly remote from support facilities such as engineering works.

A2.3.2 Environmental Factors

The following notes are summarised from the preliminary environmental study.

Foundation Conditions

Building on this site would have required maximum attention to foundations. The sequence of unconsolidated sediments was capped by a very soft clay of high plasticity and compressibility, and hence settlement of up to 20 per cent of fill thickness could have been expected. The site was flat, low-lying and 1.0 to 1.1 m AHD, and filling would have been necessary to raise the site above flood level. This filling may have impeded the natural flow of flood waters between the Fullerton Cove and Tilligerry Creek catchments.

Flora and Fauna

The site consisted of pastureland and low-lying areas dominated by water tolerant plants. A few Swamp Oaks (*Casuarina glauca)* remained on the site. Clearing of the site would not have resulted in a significant impact on the environment.

Figure 4.3 shows the major native vegetation zones in proximity to the site which included the Open-Forest and Heath areas of the coastal sand dunes, the Forest, Woodland and Heath areas of the Tomago Sandbeds and the Mangrove areas of Fullerton Cove. Both the coastal sand dune vegetation and Mangroves of Fullerton Cove had been recommended for inclusion in nature reserves. All areas supported a variety of animals and birds.

Microclimate

The major microclimatic factors of this site included the frequent occurrence of fog and the prevailing south and southeasterly winds in summer. The fog was induced by the low-lying, cleared and waterlogged flats and would have helped to confine emissions to a small area. The southerly and southeasterly winds would have dispersed emissions in the direction of the RAAF base. These winds and the daily sea breezes have their speeds slightly reduced, and turbulence increased, by the sand dunes east of the site. The prevailing northwesterly and westerly winds in winter would have dispersed the emissions towards Newcastle Bight. Fogs in proximity to the RAAF base would have imposed problems for stacks.

Water Resources

The site was poorly drained by two man-made channels, namely the Fourteen Foot Drain and the Ten Foot Drain, which flowed into Fullerton Cove. The site was subject to frequent inundation after heavy rain and remained waterlogged for long periods. The area was also a natural floodway between the Fullerton Cove and Tilligerry Creek catchments. Filling may have impeded the flow of flood waters in this area.

The groundwater aquifers in this area were thought to be connected to the Tomago Sandbeds aquifer and were under investigation by the Hunter District Water Board as a source of potable water.

Coal Resources

High grade coking coal horizons occurred on the site between 200 m and 300 m below the surface. There were no short-term plans to extract the coal but the area occurred within a gazetted Reserve under the Mining Act (1973) held by the Electricity Commission of New South Wales to allow for the assessment of the coal resources for the steel industry and for power generation. Both the Commission and New South Wales Department of Mineral Resources were concerned at indefinite sterilisation of the resource.

Coal extraction by the bord and pillar technique would not cause surface subsidence, while total extraction could result in uneven ground subsidence. The proposed smelter may have created a long-term impact upon coal reserves on the site as its presence may have reduced the extraction rate if uneven surface subsidence was to be avoided.

Heavy Minerals

Heavy mineral sands of economic grade occurred in the vegetated and partly stabilised dunes adjacent to the Williamtown site. Mineral Deposits Limited had consent to mine the dunes, which were not expected to be directly affected by the proposed smelter.

Agricultural Land Use

Agricultural use was made of the site and the cleared, flat, sandy areas within the zone bounded by the coastal dunes, Fullerton Cove and the southern boundary of the Tomago Sandbeds. Dairying, grazing, beef grazing and horse breeding were the main uses carried out in the vicinity of the site. Potential impact upon agricultural use was likely to result from fluoride emissions upon vegetation subsequently eaten by grazing animals.

Special Uses

Special uses included the Hunter District Water Board Reserves southeast of the site in the coastal dune system and the Tomago Sandbeds Water Supply Catchment area to the north, Williamtown Primary School and adjacent Church, the Williamtown RAAF base and the adjacent Domestic Air Terminal.

The primary school was located approximately 200 m from the boundary of the site and was likely to be affected by noise, increased traffic generation and the loss of visual amenity. Possible impacts to the Williamtown RAAF base related to an increase in obstruction to flight paths, the effect of emissions upon aluminium components of aircraft and a reduction in the accuracy of radar due to increased haze.

Urban Use

Within close proximity of the site the main concentration of housing was located adjacent to the Williamtown Post Office. Residential areas also occurred on the RAAF base, 2 km from the site.

Industrial Use

The closest industrial land use to the site was located approximately 8 km to the west of Tomago. Secondary industry may have been attracted to the area and would have had an effect upon the visual environment, existing surrounding land uses and access to Nelson Bay Road.

Sound Levels

Sound levels emitted from a smelter at this site would have been audible at nearby residences. Background sound levels for the rural area were lower than industrial sites. Additionally, the site and its surrounds were flat and there was a lack of dense vegetative cover.

Water Quality

Options available for the discharge of water from the site were discharge at Newcastle Bight, or the Hunter River via Fullerton Cove. However, Fullerton Cove is a backwater flushed only by tidal flow during dry periods and some difficulties could have been expected in achieving acceptable dilution within the Cove. All discharges would have had to comply with regulations imposed by the State Pollution Control Commission.

Visual Aspects

This site was ranked highest in terms of visual interest as a result of the predominantly vegetated, coastal dune system which formed a backdrop to the flat, grassed floor of the site and environs. A smelter located at Williamtown would have created a high visual impact. Landscaping requirements would also have been high.

Open Space, Natural Areas and Recreation

Newcastle Bight beach is zoned for open space and recreation use and the adjacent coastal dune system has been proposed for reservation as the Newcastle Bight Dunes Nature Reserve. A smelter located on the site would not have altered the present recreational usage of the dunes for buggy riding and the use of the beach for fishing, swimming and passive recreation.

Planning Proposals

The siting of a smelter on this site would have required rezoning of the site from Non-Urban 'A' to an industrial classification. It was probable that a buffer zone of suitable width surrounding the site would have been restricted to a minimum subdivision area of 40 ha.

Apart from applications for minor subdivision approval of rural holdings, there were no other planning proposals for the area.

Sociological

Main concerns of residents in the vicinity of the site were the change from an essentially rural setting to an industrial use, and the possibility of reduced land values. The change from a rural character to industrial could have had an impact on Newcastle residents as well as tourists using the Nelson Bay Road, as the boundary between industrial and rural areas would have been moved closer to Port Stephens. Residents in the area most likely to have been affected were those who had a clear view of the proposed smelter. The siting of a smelter at Williamtown would have had significant sociological impact due to the contrast with the existing rural lifestyle.

Economic

The smelter would have expanded the local rural retail outlets and service industries along the Nelson Bay Road, as well as expanded and diversified the economic base of Port Stephens Shire due to a multiplier effect.

The rezoning of land as industrial may have led to a decrease in land values in the vicinity of the smelter as the area would have lost its rural appeal due to likely increases in traffic volumes, sound and emissions and a lowering of visual amenity.

Land and housing values in the Tanilba Bay, Lemon Tree Passage and Medowie areas were expected to increase both during and after the establishment of a smelter.

A2.4 TOMAGO SITE

A2.4.1 Locational Factors

Formerly the location of the Courtaulds (Australia) Limited factory for the production of the man-made fibre, rayon, this site is one of the few areas of land zoned for industrial development in proximity to Newcastle which is of sufficient size for the proposed smelter. The site is adjacent to the southern boundary of the Shire of Port Stephens and as shown on *Figure 4.4* except for the area of the former factory, is well vegetated. The site is partially underlain by the Tomago Sandbeds which are part of a continuous system stretching from Tanilba Bay to Tomago, and are a source of drinking water for Newcastle.

The site is served by two routes to the Port of Newcastle to the south. The shorter route of 18.5 km is via Tomago Road, the Pacific Highway, Industrial Drive and Cormorant Road. The alternative via Nelson Bay Road and Stockton Bridge is 24 km. No rail access is available.

A low level of infrastructure development is required for the site, which is provided with access, some site fencing, water supply, sewage treatment and a telephone system. Amplification of the existing electricity supply would be required. Some engineering and other relevant support facilities are also available in the adjacent industrial areas.

A2.4.2 Former Use of the Site

A description of the former operations and processes of the Courtaulds textiles factory has been included to provide a background to the former industrial use of the site and a basis for comparison with the proposed smelter activities.

Courtaulds (Australia) Limited established a textiles factory on the proposed site in 1950 and commenced production in 1952. Factors considered in the selection of a site were the availability of a large, constant water supply, and labour force. The Tomago site proved suitable because of its proximity to Chichester Dam and Tomago Sandbeds for water supply, proximity to the Hunter River for liquid waste disposal, and the availability of skilled and semi-skilled workers in the Newcastle area.

The factory was located within 400 m of Tomago Road and covered a rectangular area of approximately 600 m by 300 m (18 ha). Buildings were orientated east-west and constructed primarily of brick with various roofing materials and floors of concrete and timber. These buildings housed the acetate and viscose-making and spinning departments, boiler house, raw material and product transfer areas, and water treatment facilities. A weighbridge and car park with provision for 900 to 1000 cars were provided near the main access gate.

Processes carried out at the factory included acetate spinning, viscose making and spinning, and yarn processing. In 1972, when the plant was near full production, 3173 t of viscose and 2700 t of acetate were produced.

The peak level of employment was approximately 1200 persons, almost one half of which were shift workers. The administrative, engineering and technical staffs were mostly day workers, although engineering, maintenance and technical personnel were in continuous attendance.

Raw materials were as follows:-

Wood pulp	-	3,300 t/y
Carbon disulphide	-	1,200 t/y
Caustic soda	-	2,400 t/y
Sulphuric acid	-	3,800 t/y
Cellulose acetate	-	2,700 t/y
Acetone	-	400 t/y
Coal (for boilers)	-	32,000 t/y

Comparison with Proposed Smelter

The proposed smelter will require an area of 78 ha compared to 18 ha of land on which the Courtaulds textiles factory was established. The existing cleared land will form part of the proposed plant area and only an estimated further 45 ha will require clearing. The smelter will cover some 15 per cent of the site which totals 508 ha.

Both the smelter and the textiles factory represent industrial developments which require substantial foundations for the various buildings, machinery and storage facilities. It has been shown by the textiles factory that suitable foundations are possible in the area and there is no evidence to suggest that conditions will differ significantly in the additional area required for the smelter.

Both fibre spinning and the smelting of aluminium involve processes in which materials are broken down into their components by chemical reaction and then formed into useful solids for the manufacture of various products. In both processes there are a number of waste products, some of which may be recycled, others which undergo some form of treatment before discharge, and finally those which may be discharged without treatment.

Aluminium smelting is a much larger operation than fibre manufacturing in terms of material throughput. Whereas some 10,500 t of raw materials were used to produce 5900 t of final products annually in textiles manufacture, the smelting process will use 550,700 t of solid materials and 3.2×10^9 kW.h of electrical energy to produce 220,000 t of solid aluminium.

Both aluminium smelting and fibre manufacturing are continuous processes requiring approximately 50 per cent of the total employees to be shift workers. However, the fibre manufacturing process employed by Courtaulds required nearly twice the number of employees as will be required for the smelter. Both processes require a skilled and semi-skilled labour force.

With the exception of the water supply and telephone connections to the site, all other services for the smelter will have to be upgraded or rebuilt.

The only materials used in fibre manufacturing not originating in New South Wales were wood chips which provided the cellulose for the viscose production. These were shipped from the USA. For this reason, as well as the cost effectiveness, road transport was used exclusively for the transport of materials in Australia. As the spun yarnwas destined for domestic markets, road transport was used for the same reason. For aluminium production, most raw materials are delivered to Newcastle by ship and all products are exported by ship. Road transport is to be used for movement between the port and the plant as it is still the most cost efficient method of handling such materials.

The majority of employees in the fibre manufacturing process travelled by private vehicle or bus service. It is expected that employees of the smelter will also travel by private vehicles and hence private vehicle movements on public roads are not expected to be higher. The existing area of car park for 900 to 1000 vehicles would prove adequate.

Although both processes produce wastes which are potentially damaging to the environment, discharges from the smelter will be much less volatile than those from the fibre production and will be subject to far greater control as a result of the improvement in emission control which has occurred in recent years. The overall potential for adverse effects is expected to be lower for the proposal than for the previous land use.

A2.4.3 Environmental Factors

The findings of the preliminary study are presented below.

Foundation Conditions

This site has good foundation conditions. The underlying sands are loose to medium dense and would require compaction prior to construction. Bedrock occurs at shallow depths and at the surface on the western side of the site. This site is generally level, with the exception of the northwest corner. Minor levelling and filling would be required.

Flora and Fauna

The Tomago Sandbeds support extensive and highly diverse vegetation assemblages ranging from Open Forest and Woodland to Heathland. Low-lying swampy areas are found interspersed with the Dry Sclerophyll associations and consist of Closed Scrub, Closed Heath, Open Heath and open water associations

Fullerton Cove, shown on *Figure 4.5* is a shallow inlet surrounded by extensive Mangrove Forests. The intervening Salt Flats consist of salt tolerant plants such as Samphire (*Salicornia quinqueflora)* and Salt Couch *(Sporobolus virginicus)*. The area has high conservation significance and has been recommended for inclusion in a nature reserve.

The vegetation of the Tomago Sandbeds is relatively undisturbed. The vegetation assemblages are well preserved in New South Wales but since the structural classification is broad, may possess unique features. Some plants found in the area are on the New South Wales Protected Plants List.

The sandbeds possess a wide diversity of fauna habitats and the estuarine areas and shallow waters of Fullerton Cove attract large numbers of migratory waders and water birds.

Microclimate

The site is largely protected from the northwesterly, easterly and south-easterly winds which are slowed by the surrounding vegetation. The site is exposed to westerly and southerly winds and wind funnels are created by areas cleared of vegetation.

Water Resources

Since the site is underlain by extensive deposits of sand, rain water infiltrates through to the underground water aquifer and there are no natural streams or water courses on the surface.

The adjacent Tomago Sandbeds Water Supply Catchment is an extensive area of water-bearing sandbeds that supply a significant proportion of Newcastle's domestic water. The groundwater table is within 1.5 to 5 m of the surface with a hydraulic gradient to the south and southwest. The Hunter District Water Board is concerned that appropriate measures are taken to protect the underground water resources because of the proximity of the proposed site to the proclaimed catchment area.

Coal Resources

Coal deposits occur on this site at depths of between 81 m and 335 m. The coal is a high fluidity, low ash coking coal suitable for blending with Upper Hunter coals of low fluidity to produce an optimum grade of coking coal. There are no short-term plans to extract the coal but, because of its quality and blending potential, it is regarded as a long-term resource by the New South Wales Department of Mineral Resources.

Heavy Minerals

An area has been mined for heavy minerals northeast of the proposed site. There is no potential for future heavy mineral sand mining on the site and hence this activity is not considered a constraint on the proposed development.

Glassmaking Sands

Low dunes on the site are capped by 1 to 2 m of sand suitable for colourless glass manufacture. The New South Wales Department of Mineral Resources regards these dunes as additional sources of glassmaking sand to supplement the present Tanilba Bay supply. These dunes are marginal to the proposed smelter site and will not be affected by the proposal.

Agricultural Land Use

Agricultural land uses occur predominantly to the east of the site where most of the land between Tomago Road and the estuarine flats of Fullerton Cove is used for grazing of dairy cattle. Dairying, poultry farming and grazing are carried out in close proximity of the site and parts of Kooragang Island are used for horse and cattle grazing. The effect of a smelter on agricultural land uses in the area would require investigation.

Special Uses

Special land uses within the vicinity of the site include the Hunter District Water Board's Tomago Sandbeds Water Supply Catchment area, the Tomago Detention Centre, a caravan park 1.5 km west of the site and Tomago Primary School.

Urban Use

Within close proximity of the site there are approximately 50 houses, mostly located on Tomago Road, including the historic Tomago House. Beyond this area, the closest large concentration of residential use is located at Raymond Terrace and Hexham.

Industrial Use

The site is within an area zoned for industrial use which is continuous along Tomago Road on either side of the site. Existing industry includes steel fabrication and warehousing. A smelter on this site will not create an impact on these industries.

Sound Levels

The site is located within an area of industrial land use with high background sound levels. The surrounding dense vegetation increases the attenuation of sound emitted from the smelter, compared with flat, unvegetated land. The small number of residences within 1 to 2 km distance of the proposed smelter are within areas zoned for industrial land use.

Water Quality

Discharge to the ocean is not practical for this site. Conditions would be imposed on the release of water to the nearby Hunter River.

Visual Aspects

The site has only moderate scenic interest. The area is densely vegetated north of Tomago Road and views are limited to the near vicinity of the road.

Open Space, Natural Areas and Recreation

Natural areas are the Tomago Sandbeds vegetation, Fullerton Cove and Kooragang Island; the latter two proposed for inclusion in nature reserves. Recreational activity is mainly limited to fishing in the Hunter River. A Bowling Club is established opposite the site on Tomago Road and the International Motordrome is nearby.

Planning Proposals

The siting of a smelter on the Tomago site would be in accordance with the existing zoning of the area for industrial purposes. A proliferation of secondary industry around the smelter could be readily accommodated in this industrial zone.

Sociological

The smelter will act as a major source of employment for Port Stephens Shire and adjacent regions. Impact on nearby residents would be minimised by the existing vegetative buffer zone which will limit views of the facility. Present residents live adjacent to the existing industrial zone, and therefore it is likely that the siting of a smelter will not markedly alter their lifestyles.

Economic

The economic base of the surrounding region will be diversified and strengthened and land values could be expected to rise as secondary industries expand in the area.

Appendix 3

RAW MATERIAL ANALYSES

APPENDIX 3

RAW MATERIAL ANALYSES

A3.1 ALUMINA

	Gove (N.T.)	Q.A.L. (Qld)	Kwinana (W.A.)
B.E.T. Surface (m^2/g)	49.2	81.5	60.3
Alpha Alumina content (%)	-	20	17
Minus 48 micron (%)	4.0	9	15
Loss on Ignition 300°C (%)	0.4	3.4	2.3
Loss on Ignition 300-1000°C (%)	0.5	1.1	0.7
Apparent density	0.97	1.03	1.01
Angle of repose (degrees)	31	28.5	34.5
Sodium (ppm)	4400	2400	4300
Calcium (ppm)	180	90	320
Iron (ppm)	140	310	210
Nickel (ppm)	20	20	20
Magnesium (ppm)	10	5	5
Fluoride (ppm)	310	400	400
Potassium (ppm)	20	10	10

A3.2 PETROLEUM COKE

Density	2.06
Ash	0.5%
Sulphur	2.5%
Iron	100 ppm
Silicon	100 ppm
Vanadium	250 ppm
Nickel	125 ppm

A3.3 PITCH

Softening point C/A ASTM 2319	108°C - 115°C
Quinoline Insoluble	12 - 18%
Benzene Insoluble	27% min
Beton resins	15% min
Coking Value	57% min
S.G. at 15.5°C	1.31 min
Distillation 0-360°C	5% max
Ash	0.4% max
Iron	0.05% max
Silicon	0.10% max
Sulphur	0.75% max
Moisture (for pencil form)	1.0 max

Appendix 4

SOIL ANALYSES

APPENDIX 4

SOIL ANALYSES

A4.1 MINERAL COMPOSITION

The sand is fine-grained and overall relatively uniform in size and grading both in surface distribution and depth. Most of the sand passes through a 250 μm mesh sieve but is retained on a 180 μm mesh sieve. Detailed analyses have shown that the average effective size of washed sand grains is 0.244 mm diameter, with an average uniformity coefficient of 1.39 *(Vallentine and Herzog, 1968)*.

The results of cone penetrometer tests carried out at several sites within the area prior to mining are illustrated in *Figure 6.4* and show that the density of undisturbed sand varies from loose near the surface to medium dense at 3.6 to 4.6 m, and generally becoming very dense below 4.6 m. Variations in the density below 4.6 m do occur over the area, indicating that the permeability and storage capacity of the undisturbed, very dense sand would not be uniform.

The sand consists primarily of quartz (average 95 per cent), rutile, zircon, ilmenite, pyroxenes and occasional feldspar grains with variable amounts of finely dispersed silt and clay as illustrated in *Figure 6.4*.

A4.2 CHEMICAL COMPOSITION

Results of analyses of fines are shown in *Table A4.1*.

Detailed soil analyses showing variation in parameters with depth are given in *Table A4.2* and pH and fluoride analyses of a number of soil samples taken at the sites shown on *Figure 6.3* are given in *Table A4.3*.

TABLE A4.1

ANALYSES OF FINES (SILT AND CLAY)

Parameters	Value
pH	4.5
Solids (percentage)	20
Ash (percentage of solids)	82
Volatile (percentage) carbonates?	18
Acid - Soluble (percentage)	15
Acid - Insoluble (percentage)	67
Iron (percentage)	3.1
Aluminium (percentage)	4.1
Organic Matter (percentage)	12.5

Source: *Parker and Herzog (1970.)*

The results show that:

i. Organic matter, water soluble phosphorus (P), potassium (K), sodium (Na) and magnesium (Mg) contents are higher in the surface soil layers than at depth.

ii. Water soluble fluoride also shows a general decrease with depth.

iii. The total aluminium (Al) content of the soil is variable, being higher in the range between 1 m and 2.5 m, than in the surface layer. Water soluble aluminium also shows a similar trend.

iv. The soils are low in fertility. Total phosphorus content ranges from 7 to 23 ppm and nitrogen (N) 1 to 15 ppm. Total Kjeldahl nitrogen is less than 0.04 per cent except in the surface 15 cm where it reaches 0.13 per cent.

v. Total soluble salts are low (<0.01 per cent) and pH ranges from 4.6 to 5.7.

TABLE A4.2

DETAILED SOIL ANALYSIS

Soil Depth (cm) *(Figure 6.3)*	Organic Matter %	pH	P W/T ppm	K W/T ppm	Na W/T ppm	Ca W/T ppm	Mg W/T ppm	Al W/T ppm	N ppm	Total Kjeldahl N %	Total Soluble Salts %	Sizing (%) Coarse	Medium	Fine	Silt	Clay
SITE S16																
0-15	-	5.7	0.8/23	8.4/61	18.7/22	6.3/100	2.6/170	5/530	15	0.13	0.01	1.4	64.7	19.8	5	2.7
15-40	0.060	5.6	0.5/10	5.5/23	6.6/12	1.3/13	0.8/55	4/276	10	0.04	0.01	1.1	75.5	18.8	2.2	2.3
40-65	0.040	5.5	0.3/8	2.1/13	4.0/9	0.6/5	0.4/30	3/150	2	0.04	<0.01	0.6	77.4	20.0	0	1.8
65-85	0.017	5.5	0.2/15	1.3/13	2.1/6	0.7/5	0.2/10	4/350	6	0.02	<0.01	0.7	73.0	20.7	4	1.7
85-2.5m	0.040	5.1	0.1/22	2.0/66	2.8/8	1.3/1	0.7/35	14/4750	2	0.02	<0.01	1.2	71.4	18.4	3	3.7
2.5-4m	0.027	5.4	0.2/12	1.7/41	2.3/8	0.7/1	0.4/20	6/1500	2	0.01	<0.01	0.9	78.2	16.7	2	3.8
4-4.5m	0.005	5.4	0.2/7	1.6/20	1.8/6	0.4/1	0.3/10	5/775	1	0.01	<0.01	1.6	78.6	16.3	1.8	1.7
SITE S17																
0-35	0.08	4.6	0.9/12	3.1/22	5.4/13	1.5/20	0.5/70	4/250	2	0.05	0.01	0.6	76.6	16.6	3.4	1.7
35-80	0.03	4.6	0.3/9	0.6/5	2.3/9	0.6/5	0.2/20	3/50	3	0.03	<0.01	1.6	82.8	14	2.7	1.8
80-100	0.02	4.9	0.3/7	0.9/5	2.8/9	0.5/5	0.1/15	2/50	3	0.04	<0.01	0.9	77.8	17.4	2.3	2.7
1-1.3m	0.005	4.9	0.2/8	0.5/5	1.3/6	0.6/1	0.2/10	2/100	6	0.03	<0.01	0.7	77.5	19.2	3.3	1.8
1.3-2m	0.03	4.9	0.2/17	0.6/52	2.0/8	1.1/1	0.3/25	20/3500	5	0.03	<0.01	1.0	72.5	20.1	0.8	3.7
2-4m	0.02	5.0	0.2/12	0.6/15	1.8/8	0.8/1	0.2/10	7/900	3	0.02	<0.01	0	56.0	28.9	2.1	7.2

COMMENTS:

W/T
- W, Water soluble elements in soil, 1:2.5 extract.
- T, Total elements in soil, tri-acid digest except total P determined on hydrochloric acid digest.
- pH, Determined on a 1:5 extract.

Sizings
- Coarse sand is the material retained on the 1.00mm sieve.
- Medium sand is the material retained on the 0.25mm sieve
- Fine sand is the material remaining.
- Silt and clay content determined using hydrometer technique.

TABLE A4.3

FLUORIDE AND pH ANALYSES OF SOILS
FROM SITE AND ENVIRONS

Sampling Site *(Figure 6.3)*	Description	Depth (cm)	Water Soluble Fluoride (ppm)	Total Fluoride (ppm)	pH
S1	Brown silty clay loam	0-10	.11		5.3
	Grey medium-textured clay	10-20	.09		-
	Grey plastic clay	20-30	.03		-
S2	Grey-brown silt	0-10	.12	29.5	4.4
	Grey-brown clayey silt	10-25	.08		-
	Grey plastic clay	25-40	.06		-
	Grey plastic clay	40	.07		-
S3	Organic grey sand	0-10	.11		-
	Grey fine-grained sand	10-40	.05		-
S4	Highly organic, black-brown peat	0-10	.23		4.2
	Moist brown peat	10-20	.08		-
	Brown-orange clayey sand	20-35	.04	62.1	4.6
	Sandy grey peat	35-45	.04		4.4
	Orange moist sand	45-55	.03	14.1	4.2
S5	Organic grey sand	0-10	.30		-
	Grey moist sand	10-20	.12		4.2
	Grey fine sand	25-35	.08		-
	Grey fine sand	35-50	.13		4.3
	Cream fine sand	50-55	.19	19.2	4.4
S6	Organic grey sand	0-10	.11		-
S7	Grey organic sand	0-10	.15	29.6	4.5
	Moist grey sand	50-60	.15		-
S8	Grey-brown organic sand	0-10	.04	34.1	-
	Moist peaty sand	50-60	.15		-
S9	Grey organic sand	0-10	.07		4.3
	Cream fine sand	50-60	.09		4.4
S10	Grey sand	0-10	.12	25.5	4.5
	Cream-orange sand	50-60	.03		4.8
S11	Grey sand	0-10	.08		-
	Cream-orange sand	50-60	.08		4.0
S12	Grey sand	0-10	.07		4.3
	Cream sand	50-60	.12		4.5
S13	Grey sand	0-10	.15		-
	Cream sand	50-60	.27		-
S14	Black-brown clayey sand	0-30	.78		6.0
S15	Grey-brown fine silt	0-10	.33	45.5	4.8

Note: ppm ≃ mg/l

vi. The total fluoride content of the soil ranges from 14.1 to 62.1 ppm and except for isolated readings is similar to the fluoride content of sandy soils measured by *Larsen and Widdowson (1971)*, (1.8 to 38.0 ppm).

A4.3 POTENTIAL EFFECTS OF EMISSIONS ON SOILS

The soils in the region of the site form the interface between the expected atmospheric emissions and the groundwater table. The reaction of these emissions with soils determine indirectly the impact of fluoride emissions on the groundwater aquifer. Secondly, fluoride concentrations in soils are considered for their potential to contribute to fluoride levels in vegetation.

A4.3.1 Sources of Soil Fluoride

Fluoride in the soil may be derived from three main sources. Fluoride can occur naturally in the soil derived from fluoride minerals such as apatite and fluorite, and the mica minerals commonly present in fine clay or colloidal particles. *Robinson and Edgington (1946)* found that the micaceous clay minerals contained relatively large quantities of fluoride ranging from 30 ppm in sericite to 7400 ppm in bentonite.

Secondly, phosphatic fertilisers are a major and widespread source of soil fluoride and can add between 8 kg F/ha.y and 20 kg F/ha.y to soil of which only 0.1 to 0.4 per cent is taken up by vegetation *(Oelschlager, 1971)*. Similarly, *Larsen and Widdowson (1971)* found that 38 kg P/ha.y in superphosphate containing approximately 4 kg F/ha.y, raised soluble soil fluoride from 0.40 to 0.60 ppm.

The third source of soil fluoride is gaseous and particulate emissions from fluoride producing industries such as the proposed development. These emissions may be in the form of hydrogen fluoride gas, particulates less than 1 μm diameter and particulates between 1 μm and 11 μm diameter. These emissions may directly contact the soil, or may enter the soil in rain water either directly, or indirectly, by the washing of vegetation.

A4.3.2 Factors Determining the Uptake of Fluoride by Soils

Factors that determine the uptake of fluoride by soils are the physical and chemical characteristics of the soil, intensity and direction of prevailing winds, levels of emissions, topography of the site and the presence of vegetation.

Fluoride in the soil may be tightly bound as a mineral particle, bound electrostatically to colloids (labile fluoride) or may be soluble in the soil water. Total fluoride is the combination of all forms of fluoride. The main characteristics of soils that determine the levels of fluoride are the presence of clay colloids, calcium and organic matter and the soil pH. *Lavado and Reinaudi (1979)* found that water soluble fluoride levels in salt-affected soils were related to soil pH rather than total fluoride levels.

Generally, sandy soils are low, and heavier textured clay soils higher in total fluorides *(Robinson and Edgington, 1946)*. Clayey soils generally are high in aluminium, clay colloids and commonly organic matter. These mineral elements form stable, insoluble fluoride compounds with hydrogen fluoride, such as aluminium fluoride.

Omueti and Jones (1977) found that clay particles, particularly in acid conditions have a higher bonding energy than particles in sandy loams and are more able to absorb fluoride from solution.

It is generally found that fluoride concentrations vary with depth in the soil profile. *Larsen and Widdowson (1971)* determined that the highest concentrations of labile fluoride occur in the top 20 cm of both sandy and clayey soils, but decreased with depth in sandy soils. In clayey soils, labile fluoride decreased less with depth and tended to rise below 60 cm. Similar trends were observed with soluble fluorides. *Omueti and Jones (1977)* found that soils of low amorphous aluminium and clay, but with high pH absorbed little fluoride, so that most of the fluoride was kept in soil solution. This meant not only that fluoride in these soils was easily leached but that most of the fluoride in the soil was water soluble and hence directly available for plant uptake. Other studies carried out by these workers have shown that absorption of fluoride is strongly pH dependent, with maximum absorption always occurring between pH 5.5 to 6.5. *Larsen and Widdowson (1971)* also found that the proportion of soluble fluoride is high in both acid and alkaline soils.

Mead et al (1979) found that defluorination of fluoroacetate (compound found in fumigated plants) can occur in the presence of soil bacteria. This is an important consideration in the leaf litter or organic horizons of both sandy and clayey soils.

Topography and prevailing winds are factors in determining the distribution of fluoride emissions over soils. Another factor is the extent and type of vegetation which absorb gaseous fluorides and which may act as a 'sink', protecting nearby soils from the effects of emissions.

A4.3.3 Effect of Soil Fluoride on Vegetation

Studies have shown that fluoride reaching the soil does not affect vegetation growth, soil reaction or fertility *(MacIntyre, 1957)*.

The Maryland Department of Agriculture reported in its Fluoride Monitoring Programme Annual Report 1972-73 for the Eastalco aluminium smelter in Buckeystown Maryland, USA, that vegetation accumulated about 0.8 per cent of the fluoride level in soil. *Hansen et al (1958)* also reported that fluoride uptake from soils exposed to several years of airborne fluoride emissions, was not appreciably higher than fluoride uptake from several soils taken from an area subject to little or no fluoride emissions.

McClenahen (1976) found that vegetation growing in areas free of fluoride emissions generally contains 10 μg/g or less fluoride in foliage, indicating that most plants are poor accumulators of soil fluoride, although plants probably differ in their ability to absorb fluoride from soil. The major mechanism of fluoride uptake in plants showing high fluoride content is thought to be by direct absorption of atmospheric emissions through the leaf stomates, rather than by the roots *(Hansen et al, 1958)*.

Appendix 5

SURFACE
WATER QUALITY

APPENDIX 5

SURFACE WATER QUALITY

A5.1 PROCEDURES

A total of 25 water monitoring and sampling sites have been selected within a 10 to 12 km radius of the proposed site. These include estuarine and fresh water swamps, lakes and stream systems throughout the subregion, as well as surface water areas on the proposed site.

The sites were sampled or monitored on the following days:

* 15th November 1979
* 26th November 1979
* 17th December 1979
* 14th January 1980
* 11th February 1980
* 12th March 1980
* 22nd April 1980
* 19th May 1980
* 23rd June 1980

Figure 6.5 shows the locations of the sampling and monitoring sites. *Table A5.1* details the chemical and physical parameters monitored, type of instrumentation and/or chemical procedures used.

TABLE A5.1

PARAMETERS MEASURED AND METHODS USED

Parameter	Methods Instrumentation/Chemical Technique	Reference
Temperature	Y.S.I. conductivity meter	-
Conductivity	Y.S.I. conductivity meter	-
pH	Leeds and Northrup 7417 meter	-
Soluble Salts	Gravimetric analysis	A.P.H.A. Standard
Suspended Solids	Gravimetric analysis	Methods for the
Total Hardness	E.D.T.A. titration	examination of water
Chloride	Silver nitrate titration	and waste water
Sulphate	Barium sulphate gravimetric analysis	(14 Edition 1975)
Total Alkalinity	Acid titration	
Phenolphthalein Alkalinity	Acid titration	
Fluoride	Specific ion electrode	

A5.2 RESULTS

Table A5.2 details the results of the water quality analyses while *Table A5.3* summarises the results into three groups. Group A are the fresh water bodies on the proposed site, Group B are estuarine water sites within the subregion, and Group C comprises the fresh water sites within the subregion but outside the proposed site. One sample from each group (W1, W2 and W22) was analysed for substances listed in Schedule 2 of the New South Wales Clean Waters Act. These results are listed in *Table A5.4*.

i. Group A

Since the proposed site is located primarily on sandbeds where there are few permanent water bodies and streams, only 4 of the 25 samples were collected from the site and represent the total number available for sampling. The results of the analyses are summarised as follows:

(a) The waters are neutral (pH6.8) with low soluble salt levels (1.8 mmhos/cm at 25°C, 1086 mg/l salt).

(b) The suspended solid level is very high (1429 mg/l) and it is unlikely that these fresh water bodies would support significant populations of fish and benthic fauna. Research studies have shown that few fish are found in fresh water bodies containing more than 400mg/l suspended solids.

(c) The total hardness of these waters is approximately 496 mg $CaCO_3$/l which is within acceptable limits. The World Health Organisation recommends a maximum total hardness of 500 mg $CaCO_3$/l.

(d) The chloride levels are low (166 mg/l) and the water would be suitable for irrigation. Research studies have shown that chloride concentrations of 175, 265, and 350 mg/l will limit production of stone fruits, citrus fruits, and vines, respectively. The chloride level is well below the acceptable level of 250 mg/l indicated in Schedule 2 of the New South Wales Clean Waters Act.

(e) The sulphate levels are low (187 mg/l) and are well below the acceptable level of 250 mg/l indicated in Schedule 2 of the New South Wales Clean Waters Act.

TABLE A5.2

SURFACE WATER QUALITY RESULTS

SAMPLING SITES DESCRIPTIONS

Site Number *(Figure 6.5)*	Description
1	Dredge Pond on plant site (high in organic matter)
2	Hunter River at Tomago
3	Fifteen Foot Drain at Williamtown
4	Tilligerry Creek
5	Campvale Swamp (high in organic matter)
6	Grahamstown Reservoir, south side
7	Grahamstown Reservoir, north side
8	Hunter River at Raymond Terrace
9	Swamp near Raymond Terrace, adjacent to the Pacific Highway
10	Hunter River at Carrington Slipways
11	Hexham Swamp, north side
12	Woodberry Swamp
13	Creek on western side of Hexham Swamp
14	Hunter River, south arm
15	Ironbark Creek near Hexham
16	Hunter River, south arm
17	Hunter River, north arm
18	Newcastle Harbour at Stockton
19	Swamp on proposed site
20	Old colliery shaft-proposed site
21	Swamp on Hunter District Water Board Reserve near Pumping Station 20
22	East "Blue Lagoon" Hunter District Water Board Reserve near Pumping Station 20
23	West "Blue Lagoon" Hunter District Water Board Reserve near Pumping Station 20
24	Fresh water lagoon on proposed site
25	Fullerton Cove

TABLE A5.2

SURFACE WATER QUALITY RESULTS

Site Number (*Figure 6.5*)	pH				Conductivity (mmhos/cm at 25°C)				Soluble Salts (mg/1)				Suspended Solids (mg/1)				Total Hardness ($mgCaCO_3/1$)			
	Max.	Min.	No.	Mean	Max.	Min.	No.	Mean.	Max.	Min.	No.	Mean	Max.	Min.	No.	Mean.	Max.	Min.	No	Mean
1	7.8	4.2	9	7.1	.54	.17	9	.26	169	106	8	125.8	9	2	8	4.4	64	21	8	30.9
2	8.0	6.1	9	7.5	48	32.4	9	38.8	39445	24750	8	31112	590	21	8	127	6200	3900	8	4819
3	7.6	6.5	9	7.0	61	.18	9	22.5	49770	262	8	21232	39	6	7	30	8330	0	8	3496
4	7.6	6.0	6	7.2	55	35	6	49	46350	25720	5	37973	50	19	5	48.8	7240	4490	5	6346
5	6.7	5.5	3	6.3	.3	.18	3	.24	377	160	2	268	119	84	2	101	79	40	2	60
6	8.3	5.7	9	7.8	.32	.22	9	.25	177	125	8	151	31	2	8	7.4	77	40	8	53
7	8.9	6.7	9	8.3	.53	.23	8	.35	1345	157	8	365	46	6	8	25	110	31	8	68
8	8.2	7.2	5	7.8	30	11	5	20	8870	8870	1	8870	15	15	1	15	1550	1550	1	1550
9	8.1	4.0	3	7.6	1	.67	3	.79	740	326	2	533	4	4	1	4	240	90	2	125
10	8	7.3	9	7.6	41	26	9	34	35200	22185	8	28771	93	20	8	71	5490	3550	8	4487
11	8.6	7.3	7	8	41	19	7	33	33440	25760	6	28523	22	13	6	16	4780	4160	6	4458
12	8	6.6	6	7.7	31	3	6	21	37676	1670	5	20398	76	26	5	55	3920	480	5	2946
13	8.4	6.1	5	8.1	20	4	5	8.6	5230	5230	1	5230	22	22	1	22	13	13	1	13
14	8	6.0	5	7.6	47	31	5	40	-	-	-	-	-	-	-	-	-	-	-	-
15	8	6.7	5	7.7	50	30	5	41	-	-	-	-	-	-	-	-	-	-	-	-
16	8	7.4	7	7.9	52	46	7	49	45400	39520	2	42460	30	28	2	29	6500	5980	2	6240
17	8.2	7.5	5	7.9	53	45	5	49	39751	37871	3	38930	119	27	3	77	6440	32	3	4190
18	8.3	7.5	5	7.9	53	49	5	52	-	-	-	-	-	-	-	-	-	-	-	-
19	7.9	7.2	9	7.7	2.5	1.9	9	2.24	1934	546	8	1604	114	6	8	21	1280	970	8	1123
20	7.9	5.8	3	7.5	2.9	1.1	3	1.97	1930	990	3	1529	8270	7	3	4262	727	110	3	334
21	5.0	3.2	4	4.5	.82	.28	4	.56	353	205	4	278	64	37	4	53	111	42	4	68
22	8.1	4.0	8	7.5	.37	.25	8	.27	184	142	8	166	9	1	8	3.4	67	30	8	51
23	7.5	4.0	8	6.8	.43	.24	8	.28	167	36	8	137	8	1	8	3.5	85	16	8	56
24	5.1	5.1	1	5.1	.53	.53	1	.53	340	340	1	340	6	6	1	6	75	75	1	75
25	8.0	7.3	5	7.6	51	39	5	48	43380	39340	4	40652	212	128	4	168	6320	6150	3	6210

Comments: Soluble Salts gravimetrically determined at 105°C
Suspended Solids determined by filtering a known aliquot through a glass fibre filter pad.
Conductivity measured with a Y.S.I. meter.
pH measured with a Leeds and Northrup 7417 meter.
Hardness and alkalinity expressed in $mgCaCO_3/1$.

TABLE A5.2 (cont'd)

SURFACE WATER QUALITY RESULTS

Site Number *Figure 6.5*	Chloride (mg/1)				Sulphate (mg/1)				Total Alkalinity (mg/1)				Phenolphthalein Alkalinity (mg/1)				Fluoride (mg/1)				Flow
	Max.	Min.	No.	Mean	Max.	Min.	No.	Mean	Max.	Min.	No.	Mean	Max.	Min.	No.	Mean	Max.	Min.	No.	Mean	
1	75	47	8	55.8	103	13	8	38.1	52	6	8	15.1	0	0	7	0	.22	.04	8	.10	No
2	20816	11853	8	15130	5814	1594	8	2546	244	143	8	170	13	0	5	4.2	1.10	.54	4	.84	Yes
3	24305	53	8	9793	3490	20	8	1285	253	57	8	151	0	0	6	0	1.50	.16	8	.54	No
4	23735	12444	5	19594	2951	1951	5	2353	160	80	5	123	12	0	3	4	.96	.42	5	.74	Yes
5	61	45	2	45	50	40	2	45	16	12	2	14	0	0	1	0	.02	.02	1	.02	No
6	51	33	8	45	67	16	8	32	334	26	8	89	0	0	4	0	.96	.12	7	.28	No
7	92	51	8	67	189	16	8	60	93	6	8	53	0	0	3	0	.28	.12	7	.18	No
8	4311	4311	1	4311	835	835	1	835	206	206	1	206	-	-	-	-	.44	.44	1	.44	Yes
9	392	112	2	252	358	358	1	358	113	20	2	67	-	-	-	-	. 8	.54	2	.68	No
10	16949	10634	8	13534	2459	1414	8	1952	217	60	8	161	17	0	8	2.5	1.08	.54	7	.90	Yes
11	14285	12370	6	13141	2292	1728	6	1982	220	148	6	175	13	9	3	11	1.00	.54	6	.84	No
12	11275	979	5	8208	1300	242	5	1280	304	36	5	230	16	16	1	16	.90	.30	5	.64	No
13	1519	1519	1	1519	2008	2008	1	2008	52	52	1	52	-	-	-	-	.18	.18	1	.18	No
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes
16	20034	18800	2	19417	2876	2395	2	2635	129	124	2	126	11	11	1	11	.88	.62	2	.76	Yes
17	19425	18870	3	19076	3144	2622	2	2883	181	140	3	155	14	7	2	11	1.16	.96	2	1.06	Yes
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes
19	465	18	8	147	214	13	8	96	1802	325	8	1242	76	0	4	37	1.2	.28	8	.48	No
20	511	172	3	294	859	65	3	428	418	27	3	206	0	0	3	0	.64	.14	3	.32	No
21	60	46	4	53	187	51	4	116	46	3	4	26	49	6	4	14	.08	.02	4	.06	No
22	52	46	8	48	87	38	8	60	52	7	8	23	0	0	2	0	.46	.06	8	.14	No
23	55	39	8	46	94	39	8	62	52	6	8	18	0	0	2	0	.64	.08	8	.16	No
24	157	157	1	157	8	8	1	8	38	38	1	38	0	0	1	0	.24	.24	1	.24	No
25	19541	18224	4	18915	2839	2547	4	2682	137	134	4	136	13	12	2	12.5	1.24	1.10	3	1.16	No

TABLE A5.3

SUMMARY OF SURFACE WATER QUALITY RESULTS

Parameter		A* Sites W1,W19,W20 and W24	B* Sites W2,W3,W4, W8,W10,W11,W12, W13,W14,W15,W16, W17,W18,and W25.	C* Sites W5,W6,W7, W9,W21,W22,and W23.
pH	No	4	14	7
	$\bar{x}$	6.8	7.7	6.9
Conductivity (mmhos/cm at 25°C)	No	4	14	7
	$\bar{x}$	1.8±0.5	36.2±3.6	0.3±0.1
Soluble Salts (mg/1)	No	3	11	7
	$\bar{x}$	1086±480	27650±3796	270±53
Suspended Solids (mg/1)	No	3	11	7
	$\bar{x}$	1429±1416	60±15	28±14
Total Hardness (mg/1)	No	3	11	7
	$\bar{x}$	496±326	4069±601	68±10
Chloride (mg/1)	No	3	11	7
	$\bar{x}$	166±69	12967±1911	80±29
Sulphate (mg/1)	No	3	11	7
	$\bar{x}$	187±121	2040±201	104±43
Total Alkalinity (mg/1)	No	3	11	7
	$\bar{x}$	487±380	153±14	41±11
Phenolphthalein Alkalinity (mg/1)	No	3	9	6
	$\bar{x}$	12.3±12.3	8.2±1.7	2.3±2.3
Fluoride (mg/1)	No	3	11	7
	$\bar{x}$	0.30±0.12	0.94±0.08	0.22±0.08

Comments: * For locations and descriptions of sites see Table A5.2

No. : number of observations (in this case number of sites)

$\bar{x}$: mean ± standard error

Standard error: Standard Deviation / $\sqrt{\text{Number}}$

A : Fresh water sites located on the proposed site

B : Subregional estuarine water sites

C : Subregional fresh water monitoring sites.

Soluble and suspended matter determined gravimetrically at 105°C.

mg/1 ≡ ppm

TABLE A5.4

DETAILED WATER ANALYSIS

Parameters	Sites W1	W2	W22	Schedule 2 #
pH	4.6	7.5	4.9	6.5-8.5
Conductivity (mmhos/cm at $25^{o}C$)	0.21	41.34	0.25	-
Total Soluble Salts	134	34890	181	-
Total Hardness as $CaCO_3$	24	5380	88	-
Chloride	49	16258	31	250*
Sulphate	29	2397	48	250*
Total Nitrogen	<1	<1	<1	<10.0
Nitrate Nitrogen	<0.2	<0.2	<0.2	-
Arsenic	<0.01	<0.01	<0.01	0.05
Barium	0.1	9	0.15	1.0
Boron	0.35	<0.1	<0.1	1.0*
Cadmium	<0.02	<0.02	<0.02	1.0
Chromium	<0.1	<0.1	<0.1	0.05
Copper	<0.1	<0.1	<0.1	1.0
Iron	0.5	<0.2	<0.2	0.3
Lead	<0.5	<0.5	<0.5	0.05
Manganese	0.2	0.3	<0.1	0.05
Mercury (ppb)	2	4	<1	<1
Silver	<0.01	<0.01	<0.01	0.05
Zinc	<0.1	<0.1	<0.1	5.0
BOD_5 at $20^{0}C$	1.0	1.6	0.6	-

Comments: All results unless otherwise indicated are reported as mg/1 (≡ppm)
Mercury waters were not filtered or acid treated.
Barium, cadmium, silver and arsenic waters were acid treated.
W1, W22 are fresh water sites.
W2 is an estuarine water site.
#, Schedule 2, Restricted Substances, New South Wales Clean Waters Act.
*, Limits indicated do not apply to these substances in regard to tidal waters.
W1, Dredge Pond on Tomago Site.
W2, Hunter River estuary
W22, "Blue Lagoon" in Hunter District Water Board Water Supply Catchment.

(f) The alkalinity level of 487 $mgCaCO_3/l$ is within the generally agreed acceptable range of 30 to 500 $mgCaCO_3/l$ High alkalinity levels have been shown to assist in promoting algal growth.

(g) The fluoride level of 0.30 mg/l is well below the acceptable level of 1.5 mg/l indicated in Schedule 2 of the New South Wales Clean Waters Act.

ii. Group B

Included in this group are 14 estuarine and salt water sites. Soluble salts (27,650 mg/l), chloride (12,967 mg/l) and sulphate (2040 mg/l) levels are higher than Group A. Suspended solids (60 mg/l) and total alkalinity (153 mg/l) are lower. Fluoride (0.94 mg/l) results are lower than expected for ocean water (1.4 mg/l), reflecting the influence of fresh water influxes and the estuarine nature of many of the water sites.

iii Group C

Results for Group C are overall lower than Group A. Most sites are larger bodies of water with more extensive catchment areas than Group A sites, and include Grahamstown Reservoir and the "Blue Lagoon" in the Hunter District Water Board proclaimed Tomago Sandbeds Water Supply Catchment (W22 and W23).

A5.3 SUBSTANCES IN EXCESS OF LEVELS SPECIFIED IN NEW SOUTH WALES CLEAN WATERS ACT

Table A5.4 shows that the existing ambient concentration of the following substances already exceed the maximum permissible discharge levels from an industrial site.

i. pH at sites W1 and W22

ii. Barium at site W2

iii. Mercury at sites W1 and W2.

A5.4 HUNTER RIVER 24 HOUR SURVEY

On the 18th and 19th December 1979, the Hunter River at site W2 was monitored and sampled over a twenty-four hour period. Parameters measured were pH, conductivity, temperature and fluoride levels. *Figure 6.6* illustrates the results of this survey in graphical form and shows that:

i. There was little change in pH over the twenty-four hour period. The range was 7.5 to 8.0

ii. The water temperature was considerably higher than the ambient air temperature. A longer monitoring period would be required to assess the influence of diurnal and tidal changes on water temperature.

iii. The conductivity, which is indicative of salinity, followed the normal pattern. At high tide, the salinity was high and at low tide the salinity was low, due to fresh water influxes from the Hunter River.

iv. The approximate levels of fluoride in ocean water and fresh water are 1.4 and 0.1 mg/1, respectively. The fluoride levels in the estuarine portion of the Hunter River follow the same trends as salinity as illustrated in *Figure 6.6*.

Appendix 6

GROUNDWATER

APPENDIX 6

GROUNDWATER

A6.1 AQUIFER DEFINITION AND EXTENT

The site is located on sand sheets and dunes that form part of a large underground water aquifer extending from Tomago in the southwest to Tanilba Bay in the northeast, known as the Tomago Sandbeds.

The sandbeds extend to an average depth of 18 m below the surface and are relatively unconsolidated and continuous over the entire area. The fine grained sand forms a fairly uniform aquifer in which the water table varies from 1.5 m to 5 m below the surface.

Interbedded with the sands are clays, gravels and shell horizons, as well as peats, lignites and other carbonaceous material. Ascending the sequence, the deposits consist of coarse gravels, estuarine clays and sands, beach and dune sands, and in some places flood-deposited loams. *Griffin (1964)* found that the clay horizons, which were originally thought to have formed an impervious seal at the base of the sequence *(Corlette, 1944)*, were not continuous over the entire area, but formed lenticular masses which vary considerably in thickness and extent. Bedrock occurs below the estuarine clays at depths between 20 m and 30 m.

The exact limits of the groundwater aquifer have not been precisely defined, but the proclaimed boundary of the Tomago Sandbeds Water Supply Catchment shown on *Figure 6.7* is considered the approximate limits of the groundwater aquifer suitable for water supply. This boundary encompasses an area of 106 km^2.

A6.2 GROUNDWATER USAGE

The Hunter District Water Board has developed the sandbeds as a major source of domestic water for Newcastle. Within the Tomago Sandbeds Water Supply Catchment, approximately 91 km^2 are utilised for water supply.

In 1977-78, a total of 13,577 Ml of water were delivered to the Newcastle area from the Tomago Sandbeds, representing 16 per cent of total domestic water requirements. Other sources of domestic water are Chichester Dam and Grahamstown Reservoir which jointly delivered 71,027 Ml of water in 1977-78.

The quantity of water stored in the sandbeds is variable and generally related to rainfall patterns, recharge and use. Over a ten month period (15th September 1976 to 13th July 1977), the quantity of water stored in the sandbeds averaged 42,828Ml. The lowest amount stored being 33,102 Ml in the summer months (February) and the highest in winter (June) when 47,722 Ml were stored.

Within the Tomago Sandbeds there are 20 primary pumping stations (see *Figure 6.7)* which supply water to a central treatment plant at Tomago, where the water is treated, and pumped to reservoirs for distribution.

The Tomago Sandbeds are not utilised as a year-round water source. Most stations are operated only during the summer months (October to March) when the demand is greatest. The number of stations delivering water to the central treatment plant at any one time is dependent on demand, water quality and the storage situation with regard to other sources and supply.

The operations over any one year at any particular pumping station follow no particular pattern, none operate continuously, but water may be pumped for periods of several weeks at a time. Usually stations with consistently low iron contents are used more frequently, but when water demand is high, stations are 'mixed' in an attempt to obtain the lowest possible iron content.

Water table contours are shown on *Figure 6.7*. Both the configuration of the water table when no stations are pumping and when stations 1, 2, 3, 4, 5, 7, 9, 10 and 20 were pumping are shown. From this figure, it can be seen that, apart from changes in the Grahamstown area, flow directions remain relatively constant over the area, although actual water levels may change.

Within 5 km of the proposed site there are three pumping stations (1, 2 and 20) under the control of the Hunter District Water Board. Stations 1 and 2 are the original pumping stations first brought into service in 1939. Both of these stations use a shallow-well suction-lift system for drawing water from a depth of 12 m. Station 1 originally had a maximum capacity of 5 Ml/d but is being modified to increase capacity to 9 Ml/d. Station 2 has a maximum capacity of 7.3 Ml/d.

Station 20 is a more recent pumping station using deep bore pumps which draw water from a depth of 20 m below the surface. The station has a maximum capacity of 5.2 Ml/d and consists of eight bores installed 220 m apart in a straight line. This line is orientated north-south to parallel the water table contours and to intercept groundwater which flows naturally from the sandbeds to the Hunter River to the northwest.

Table A6.1 lists the hours of operation of the 20 stations over a 12 month period. Stations 1 and 2 were utilised more frequently than other stations while station 20 was utilised the least. Stations 1 and 2 are located close to the central treatment plant and are easily accessible. Station 1 in particular, has consistently good water quality. On the other hand, station 20 had a moderately high iron content and problems with screen blockages over the 12 month period (*Hunter District Water Board*).

Water pumped from the sandbeds is treated at the Hunter District Water Board's plant at Tomago.

After aeration in spray basins, to remove hydrogen sulphide, to lower carbon dioxide and to increase oxygen content, the water gravitates to treatment plants. Treatment processes include dosing with lime, alum and chlorine. After flocculation and sedimentation processes, the water is filtered through rapid sand filters and then passed to a 9.1 Ml capacity clear water reservoir for delivery to service reservoirs and pumping stations.

The Hunter District Water Board is examining means of augmenting the Newcastle - Lake Macquarie domestic water supplies. Growth in the region over the decade has placed a strain on existing water sources and the Board is concerned that suitable sources are available to meet future demand.

TABLE A6.1

HOURS OF OPERATION OF PUMPING STATIONS
OVER THE PERIOD 4TH JULY 1975 TO 1ST JULY 1976

Station	Operation (hours)	Equivalent days
1	1580	65.8
2	1640	68.3
3	750	31.3
4	850	35.4
5	1350	56.3
6	420	17.5
7	1150	47.9
8	1200	50.0
9	1020	42.5
10	460	19.2
11	1050	43.8
12	670	27.9
13	-	-
14	570	23.8
15	250	10.4
16	-	-
17	-	-
18	-	-
19	1000	41.7
20	160	6.7

Source: *Hunter District Water Board*

Within the Tomago Sandbeds, investigations are being carried out to upgrade and increase the capacity of existing pumping stations, and feasibility studies are being conducted to determine the capacity for these stations to supply water on a year-round basis.

Investigations are also being carried out to determine the feasibility of placing additional stations within the sandbeds to augment existing supplies. Although a number of areas within the catchment are being considered, the area immediately southwest of pumping station 2 is considered a potential site by the Board.

A6.3 INFILTRATION, RECHARGE AND FLOW

The water stored in the sandbeds is derived entirely from rainfall by direct absorption through the pervious surface of the sand. The quantity that passes into storage is that portion of the rainfall which is not lost by evaporation, plant transpiration, underground flow and runoff.

Over most of the sandbeds and on the proposed site, the groundwater table is found within 1.5 m to 5 m of the surface, the water being stored in the interstices of the sand. The permeability and storage capacity of the sandbeds are related to soil type, particle size distribution, density of the soil, and the presence of impervious layers in the aquifer formation.

Permeability testing has been carried out by *Gerard and Herzog (1971)* at eight sites within the area mined by Rutile and Zircon Mines (Newcastle) Limited shown on *Figure 6.1*. Tests were carried out during pumping prior to, during, and after mining, but only the results of tests carried out prior to mining are indicative of the permeability of sand on the site. Their results showed that the average permeability of the sandbeds is .025 cm/s or 20 m/d.

Groundwater contours determined by the Hunter District Water Board are shown on *Figure 6.7*, and indicate a natural hydraulic gradient towards the Hunter River, the Pacific Ocean and Port Stephens.

Detailed investigations of actual groundwater flows on the proposed site have been carried out by Australian Groundwater Consultants Pty. Limited. A series of bores, shown on *Figure 6.8*, have been monitored continuously since August 1979. The results presented in a report by *Australian Groundwater Consultants Pty. Limited (1980)* show that the natural flow of groundwater is to the south and southwest from the vicinity of GW3. The Hunter District Water Board has identified a groundwater high separating flows to the south and north trending in a southwest direction from the vicinity of pumping station 2 shown on *Figure 6.7*. The results obtained by Australian Groundwater Consultants Pty. Limited indicate that this groundwater high continues as shown in *Figure 6.8* and although the actual position of this high may vary slightly with seasonal conditions overall flow directions would remain relatively constant.

Further evidence of a northwesterly flow of groundwater north of the high is provided by surface flows from the natural lagoon east of GW4 which are to the northwest as indicated on *Figure 6.8*.

No definitive results have been obtained for groundwater flows from the bedrock high on the western portion of the site but it has been assumed that flows are away from the maximum elevation and probably not connected to the groundwater of the Tomago Sandbeds.

The Hunter District Water Board has installed lysimeters to measure the amount of rainfall reaching the water table. In general, approximately 20 to 25 per cent of the rainfall reaches the water table, and hence less than 25 per cent of the average annual rainfall is available for pumping. A safe yield of 625 $kl/d.km^2$ has been adopted by the Hunter District Water Board.

The Hunter District Water Board (1957) has conducted experiments which show that the incidence and character of rainfall is of importance in determining the amount of rainfall that will percolate into the sand.

McGrath (1967) found that figures such as 30 per cent of rainfall thought to be available for pumping were not applicable to actual rainstorms, since the infiltration for short periods depended very much on antecedent conditions.

After a fairly dry period, good rains may have little or no effect on the water level, since they contribute to wetting the dry surface sands. Heavy concentrated rains make the greatest contribution to storage. Thus, although the Tomago Sandbeds have an annual average rainfall of 1156 mm per annum, it is not this yearly rainfall total that is critical for storage, but rather the individual weather sequences.

A6.4 EVAPORATION

The maximum, minimum and average monthly evaporation for the Tomago Sandbeds is presented in *Table A6.2*. The data are for an 11 year period from 1969 to 1979, recorded by the Hunter District Water Board at pumping station 8.

TABLE A6.2

EVAPORATION
(mm)

Month	Maximum	Minimum	Average
January	208.2	126.4	155.26
February	146.8	98.0	126.2
March	180.8	89.4	125.06
April	121.1	68.0	83.74
May	79.1	37.84	59.43
June	104.0	31.8	52.46
July	60.2	38.3	47.79
August	79.2	50.0	66.72
September	94.2	64.7	85.7
October	170.6	90.4	119.55
November	153.3	121.0	129.4
December	215.0	149.0	163.4
Total	1612.5	964.84	1214.76

Source: *Hunter District Water Board*

The average evaporation measured by open methods is 1214.76 mm which is 58.64 mm higher than the average annual rainfall. Evaporation exceeds precipitation in all months except April, May and June. From July to December the excess is increasing, whereas from December to March, the difference is steadily declining. Due to the forest cover the principal water loss is by evapotranspiration.

A6.5 EVAPOTRANSPIRATION

The Hunter District Water Board (1957) and *McGrath (1967)* consider that evaporation and transpiration, where evaporation covers direct water loss from the water table as well as from the land surface, account for a large amount of the water lost from the Tomago Sandbeds.

Experiments carried out by the Board have determined that 1.2 m of sand cover is sufficient to prevent evaporation from the water table and consequently, water losses overall from storage by evaporation are probably not great, except after periods of heavy rain when many low-lying areas would have less than 1.2 m of sand above the water table.

In an attempt to gain some measure of evapotranspiration losses, the Board assumed as part of its investigations, that all the salt present in the groundwater must have come from rainfall, since any salt initially present in the sand would have been leached out in past geological ages. Thus the ratio of the salt content of the underground water to that of rainwater, represented the degree of concentration brought about by evaporation and transpiration. The Board found that the average chloride content of the groundwater is 40 mg/l as against 10 mg/l in rainwater. This indicated that 75 per cent of the rainfall had been lost by evaporation and transpiration. As earlier experiments had ruled out that direct evaporation from the water table was a major factor, it was concluded that transpiration losses were high. *McGrath (1967)* calculated that in an average year, actual evapotranspiration accounted for over 86 per cent of the rainfall.

A6.6 GROUNDWATER QUALITY

A6.6.1 Groundwater Monitoring by the Hunter District Water Board

The Hunter District Water Board has been monitoring the quality of water in the Tomago Sandbeds on a regular basis since 1930. Early analyses showed that the water was of very variable quality. Some samples were clear while in others, colour was up to 200 parts on the platinum-cobalt scale. A few showed considerable turbidity and chemical analyses and water 'softness' were widely variable. Iron content was frequently high (up to 6 mg/l), free oxygen was found to be practically absent and carbon dioxide was high, averaging about 100 mg/l with occasional samples up to 240 mg/l. pH was found to vary from 5.0 to 6.5 being usually around 5.5, and free hydrogen sulphide was present in nearly all samples ranging from

0.5 to 1.0 mg/1.

It was found that after pumping commenced, the iron content increased to an average maximum of 4.4 mg/1 in 1949 *(Hunter District Water Board, 1957)*. Since this time, the iron content has decreased to a level suitable for treatment. Apart from the iron content, it has been found that there has been little variation in the quality of the water of the sandbeds since pumping commenced. Those inspection points that yielded good water initially have continued to do so, while the unsatisfactory points likewise, have shown little tendency to change in spite of the large quantity of water pumped from the sandbeds.

Analyses of water from pumping stations 1, 2 and 20 for three years are given in *Table A6.3*.

TABLE A6.3

GROUNDWATER ANALYSIS

Parameter	Pumping Stations								
	No. 1			No. 2			No. 20		
	1961	1968	1970	1961	1968	1970	1961	1969	1970
Colour (platinum-cobalt scale)	20	10	20	65	63	62.5	118.3	70.0	157.5
Turbidity	0	3.5	1.5	0	16.3	13	0	30.8	28.3
pH	5.5	5.8	5.5	5.6	5.1	5.5	5.6	5.5	4.8
Iron	0.6	0.5	0.5	2.3	1.8	1.8	7.2	2.5	4.3
Chloride	38.7	40.8	47.3	49.7	49.0	50.5	37.7	34.5	36.0
Nitrogen (NH_3)	0	60.8	50.0	0	201.4	189.0	0	64.0	30.0
Oxygen	-	1.1	0.5	0	1.9	1.8	0	1.1	2.1
Hardness ($CaCO_3$)	17.3	29.5	26.7	41.0	42.6	37.8	41.3	28.6	23.9
Alkalinity ($CaCO_3$)	-	10.9	11.3	16.0	16.5	16.5	48.5	13.8	7.8

Source: *Soil Mechanics Limited (1971)*.

Comments: All units, unless otherwise indicated, are in mg/1.

A6.6.2 Groundwater Monitoring by James B. Croft and Associates

Procedures

Samples of groundwater from the site and surrounding sandbeds have been collected for analysis since December 1979. The nine groundwater sites include four bores on the site, shown on *Figure 6.8* sunk by Australian Groundwater Consultants Pty. Limited and five bores located at pumping stations 1,2 and 20 within the Tomago Sandbeds Water Supply Catchment area.

At pumping station 20, samples have been taken from bores operating at the time of sampling, while at stations 1 and 2, only one point is available for sampling.

The sites were sampled on the following days:

* 5th December 1979
* 16th January 1980
* 20th February 1980
* 27th March 1980
* 23rd April 1980
* 20th May 1980
* 26th June 1980

Table A6.4 details the chemical and physical parameters monitored as well as the type of instrumentation and/or chemical procedures used.

Results

Table A6.5 details the results of the water quality analyses carried out on the groundwater samples. The results indicated the following:-

i. The groundwater is acidic (pH 6.0) except for GW4 which is neutral (pH 7.2).

ii. GW4 has high soluble salts (1548 mg/l) and conductivity (2.20 mmhos/cm at 25^{o}C) than the remaining sites which have salt contents of 135 mg/l (average) and conductivity (0.18 mmhos/cm at 25^{o}C).

iii. The fluoride (average 0.08 mg/l) and sulphate (average 44 mg/l) are low except for GW4 which has a sulphate level of 135 mg/l. Results are all below the maximum levels indicated in Schedule 2 of the New South Wales Clean Waters Act.

TABLE A6.4

PARAMETERS MEASURED AND METHODS USED

Parameter	Methods Instrumentation/Chemical Technique	Reference
Conductivity	Y.S.I. conductivity meter	-
pH	Leeds and Northrup 7417 meter	-
Soluble Salts	Gravimetric analysis	A.P.H.A. Standard Methods for the examination of water and waste water.
Total Hardness	E.D.T.A. Titration	
Chloride	Silver nitrate titration	
Sulphate	Barium sulphate gravimetric analysis	(14th Edition 1975)
Total Alkalinity	Acid titration	
Fluoride	Specific ion electrode	

TABLE A6.5

GROUNDWATER QUALITY

Site	Description	pH	Conductivity mmhos/cm at 25°C	Soluble Salts mg/l	Fluoride mg/l	Total Hardness $mgCaCO_3/l$	Chloride mg/l	Sulphate mg/l	Total Alkalinity $mgCaCO_3/l$
GW1	Borehole adjacent to main gate and access road	6.2	0.16±0.03	111±12	0.04±0.02	25±4	31±6	45±14	13±4
GW2	Borehole on transmission line easement	6.0	0.12±0.01	88±6	0.04±0.02	19±3	35±4	27±9	12±4
GW3	Borehole adjacent to disused airstrip	6.2	0.13±0.003	201±58	0.06±0.02	17±4	37±14	51±9	13±2
GW4	Borehole adjacent to disused airstrip	7.2	2.20±0.3	1548±209	0.40±0.010	200±34	484±80	135±29	494±81
GW5	Pumping Station 1	5.0	0.20±0.01	160±6	0.26±0.010	51±6	43±2	38±3	13±1
GW6	Pumping Station 2	5.9	0.20±0.02	151±13	0.04±0.02	39±4	48±3	28±8	19±3
GW7	Pumping Station20*	5.5	0.16±0.02	91±7	0.04±0.02	23±3	41±2	30±6	16±3
GW8	Pumping Station 20*	6.4	0.25±0.03	166±11	0.06±0.02	56±12	42±3	35±9	35±5
GW9	Pumping Station 20*	5.7	0.18±0.03	112±4	0.06±0.02	33±14	41±1	13±8	22±4

COMMENTS: Results are reported as the mean of, in most cases, seven samples ± standard error.

*Three bores from pumping station 20 are sampled every month.

iv. The total hardness of water at all sites is well below the World Health Organisation's maximum total hardness of 500 $mgCaCO_3/l$.

v. The chloride levels at all sites except GW4 are below the maximum level indicated in Schedule 2 of the New South Wales Clean Waters Act.

vi. The total alkalinity of GW4 is higher (494 $mgCaCO_3/l$) than the remaining sites (average 18 $mgCaCO_3/l$, but all results are within the acceptable range of 30 to 500 $mgCaCO_3/l$.

The results for GW4 are anomalous with results obtained from all remaining sites. It is probable that GW4 has been contaminated by an external source, or alternatively represents an isolated, more saline site within the groundwater aquifer.

Detailed laboratory studies have been conducted to ascertain the effects of gaseous and particulate emissions on the quality of the groundwater. Results to date of the study are given in *Appendix 6.8*.

6.7 GROUNDWATER MONITORING

The existing groundwater monitoring programme *(Appendix A6.6.2)* will be continued on a monthly basis and the samples analysed for the parameters indicated in *Table A6.4*. More remote bores will be sampled to give background information. Further details of the monitoring programme are given in *Section 8.13* of *Volume 1*.
Close liaison will be maintained with the Hunter District Water Board and if necessary additional bores may be sampled.

This monitoring programme will ascertain the influence, if any, of the smelter development on the groundwater within the Tomago Sandbeds.

A6.8 LABORATORY STUDIES TO ASSESS THE EFFECTS OF THE SMELTER ON THE QUALITY OF GROUNDWATER IN THE TOMAGO SANDBEDS

6.8.1 Background

Laboratory experiments are being conducted to assess the potential effects of fluoride emissions from the smelter on groundwater in the Tomago Sandbeds. These studies were requested by the Hunter District Water Board, the authority with the responsibility of providing and ensuring the quality of Newcastle's water supply.

Figure 7.11 illustrates conceptually the potential paths for emissions to reach the groundwater. The following four experiments were designed to examine factors affecting the progress of emissions along the paths.

i. The washing of fluoride from the surface of leaves.
ii. Decomposition of vegetation high in fluoride.
iii. The movement of fluoride during bushfires.
iv. Transfer of fluoride from soils to groundwater.

6.8.2 The Washing of Fluoride from the Surface of Leaves

Aim

Particulate and gaseous fluorides from the smelter may precipitate on the surface of leaves. An experiment was designed to test the potential for rainwater to transfer fluoride salts from the leaves to the soil surface.

Preliminary Test

A test was carried out to determine the ratio of leaf to solution that would give reliable results.

Leaves were washed for 1 minute in distilled water and millivolt readings taken of the wash liquid. Millivolt readings relate to fluoride concentration. Results are presented in *Table A6.6*.

TABLE A6.6.

LEAF WASH

Wt (g) green leaf	Vol. (ml) distilled water *	Meter Reading (MV)
20	10	1.08
10	10	1.15
5	10	1.05
Blank		0.75

* 10 ml distilled water for washing, plus 10 ml TISAB for fluoride extraction after leachate has been drained from leaves.

The table indicates that 10 g of leaf washed in 10 ml of distilled water gave the best extraction.

Fluoride in washed and unwashed leaves and leachate

Fluoride contaminated leaves collected adjacent to the existing aluminium smelter at Kurri Kurri were washed separately in distilled water and alconox/EDTA solution. Fluoride levels in unwashed leaves, in washed leaves and in the leachate from the leaves were analysed.

Results are presented in *Tables A6.7 to A6.10*.

TABLE A6.7

FLUORIDE IN LEACHATE

Replications	Wt. fresh leaf (g)	Vol. water (ml)	ppm F in leachate
1	10	10	3.30
2	10	10	3.50
3	10	10	3.50
4	10	10	3.50
Blank		10	<0.01

Comments: Volume of solution after washing-6ml .
Volume of solution used in analysis-5ml .

TABLE A6.8

FLUORIDE IN DRIED LEAVES WASHED WITH ALCONOX/EDTA

Replications	Wt. dried leaf (g)	ppm.F in leaf	
1	0.2572	184.68	
2	0.2564	185.26	Mean: 195.61
3	0.2523	227.90	SE : 76.92
4	0.2573	184.61	

Comments: Green leaves washed, oven dried, and analysed using standard procedure.

TABLE A6.9

FLUORIDE IN LEAVES WASHED WITH DISTILLED WATER

Replications	Wt. dried leaf	ppm.F in leaf	
1	0.2556	371.67	
2	0.2572	369.36	Mean: 335.41
3	0.2566	224.08	SE : 52.53
4	0.2523	376.54	

TABLE A6.10

FLUORIDE IN UNWASHED LEAVES

Replications	Wt. dried leaf	ppm.F in leaf	
1	0.2586	367.36	
2	0.2540	275.59	Mean: 347.8
3	0.2533	375.05	SE : 34.13
4	0.2545	373.28	

Mean difference between unwashed and alconox washed leaves - 44 per cent.
Mean difference between unwashed and distilled water washed leaves - 4 per cent.
Mean difference between distilled water and alconox washed leaves - 42 per cent.

Results and Discussion

Table A6.7 shows that fluoride in the wash from distilled-water-washed leaves is low (3.5ppm).

Tables A6.8 to A6.10 detail the measured fluoride levels in unwashed leaves and leaves washed either with the alconox solution or distilled water. The percentage difference between unwashed and alconox washed leaves is 44 per cent. This generally agrees with the findings by *Benedict et al (1965)* and *Hutchison (1979)*.

However, the percentage difference between unwashed and distilled-water-washed leaves was very small (4 per cent) and in some cases, negligible. Therefore it appears that distilled water does not significantly wash fluorides from the outer leaf surface. This is further exemplified by the fact that the leachate from the distilled water wash was only 0.3 per cent of the total fluoride in and on the leaf.

The alconox solution 'washed' more fluoride from the leaf surface than the distilled water. Studies by *McClune et al (1965)* indicate that alconox solution may wash not only fluoride from the leaves but may leach fluoride from within the leaf and hence the use of alconox solution for washing the surface of leaves should be regarded with caution. Therefore the alconox solution may have washed significant amounts of fluoride from within the leaf as well as from the leaf surface.

The distilled water washing procedure may be a more reliable indication of the soluble fluorides collected on a leaf surface. The low fluoride level of the leachate and the small difference in foliar fluoride levels of washed and unwashed leaves tends to indicate the transfer of fluoride from the leaf surface to the soil is negligible. Furthermore under natural conditions, rainfall usually lasts for more than one minute and can occasionally last for up to two hours. The volume of water falling over a square centimetre in two hours can be as high as 114 ml. Therefore with such a large volume, even if most of the fluoride was washed from the outer leaf surfaces, insignificant concentrations of fluorides would reach the soil.

6.8.3 Decomposition of Vegetation high in Fluoride

Aim

The objective of this experiment was to estimate the decomposition rate of vegetation high in fluoride and the resultant movement of fluoride from the leaf litter to the surface soil layers.

Method

A species common to both the Tomago site and the area surrounding the Kurri Kurri smelter was used in the experiment. The common species is the Ball Honey-myrtle *(Melaleuca nodosa)*.

Fresh leaf samples were obtained from an area close to the Kurri Kurri smelter (Site A) and the Tomago site (Site B). Known weights of leaves were placed in separate fibreglass fly mesh bags on the Tomago site and their decomposition carefully monitored. Half the bags were trampled to simulate animal disturbance which could affect the rate of decomposition. The experiment was commenced on the 2nd April 1980, and it is the intention that leaves will be sampled at 1,3,5,8 and 12 monthly intervals. To date, results have been obtained for the first two sampling periods.

The matrix in *Table A6.11* details the experimental design.

At the commencement of the experiment (T_0) and at the end of each sampling period the fresh leaves and litter were analysed for fluoride and weight changes measured. At the same times, total and water soluble fluoride, as well as organic content in the soils beneath the litter bags were determined.

Results

A summary of all the results obtained to date is presented in *Table A6.12*. It is important to note that the experiment is still in progress and will continue until March 1981.

TABLE A6.11

DECOMPOSITION OF VEGETATION

Site	T_0	T_1	TIME T_3	T_5	T_{12}
A_1D	A_1DT_0	A_1DT_1	A_1DT_3	A_1DT_5	A_1DT_{12}
A_2U					A_2UT_{12}
A_3D					A_3DT_{12}
A_4U					A_4UT_{12}
B_1D					B_1DT_{12}
B_2U					B_1UT_{12}
B_3D					$B3DT_{12}$
B_4U	B_4UTo	B_4UT_1	B_4UT_3	B_4UT_5	B_4UT_{12}

T_0 = start of experiment, 2nd April 1980.
T_1 = 1 month 2nd May 1980.
T_3 = 3 months 2nd July 1980.
T_5 = 5 months 2nd September 1980.
T_{12} = 12 months 2nd March 1981.
U = Undisturbed
D = Disturbed
A = Leaf high in fluoride.
B = Leaves low in fluoride.

Two replications for disturbed and undisturbed sites. e.g. $B_1$and B_3.

Discussion

The results to date show no sign of litter decomposition, in fact an increase in weight occurred due to soil particles accumulating in the litter bags. With time, the weight loss due to decomposition should exceed the weight gain from the accumulation of soil. At time (T_3) there was a loss of fluoride from the litter signifying that decomposition and/or leaching of fluorides had occurred.

This loss of fluorides from the litter was reflected in the soils. The total fluoride levels in the soils beneath the high-in-fluoride litter increased by 40 to 75 per cent. In comparison, soils beneath low-in-fluoride litter showed a decrease, then a recovery of total fluoride levels. The decrease at time T_1 (1 month) in the soils may be due to changes in soil chemistry, pH and other factors associated with changes in soil moisture.

The increases in total soil fluoride in the soils beneath the high fluoride litter added to the water soluble fluoride contents. After T_3 , the water soluble fluoride level stabilised, possibly as a result of the gradual fixation of fluorides. After T_1 the amount of fluoride released into the soil as water soluble fluorides was less than the amount of fluoride fixed in the soil.

The test is still in progress. Litter and soils will be analysed at the periods indicated.

6.8.4 The Movement of Fluoride During Bushfires

Objectives

It is conceivable that fire through vegetated areas close to aluminium smelters may release fluoride to the atmosphere. Studies carried out by *Harwood and Jackson (1975)* showed that during a controlled burn, 10 to 20 per cent of plant nutrients (potassium, phosphorus, calcium and magnesium) in a *Eucalyptus regnans* forest in Tasmania were lost from the total fuel as smoke and aerosols.

Consequently, this experiment was designed to examine the loss or release of fluoride from vegetation grown near an aluminium smelter.

Method

Two plant species, *Melaleuca nodosa* and *Eucalyptus tereticornis* which are relatively common on the Tomago site and near the Kurri Kurri smelter were used in the study.

TABLE A6.12

RESULTS OF DECOMPOSITION OF VEGETATION

Site	Time	Decomposition Weight Dry Litter (g)	Fluoride in litter μg F/g	pH	Soil Analysis Moisture Content (%)	Organic Matter (%)	Fluoride (μg F/g) Total	Water Soluble
A_1D	T_0	58	320	4.7	3.7	2.4	24.8	0.018
	T_1	70		4.9	9.9	3.4	28.5	0.093
	T_3	45	139	-	-	17.7	102.1	0.068
A_3D	T_0	58	243					
	T_1	83						
	T_3	79	228					
A_2U	T_0	58	243	4.5	5.5	5.3	29.9	0.017
	T_1	62		4.9	15.4	6.6	29.4	0.068
	T_3	64	223	-	-	7.6	52.9	0.074
A_4U	T_0	58	150					
	T_1	68						
	T_3	89	225					
B_1D	T_0	58	21	4.6	3.3	3.8	33.7	0.011
	T_1	67		5.1	12.2	5.4	7.9	0.039
	T_3	77	0	-	-	6.0	36.9	0.042
B_3D	T_0	58	28					
	T_1	69						
	T_3	77	8					
B_2U	T_0	58	20	4.6	4.1	3.9	27.6	0.006
	T_1	70		5.4	16.5	8.0	19.1	0.012
	T_3	82	0	-	-	6.4	27.1	0.016
B_4U	T_0	58	20					
	T_1	64						
	T_3	81	0					

Comments: For the soil analysis the two representative samples were composited and then analysed, for example $A_1D\ T_0$ + $A_3D\ T_0$; A_2UT_0 + $A_4U\ T_0$;.........B_2UT_1 + B_4UT_1.

The samples were oven dried and ashed in a muffle furnace, until smoke had ceased emanating from the furnace. Two ashing temperatures used were 750°C and 500°C, which represent a controlled burn and the lower limit of a controlled burn respectively *(Vines, 1968)*. Fluoride analyses were conducted on the fresh leaves, ash, and wash liquid. A quantity of 50 g of fresh leaf was used in the experiment.

Results

Results are presented in *Tables A6.13 to A6.19*.

TABLE A6.13

FRESH/DRY WEIGHTS

Species	Replications	Fresh Wt. (g)	Dry Wt.* (g)	Percentage
Melaleuca nodosa	1	46	25.8	43.9
	2	55.1	33.5	39.2
Eucalyptus tereticornis	1	76.5	45.2	40.9
	2	73.9	43.6	41.0

* dried at 80°C.

TABLE A6.14

FLUORIDE IN FRESH LEAVES

M. nodosa	216 ppm.F
E. tereticornis	162 ppm.F

Variations in the fluoride contents of species occur in the field and similar results were obtained for the two species analysed as shown in *Table A6.15*.

TABLE A6.15

FLUORIDE IN ASH

Species	Replications	Temperature (^{o}C)	ppm. F
M. nodosa	1	750	874.3
	2	750	374.0
E. tereticornis	1	750	372.8
	2	750	702.9
M. nodosa	1	500	266.8
	2	500	319.4
E. tereticornis	1	500	371.4
	2	500	222.5

TABLE A6.16

WEIGHT DIFFERENCES ON ASHING

Species	Replications	Temperature (^{o}C)	Dried Wt. (g)	Ashed Wt. (g)	Percentage Difference
M. nodosa	1	750	3.16	0.26	91
	2	750	3.94	0.64	83
E. tereticornis	1	750	4.99	0.97	80
	2	750	5.00	0.74	85
M. nodosa	1	500	3.33	0.86	74
	2	500	3.39	0.74	78
E. tereticornis	1	500	4.99	1.28	74
	2	500	5.00	1.51	70

Washing of Ash

Part of the experiment was designed to study the solubility of fluoride in the ash. A quantity of 0.25 g of ash was ground to a fine powder and agitated with 20 ml of distilled water for 20 minutes. The ash/water solution was filtered through Whatman No. 4 filter paper and the leachate analysed for fluoride. *Table A6.17* presents the results.

TABLE A6.17

FLUORIDE IN LEACHATE

Species	Replications	Temperature (^{o}C)	Volume Leachate (ml)	ppm.F
Melaleuca nodosa	1	750	-	-
	2	750	16.7	2.0
Eucalyptus tereticornis	1	750	16.3	2.0
	2	750	16.9	4.8
Melaleuca nodosa	1	500	16.4	0.58
	2	500	16.3	0.76
Eucalyptus tereticornis	1	500	16.3	1.08
	2	500	-	-

A summary of all results is presented in *Tables A6.18 and A6.19.*

Discussion

The results show that a high percentage of fluoride is lost as smoke (70 to 50 per cent *Table A6.19).*

For *Melaleuca nodosa,* 67.7 per cent of the fluoride in the green leaf was lost as smoke for a fire at 500^{o}C and this rose to 69.1 per cent for a fire at 750^{o}C *(Table A6.19).* Although there is no statistically significant difference between these figures, it appears that with increasing fire temperatures, the percentage of fluoride released in smoke increases. A similar trend occurred for *Eucalyptus tereticornis,* and overall is probably a result of more complete breakdown of organically

TABLE A6.18

SUMMARY OF FLUORIDE CONTENTS IN COMPONENTS
(Total μg.F)

Sample	F in green leaf	F in ashed leaf	F in ash leachate	F in smoke	Wt(g) of smoke
Temperature 750°C					
Melaleuca nodosa					
Rep.1	682.1	228.9	-	453.2	2.9007
Rep.2	850.8	239.6 (B)	99.74 (A)	611.2	3.3039
Eucalyptus tereticornis					
Rep.1	810.0	362.3	152.4	447.7	4.0248
Rep.2	810.5	384.8	225.8	425.7	4.2597
Temperature 500°C					
Melaleuca nodosa					
Rep.1	718.3	230.59	39.4	487.7	2.4660
Rep.2	730.4	237.31	44.4	493.1	2.6432
Eucalyptus tereticornis					
Rep.1	809.6	476.9	108.0	332.7	3.7096
Rep.2	810.6	336.8	49.2	473.8	3.4863

TABLE A6.19

PERCENTAGES OF FLUORIDE IN COMPONENTS

Sample	F in green leaf	F in ash (% of green leaf)	F in ash leachate (% F in ashed leaf)*	F in smoke (% of green leaf)	% Wt of smoke (% of green leaf)
Temperature 750°C					
Melaleuca nodosa					
Rep.1	100	33.6	-	66.4	91.7
Rep.2	100	28.2	42.0 (C)	71.8	83.8
				$\bar{x}$69.1	$\bar{x}$87.7
Eucalyptus tereticornis					
Rep.1	100	44.7	42.0	55.3	80.6
Rep.2	100	47.5	72.0	52.5	85.2
				$\bar{x}$53.9	$\bar{x}$82.9
Temperature 500°C					
Melaleuca nodosa					
Rep.1	100	32.1	18.0	67.9	73.9
Rep.2	100	32.5	18.0	67.5	78.1
				$\bar{x}$67.7	$\bar{x}$76.0
Eucalyptus tereticornis					
Rep.1	100	58.9	22.0	41.1	74.3
Rep.2	100	41.5	14.0	58.5	69.7
				$\bar{x}$49.8	$\bar{x}$72.0

$\bar{x}$ = mean

*C = $\frac{A}{B} \times 100$

bound fluoride in the leaf at higher temperatures.

The percentage of water soluble fluoride in the ash is not significantly different between species, but does differ between temperatures *(Table A6.19)*. The higher the temperature of the fire the greater the solubility of the ash. This again is attributed to a more complete breakdown of organically bound fluoride during combustion at higher temperatures.

The higher temperature of 750^{o}C showed significantly more smoke lost on a weight basis than that of 500^{o}C *(Tables A6.18 and A6.19)*.

Fluoride in the ash remained fairly similar between the two temperatures *(Table A6.19)*.

In summary, it appears that combustion of vegetation results in a significant release (50 to 70 per cent) of fluoride in smoke. Only 30 to 50 per cent of fluoride from the green leaf remains in the ash, and 40 per cent of this is water soluble.

For sparse vegetation cover the likelihood of significant water soluble fluorides being released as a result of combustion is small. However in dense forests, the amount of water soluble fluoride releases from the vegetation as a result of combustion may be significant.

6.8.5 Transfer Mechanisms from Soils to Groundwater

Three separate studies have been conducted to examine the absorption and adsorption of fluoride within two soil profiles from the Tomago Sandbeds. The locations of the two soil profiles are shown on *Figure 6.3 as S16 (Profile 1) and S17 (Profile 2)* respectively.

Study 1: Absorption of Fluoride in each soil layer of the profile

From a knowledge of the concentration of fluoride added to a soil sample and measurement of the concentration in the filtrate, the absorptive and adsorptive capacity of the soils in each layer of both profiles were estimated.

Methods and Experimental Design

A known volume (10 ml) of fluoride solution was added to 20 g of soil from each layer of both soil profiles. The mixture was agitated gently to ensure even contact of solution with soil and left to stand for 24 hours before filtering through Whatman No 4 filter paper. The total volume of filtrate was measured and analysed for fluoride.

The initial concentrations of fluoride solutions for *profile 1* were:-

Control (c)	-	no NaF
1.0 µg.F/ml	-	diluted from 20.0 µg.F/ml.
2.0 µg.F/ml	-	diluted from 20.0 µg.F/ml.
20.0 µg.F/ml	-	0.0442 g NaF/litre distilled water.

For *profile 2* the absorption of fluoride from dilute solutions as well as that of the worst case, 20.0 µg.F/ml, was investigated.

Therefore, the solutions for *profile 2* were:-

Control (c) - no fluoride
0.2 µg.F/ml.
1.0 µg.F/ml.
20.0 µg.F/ml

Results

The results are presented in conjunction with *Study 2*.

Study 2: Absorption and Transfer of Fluoride through the Soil Profile.

Although *Study 1* indicates the absorptive capacity of fluoride in each soil layer, it does not give a true indication of the absorptive capacity of the whole profile. In reality, the fluoride solution leached from the surface layer contains not only fluoride ions, but also other ions such as calcium, magnesium, iron, aluminium and complex salts.

Interaction of fluoride with these ions and salts occurs at varying rates under different conditions. It is possible, therefore, for fluoride to be partially precipitated in the filtrate of one layer, and be totally taken into solution in the following layer due to the changed ionic environment of the filtrate.

To study the absorptive capacity of the profile, the filtrate of each layer was added to the next lower layer. This ensured that not only fluoride, but also all the dissolved salts and ions from the preceding layer were present for reaction in the layer below.

Methods and Experimental Design

A known volume (50 ml) of fluoride solution was added to 100 g of soil from the surface layer of both profiles. The mixture was agitated gently to ensure even contact of the soil with solution and left to stand for 24 hours before filtering through Whatman No. 4 filter paper. A 5 ml sample was analysed for fluoride. The remaining filtrate solution was made up to 55 ml, 5 ml of which was analysed for fluoride.

The analysis of the 55 ml solution was then the 'initial' fluoride concentration for the next layer in the profile and the remaining 50 ml was added to the next soil layer. The process was continued until all layers had been treated. Fluoride solution, of the same concentration as initially used and not distilled water, was added to bring the 'final' filtrate to a volume of 55 ml. Distilled water was not used as this would have created a 50 per cent dilution and by layer 7 the fluoride level in the filtrate would have been immeasurable because of experimental dilution.

Sodium fluoride solutions were used for *profile 1* and *profile 2*. The concentrations were:-

Control (c) - no fluoride
1.0 g.F/ml
5.0 g.F/ml
20.0 g.F/ml.

Scrubber dust collected from an operating smelter was also made into solutions and used in this experiment. However, only 10 per cent of fluoride in the dust is soluble.

Profile 2 only was studied with the dust solutions.

Results and Discussion

Because of their design, both experiments were basically a study of the absorption of fluoride solutions in each layer, rather than a study of the decrease in soluble fluoride with profile depth. For this reason, the results of both experiments were amalgamated into *Table A6.20*

Figures 7.12, 7.13 and *7.14* show these results graphically. Both profiles showed a general trend for decreased percentage absorption with increased fluoride concentration *(Figures 7.12* and *7.13)*. However the absorption even at 20 ppm.F did not drop on an average below 75 per cent.

Therefore, for the worst case of 20 ppm.F within the surface soil water of the Tomago Sandbeds, the expected fluoride level reaching the groundwater (for a profile with 7 horizons) with a rainfall corresponding to a yearly average, is equivalent to:-

Layer 1	:	Fluoride concentration	:	20 ppm
		Percentage fluoride absorbed by soil	:	75 %
Layer 2	:	Receives	:	5 ppm.F
		Percentage fluoride absorbed by soil	:	75%
Layer 3	:	Receives	:	1.25 ppm.F
and so on, until				
Layer 7	:	Fluoride leached into groundwater	:	<<0.02 ppm.

This level is well below that recommended for drinking water of 1.0 μg.F/ml.

These experiments were studied with supersaturated soils. Each layer was saturated with the addition of the fluoride solution. Under field conditions, supersaturation of all layers occurs infrequently, and probably only during long or heavy rainfall such as that during rain depressions or storms.

At low fluoride concentrations, the percentage fluoride absorption by the soil increased to about 80 per cent. This was particularly well illustrated in *Study 1*.

TABLE A6.20

SUMMARY OF RESULTS

(Fluoride ab/adsorbed by each soil layer)

Layer	Profile 1 Input Exp.	Profile 1 Column Exp.	Profile 1 Mean	Profile 2 Input Exp.	Profile 2 Column Exp.	Profile 2 Mean
		1.0 μg.F/ml, % Absorption of Fluoride				
2	93.3	80.3	86.8	96.2	90.4	93.3
3	40.3	-	40.3	96.6	85.2	90.9
4	-	78.4	78.4	69.0	90.1	79.6
5	86.3	48.6	67.5	97.1	93.2	95.2
6	85.7	78.9	82.3	98.0	90.4	94.2
7	96.8	62.9	79.9	99.6	91.6	95.6
8	96.2	94.4	95.3			
		2.0 μg.F/ml, % Absorption of Fluoride				
2	49.6					
3	73.7					
4	59.5					
5	63.4					
6	82.5					
7	88.5					
8	87.9					
		5.0 μg.F/ml, % Absorption of Fluoride				
2		96.7			96.6	
3		59.6			92.4	
4		90.5			78.8	
5		29.1			89.6	
6		44.0			87.9	
7		79.0			86.9	
8		87.6				

TABLE A6.20 (cont'd)

SUMMARY OF RESULTS (cont'd)
(Fluoride ab/adsorbed by each soil layer)

Layer	Profile 1 Input Exp.	Profile 1 Column Exp.	Profile 1 Mean	Profile 2 Input Exp.	Profile 2 Column Exp.	Profile 2 Mean
	20.0 µg.F/ml, % Absorption of Fluoride					
2	88.0	95.0	91.5	82.1	82.5	82.3
3	55.4	95.7	75.5	75.5	91.2	83.4
4	66.3	88.1	77.2	-	-	-
5	63.3	52.0	57.7	17.8	66.9	51.3
6	93.5	48.7	71.1	90.0	80.2	85.1
7	74.3	72.8	73.6	82.9	72.4	77.7
8	63.4	69.3	66.4			
	0.2 µg.F/ml, % Absorption of Fluoride					
2				99.0		
3				99.0		
4				99.0		
5				99.5		
6				99.0		
7				99.0		

Comment: Overall average fluoride absorption for 0.2, 1, 2µg.F/ml dosages is approximately 87%

DUST SOLUTIONS

% Absorption of Fluoride

Layer	Dose µg.F/ml actual 0.30	0.36	20.0	56.0
2	0	25.2	96.8	71.6
3	69.6	93.3	91.8	88.8
4	71.6	52.9	50.5	48.6
5	81.1	84.8	53.8	32.3
6	78.0	91.2	88.4	88.7
7	-	97.4	81.9	78.6

However *Study 2* showed several irregularities *(Figure 7.12)*, especially for *profile 1* which may be a result of the inaccuracy of the fluoride electrode at concentrations less than 0.01 ppm.F. However, a more probable explanation is that the fluoride in previous layers was reacting slowly with the soil solution so that fluoride in solution was complexed, but able to be filtered through to the next layer. In this next layer, changes in pH and/or ion and salt concentrations may have led to a release of the complexed fluoride, hence resulting in an apparent reduction in fluoride absorption. Further details of the soil complexing procedure is given in *Appendix 4.3.*

The irregularities were especially prevalent for layer 6 in *profile 1* which had a high concentration of water soluble aluminium, magnesium and clay *(Figure 7.12)*. Therefore, although fluoride absorption at low concentrations tends to be greater than that at high fluoride concentrations, the actual percentage absorbed by the soil is dependent on ion movement and changes in pH which critically affect the solubility of fluoride in the soil and leachate.

Results of absorption of fluoride from scrubber dust solutions are presented in *Table A6.20* and *Figure 7.14*. In general, the trend for higher absorption at low concentrations is still followed.

The low absorption for 0.30 and 0.35 ppm.F in layer 2 was probably due to an interaction of soil salts with various salts in the scrubber dust. Layer 2 had a high concentration of calcium, magnesium and phosphorus, with a pH of 4.6. These high salt levels may have interacted in some way with the aluminium salts of the scrubber dust so that less fluoride could be absorbed at low concentrations.

Since the dust is only 10 per cent soluble, only 2.0 ppm.F will be available for active interaction with the soil solution. Even if 50 per cent of the fluoride in this dust solution was absorbed by each layer of soil, the expected concentration reaching the groundwater after passing through seven layers would be 0.0156 ppm.F. This is negligible compared with the acceptable level of fluoride in water of 1.0 μg.F/ml.

Study 3: Column Experiments

Aim

This experiment was aimed at determining the time taken for all active sites on the soil particles to be occupied by fluoride ions and the effect continuous dilution has on fluoride absorption by the soil. It is hypothesised that no absorption will occur at fluoride concentrations less than 1 mg/l.

Method

Two soil profiles considered representative of the Tomago site were sampled from sites S16 and S17 on *Figure 6.3* to a depth of 2 metres. The profiles were scaled down to fill 1.3m polythene columns of 85 mm diameter. The soil samples from each layer were hand mixed and not air dried prior to placement in the columns.

The experimental design is as follows:-

Column 1A	profile from a high dune (S16)-circulation treatment.
Column 2A	profile from a low dune (S17)-circulation treatment.
Column 1B	profile from a high dune (S16)- flow through treatment.
Column 2B	profile from a low dune (S17)-flow through treatment.

Due to the difficulty in collecting sufficient sand it was not possible to duplicate the design, or to set up a number of columns to test different fluoride concentrations.

A solution containing 20 mg.F/l was used to represent the worst case and was prepared using A.R. sodium fluoride chemical. Each column was saturated with the stock solution (20 mg.F/l); the volume required for saturation was 3 litres.

For the circulation experiment (i.e. columns 1A and 2A) the fluoride solution was allowed to drain out of the bottom of the column, the volume of leachate noted, sampled, and analysed for fluoride. The remaining leachate was returned to the top of the column. This process was repeated at 24 hour intervals.

The process for the flow through experiment was similar to the circulation experiment, except that fresh stock solution (20 mg.F/1) was used in place of the leachate.

Discussion and Results

Table A6.21 details the results obtained for the circulation experiment.

TABLE A6.21

CIRCULATION EXPERIMENT

Date sampled	Vol. leachate (litres)	Vol. leachate recirculated (litres)	ppm.F in leachate	Percentage F absorbed by soil
Profile 1 (S16)				
17.7.80 start		3	20	
18.7.80	2.20	2.2	0.04	99.8
19.7.80	2.27	2.27	0.01	99.9
20.7.80	2.21	2.21	<0.01	> 99.9
21.7.80	2.18	2.18	<0.01	> 99.9
22.7.80			0.2	99
Profile 2 (217)				
17.7.80 start		3	20	
18.7.80	2.35	2.35	0.01	99.9
19.7.80	2.37	2.37	0.01	99.9
20.7.80	2.32	2.32	0.01	99.9
21.7.80	2.33	2.33	0.01	99.9
22.7.80			0.1	99.5

Profiles 1 and 2 have the capacity to remove 99.9 per cent of water soluble fluoride leached from the soil surface. The volume of leachate remained fairly consistent at approximately 2.3 litres (which is equivalent to approximately half of the yearly average rainfall, that is, two circulations of leachate through the column is equivalent to the yearly average rainfall). The results to date for five circulations of leachate is equivalent to 2.5 years of rainfall.

The experiment indicates that at very low surface soil water fluoride concentrations (<1mg.F/1) fluoride is still absorbed by the soil, as indicated in *Table A6.22*. This finding is significant since large areas of the Tomago Sandbeds will receive very low concentrations of fluoride.

Table A6.22 details the results obtained for the "flow through" experiment.

TABLE A6.22

FLOW-THROUGH EXPERIMENT

Date sampled	Vol. leachate	Vol. fresh 20 ppm.F solution recirculated	ppm.F	Percentage F absorbed by soil (approximate)
Profile 1				
17.7.80	Saturated soil column with 2.8 litres, 20 ppm.F			
18.7.80	1.98	1.98	0.2	99.0
19.7.80	2.11	2.11	0.04	99.8
20.7.80	2.04	2.04	0.01	99.9
21.7.80	1.94	1.94	0.01	99.9
22.7.80			<0.01	
Profile 2				
17.7.80	Saturated soil column with 3.0 litres, 20 ppm.F			
18.7.80	2.2	2.2	<0.01	99.9
19.7.80	2.4	2.4	<0.01	99.9
20.7.80	2.4	2.4	0.04	99.8
21.7.80	2.5	2.5	1.16	94.2
22.7.80			2.00	90.0

Average for Profiles 1 and 2 is 0.6 ppm.F.

The 'flow through' experiment showed that using the highest possible surface fluoride concentration of 20 ppm, then after 4 years, leachate entering the aquifer near the smelter site will contain an average fluoride content of 0.6 ppm.

The possibility of this level being reached is very remote. In reality, it is likely that the maximum surface soil water fluoride concentration per year will be 1.5 ppm. Assuming 1.5 ppm, the studies indicate that approximately 87 per cent of the soluble fluoride will be absorbed by the soil and the concentration of fluoride in the leachate reaching the groundwater will be less than 0.20 ppm which is well below the permissible level of 1 ppm fluoride in drinking water. The continuous flow of water into and out of the aquifer results in a 50 per cent dilution and hence concentrations of fluoride in the leachate will be less than 0.10 ppm.

With time, all the active sites on the soil particles available for absorption may become occupied by fluoride ions. It is difficult to predict when this is likely to occur but is unlikely within the next 100 years.

Conclusions

i. The flow through and circulation experiments will continue to determine the effect of time on fluoride ad/absorption on re-release of the ad/absorbed ions.

ii. The results of the circulation experiment indicate that after five days (≡2.5 years of rainfall, ad/absorbed fluoride ions may be very slowly re-released from the active sites. However, under field conditions it is probable that these re-released fluoride ions will be re-absorbed further down in the profile.

iii. The experiments have indicated that the ad/absorption of fluoride ions onto soil particles is not strongly dependent on concentration of fluoride ions in solution. Approximately 75-95 per cent absorption occurs for solutions containing 2 to 20 mg.F/1.

iv. After many years of operation, leachate reaching the groundwater will contain less than 0.3 ppm.F through the action of natural dilution and assuming a worst case of 20 ppm.F concentration in the soil water. In reality, levels will be nearer 0.1 ppm.F and this, combined with the existing fluoride levels in groundwater of 0.08 ppm, will raise levels to 0.18 ppm.F which is considerably less than the 1 ppm.F added for dental health benefits.

Appendix 7

AIR QUALITY

APPENDIX 7

AIR QUALITY

A7.1 DUST LEVELS

A7.1.1 Procedures

A total of eight dust deposition gauges were installed on the proposed site during November 1979 at the locations shown in *Figure 6.3*. These stations are serviced at monthly intervals and analysed for:

* Total dust (g/m^2.mth)
* Residue after ashing at 450°C (g/m^2.mth)
* Water soluble fluoride (mg/l)
* Total fluoride (μgF/g).

The procedure used is based on the British Standard 1747-Part 1-1969, except that a'V' shaped glass funnel is used and not a parallel-sided funnel, as specified in the Standard.

A7.1.2 Results

The results of analyses are given in *Table A7.1* and show a month to month variation attributed to:

* Natural conditions, including wind patterns, temperature and rainfall, and the response of vegetation and its seasonal effectiveness as ground cover.

* Activities on the site including clearing, and trail bike riding.

The average measured dust fallout level for the site for the November to June period was 1.95±0.18 g/m^2.mth which is considerably less than the level measured by the State Pollution Control Commission in Newcastle, which was 4.22 ± 0.27 g/m^2.mth for October-November 1977.

The water soluble fluoride is not only a measure of the soluble fluoride content in the dust, but also of the fluoride present in rain water falling on the dust deposition gauges. Water soluble fluoride (<0.25 mg/l) levels are very low. The average total fluoride in the dust is 3.5 μgF/g or 0.0003 per cent. Approximately 50 per cent of the total dust is composed of organic matter.

TABLE A7.1

AIR QUALITY

Site	Total Dust (g/m^2.mth)	Residue (g/m^2.mth)	Total Fluoride in Dust (μg/g)	Water Soluble* Fluoride (ppm)
D1	2.03 ± 0.52	1.76 ± 0.25	3.5 ± 1.0	0.20 ± 0.04
D2	3.13 ± 0.43			0.14 ± 0.02
D3	1.53 ± 0.23			0.14 ± 0.02
D4	1.70 ± 0.32			0.12 ± 0.02
D5	1.61 ± 0.23			0.14 ± 0.04
D6	1.69 ± 0.30			0.14 ± 0.04
D7	1.80 ± 0.24			0.12 ± 0.02
D8	2.11 ± 0.28			0.18 ± 0.04

Comments: *Fluoride content in the water collected in the dust deposition gauge.

Values cited above are the mean±standard error of monthly results obtained between November 1979 and June 1980.

Residue is material left after ashing at 450°C and was only determined on total dust collected over December/January 1980.

μg/g ≡ ppm

A7.2 FLUORIDE LEVELS

A7.2.1 Procedures

A total of 20 static ambient fluoride monitoring stations shown on *Figure 6.3* were installed on the 11th February 1980.

These stations consist of a plastic louvered-box mounted on a post 2 m above the ground. A cylinder of Whatman No. 1 filter paper impregnated with calcium formate is mounted in a vertical position inside the box. Filter papers are normally collected monthly, cut into strips, agitated in TISAB solution and analysed using a fluoride specific ion electrode.

Calcium formate stations measure only the gaseous fluoride component of the total fluoride which is composed of free gaseous, particulate and gaseous fluorides attached to particulates.

The fluoride content is expressed as μg gaseous $F/cm^2.d$. An equation developed by *Israel (1974)* was used to convert gaseous fluoride concentration per unit area per day to fluoride concentration per unit volume of air. *Israel's* equation provides a correlation between fluoride accumulated in the calcium formate papers and the exposure rates and can be used to estimate annual average gaseous concentrations with an accuracy of about ± 50 per cent from the relation:

$$C_{gas}(\mu g/m^3) = 0.09\ C_{calcium\ formate}\ (\mu gF/dm^2.d.)$$

Notes: $\mu g/dm^2.d. = \mu gF/100.cm^2 d.$
C = concentration

A7.2.2 Results and Discussion

Papers are collected monthly and the results of analyses are given in *Table A7.2*. These show that there is little variation in static ambient fluoride levels on and near the proposed site.

The overall mean of the results obtained to date (February to June 1980) is 0.0072 ± 0.0017 $\mu gF/cm^2 d$ which is equivalent to approximately 0.06 ± 0.03 $\mu gF/m^3$.

There has been a significant increase in the average fluoride level on the site during May and June 1980. This increase has been attributed to:

i. Emissions from industries in the Mayfield and Kooragang Island area which have been carried to the proposed site by the occasional gentle southerly breeze.

ii. Trapping of emissions on the site by winter inversions.

TABLE A7.2

STATIC AMBIENT FLUORIDE LEVELS

Station Number	Gaseous Fluoride ($\mu gF/cm^2.d$) Feb. 1980	Mar. 1980	Apr. 1980	May 1980	June 1980
1	0.0035	0.0056	0.0023	0.0067	0.014
2	0.0045	0.0065	0.0036	0.0067	0.013
3	0.0029	0.0047	0.0023	0.0054	0.010
4	0.0021	0.0075	0.0054	0.0080	0.016
5	0.0029	0.0056	0.0036	0.0054	0.013
6	0.0035	0.0056	0.0023	0.0067	0.013
7	0.0045	0.0079	0.0036	0.0067	0.019
8	0.0054	0.0065	0.0036	0.0067	0.016
9	0.0045	0.0056	0.0036	0.0067	0.010
10	0.0045	0.0056	0.0036	0.0067	0.010
11	0.0054	0.0093	0.0054	0.0092	0.016
12	0.0067	0.0102	0.0068	0.0092	-
13	0.0035	0.0047	0.0023	0.0067	0.012
14	0.0054	0.0079	0.0185	0.0092	0.019
15	0.0029	0.0056	0.0036	0.0022	0.008
16	0.0045	0.0065	0.0036	0.0067	0.016
17	0.0045	0.0065	0.0077	0.0080	0.019
18	0.0035	0.0056	0.0036	0.0080	0.016
19	0.0029	0.0046	0.0023	0.0048	0.007
20	0.0035	0.0056	0.0077	0.0092	0.016
Mean ±SE, $\mu gF/cm^2.d.$	0.0041± 0.0002	0.0064± 0.0003	0.0048± 0.0008	0.0069± 0.0004	0.01384± 0.0008
Mean ± 50%, $\mu gF/m^3$ **	0.04±0.02	0.06±0.01	0.04±0.02	0.06±0.03	0.12±0.06

Comments: $\mu gF/cm^2.d = \frac{\mu g\ F\ sample - \mu g\ F\ blank}{area\ of\ paper\ (cm^2)\ x\ number\ of\ days}$

SE = standard error = standard deviation / $\sqrt{number}$

Overall Mean ±SE = 0.0072 ± 0.0017 $\mu g\ F/cm^2.d.$
= 0.06 ± 0.03 $\mu g\ F/m^3$.

** = mean ±50%, i.e. Israel's correlation has an accuracy of ±50%.

The results obtained for stations 11 and 12 are considerably higher than the overall average fluoride level.

Station 11 is located near the Hunter River and a vegetable garden where the application of fertilisers and insecticides to the garden and salt spray from the Hunter River would be the cause of the abnormally high ambient fluoride levels at this site.

Station 12 is located near a coating factory and it is likely that some of the substances used for various coating applications contain fluoride. Spray drift during the coating process could cause localised high fluoride levels as indicated by the measured levels at station 12.

There is little information on acceptable static fluoride levels. The static ambient fluoride levels on and near to the proposed site are, on average, slightly higher than levels measured elsewhere in Australia. The static fluoride level measured at a proposed aluminium smelter site in Queensland was 0.0036 $\mu g/cm^2.d$, some 50 per cent lower than existing levels measured at the proposed Tomago smelter site.

In North America the acceptable levels for Ontario, Montana and Maryland are 0.0133, 0.0107 and 0.050 $\mu g/cm^2.d$ respectively. The overall average static ambient fluoride levels for the proposed site is considerably less than the USA accepted levels.

It has been determined that significant leaf damage occurs in sensitive flora species, or an accumulation of fluoride in forage of more than 35 ppm on an annual average, results from exposure to a 30 day average air concentration of gaseous fluoride of approximately 0.3 $\mu g/m^3$. *(State Pollution Control Commission, 1980)*. The statistically determined level using Israel's equation for the proposed site is 0.06 ± 0.03 $\mu gF/m^3$ (gaseous) which is considerably less than 0.3 $\mu g/m^3$.

7.3 AIR QUALITY MONITORING

The existing dust and static formate sampling monitoring programmes outlined in *Appendices 7.1 and 7.2* will continue at two monthly intervals. The air sampling programme will be extended by the installation of six dual tape samplers which can measure the actual concentration of airborne fluoride per unit volume over a short time period. Sites for the samplers will be chosen as described in *Section 8.13* in *Volume 1* in consultation with the State Pollution Control Commission.

Appendix 8

AMBIENT SOUND LEVELS

APPENDIX 8

AMBIENT SOUND LEVELS

A8.1 SOUND LEVELS

A8.1.1 Procedures

Sound levels were monitored at a total of fourteen sites within the Tomago area during November 1979 and January 1980. The locations of measuring sites are shown on *Figure 6.11*.

A Bruel & Kjaer Precision Impulse Sound Level Meter, type 2209, and a Sony TC5, 10-2 Portable Tape Recorder were used to measure sound levels at each of the sites. Calibration was checked regularly using a Bruel & Kjaer Sound Level Calibrator, type 4230. Measurements were carried out in accordance with Australian Standard AS1055-1978.

With the sound level meter set on fast response and using the 'A' weighted scale (approximates the loudness level sensitivity of the human ear) sixty random readings were taken at each site over a period of between 2 and 5 minutes. The time period was dependent upon vehicular traffic as noise levels generated by vehicles passing opposite or adjacent to the monitoring site were eliminated.

Table A8.1 provides details of measurement times and meteorological information.

Night time and day time background sound levels (Leq, L_{10}, L_{95}) were calculated for each monitoring station.

The equivalent sound level (Leq) is defined as the level of continuous sound which emits the same energy as a fluctuating sound over a fixed period. The subjective reaction to sound is related to the sound level exceeded for 10 per cent of the time (L_{10}), while L_{95} is background sound, and is the sound level exceeded for 95 per cent of the time.

TABLE A8.1

FIELD MEASUREMENT CONDITIONS

	DAY	NIGHT
Sites N1, N2, N3, N4, N5, N6, N7		
Date :	21st November 1979	21st November 1979
Time :	1.30pm to 4.15pm	10.05pm to 11.45pm
Cloud Cover (percentage)	0 - 10	0
Temperature (°C)	24 - 36	13 - 17
Wind Intensity (km/h)	9 - 18	0
Wind Direction	southeasterly	0
Sites N1 to N14 inclusive		
Date :	24th January 1980	24th January 1980
Time :	3.50pm to 4.15pm	10.05pm to 11.55pm
Cloud Cover (percentage)	5	0
Wind Intensity (km/h)	14 - 36	0 - 9
Wind Direction	easterly	southeasterly

A8.1.2 Results

The proposed site is located in an industrial area and adjacent to two main road routes, the Pacific Highway and Tomago Road. A summary of the measured ambient sound levels is given in *Table A8.2* and shows that the measured mean background (L_{95}) sound level was 46 dB(A) during the day and 36 dB(A) at night.

The higher day time sound level is a result of higher traffic volumes on the main roads, and the activities of the majority of industrial facilities which operate only during the day.

Background sound contours for day and night time periods are shown in *Figure 6.11*.

TABLE A8.2

SUMMARY OF AMBIENT SOUND LEVELS (dB(A))

Site	Day Leq	Day L_{10}	Day L_{95}	Night Leq	Night L_{10}	Night L_{95}	Comments
N 1	50	53	45	41	44	36	Traffic sound
N 2	51	55	44	29	31	29	Industrial sound
N 3	52	56	45	42	41	31	Traffic sound
N 4	53	58	45	42	45	30	Industrial sound
N 5	51	54	44	38	39	37	Traffic sound
N 6	55	59	42	45	44	39	Traffic and piggery sound
N 7	62	69	53	51	55	45	Traffic sound
N 8	58	62	49	46	45	29	Industrial sound
N 9	53	59	44	48	51	32	Industrial sound
N10	52	55	45	32	34	31	Industrial sound
N11	45	48	43	34	39	30	Industrial sound
N12	42	45	40	32	34	30	-
N13	43	45	42	35	38	31	-
N14	43	47	41	33	35	30	-
Mean	54	59	46	44	46	36	

Comments: Sites N1 and N7 are the mean of two sets of measurements taken on 21st November 1979 and 24th January 1980. Majority of industry in the area operates only during the day.

A8.2 SOUND SURVEYS OVER 24 HOURS

In addition to the random measurements taken at the fourteen sites on the occasions listed in *Table A8.1* two 24 hour surveys were conducted.

A8.2.1 Procedures

The two 24 hour surveys were conducted at site N5 on the 18th and 19th

January 1980 and 20th and 21st January 1980. Sixty random sound readings as well as a vehicle count was conducted at hourly intervals over 24 hours.

A8.2.2 Results

The results of these surveys, illustrated in *Figure 6.12*, provide detailed information on the overall sound climate on the site.

The 24 hour studies show that:

i. Background sound levels are dependent on time of day and vehicular movements.

ii. The background day time sound levels on a Sunday are similar to day time levels measured during the week. Normal noise reductions which would be expected on a Sunday as a result of local industries not operating are offset by increased vehicular movements at weekends.

A8.3 FREQUENCY ANALYSES

Frequency analyses at sites N2 and N10 were recorded with the sound level meter set on linear. A Bruel & Kjaer Octave Frequency Analyser type 1613 and a Portable Graphic Level Recorder type 2306 were used for the analyses.

The results of the frequency analyses are given in *Table A8.3* and shown graphically in *Appendix 8.5*.

The night time sound components at sites N2 and N10 are predominantly low frequency (<1000 Hz) signals. Site N10 is located near an engineering works which only operates during the day and the magnitude of the sound levels generated by this sound source are similar at each frequency band, except for the 16 kHz and 31.5 kHz frequency bands.

TABLE A8.3

OCTAVE FREQUENCY ANALYSES

Site	dB(Lin)	Sound Pressure Levels in dB(Lin) Octave Band Centre Frequency (Hz) 31	63	125	250	500	1K	2K	4K	8K	16K	31.5K
N2 night	61	65	57	52	40	36	42	42	30	32	28	26
N10 day	58	56	60	56	45	45	42	45	46	42	30	25
N10 night	45	48	46	42	35	30	30	24	20	20	20	16

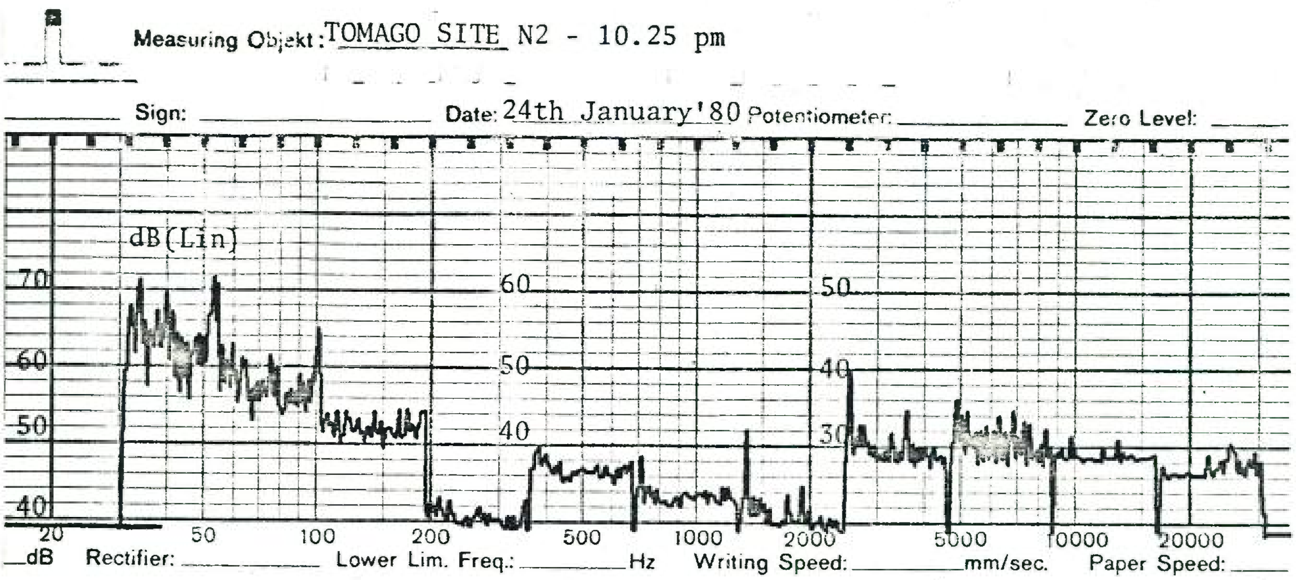
Comments: dB(Lin) is the summation of sound levels of each octave band

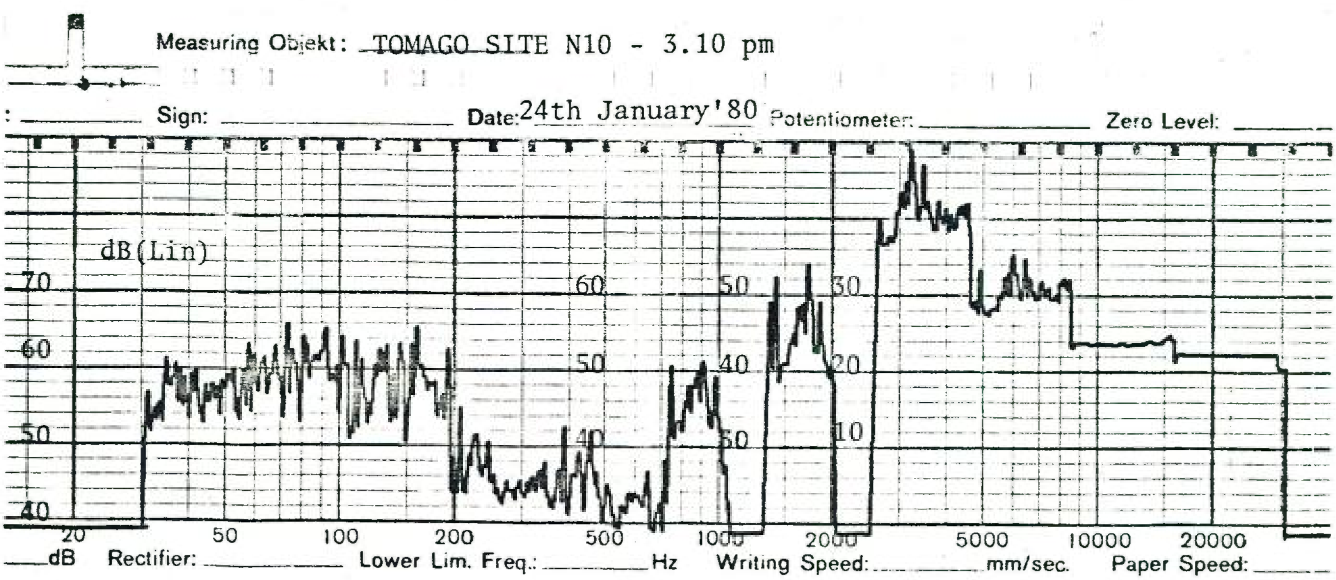
A8.4 MONITORING PROGRAMME

Noise studies will continue at sites N1 to N14 inclusive, at six monthly intervals to determine accurate background noise levels for the site. Similar studies will be initiated when the smelter is in full operation to determine the effect of the smelter on the overall noise climate. Details of the proposed monitoring programme are provided in *Section 8.13* in *Volume 1*.

APPENDIX 8.5

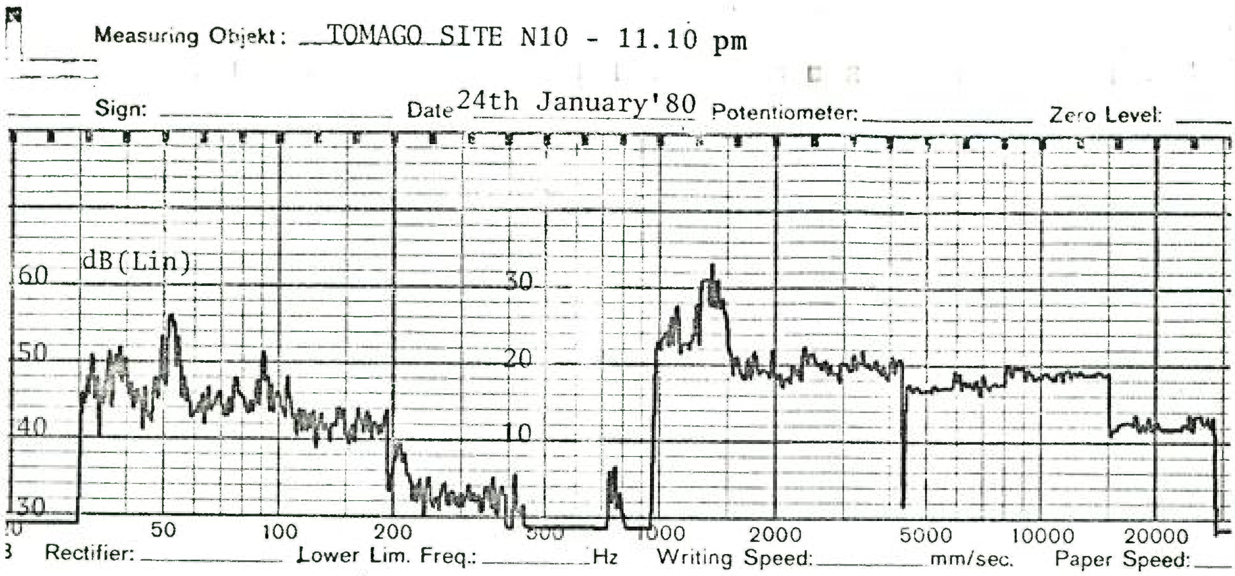
OCTAVE FREQUENCY GRAPHS





APPENDIX 8.5 (cont'd)

OCTAVE FREQUENCY GRAPHS



Appendix 9

FLORA

APPENDIX 9

FLORA

A9.1 FIELD INVESTIGATIONS

Field observations and aerial photograph interpretation were used to map the extent of vegetation assemblages shown on *Figure 6.13*. Assemblage characteristics examined included species diversity and dominance and vegetation structure. Mapping was carried out over a period of four weeks during November and December 1979.

A9.2 NATIVE VEGETATION ASSEMBLAGES

ESTUARINE AREAS

i. Mangroves

Bordering the Hunter River, Fullerton Cove and Kooragang Island, are stands of the Grey Mangrove *(Avicennia marina)*. The River Mangrove *(Aegiceras corniculatum)* is also present but is a less common species favouring sheltered sites. These stands are classified as Closed Forest to Tall Shrubland according to Specht's Structural Classification *(Specht et al, 1974)*.

ii. Salt Marsh

On the landward side of the Mangrove stands, areas under tidal influence are dominated by salt-tolerant plants or bare mud. Changes in microtopography result in the dominant species varying between Sand Couch *(Sporobolus virginicus)*, Samphire *(Salicornia quinqueflora)* and *Juncus maritimus*.

TOMAGO SANDBEDS

i. Dry Sclerophyll Closed Forest to Woodland

Throughout the wooded areas, species dominance, height and cover vary. The two most common associations are the Rusty Gum *(Angophora costata)*-Red Bloodwood *(Eucalyptus gummifera)* Association and the Rusty Gum-Scribbly Gum *(Eucalyptus haemastoma)*-Red Bloodwood Association.

The trees in these two associations vary from between 10 m and 20 m in height. Saw Banksia *(Banksia serrata)* and Woody Pear *(Xylomelum pyriforme)* are common understorey plants in both associations and reach a maximum height of 10 m. The Saw Banksia is evenly distributed throughout. The ground cover is generally dense, approximately 1 m tall and consists of a wide diversity of plants typical of heathland. Bracken Fern *(Pteridium esculentum)* and Blady Grass *(Imperata cylindrica var. major)* are very common, while Peas, Wattles, Epacrids and members of the *Proteaceae* family predominate.

The distribution of plants within the two associations is highly variable. Clumps of Blackbutt *(Eucalyptus pilularis)* or Scribbly Gum, as well as isolated Stringybarks (such as *Eucalyptus globoidea)* are commonly found within the Rusty Gum-Red Bloodwood Association.

The Blackbutt-Rusty Gum Association to the northeast of the disused airstrip differs, in that the Blackbutts are taller (up to 25 m in height) and there are fewer Bloodwoods. Although not confined to it, Christmas Bush *(Ceratopetalum gummiferum)* is a common understorey plant in this association.

To the west of the disused airstrip is the Spotted Gum-Ironbark Association, consisting of the Spotted Gum *(Eucalyptus maculata)* and the two Ironbarks, the Narrow-leaved Ironbark *(E. crebra)* and Northern Grey Ironbark *(E. siderophloia)*. The trees are up to 20 m high and exhibit 50 per cent to 70 per cent cover.

The understorey varies from sparse to dense, with the main shrubs being Sickle Wattle *(Acacia falcata)*, Myrtle Wattle *(Acacia myrtifolia)* and Blackthorn *(Bursaria spinosa)*. Ball Honey-myrtle *(Melaleuca nodosa)* also occurs as a dense understorey commonly up to 8 m in height. The ground cover, consisting mainly of grasses (particularly Blady Grass), varies considerably in density.

The Forest Red Gum *(Eucalyptus tereticornis)* stand to the northwest of the disused airstrip contains occasional Rusty Gums and Broad-leaved Paperbarks *(Melaleuca quinquenervia)* and possesses an Open-forest structure. The understorey consists of scattered Dogwood *(Jacksonia scoparia)*, Pine-leaf Geebung *(Persoonia pinifolia)* and Silky Hakea *(Hakea sericea)*. The dense ground cover consists predominantly of Blady Grass, Bracken Fern and Spiny-headed Mat-rush *(Lomandra longifolia)*.

On the northeastern side of the disused airstrip, a small clump of young Flooded Gum *(Eucalyptus grandis)* has developed with trees up to 15 m in height. A predominant understorey plant is the Cheese Tree *(Glochidion ferdinandi)* while the ground cover is typical of much of the site, being dominated by Bracken Fern and Blady Grass.

The Rusty Gum-Stringybark Association is poorly represented on the site; the Stringybark *(Eucalyptus globoidea)* being a minor component of the Open-forest. The understorey consists of scattered Forest Oak *(Casuarina torulosa)*, Cheese Tree, Blackthorn and Pine-leaf Geebung *(Persoonia pinifolia)*. Grasses such as Kangaroo Grass *(Themeda australis)* and an occasional Bracken Fern form the ground cover.

ii. Swampland

Broad-leaved Paperbark *(Melaleuca quinquenervia)*- Swamp Mahogany *(Eucalyptus robusta)* swamps are scattered over the site. The dominant trees exhibit an Open-forest structure and Woollybutt *(Eucalyptus longifolia)* sometimes occurs as a subordinate.

The understorey vegetation varies according to the degree of waterlogging. The most common species are *Gahnia clarkei, Baumea articulata, Elocharis acuta, Baumea juncea* and *Carex appressa*. In drier areas under the Paperbarks and Swamp Mahogany, grasses, Cheese Trees and *Parsonsia straminea* are common.

Coastal bogs *(Goodrick, 1970)* consisting of a variety of heath plants, usually surrounded by Broad-leaved Paperbark and Swamp Mahogany also occur. Water Lillies *(Nymphaea capensis)* occur in open water, whereas sedges are common in the drier areas.

The third swamp type in the sandbeds is the *Lepironia* swamp. It consists predominantly of pure stands of the sedge *Lepironia articulata* while Water Ribbons *(Triglochin procera)* are sometimes common.

iii. Closed Scrub

Two significantly different areas of Ball Honey-myrtle *(Melaleuca nodosa)* Closed Scrub are shown on *Figure 6.13*.

The eastern area consists of a dense layer of Ball Honey-myrtle up to 7 m in height. Occasional Ironbarks, Stringy-barks, Red Gums and Rusty Gums emerge through the dense canopy formed by the Ball Honey-myrtle. Below the canopy there are few shrubs or herbs. The vine, *Parsonsia straminea* is common and one Elk Horn *(Platycerium bifurcatum)* was found growing on a fallen log.

The Closed Scrub adjacent to the sand mined area displays a much wider diversity. The dense vegetation, varying in

> height from 2 to 6 m, is dominated by Ball Honey-myrtle but also contains Rock Banksia *(Banksia aspleniifolia)*, Tantoon *(Leptospermum flavescens)*, Feather Honey-myrtle *(Melaleuca thymifolia)* and others. Intermixed with the dominant trees and shrubs is a diversity of small shrubs and ground covers forming a typical heathland. Rusty Gum, Grey Gum *(Eucalyptus punctata)* and Saw Banksia *(Banksia serrata)* form occasional small clumps throughout the area.

On the numerous easements that have been cleared, young plants typical of the sandbed and associated vegetation are found. The number of weeds is minimal.

Associated with the cleared and low-lying land are remnants of the original vegetation marked by isolated Swamp Oaks scattered throughout the pasture-land. At the Tomago Road - Pacific Highway intersection, and west of the Hunter River, are stands of Swamp Oak and Red Gum. Paperbarks also occur in the largest of the stands.

The area of regeneration to the west of Old Punt Road consists predominantly of Paperbarks and Oaks with some Spotted Gum.

LOW-LYING AND PASTORAL LAND

The areas shown on *Figure 6.13* as Reed Swamp have a broad range of characteristics including features belonging to She-Oak Swamps. Patches of the Common Reed *(Phragmites australis)* occur on the Mangrove-lined perimeters of the low-lying areas. Scattered individuals of Swamp Oak also occur with an understorey of *Juncus* species. The intermediate areas are dominated by grasses and *Scirpus caldwelli*.

Semi-permanent swamps around Fullerton Cove consist of sparsely grassed land with clumps of *Juncus maritimus* and small remnants of other salt-tolerant species. In the numerous shallow channels, Arrowgrass *(Triglochin striata)* and Water Buttons *(Cotula coronopifolia)* occur. Some of the larger man-made channels contain Common Reed and on their banks Sand Couch and Samphire.

Semi-permanent swamps on Kooragang Island consist of Fresh Meadow dominated by Water Buttons, Seasonal Fresh Swamp dominated by Water Ribbons, and some Salt Marsh near Mangroves.

A9.3 FLORA SPECIES LIST

PLANTS OCCURRING NATURALLY ON AND IN THE VICINITY OF THE SITE AND WITHIN THE AREA SHOWN ON FIGURE 6.13.

FAMILY/Scientific Name	Common Name	Distri-bution	Abundance
<u>*PTERIDOPHYTA*</u>			
ADIANTACEAE			
Adiantum aethiopicum# L.			S
Cheilanthes tenuifolia (Burm.f) Sw	Rock Fern	e	F
BLECHNACEAE			
Blechnum indicum Burm.f.		c	S
DENNSTAEDTIACEAE			
Pteridium esculentum (Forst.f.)Cockayne	Bracken	a,b,e	A
GLEICHENIACEAE			
Gleichenia microphylla R.Br	Scrambling Coral Fern	b-c	F
POLYPODIACEAE			
Platycerium bifurcatum (Cav.)C.Ch.	Elkorn	b	R
SCHIZAEACEAE			
Schizaea bifida Willd.		b	F
<u>*ANGIOSPERMAE*</u>			
AMARANTHACEAE			
*Alternanthera philoxeroides** (Mart.) Griseb	Alligator Weed	c	S
AMARYLLIDACEAE			
Crinum pedunculatum R.Br	Swamp Lilly	d	R
APOCYNACEAE			
Parsonsia straminea (R.Br)F.Muell		b	S
ARALIACEAE			
Polyscias sambucifolia (Sieb.ex DC.) Harms			S
BAUERACEAE			
Bauera capitata Ser. ex DC.		b	F
BIGNONIACEAE			
Pandorea pandorana (Andr.) Steen	Wonga Wonga Vine	b	C
CAMPANULACEAE			
Wahlenbergia gracilis (Forst.et F) Schrad		a,b	F

A9.3 (cont'd)

FAMILY/Scientific Name	Common Name	Distribution	Abundance
CASSYTHACEAE			
Cassytha glabella R.Br.		b	F
C. pubescens R.Br.		b	F
CASUARINACEAE			
Casuarina glauca Sieb. ex. Spreng	Swamp Oak	c,e	C
C. littoralis Salisb	Black She-oak	b	S
C. torulosa Ait	Forest Oak	b,a	S
CELASTRACEAE			
Maytenus silvestris			
CHENOPODIACEAE			
Atriplex cinerea Poir	Coast Saltbush	d	R
Salicornia quinqueflora Bunge ex Urgen	Samphire	d	R
COMMELINACEAE			
Commelina cyanea R.Br.	Wandering Sailor	e	R
COMPOSITAE (ASTERACEAE)			
*Ambrosia tenuifolia** Spreng	Ragweed	e	S
Bidens pilosa L.	Cobbler's Pegs	e	S
*Chrysanthemoides monilifera**(L.)T.Norl.	Boneseed	b,e	R
Helichrysum diosmifolium (Vent.)	Tick Bush	b	F
Onopordum acanthium	Thistle	e	S
Senecio lautus Forst. ex Willd	Variable Grounsel	e	C
Cotula coronopifolia L.	Water Buttons	c	S
C. reptans Benth.	Creeping Cotula	c	S
CONVOLVULACEAE			
Cuscuta australis R.Br.	Dodder	b	S
CUNONIACEAE			
Callicoma serratifolia Andr	Callicoma	b	R
Ceratopetalum gummiferum# Sm.	Christmas Bush	b	F
CYPERACEAE			
Baumea articulata (R.Br.) S.T.Blake		b,c	S
*B. juncea*** (R.Br.) Palla		b	S
Carex appressa R.Br.		b	S
Caustis recurvata# Spreng		b	S
C. flexuosa R.Br.		b	S
Eleocharis acuta		c	F
Gahnia aspera (R.Br.) Spreng		c,b	S
G. clarkei		c,b	S
Lepidosperma flexuosum Labill		b	F
Lepironia articulata (Retz) Domin		c	S
Schoenus ericetorum R.Br.		b	C
Scirpus caldwellii		b	S
S. inundatus Spreng		c	S
S. nodosus Rottb		c,b,e	C

A9.3 (cont'd)

FAMILY/Scientific Name	Common Name	Distribution	Abundance
DILLENIACEAE			
Hibbertia aspera DC.	Rough Guinea Flower	b	S
H. dentata R.Br. ex DC.	Twining Guinea Flower	b	S
H. fasciculata R.Br. ex DC.	Bundled Guinea Flower	b	S
H. linearis R.Br. ex DC.	Showy Guinea Flower	b	S
H. scandens (Willd.) Gilg	Climbing Guinea Flower	b	C
H. sericea (R.Br. ex DC) Benth	Blue Mountain Guinea Flower	b	S
DROSERACEAE			
Drosera binata Labill	Forked Sundew	b	R
D. peltata Sm. ex Willd	Pale Sundew	b	S
D. pygmaea DC.	Tiny Sundew	b	S
D. spathulata Labill	Rosy Sundew	b	S
EPACRIDACEAE			
Astroloma humifusum (Cav.)R.Br.	Cranberry Heath	b	S
A. pinifolium (R.Br)Benth	Pine Heath	b	F
Brachyloma daphnoides (Sm.)Kunth	Daphne Heath	b	S
Epacris paludosa R.Br.	Swamp Heath	b	S
E. pulchella Cav.	NSW Coral Heath	b	C
E. microphylla R.Br.	Coral Heath	b	C
E. obtusifolia Sm.	Blunt-leaf Heath	b	C
Leucopogon ericoides (Sm.) R.Br.			C
L. lanceolatus (Sm.)R.Br.	Lance Beard-Heath		S
L. leptospermoides R.Br.	Teatree Beard-heath	b	S
L. microphyllus R.Br.	Straggling Beard-heath	b	C
L. parviflorus (Andr.)Lindl.	Coast Beard-heath	b	C
L. virgatus R.Br.	Common Beard-heath	b	C
Melichrus urceolatus R.Br.	Urn Heath	b	S
Monotoca elliptica (Sm.)R.Br.	Tree Broom Heath	b	F
Sprengelia sprengelioides (R.Br.) Druce	White Swamp-heath	b	F
Styphelia viridis Andr.	Green Five Corners	b	C
Woollsiapungens (Cav.)F. Muell	Woollsia	b	C
EUPHORBIACEAE			
Amperea xiphoclada (Sieb.ex Spreng) Druce	Broom Spurge	b	C

A9.3 (Cont'd)

FAMILY/Scientific Name	Common Name	Distri-bution	Abundance
Breynia oblongifolia J.Muell	Coffee Bush	b	F
Glochidion ferdinandi (J.Muell)F.M.Bailey	Cheese Tree	b	S
Poranthera corymbosa Brogn	Clustered Poranthera	b	S
P. microphylla Brogn	Small Poranthera	b	S
Ricinocarpus pinifolius Desf.	Wedding Bush	b	C
GOODENIACEAE			
Dampiera stricta (Sm.)R.Br.	Blue Dampiera	b	F
Goodenia hederacea Sm.	Ivy Goodenia	b	S
G. ovata Sm.	Hop Goodenia	b	S
G. stelligera R.Br.	Spike Goodenia	b	S
Scaevola ramosissima (Sm.) Krause	Hairy Fan-flower	b	S
GRAMINEAE (POACEAE)			
*Andropogon virginicus** L.		e	S
Axonopus affinis A.Chase	Narrow-leaved Carpet Grass	e	S
Briza maxima L.	Quaking Grass	e	S
*Chloris gayana** Kunth	Rhodes Grass	e	S
Cynodon dactylon (L.) Pers.	Couch	e	C
Dichelachne crinita (L.)Hook.f.	Long-hair Plume Grass	b	F
Entolasia marginata (R.Br.) Hughes		a-b	F
*Eragrostis sp.**	A Love Grass	e	S
Imperata cylindrica (L.)Beauv.var major(Nees)C.E.Hubbard	Blady Grass	a,b,e	A
Paspalum dilatatum Poir	Paspalum	e	F
*Pennisetum clandestinum** Hochst.et Chiov	Kikuyu	e	F
Phragmites australis (Cav.) Trin			R
Rhyncelytrum repens Willd	Natal Grass	e	S
Sporobolus virginicus (L.) Kunth	Sand Couch	d	F
Themeda australis (R.Sm) Stapf	Kangaroo Grass	a	F
HAEMODORACEAE			
Haemodorum corymbosum Vahl.		b	S
HALORAGACEAE			
Haloragis micrantha (Thunb.)R.Br. ex.Sieb. et Zucc	Creeping Raspwort	b	S
H. teucroides (DC.) Schlecht	Germander Raspwort	b	F
IRIDACEAE			
Patersonia glabrata R.Br.	Leafy Purple-flag	b	S
JUNCACEAE			
Juncus continuus		b	S
J. maritimus		d	F
J. planifolius R.Br.		c-e	S
JUNCAGINACEAE			
Triglochin procera R.Br.	Water Ribbons	c	R
T. striata Ruiz et Pav	Arrow Grass	d	S

A9.3 (cont'd)

FAMILY/Scientific Name	Common Name	Distribution	Abundance
LENTIBULARIACEAE			
Utricularia cyanea R.Br.		c-b	R
U. dichotoma Labill	Fairies' Apron	c-b	R
LILIACEAE			
Blandfordia grandiflora# R.Br.	Christmas Bell	b	R
Dianella caerulea Sims	Paroo Lily	b	S
D. revoluta R.Br.	Black-anther Flax-lily	b	S
Sowerbaea juncea Sm	Vanilla Plant	b	S
Thysanotus sp.	Fringe Lily	a	S
Tricoryne elatior R.Br.	Yellow Rush Lily	b	S
LOBELIACEAE			
Lobelia alata Labill	Angled Lobelia	b	R
L. dentata Cav.	Wavy Lobelia	b	S
Pratia purpurascens (R.Br.)	White root	b	S
LOGANIACEAE			
Mitrasacme paludosa R.Br.	Swamp Mitrewort	b	R
LORANTHACEAE			
Amyema pendula (Sieb ex Spreng.) Tiegh.	Drooping Mistletoe	b	S
A. quandong (Lindl.) Tiegh.	Grey Mistletoe	b	S
Dendropthoe vitellina (F.Muell) Tiegh	Long-flower Mistle-toe	b	S
MENYANTHACEAE			
Villarsia exaltata (Simd.) Don		c	S
MIMOSACEAE			
Acacia botrycephala (Vent.) Desf	Sunshine Wattle	b	C
A. decurrens (Wendl.) Willd.	Sydney Green Wattle	b	F
A. elongata Sieb. ex DC.	Slender Wattle	b	F
A. falcata Willd.	Sickle Wattle	a	S
A. longifolia (Andrews) Willd	Coast Wattle	b	S
A. myrtifolia (Sm.) Willd	Myrtle Wattle	b	C
A. suaveolens (Sm.) Willd		b	F
A. terminalis Macbride	New Year Wattle	b	S
A. ulicifolia (Salisb.) Court	Prickly Moses	b	F
MORACEAE			
Ficus rubiginosa Desf. ex Vent.	Rusty Fig	e	R
MYRTACEAE			
Angophora costata (Gaertn.) Druce	Rusty Gum	b	A
A. floribunda (Sm.) Sweet	Rough-barked Apple	b	R
Baeckia diosmifolia Rudge	Diosma Heath-myrtle	b	S
B. imbricata (Gaertn.) Druce	Ridged Heath-myrtle	b	S
B. ramosissima A.Cunn. in Field	Rosy Heath-myrtle	b	S
Callistemon citrinus (Curtis)Skeels	Lemon Bottlebrush	b	S
C. linearifolius D.C.	Netted Bottlebrush	b	S
C. linearis D.C.	Narrow-leaved Bottlebrush	b	F

A9.3 (Cont'd)

FAMILY/Scientific Name	Common Name	Distribution	Abundance
C. pachyphyllus Cheel	Smooth Bottlebrush	b	S
C. salignus (SM.) D.C.	Willow Bottlebrush	b	R
Calytrix tetragona Labill	Common Fringe-myrtle	b	S
Darwinia leptantha Briggs	Narrow Scent-myrtle	b	S
Eucalyptus botryoides Sm.	Bangalay	b	S
E. crebra R. Muell.	Narrow-leaved Iron-bark	a	S
E. globoidea Blakely	White Stringybark	b	S
E. grandis W.Hill ex Maiden	Flooded Gum	a	R
E. gummifera (Gaertn) Hochr	Red Bloodwood	b	A
E. haemastoma Sm.	Scribbly Gum	b	A
Eucalyptus longifolia Link	Woollybutt	b	R
E. maculata Hook	Spotted Gum	a	S
E. pilularis Sm.	Blackbutt	b	F
E. resinifera Sm.	Red Mahogany	b	S
E. robusta Sm.	Swamp Mahogany	b-c	F
E. siderophloia Benth	Northern Grey Iron-bark	a	R
E. tereticornis Sm.	Forest Red Gum	b	F
E. umbra subsp. umbra R.T. Baker	Bastard Mahogany	b	S
Leptospermum arachnoides Gaertn.	Stiff Teatree	b	S
L. attenuatum Sm.		b	S
L. flavescens Sm.		b	F
L. juniperinum Sm.	Prickly Teatree	b	F
L. liversidgei Baker	Lemon-scented Tea-tree	b	S
L. parvifolium Sm.	Small-leaf Teatree	b	S
Melaleuca ericifolia Sm.	Swamp Paperbark	b	R
M. nodosa Sm.	Ball Honey-myrtle	b	C
M. quinquenervia (Cav.) S.T.	Broad-leaved Paper-bark	b-c	F
M. sieberi Schau in Walp	Sieber's Paperbark	b	S
M. styphelioides Sm.	Prickly-leaved Paperbark	b	S
M. thymifolia Sm.	Feather Honey-myrtle	b	F
MYRSINACEAE			
Aegiceras corniculatum (Stekm.)Blanco	River Mangrove	d	R
NYMPHAEACEAE			
Nymphaea capensis Thunb.	Water Lily	c	R
OLACACEAE			
Olax stricta R.Br.	Eastern Olax	b	S
ORCHIDACEAE			
Acianthus fornicatus R.B.r.	Pixie Caps	b	S
Caladenia alba R.Br.	White Caladenia	b	F
C. carnea R.Br.	Pink Fingers	b	S
Chiloglottis reflexa (Labill)Druce	Autumn Bird Orchid	b	S

A9.3 (cont'd)

FAMILY/Scientific Name	Common Name	Distri-bution	Abundance
Dipodium punctatum# (Sm.)R.Br.	Hyacinth Orchid	b	R
Diurus punctata Sm.	Purple Diurus	b	F
D. sulphurea R.Br.	Tiger Orchid	b	S
Glossodia minor R.Br.	Small Wax-lip Orchid	b	S
G. major R.Br.	Wax-lip Orchid	b	F
Microtis parviflora R.Br.	Slender Onion-Orchid	b	F
Pterostylis nutans R.Br.	Nodding Greenhood	b	F
Thelymitraixioides Swartz	Dotted Sun-Orchid	b	S
OXALIDACEAE			
Oxalis corniculata L.	Yellow Wood Sorrel	a,e	S
PAPILIONACEAE (FABACEAE)			
Aotus ericoides (Vent.) G. Don	Common Aotus	b	S
Bossiaea ensata Sieb. ex. DC.	Small Leafless Bossiaea	b	C
B. heterophylla Vent.	Variable Bossiaea	b	C
B. rhombifolia Sieb. ex.DC.	Appressed Bossiaea	b	F
Daviesia corymbosa Sm.	Clustered Bitter-pea	b	S
Dillwynia floribunda Sm.	Flowery Parrot-pea	b	F
D. glaberrima Sm.	Heath Parrot-pea	b	S
D. ramosissima Benth.	Bushy Parrot-pea	b	S
D. retorta (Weddl.) Druce	Twisted Parrot-pea	b	F
Glycine cladestina Wendl.	Twining Glycine	b	F
Gompholobium grandiflorum Sm.	Handsome Wedge-pea	b	S
G. latifolium Sm.	Broad Wedge-pea	b	S
G. pinnatum Sm.	Pinnate Wedge-pea	b	S
Hardenbergia violacea (Schneev.)Stearn	False Sarsparilla	b,a	C
Hovea linearis R.Br.	Erect Hovea	b	S
Indigofera australis Willd.	Austral Indigo	b	S
Jacksonia scoparia R.Br.	Winged Broom-pea	b	S
Kennedia prostrata R.Br.	Running Postman	b	S
K. rubicunda Vent.	Dusky Coral Pea	b	C
Mirbelia rubiifolia (Andr.) G. Don	Heathland Mirbelia	b	F
Oxylobium ilicifolium (Andr.) Domin	Prickly Shaggy-pea	b	S
O. robustum J. Thompson	Tree Shaggy-pea	b	S
Pultenaea euchila			
Phyllota phylicoides (Sieb.ex.DC.)Benth	Heath Phyllota	b	S
Sphaerolobium vimineum Sm.	Leafless Globe-pea	b	S
*Trifolium repens** L.	White Clover	e	S
Viminaria juncea (Schrad.) Hoffmgg			
PALMAE			
Livistona australis# (R.Br.)Mart	Cabbage Palm	e	R
PHILESIACEAE			
Eustrephus latifolius R.Br.	Wombat Berry	b	S
Geitonoplesium cymosum (R.Br.) A.Cunn	Scrambling Lily	b	S

A9.3 (cont'd)

FAMILY/Scientific Name	Common Name	Distri-bution	Abundance
PHILYDRACEAE			
Philydrum lanuginosum Gaertn	Frogmouth	c	R
PHYTOLACCACEAE			
*Phytolacca octandra** L.	Inkweed	e	S
PITTOSPORACEAE			
Billardiera scandens Sm.	Dumplings	b	F
Bursaria spinnosa Cav.		a	F
Pittosporum undulatum Vent.		b	S
PLANTAGINACEAE			
*Plantago sp.**		e	S
POLYGALACEAE			
Comesperma ericinum DC.	Pyramid Flower	b	F
C. volubile Labill	Love Creeper	b	S
PRIMULACEAE			
Samolus repens (Forst. et.f.) Pers	Creeping Brookweed	d	S
PROTEACEA			
Banksia aspleniifolia Salisb	Rock Banksia	b	F
B. collina R.Br.		b	S
B. integrifolia L.f.	Coast Banksia	b	R
R. robur Cav	Large-leaved Banksia	b	R
B. serrata L.f.	Saw Banksai	b	A
B. serratifolia Salisb	Swamp Banksai	b	F
B. spinulosa Sm.	Hill Banksia	b	R
Conspermum ericifolium Sm.	Heath Conosperm	b	S
Grevillea sericea (Sm.) R.Br.	Pink Spider-flower	b	S
Hakea gibbosa Cav.	Peeling Hakea	b	S
H. sericea Schrad	Silky Hakea	b	F
H. teretifolia (Salisb)J. Britten	Dagger Hakea	b	F
Isopogon anemonifolius (Salisb)Knight	Drumsticks	b	C
Lambertia formosa Sm.	Mountain Devil	b	C
Lomatia silaifolia# (Sm.) R.Br.	Crinkle Bush	b	R
Petrophile sessilis Sieb.ex.Schult et.f.	Prickly Conesticks	b	F
Persoonia lanceolata Andr	Lance-leaf Geebung	b	S
P. levis (Cav.) Domin	Broad-leaved Geebung	b	C
P. pinifolia R.Br.	Pine-leaf Geebung	b	F
Symphionema paludosum R.Br.	Swamp Symphionema	b	S
Xylomelum pyriforme# (Gaertn.)Knight	Woody Pear	b	F
RESTIONACEAE			
Hypolaena fastigata R.Br.		b	S
Leptocarpus tenax (Labill.) R.Br.		c	S
Lepyrodia gracilis Benth.		c	S
Restio complanatus R.Br.		c	S
R. tetraphyllus Labill		c	R
spp. meiostachyus Johnson et Evans			

A9.3 (cont'd)

FAMILY/Scientific Name	Common Name	Distri-bution.	Abundance
RHAMNACEAE			
Alphitonia excelsa (Fenzl) Benth.		b	R
ROSACEAE			
*Rubus vulgaris** Weike et Nees	Blackberry	e	S
RUBIACEAE			
Pomax umbellata (Gaertn.) Soland ex A		b	S
RUTACEAE			
Boronia falcifolia# A.Cunn.	Sickle Boronia	b	S
B. parviflora Sm.	Swamp Boronia	b	S
Boronia pinnata# Sm.	Pinnate Boronia	b	S
Correa reflexa Labill.	Correa	b	R
C. alba Andr.	White Correa	b	R
Eriostemon australasius# Pers.	Pink Waxflower	b	F
Phebalium squameum (Labill.) Engl.	Satinwood	b	S
P. squamulosum Vent.	Scaly Phelabium	b	S
Philotheca salsolifolia Benth.		b	S
Zieria smithii Andr.	Sandfly Zieria	b	F
SANTALACEAE			
Choretrum candollei F.Muell ex Benth	White Sour-bush	b	S
Exocarpus cupressiformis Labill	Native Cherry	a,b	F
E. strictus R.Br.	Pale-fruit Ballart	b	S
SAPINDACEAE			
Dodonaea triquetra Wendl.	Large-leaf Hop-bush	b	F
SCROPHULARIACEAE			
Euphrasia speciosa R.Br.	Large Eyebright	b	S
SMILACACEAE			
Smilax glyciphylla Sm.	Sarsasparilla	a	R
SOLANACEAE			
Solanum stelligerum Sm.	Star Nightshade	b	S
STERCULIACEAE			
Rulingia pannosa R.Br.	Kerrawang	b	S
THYMELACEAE			
Pimelea linifolia Sm.	Rice Flower	b	C
TREMANDRACEAE			
Tetratheca ericifolia Sm.	Heath Pink-bell	b	S
T. thymifolia Sm.	Thyme Pink-bell	b	S
TYPHACEAE			
*Typha latifolia** L.	Great Reedmace	c	R
T. orientalis Pers.		c	R
UMBELLIFERAE			
Actinotus helianthi# D.C.	Flannel Flower	b	F
*Foeniculum vulgare** Mill.	Fennel	b	S
*Hydrocotyle bonariensis** Lan.		e	S
Platysace ericoides (Sieb.ex.Spreng.) C. Norman	Heath Platysace	b	S

A9.3 (cont'd)

FAMILY/Scientific Name	Common Name	Distri-bution	Abundance
P. lanceolata (Labill.) Druce	Shrubby Platysace	b	S
P. linearifolia (Cav.)C. Norman	Narrow-leaved Platysace	b	S
Trachymene sp.			S
Xanthosia pilosa Rudge			S
VERBENACEAE			
Avicennia marina (Forsk.) Vierh.	Grey Mangrove	d	A
Chloanthes stoechadis R.Br.		b	S
*Lantana camara** L.	Lantana	a,b,e	R
*Verbena bonariensis** L.	Purple Tops	e	R
VIOLACEAE			
Viola betonicifolia Sm.	Purple Violet	b	S
V. hederacea Labill	Ivy-leaf Violet	b	S
Hybanthus filiformis (DC.) F.Muell.		b	S
XANTHORRHOEACEAE			
Lomandra glauca (R.Br.) Ewart	Pale Mat-rush	b	F
L. longifolia Labill	Spiny-headed Mat-rush	a,b	F
L. micranthra (Endl.) Ewart	Small-flower Mat-rush	b	S
L. multiflora (R.Br.) J. Britt	Many-flowered Mat-rush	a,b	S
Xanthorrhoea minor R.Br.	Small Grass-tree	b	S
X. resinosa ssp.fulva Lee	Spear Grass-tree	b	R
XYRIDACEAE			
Xyris operculata Labill	Tall Yellow-eye	c	R
ZAMIACEAE			
Macrozamia communis L.A.S. Johnson		b	F

DISTRIBUTION

a: Rock Outcrop
b: Sandbeds
c: Swampland
d: Mangroves-Salt Marsh
e: Pastureland-Cleared Land

ABUNDANCE

A: Abundant
C: Common
F: Frequent
S: Seldom
R: Rare

* Exotic plants
\# Protected plants
** Population of adequate size but needs constant monitoring (Specht et al 1974).

ACKNOWLEDGEMENTS

Don McNair and Rutile and Zircon Mines (Newcastle) Limited are gratefully acknowledged for providing details of species in the Tomago Sandbeds. The National Herbarium is acknowledged for identifying a number of plants.

A9.4 HORTICULTURAL SPECIES LIST

SPECIES THAT HAVE BEEN PLANTED BY RESIDENTS
IN THE VICINITY OF PROPOSED SITE

FAMILY/Scientific Name	Common Name
AMARYLLIDACEAE	
Allium cepa	Onion
ANACARDIACEAE	
Schinus molle L.	Pepper Tree
APOCYNACEAE	
Nerium oleander	Oleander
Plumeria acutifolia	Frangipani
ARACEAE	
Philadendron spp.	Philadendron
BIGNONIACEAE	
Jacaranda mimosaefolia	Jacaranda
CANNACEAE	
Canna indica	Canna
CEASALPINIACEAE	
Bauhinia sp.	Bauhinia
COMPOSITAE	
Lactuca sativa	Lettuce
CRUCIFERAE	
Brassica oleracea	Cabbage
CUCURBITACEAE	
Cucurbita maxima	Pumpkin
CUNONIACEAE	
Ceratopetalum gummiferum	Christmas Bush
GRAMINEA (POACEAE)	
Zea sp.	Corn
HAMAMELIDACEAE	
Liquidamber styraciflua	Sweet Gum
IRIDACEAE	
Gladiolus sp.	Gladiolus
LAURACEAE	
Cinnamomum camphora	Camphor Laurel
LILIACEAE	
Yucca filamentosa	Yucca
LYTHRACEAE	
Lagerstroemia indica	Crepe Myrtle
PAPILIONACEAE (FABACEAE)	
Erythrina indica	Coral Tree
Lathyrus sp.	Sweet Pea

A9.4 (cont'd)

FAMILY/Scientific Name	Common Name
Phaseolus sp.	Bean
MAGNOLIACEAE	
Magnolia sp.	Magnolia
MORACEAE	
Ficus microcarpa	
F. sp.	
Morus nigra	Mulberry
MYRTACEAE	
Callistemon sp.	Bottlebrush
Melaleuca armillaris	
Syncarpia glomulifera	Turpentine
Tristania conferta	Brush Box
NYCTAGINACEAE	
Bougainvillea sp.	Bougainvillea
PASSIFLORACEAE	
Passiflora sp.	Passionfruit
PINACEAE	
Pinus elliottii	Slash Pine
P. radiata	Radiata Pine
PITTOSPORACEAE	
Pittosporum sp.	
POLYPODIACEAE	
Platycerium bifurcatum	Elk Horn
PROTEACEAE	
Grevillea banksii	Bank's Grevillea
G. robusta	Silky Oak
ROSACEAE	
Rosa spp.	Roses
SALICACEAE	
Populus nigra	Poplar
Salix babylonica	Weeping Willow
SOLANACEAE	
Lycoperscion esculentum	Tomato
THEACEAE	
Camellia spp.	
VITACEAE	
Vitis sp.	Grape

A9.5 VEGETATION ANALYSIS

A9.5.1 General

Three separate studies are being conducted to determine fluoride levels in vegetation.

Study 1 commenced in December 1979 and examines fluoride levels in the dominant plant species growing within 5 km of the site.

Study 2 commenced in January 1980 and examines levels of fluoride in one species, Spotted Gum *(Eucalyptus maculata)*, within a 40 km radius of the proposed site.

Study 3 commenced in July 1980 and examines levels of fluoride in some horticultural crops and garden flora growing near the proposed site.

Studies 1, 2 and 3 are continuous programmes which will provide accurate background fluoride levels in dominant native flora species, a common tree species *(Eucalyptus maculata)* and some major horticultural/garden flora, respectively.

A9.5.2 Procedures

Study 1

To date, two representatives of 14 different species have been sampled on four occasions (December 1979, February, March and April 1980) at the sites shown on *Figure 6.13*. Usually representative samples were taken from separate trees of each species and a list of sites and sampled species is given in *Table A9.1*.

Samples were collected from the tree canopy (greater than 10 m) and stored in plastic bags in an insulated container (to reduce sweating) for transportation to the laboratory.

Samples were washed in EDTA-alconox solution (except forage samples), oven dried at 80°C, ground to pass a 40 mesh sieve, extracted in nitric acid, buffered to pH of 5.5 and analysed using a fluoride specific ion electrode. An international vegetation sample was used to check the accuracy of the method.

Study 2

Spotted Gum *(Eucalyptus maculata)* is widespread throughout the Newcastle area and because of this is considered a highly suitable emission indicator for the aluminium industry in the Hunter Region. A total of 25 sampling sites were selected within a 40 km radius of Newcastle, as shown on *Figure 7.10* and were sampled on three occasions (January, March and May 1980).

Study 3

Common vegetables, citrus, and garden flora were collected from private gardens, on Tomago Road. The vegetables were immature plants fertilised with manure, while the citrus were primarily adult plants bearing fruit. A passionfruit vine was also sampled.

The garden flora included an ornamental fir tree, roses, and a hibiscus. Sample collection and analytical techniques were similar to *Study 1*.

A9.5.3 Results

Study 1

The results of the study are illustrated in *Table A9.1* and show that adsorbed fluoride levels vary from species to species.

The importance of sampling more than one tree of each species is illustrated by a specific example. Two Coast Banksias *(Banksia serrata)* were sampled at site 9 during December 1979. One individual, which was relatively healthy, had lower fluoride levels (20 ppm) than the other which was visibly diseased (48 ppm). Misleading and biased results would

Sit
1
2
3
4
4
5
6
7
8
8
8
9
9
9
10
11
12
12
13
13
14
15
16
17
18
19
20
21
22

Com

would have been obtained if only one representative sample was collected.

Table A9.2 lists the average background fluoride levels, for the period December 1979 to June 1980, in the dominant species occurring on and near the proposed site. The background fluoride levels generally lie within the acceptable range, 2 to 20 ppm F, adopted by *Weinstein (1977)* as being background.

TABLE A9.2

AVERAGE FLUORIDE LEVEL IN EACH OF THE DIFFERENT SPECIES

Sampling period: December 1979 to June 1980

Species	Number	Mean Fluoride Level (ppm) ± S.E.
Pinus radiata	6	12.1 ± 3.6
Cynodon dactylon *	29	10.5 ± 1.5
Pennisetum clandestinum *	8	17.2 ± 3.2
Eucalyptus tereticornis	16	11.7 ± 1.3
E. maculata	8	11.7 ± 3.7
E. gummifera	16	7.9 ± 1.9
E. pilularis	16	19.3 ± 2.7
E. robusta	16	22.0 ± 4.4
E. haemastoma	16	12.0 ± 2.2
Angophora costata	16	12.7 ± 1.9
Banksia serrata	16	19.1 ± 4.3
Melaleuca quinquinervia	15	12.0 ± 2.2
Avicennia marina	24	15.2 ± 2.5
Juncus maritimus	21	10.7 ± 1.9

Comments: $S.E. = \text{standard error} = \frac{\text{standard deviation}}{\sqrt{\text{number}}}$

* leaves not washed.

Study 2

Table A9.3 details the fluoride levels occurring in Spotted Gum *(Eucalyptus maculata)* within a 40 km radius of Newcastle. The results show that generally fluoride levels decrease with distance from source. However, the overall mean fluoride level at each site, except site 22, lies well within the acceptable range indicated by *Weinstein (1977)* as 2 to 20 ppm.

TABLE A9.3

STUDY 2: FLUORIDE LEVELS IN SPOTTED GUM (*Eucalyptus maculata*)

SITE	A FLUORIDE(ppm)		B FLUORIDE(ppm)		C FLUORIDE(ppm)		MEAN±SE
	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	
1	8.0	6.9	1.9	1.9	3.9	2.9	4.2 ±1.1
2	3.0	7.9	6.3	0.0	1.9	2.3	3.6 ±1.2
3	8.0	8.0	0.0	1.9	1.9	0.0	3.3 ±1.5
4	8.0	9.9	1.9	5.4	2.4	2.9	5.1 ±1.3
5	7.9	7.9	13.5	4.7	1.9	7.8	7.3 ±1.6
6	7.8	9.8	4.7	0.0	2.0	5.1	4.9 ±1.5
7	35.7	13.9	12.3	12.3	10.2	3.8	14.7 ±4.4
8	2.0	7.8	8.8	1.9	4.9	9.9	5.9 ±1.4
9	19.9	7.8	3.9	8.5	13.6	14.7	11.4 ±2.3
10	8.0	3.9	9.7	11.9	7.9	10.0	8.6 ±0.9
11	35.9	14.0	19.3	3.4	8.8	3.6	14.2 ±5.0
12	35.5	24.0	19.3	19.8	11.6	19.9	21.7 ±3.2
13	11.8	13.7	11.5	19.5	5.8	8.8	11.8 ±1.9
14	19.9	19.8	7.8	15.8	13.7	10.3	14.5 ±2.0
15	11.8	19.9	7.8	3.9	3.6	9.9	9.5 ±2.5
16	7.8	7.9	3.9	7.8	2.4	0.0	5.0 ±1.4
17	19.0	2.0	4.9	0.0	1.9	2.9	5.2 ±2.8
18	7.9	2.0	0.0	1.9	3.5	-	3.1 ±1.3
19	19.8	19.9	13.1	7.7	1.9	3.9	11.0 ±3.2
20	10.8	29.9	19.3	11.6	8.4	-	16.0 ±3.9
21	24.5	16.1	19.3	3.9	15.8	12.8	15.4 ±2.8
22	27.8	19.8	39.2	11.6	31.7	26.9	26.2 ±3.9
23	29.4	19.9	11.8	4.9	7.9	7.9	13.6 ±3.8
24	11.9	23.8	5.9	9.9	8.6	-	12.0 ±3.1
25	19.9	17.9	10.5	21.6	3.9	3.9	12.9 ±3.2

COMMENTS: A sampled January 1980
B " March 1980
C " May 1980

Site 22 is located near a very large industrial laboratory complex which may be a source of fluoride and would explain the higher fluoride level of 26.2 ppm.

Based on *Weinstein's* acceptable fluoride level in vegetation, the concentration of heavy industry in Newcastle, including the B.H.P. steelworks, and fertiliser plants on Kooragang Island, and the Alcan aluminium smelter at Kurri Kurri would appear to have had little effect on the levels of fluoride in Spotted Gum on an overall regional scale. However, results to date are preliminary and a longer time period would be required to assess seasonal variations.

Study 3

Table A9.4 details the fluoride levels occurring in domestic garden plants growing in private gardens on Tomago Road. A more detailed survey will be conducted during summer when the plants are actively growing and the vegetables mature.

Small commercial stone-fruit, apple and citrus orchards are located at Medowie some 15 km northeast of the site. When the stone-fruit trees come into leaf, samples will be collected and analysed for foliar fluoride.

TABLE A9.4

DOMESTIC GARDEN FLORA FLUORIDE LEVELS (ppm)

Sample	Location	Fluoride
Corn	Site 3	78.1
Spinach	Site 3	19.8
Peas	Site 3	19.7
Brocolli	Site 3	34.0
Rhubarb	Site 3	19.8
Lemon Tree	Site 3	39.6
Orange Tree	Site 3	19.5
Ornamental Pine	Site 2	39.2
Rose Bush	Site 2	16.8
Hibiscus Tree	Site 2	49.6
Passionfruit Vine	Site 1	19.8
Orange Tree	Site 1	19.8
Grapefruit	Site 1	19.7

Comments: Site 1 - House No.16, *Figure 6.18*
Site 2 - House No.22, *Figure 6.18*
Site 3 - House No.23, *Figure 6.18*
Only leaves sampled and analysed for fluoride.

A9.5.4 Statistical Accuracy

The Company intends to continue the above monitoring programme in a modified form (see *Section 8.13)* thus the statistical accuracy will improve as the number of sampling periods increase.

A9.5.5 State Pollution Control Commission's Survey

The State Pollution Control Commission (S.P.C.C.) conducted a number of fluoride in vegetation surveys between 1973 and 1978. *Table A9.5* presents a summary of the results.

TABLE A9.5

FOLIAR FLUORIDE CONCENTRATIONS
AT SITES IN NEWCASTLE
(ppm)

Site	Description	Species	Mean ± S.E.
1	41 Fullerton Street, Stockton	oleander	49 ± 6
2	Forfar Street, Stockton	oleander	76 ± 11
3	288 Fullerton Street, Stockton	oleander	171 ± 23
4	Fort Wallace, Stockton	eucalyptus	45 ± 7
5	Rankin Street, Stockton	oleander	59 ± 7
6	Golf Club, Stockton	eucalyptus	43 ± 4
7	Fern Bay	eucalyptus	32 ± 4
8	Kooragang Island	mangrove	240 ± 89
9	Kooragang Island	mangrove	749 ± 166
10	Industrial Highway, Mayfield	brushbox	128 ± 15
11	Public School, Mayfield	brushbox	173 ± 12
12	King Street, Stockton	-	24 ± 5

Comments: Sample period 1973 to 1978
Collected and analysed by the *State Pollution Control Commission*

The fluoride level at all sites greatly exceeds *Weinstein's (1977)* acceptable background level of between 2 and 20 ppm, however all the sites are located in areas that have high atmospheric fluoride levels.

The atmospheric fluoride sources are:

B.H.P. Steelworks
Fertiliser Works
Fluoride Chemical Plant
Sea spray.

The State Pollution Control Commission's studies indicate that there are localised areas within Newcastle that have very high atmospheric fluoride levels, whereas the present studies close to the site show that on an overall regional scale, the fluoride in vegetation levels lie within the acceptable background range of between 2.0 ppm and 20.0 ppm *(Weinstein, 1977)*.

A9.6 POTENTIAL EFFECTS OF EMISSIONS ON NATIVE VEGETATION

A9.6.1 Effect of Emissions on Vegetation

Particulate and gaseous fluorides are of differing significance to plants. Particulates rest on the leaf surface rather than penetrate into the leaf, whereas gaseous fluorides move into the plant tissue via the stomates. It is generally considered that fluorides remain in the leaf, but some studies have produced evidence of the translocation of fluorides to other plant organs such as stems and roots *(Weinstein 1977, Keller 1974)*.

Vegetation growing in areas free of industrial fluoride generally contain between 2 ppm and 20 ppm fluoride, but excess fluorides within plants can produce visible foliar injury *(Weinstein, 1977)*. Generally, foliar injury develops at fluoride concentrations well above those at which metabolic processes are influenced. The yellowing of tips and leaf margins called chlorosis is usually followed by death (necrosis) of the leaf. Similar symptoms can also be caused by other emissions such as sulphur dioxide, ozone, chloride, diseases and metal deficiencies *(Weinstein, 1977)*.

The metabolic changes associated with visible symptoms in the plant are complex. For this reason, symptom expression is not always strictly related to fluoride dosage. However, for most species, foliar fluoride levels of 200 µg.F/g and higher result in visible damage to the plant *(Thompson et al, 1979).* At these levels cellular damage occurs such as:

i. collapse of spongy mesophyll and lower epidermis, followed by -

ii. distortion and chloroplast destruction in the pallisade cells, and finally

iii. the upper epidermis distorts and collapses *(Solberg and Adams 1956).*

At lower foliar levels, metabolic damage can occur. These changes are generally very complex and interactions can occur depending on foliar concentration, species sensitivity and other factors. The documented metabolic effects are summarised below:-

i. Reductions in photosynthesis caused by inhibition of the early stages of chlorophyll formation *(McNulty and Newman, 1957).*

ii. Increases in plant respiration by activation of enzymes associated with cellular injury such as peroxidase, cytochrome oxidase and glucose-6-phosphate dehydrogenose *(Lee et al, 1966).*

iii. Changes in the respiratory pathway from glycolysis towards the pentose phosphate pathway *(Ross et al, 1962).*

iv. Reductions in protein synthesis, especially ribosomal RNA *(Chang, 1975).*

v. Inhibition of plant hormones, especially auxin, which leads to inhibition of cell elongation (and hence leaf buckling) and inhibition of apical dominance (and hence branching, or 'staghorn' effects) *(Doley, 1975).*

vi. Reductions in mineral nutrients available for plant growth by precipitation of fluoride with minerals such as magnesium, calcium and manganese *(Garrec et al, 1978).*

Fluorides can produce stress in plants. Accumulating in the leaves the fluoride may weaken a plant, making it more susceptible to natural stresses such as fire, insect attack and drought.

Mutagenic Effects of Fluorides

Few studies have been conducted on the mutagenic effects of fluorides on plants or animals and there is some controversy over the findings of these studies. Generally those investigations that have reported positive mutagenic effects from fluorides have been criticised on such grounds as the use of unrealistic fluoride exposure levels, inconsistency of results or inadequate control methods.

The most publicised study linking fluoride and cancer in humans is that of *Yiamouyiannis and Burk (1977).* However, the *National Health and Medical Research Council (1979)* consider that if fluoride and cancer is as closely linked in time as hypothesised by Yiamovyiannis and Burk, Australian cities should have shown trends of increasing cancer mortality and cancer registrations within a few years of fluoridation of water supplies. To date, there is no evidence of such a trend.

Studies carried out by the U.S. National Institute of Dental Research/L. Hon Bionetics inc. *(Martin et al, 1979)* on mice indicate a lack of mutagenic effects of fluoride over five generations of mice. These studies are considered to be the only adequate studies of sodium fluoride using short term test systems validated for assessment of carcinogenuity. The findings contradict such studies as those by *Mohamed and Chandler (1977)* which showed a two to three fold increase in bone marrow and testicular cell chromosome abnormalities in mice fed on a low fluoride diet and distilled water or 1-200 ppm fluoride water.

Overall, it is suggested by the Council that evidence for mutagenic/carcinogenic properties of fluorides is questionable and not proven, while a few reliable studies indicate no significant mutagenic/carcinogenic properties.

A9.6.2 Factors Determining the Uptake of Fluoride by Vegetation

Each plant species has its own tolerance to fluorides. Some species such as cotton are able to tolerate high foliar fluoride levels without serious physiological disabilities. However, sensitive species such as gladiolus absorb only small amounts before showing visible symptoms of fluoride damage *(Jacobson et al, 1966)*.

Weinstein (1977) found that the threshold of foliar fluorides for susceptible species was less than 150 ppm, and for many, was less than 100 ppm. Plants that are intermediate to resistant in terms of fluoride tolerance can probably tolerate over 200 ppm fluorides.

Guderian (1977) proposed the following formula to relate fluoride accumulation in plants to atmospheric fluorides:

$F = K \times C \times T$ where F = increase in fluoride content above the normal level
C = concentration of gaseous fluorides in the atmosphere
T = exposure time
K = represents internal and external factors that influence fluoride uptake.

The internal and external factors (K) that influence the uptake of emissions by vegetation are highly variable. *McLaughlin and Barnes (1975)* list these as intensity, duration and frequency of fluoride exposure, environmental conditions and physiological condition of the vegetation at the time of exposure. *Weinstein (1977)* reports that light intensity, temperature and water stess have also been found to control the effect of fluorides on plants. However, it is apparent that the major factor determining fluoride uptake is the tolerance to fluorides of each particular plant species. This is the overriding factor in assessing the possible impacts of fluoride concentrations on vegetation around a smelter.

Guderian (1977) states that an average of 0.85 $\mu g/m^3$ of hydrogen fluoride in the air results in up to 85 ppm fluoride in dry matter, whilst in certain European grass and clover species 1.1 $\mu g/m^3$ of hydrogen fluoride results in foliar fluoride accumulation of 330 ppm. *Hodge and Smith (1977)* state that factory emissions of 1 ppb fluoride (which approximately equals 1 $\mu g.F/m^3$) results in 30 ppm in foliage downwind. These figures cannot be readily related to the proposed development because of the different plant species, climate and topography found in the European examples.

Appendix 10

FAUNA

APPENDIX 10

FAUNA

A10.1 FIELD STUDIES

Both day and night observations of animals, or signs of animal activity on the site were recorded during November and December 1979. Small mammal trapping was carried out at the sites shown in *Figure 6.13* under licence from the New South Wales National Parks and Wildlife Service. Trap-nights totalled 360.

A10.2 TRAPPING METHODOLOGY

The small mammal trapping was carried out over a 10 day period in December 1979. A total of 60 Elliot traps were used of which 50 were 33x9x10 cm and 10, 46x15.5x15 cm. Placement of traps was in a roughly linear or rectangular pattern with individual traps located subjectively in areas thought likely to be frequented by small fauna species, e.g., near hollow logs, across small tracks through undergrowth.

Traps were set each evening with a peanut butter, rolled oats, honey and vanilla mixture and checked each morning. Five habitats were sampled in this manner.

Seasonal variations

The sampling programme for fauna species gives a guide to a large proportion of species on the site but is not completely representative of fauna populations since trapping was confined to the summer months. Trapping during different seasons would be expected to reveal the presence of additional species of small mammals and a more accurate representation of the abundance of individual species would be gained. Autumn is considered a favourable period for trapping and some species such as *Antechinus stuartii* reach their peak population levels at this time *(Wood, 1970)*. The use of pit traps may also indicate the presence of some small fauna species.

A10.3 FAUNA SPECIES LIST

MAMMALS OBSERVED OR KNOWN TO OCCUR ON THE PROPOSED SITE

Scientific Name	Common Name	Abundance
Native:		
Sminthopsis murina	Common Dunnart	F
Pseudocheirus peregrinus	Ringtail Possum	C
Phascolarctos cinereus	Koala	F
Macropus giganteus	Grey Kangaroo	S
M. rufogriseus	Red-necked Scrub Wallaby	A
Wallabia bicolor	Swamp Wallaby	S
Pseudomys novaehollandiae	New Holland Mouse	C
Rattus lutreolus	Swamp Rat	S
Pteropus poliocephalus	Grey-headed Fruit Bat	C
	Unidentified Bat	-
Introduced:		
Oryctolagus cuniculus	Rabbit	R
Lepus europaens	Hare	A
Rattus rattus	Black Rat	F
Mus musculus	House Mouse	F
Canis familiaris	Dog	S
Vulpes vulpes	Red Fox	F
Felis catus	Cat	F
Sus scrofa	Pig	R

REPTILES OBSERVED ON THE PROPOSED SITE

Amphibolurus barbatus	Bearded Dragon	C
Varanus varius	Lace Monitor	F
Ctenotus taeniolatus	Copper-tailed Skink	C
Sphenomorphus quoyii	Eastern Water Skink	F
Lamphropholis guichenoti	Garden Skink	C
Pseudechis porphyriacus	Red-bellied Black Snake	A

AMPHIBIANS OBSERVED ON THE PROPOSED SITE

Litoria fallax	Dwarf Tree Frog	A

Key: A - abundant
C - common
F - frequent
R - rare
S - seldom

A10.3 FAUNA SPECIES LIST (cont'd)

MAMMALS EXPECTED TO OCCUR ON THE PROPOSED SITE

Scientific Name	Common Name
Tachyglossus aculeatus	Echidna
Antechinus stuartii	Broad-footed Marsupial Mouse
Dasyurus maculatus	Tiger Cat
Perameles nasuta	Long-nosed Bandicoot
Isoodon macrourus	Short-nosed Bandicoot
Petaurus breviceps	Sugar Glider
Trichosurus vulpecula	Brush-tailed Possum
T. caninus	Mountain Possum
Schoinobates volans	Greater Glider
Rattus fuscipes	Southern Bush Rat

Note: The above list was compiled from a species list of mammals occurring in the Myall Lakes area prepared by the New South Wales National Parks and Wildlife Service. The mammals listed would be found in the Tomago Sandbeds area.

REPTILES EXPECTED TO OCCUR ON THE PROPOSED SITE

Chelodina longicollis	Long-necked Tortoise
Diplodactylus vittatus	Wood Gecko
Underwoodisaurus milii	Thick-tailed Gecko
Lialis burtonis	Burton's Legless Lizard
Pygopus lepidopodus	Common Scaly-foot
Amphibolurus muricatus	Jacky Lizard
Carlia vivax	
Cryptoblepharus boutonii	Fence Skink
Ctenotus robustus	
Egernia whitii	White's Skink
Leilopisma delicata	
L. platynota	Red-throated Skink
Sphenomorphus tenuis	
Tiliqua scincoides	Eastern Blue-tongued Lizard
Morelia spilotes	Carpet Python
Boiga irregularis	Brown Tree Snake
Dendrelaphis punctulatus	Common Tree Snake
Acanthophis antarcticus	Common Death Adder
Cryptophis nigrescens	Eastern Small-eyed Snake
Demansia psammophis	Yellow-faced Whip Snake
Furina diadema	Red-naped Snake
Hemiaspic signata	Black-bellied Swamp Snake
Pseudonaja textilis	Eastern Brown Snake
Vermicella annulata	Bandy Bandy

Note: Derived from *Cogger (1975)*

A10.3 FAUNA SPECIES LIST (cont'd)

AMPHIBIANS EXPECTED TO OCCUR ON THE PROPOSED SITE

Scientific Name	Common Name
Crinia signifera	Common Eastern Froglet
Lymnodynastes peronii	Brown-striped Frog
L. tasmaniensis	Spotted Grass Frog
Pseudophryne bibronii	Brown Toadlet
Litorea aurea	Green and Golden Bell Frog
L. caerulea	Green Tree Frog
L. citropa	Blue Mountain's Tree Frog
L. dentata	Bleating Tree Frog
L. freycineti	Freycinet's Frog
L. latopalmata	
L. lesueurii	Lesueur's Frog
L. nasuta	Rocket Frog
L. peronii	Peron's Tree Frog
L. verreauxii	

Note: Derived from *Cogger (1975)*

A10.4 BIRD SPECIES LIST

BIRDS OCCURRING ON AND IN THE VICINITY OF THE SITE AND WITHIN THE AREA shown on *Figure 6.13*

Scientific Name	Common Name	Probable Location
Pelecanus conspicillatus	Australian Pelican	Hunter River
Phalacrocorax sulcirostris	Little Black Cormorant	Hunter River
P. melanoleucos	Little Pied Cormorant	Hunter River and waterhole
Tachybaptus novaehollandiae	Little Grebe	Dredge Pond
Ardea novaehollandiae	White-faced Heron	Salt and fresh water swamps
Butorides striatus	Mangrove Heron	Mangroves
Ardeola ibis	Cattle Egret	Pastureland
Egretta alba	Large Egret	Banks of Hunter River
E. garzetta	Little Egret	Swamp
Threskiornis molucca	White Ibis	Swamp and pastureland
Plegadis falcinellus	Glossy Ibis	Swamp beside Hunter River
Anas superciliosa	Black Duck	Waterhole
A. castanea	Chestnut Teal	Waterhole
Elanus notatus	Black-shouldered Kite	Over pastureland
Haliastur sphenurus	Whistling Kite	Over most areas
Aquila audax	Wedge-tailed Eagle	Over whole area
Haliaeetus leucogaster	White-breasted Sea-Eagle	Over whole area
Porphyrio porphyrio	Swamphen	Swamps
Vanellus miles	Spur-winged Plover	Swamps - pastureland
Gallinago hardwickii	Japanese Snipe	Salt marsh beside Hunter River
Larus novaehollandiae	Silver Gull	Hunter River
Sterna bergii	Crested Tern	Hunter River
Columba livia	Domestic Pigeon*	Courtauld's Factory
Geopelia striata	Peaceful Dove	Tomago Sandbeds
Phaps chalcoptera	Common Bronzewing	Tomago Sandbeds
Ocyphaps lophotes	Crested Pigeon	Pastureland
Cacatua roseicapilla	Galah	Pastureland
Platycercus eximius	Eastern Rosella	Pastureland
Cacomentis pyrrhophanus	Fan-tailed Cuckoo	Tomago Sandbeds
Eudynamys scolopacea	Indian Koel	Tomago Sandbeds
Centropus phasianinus	Pheasant Coucal	Tomago Sandbeds near swamp
Hirundapus caudacutus	Spine-tailed Swift	Over pastureland
Ceyx azureus	Azure Kingfisher	Beside Hunter River
Dacelo novaeguineae	Kookaburra	Tomago Sandbeds and pastureland
Halcyon sancta	Sacred Kingfisher	Tomago Sandbeds
Eurystomus orientalis	Dollarbird	Tomago Sandbeds
Hirundo neoxena	Welcome Swallow	Open areas throughout
Cecropis ariel	Fairy Martin	Flocks overhead
Anthus novaeseelandiae	Richard's Pipit	Pastureland and saltmarsh

A10.4 BIRD SPECIES LIST (cont'd)

Scientific Name	Common Name	Probable Location
Cisticola exilis	Golden-headed Cisticola	Swamp
Acrocephalus stentoreus	Clamorous Reed-warbler	Swamp
Malurus cyaneus	Superb Blue Wren	Tomago Sandbeds
M. lamberti	Variegated Wren	Tomago Sandbeds
Acanthiza nana	Yellow Thornbill	Tomago Sandbeds
A. chrysorrhoa	Yellow-rumped Thornbill	Tomago Sandbeds
Sericornis frontalis	White-browed Scrub-wren	Tomago Sandbeds
Eopsaltria australis	Eastern Yellow Robin	Tomago Sandbeds
Rhipidura fuliginosa	Grey Fantail	Tomago Sandbeds
R. rufifrons	Rufous Fantail	Tomago Sandbeds
R. leucophrys	Willie Wagtail	
Myiagra rubecula	Leaden Flycatcher	Tomago Sandbeds
Pachycephala rufiventris	Rufous Whistler	Tomago Sandbeds
Colluricincla harmonica	Grey Shrike-thrush	Tomago Sandbeds
Psophodes olivaceus	Eastern Whipbird	Tomago Sandbeds
Climacteris leucophaea	White-throated Tree-creeper	Tomago Sandbeds
Dicaeum hirundinaceum	Misteltoe Bird	Tomago Sandbeds
Zosterops lateralis	Silvereye	Tomago Sandbeds
Myzomela sanguinolenta	Scarlet Honeyeater	Tomago Sandbeds
Lichenostomus chrysops	Yellow-faced Honey-eater	Tomago Sandbeds
Phylidonyris nigra	White-cheeked Honey-eater	Tomago Sandbeds
Acanthorhynchus tenuirostris	Eastern Spinebill	Tomago Sandbeds
Manorina melanocephala	Noisy Miner	Tomago Sandbeds
Anthochaera chrysoptera	Little Wattlebird	Tomago Sandbeds
Aegintha temporalis	Red-browed Firetail	Tomago Sandbeds
Passer domesticus	House Sparrow*	Open areas
Sturnis vulgaris	Common Starling*	Open areas, roads
Acidotheres tristis	Common Myna*	On Pacific Highway
Oriolus sagittatus	Olive-backed Oriole	Tomago Sandbeds
Dicrurus hottentottus	Spangled Drongo	Tomago Sandbeds
Grallina cyanoleuca	Australian Magpie Lark	Common Pastureland
Artamus cyanopterus	Dusky Woodswallow	Tomago Sandbeds
Cracticus nigrogularis	Pied Butcher-bird	Tomago Sandbeds
Gymnorhina tibicen	Australian Magpie	Pastureland
Corvus coronoides	Australian Raven	Throughout

Note: * indicates introduced species

A10.4 BIRD SPECIES LIST (cont'd)

BIRDS EXPECTED TO OCCUR IN THE SUBREGION
shown on *Figure 6.14*

Scientific Name	Common Name	Probable Location
Anhinga melanogaster	Darter	Hunter River
Phalacrocorax varius	Pied Cormorant	Hunter River
P. carbo	Black Cormorant	Hunter River
Ardea novaehollandiae	White-necked Heron	Swampland
Botaurus poiciloptilus	Brown Bittern	Reed swamps along Hunter River
Anas gibberifrons	Grey Teal	Fresh and salt water
Circus aeruginosus	Swamp Harrier	Wetlands
Falco berigora	Brown Falcon	Tomago Sandbeds and open areas
Coturnix australis	Brown Quail	Grassland, wetland margins
Gallinula tenebrosa	Dusky Moorhen	Freshwater
Himantopus himantopus	Pied Stilt	Freshwater, brackish wetlands
Numenius madagascariensis	Eastern Curlew	Mud banks of Hunter River
N. phaeopus	Whimbrel	Mud banks
Gelochelidon nilotica	Gull-billed Tern	Hunter River
Hydroprogne caspia	Caspian Tern	Hunter River
Sterna bergii	Crested Tern	Hunter River
Calyptorhynchus magnificus	Red-tailed Black Cockatoo	Tomago Sandbeds
Glossopsitta pusilla	Little Lorikeet	Tomago Sandbeds
Cuculus pallidus	Pallid Cuckoo	Tomago Sandbeds and open areas
Ninox novaeseelandiae	Boobook Owl	Tomago Sandbeds
Podargus ocellatus	Tawny Frogmouth	Tomago Sandbeds
Acrocephalus stentoreus	Reed Warbler	Reeds, fresh water-brackish swamps
Stipiturus ruficeps	Southern Emu-wren	Reeds, fresh water-brackish swamps
Daphoenositta chrysopter	Varied Sitella	Tomago Sandbeds
Anthochaera corunculata	Red Wattlebird	Tomago Sandbeds
Philemon corniculatus	Noisy Friarbird	Tomago Sandbeds
Sericornis pyrrhopygia	Chestnut-rumped Hylacola	Tomago Sandbeds
Gerygone levigaster	Mangrove Warbler	Mangroves
Philidonyris novaehollandiae	New Holland Honey-eater	Tomago Sandbeds
Ephthianura albifrons	White-fronted Chat	Salt marsh, Mangroves

Note: The above list is based on observations in the Myall Lakes National Park and *A. Morris' (1975)* County of Northumberland species list.

A10.5 FISH AND CRUSTACEA RECORDED IN THE HUNTER RIVER

FISH

Family/Scientific Name	Common Name
DASYATIDAE	
Dasyastis fluviorum	Estuary stingray
UROLOPHIDAE	
Urolophus testaceus	Common stingray
ELOPIDAE	
Elops australis	Giant Herring
ANGUILLIDAE	
Anguilla australis	Short finned eel
A. reinhardtii	Long finned eel
MURAENESCOCIDAE	
Muraenesox cinereus	Pike eel
CLUPEIDAE	
Potamalosa richmondia	Freshwater herring
Sardinops neopilchardus	Pilchard
ENGRAULIDAE	
Engraulis australis	Anchovy
RETROPINNIDAE	
Retropinna semoni	Smelt
PLOTOSIDAE	
Euristhmus lepturus	Longtailed catfish
ANTENNARIIDAE	
Antennarius striatus	Striped angler fish
HEMIRHAMPHIDAE	
Hyorhamphus ardelio	River garfish
POECILIDAE	
Gambusia affinis	Mosquito fish
MONOCENTRIDAE	
Cleidopus gloriamaris	Knight fish
SCORPAENIDAE	
Centropogon australis	Fortesque
Notesthes robusta	Bullrout
TRIGLIDAE	
Cheilodinichthys kumu	Red gurnard
PLATYCEPHALIDAE	
Platycephalus bassensis	Sand flathead
Platycephalus fuscus	Dusky flathead
CENTROPOMIDAE	
Priopidichthys marianus	Ramsay's perchlet
Velambassis jacksoniensis	Port Jackson perchlet

A10.5 FISH AND CRUSTACEA RECORDED IN THE HUNTER VALLEY (cont'd)

Family/Scientific Name	Common Name
SERRANIDAE	
Percalates novemaculeatus	Bass
P. colonorum	Estuary perch
THERAPONIDAE	
Therapon servus	Grunter
PRIACANTHIDAE	
Priacanthus macracanthus	Red bullseye
SILLAGINIDAE	
Sillago bassensis	School whiting
S. ciliata	Sand whiting
S. maculata	Trumpeter whiting
POMATOMIDAE	
Pomatomus saltatrix	Tailor
CARANGIDAE	
Caranx sansun	Papuan trevally
Usacaranx georgianus	Skipjack trevally
Trachurus mccullochi	Yellowtail
LUTJANIDAE	
Lutjanus argentimaculatus	Mangrove jack
GERRIDAE	
Gerres ovatus	Silver biddy
SPARIDAE	
Acanthopagrus australis	Yellowfin bream
SCIAENIDAE	
Sciaena antarctica	Jewfish (mulloway)
MONODACTYLIDAE	
Monodactylus argenteus	Silver batfish
KYPHOSIDAE	
Girella tricuspidata	Blackfish (luderick)
SCATOPHAGIDAE	
Selenotoca multifasciata	Butterfish
Scatophagus argus	Tiger scat
ENOPLOSIDAE	
Enoplosus armatus	Old wife
MUGILIDAE	
Liza argentea	Flat tailed mullet
Mugil cephalus	Sea mullet
Myxus elongatus	Sand mullet
SPHYRAENIDAE	
Sphyraena novaehollandiae	Short finned sea pike
POLYNEMIDAE	
Polydactylus specularis	Lesser tassel fish

A10.5 FISH AND CRUSTACEA RECORDED IN THE HUNTER VALLEY (cont'd)

Family/Scientific Name	Common Name
GOBIDAE	
Arenigobius bifrenatus	Bridled goby
Bathygobius krefftii	Goby
Favonigobius lateralis	Sand goby
Leme purpurascens	Eel goby
Redigobius macrostomus	Compressed goby
Paraphya semivestita	Glass goby
ELEOTRIDAE	
Mogurnda australis	Striped gudgeon
Philypnodon grandiceps	Flatheaded gudgeon
BOTHIDAE	
Pseudorhombus jenynsii	Small-toothed flounder
SOLEIDAE	
Aseraggodes macleayanus	Narrow banded sole
CYNOGLOSSIDAE	
Paraplagusia unicolour	Lemon tongue sole
MONACANTHIDAE	
Monacanthus macrolepsis	Fan-bellied leatherjacket
TETRAODONTIDAE	
Torquigener hamiltoni	Common toadfish
DIODONTIDAE	
Dicotylichthys myersi	Porcupine fish
CRUSTACEA	
SQUILLIDAE	
Squilla laevis	Mantis shrimp
MYSIDAE	
?	Possum shrimp
PENAEIDAE	
Penaeus plebejus	King prawn
P. monodon	Giant tiger prawn
P. merguiensis	Banana prawn
P. esculentes	Brown tiger prawn
Metapenaeus macleayi	School prawn
M. bennettae	Inshore greasyback prawn
M. ensis	Offshore greasyback prawn
SERGESTIDAE	
Acetes australis	White shrimp
PALAEMONIDAE	
Macrobrachium novae-hollandiae	Long arm prawn
Macrobrachium sp.	
Palaemon sp.	
P. serenus	

A10.5 FISH AND CRUSTACEA RECORDED IN THE HUNTER VALLEY (cont'd)

Family/Scientific Name	Common Name
ATYIDAE	
Paratya sp.	
ALPHEIDAE	
Alpheus edwardsii	
HIPPOLYTIDAE	
?	
PORTUNIDAE	
Ovalipes australiensis	Beach crab
Portunus pelagicus	Blue swimmer crab
P. sanguinolentus	Blood spotted crab
Scylla serrata	Mud crab
Charybdis feriatus	Scarlet crab
OCYPODIDAE	
Macrophthalmus latifrons	
HYMENOSOMATIDAE	
Halicarcinus australis	
GRAPSIDAE	
Paragrapsus laevis	
THALASSINIDAE	
Laomedea healyi	
LEUCOSIIDAE	
Philyra undecimspinosa	Pebble crab

Note: from *Ruello (1976)*

A10.6 FAUNA ANALYSES

A10.6.1 Procedure

A total of 27 fauna samples were collected on, or near, the proposed site.

A pig jaw and cow bones were supplied by a farmer from local stock, an eel, fish and prawns caught in the Hunter River, and a rat was trapped. Other animals were found dead in the area, and included two Koalas *(Phascolarctos cinereus)*. The liver, kidney, muscle, stomach content, and a bone sample from the foreleg of the Koalas were analysed for fluoride. As Koalas are prevalent in the area, additional Koala samples were obtained from Taronga Park Zoo (Sydney) and Blackbutt Reserve (Newcastle) to determine accurately typical background fluoride levels in Koalas.

The bone samples were ashed and extracted in perchloric acid, buffered, and analysed using a fluoride specific ion electrode (method based on *Stewart et al, 1974).*

Fresh tissue was analysed by fusing the ground dried tissue with alkali, dissolved in water, buffered to pH 5.5, and analysed using a fluoride ion specific electrode (method based on *Wright and Davison, 1975).*

A literature survey was carried out to determine typical fluoride levels in animals collected from a fluoride free environment.

A10.6.2 Results

Table A10.1 details the results of the literature survey; *Table A10.2* fluoride content in animal bones, and *Table A10.3* fluoride levels in Koalas.

TABLE A10.1

LITERATURE SURVEY
OF FLUORIDE LEVELS IN ANIMALS

Sample	µgF/g	Reference
Rat	473 - 635	*Singer and Armstrong (1968)*
Cow jaw	1207	*Stewart et al (1974)*
Hawk	1445	*Stewart et al (1974)*
Crab Shell	42 - 356	*Stewart et al (1974)*
Eel	2885	

TABLE A10.2

FLUORIDE IN FAUNA

Species	Location	Date	F in Bone (μgF/g ashed bone)			F in Fresh Tissue (μgF/g dried tissue)			Comments
Cow	Pat Healey's Farm Tomago	January 1980	Jaw	1413±181	(2)				Mature aged dairy cow
			Teeth	1151±139	(2)				
			Anterior vertebrae	1582± 82	(2)				
			Middle vertebrae	1737± 85	(2)				
			Posterior vertebrae	1552±117	(2)				
			Rib bones	1699± 80	(2)				
			Pelvic bone	1831± 6	(2)				
Pig	Farm, Tomago	January 1980	Jaw bone	417± 22	(2)				Pig taken to butchers
			Teeth bones	263					
Chicken	Farm, Tomago	January 1980	Mixed bones	674± 35	(2)				1 week old chicken
Prawns	Hunter River	March 1980	Whole shells	256					
Oysters	Lemon Tree Passage	March 1980	Whole shells	136	(1)	Whole animals	102	(1)	4 years old, mature
	Lemon Tree Passage	June 1980	Whole shells	15	(1)	Whole animals	11	(1)	2 years old, grown on raft
Eel	Hunter River	June 1980	Mixed bones	1033±1.0	(2)				Eel about 1 m long
Mud Crabs	Hunter River, Hexham Bridge	December 1979	Mixed shells	308±0.1	(2)				Baby crabs, mixed species
Mullet	Hunter River	June 1980	Fish 1 vertebrae	471±86	(2)	Fish 1 gills	280	(1)	
			1 scales	410±45	(2)	1 kidneys	25±22	(2)	
						flesh	6	(1)	
			Fish 2 vertebrae	435±114	(2)	Fish 2 gills	236		
			scales	401± 57	(2)	2 kidneys	193±74	(2)	
						flesh	11	(1)	
Rat	Tomago	December 1980	Mixed bones	536	(1)				
	Tomago, rep 1	March 1980	Mixed bones	1548	(1)				
	Tomago, rep 2		Mixed bones	1485	(1)				
Antechinus (Marsupial Mouse)	Wyong	June 1980	Mixed bones	1127	(1)	Liver	6	(1)	Mature male mouse probably died of old age
Mouse, pet	Pet Shop, Newcastle	June 1980	Mixed bones	1031	(1)	Liver	23	(1)	Baby male mouse from pet shop

TABLE A10.2 (cont'd)

FLUORIDE IN FAUNA

Species	Location	Date	F in Bone (µgF/g ashed bone)	F in Fresh Tissue (µgF/g dried tissue)	Comments
Cat	Tomago	June 1980	Tail bones 367 (1)		Probably a pet
Rabbit	Tomago	June 1980	Vertebrae 125±34 (2) Limbs 116±10 (2)	Kidneys 4 (1)	
Fox	Tomago	December 1980	Legs 2468±53 (2)		
Wallaby	Tomago	February 1980 June 1980	Tail bones 565±32 (2) Tail bones 856±88 (2)		
Kookaburra	Tomago	December 1980	Mixed bones 2615±16 (2)		
Raven	Tomago	December 1980	Mixed bones 828±38 (2)		
Azure Kingfisher	Tomago	January 1980	Mixed bones 458± 4 (2)		
Sacred Kingfisher	Tomago	February 1980	Mixed bones 1123±98 (2)		
Galah	Tomago	June 1980	Rep.1 vertebrae and skull 570±161 (2) Rep.2 vertebrae and skull 751±100 (2)		
Frogmouth	Tomago	April 1980	Leg and wing 3174 (1) Jaw bones 3921 (1)		
Sacred Kingfisher	Tomago	February 1980	Mixed bones 1221 (1)		
Termites	Tomago	July 1980	Whole termites 55 (1)		

Comments: (2) number of determinations

TABLE A10.3

FLUORIDE LEVELS IN
KOALA *(Phascolarctos cinereus)*

Date	Location	F in bone μgF/g ashed bone	F in fresh tissue μgF/g dried tissue	Comments
January 1980	Tomago	Foreleg 3510±186 (2)	Liver 4.9 (1) Kidney 2.7 (1) Muscle 3.7±1.5 (2)	Old male teeth dis-coloured
June 1980	Tomago	Foreleg 2643 (1) Hindleg 2666 (1) Vertebrae 3096±746 (2)	Liver 10.2 (1) Kidney 10.3 (1) Muscle 4.4 (1)	Young female teeth not discoloured
June 1980	Taronga Park Zoo (Sydney)	Ribs 3582±1057(2)	-	Old male
June 1980	Blackbutt Reserve (Newcastle)	Vertebrae 3298±889 (2)	-	Old male

Comments: (2) number of determinations

A10.6.3 Discussion

Fauna Samples

The measured fluoride levels in the rat, eel, cow, kookaburra, and mud crab collected in the Tomago area are similar to published data (refer to *Tables A10.1 and A10.2)*.

The fluoride content of oysters is dependent upon age; mature oysters (four years old) had significantly higher fluoride levels (137 μgF/g) than two year old oysters (16 μgF/g).

Termites collected from the Tomago area had a fluoride content of 55 μgF/g.

Koalas

Koalas breed in summer and the young are weaned on slime (partially digested leaves) from the mother's anus. The weaning period is one month whereafter the young eat leaves.

They drink water when available, although probably can survive without it as they urinate infrequently. Their diet consists of eucalyptus leaves and ingestion of soil.

Koalas are very susceptible to chills, pneumonia, kidney trouble, conjunctivitus and parasites.

There is little difference in bone fluoride levels between the Koalas sampled at the proposed site (≈3000 μgF/g, Tomago), Blackbutt Reserve (≈3300 μgF/g, Newcastle), and Taronga Park Zoo (≈3500 μgF/g, Sydney). Therefore, the bone fluoride levels measured could be considered as background for Koalas.

The fluoride levels in the Koalas are significantly higher than levels measured in other fauna. This is probably attributed to the ingestion of soil which is naturally high in fluoride and the fact that they urinate infrequently indicating high absorption efficiency of the kidneys. The fluoride may be absorbed via the kidney and blood to the bone.

Invertebrates

Murray (1980) conducted a detailed study of fluoride concentrations and injury indicators on Kooragang Island, 3to 5 km south of the proposed site. Part of this work included studies on fluoride levels in invertebrates. *Table A10.4* presents a summary of the results of this study.

The results show substantial fluoride accumulation in insects collected on Kooragang Island when compared with similar samples collected from

Karuah some 33 km northeast of Kooragang Island. The high fluoride content in the invertebrates indicates that fluorides move along food chains but do not appear to be magnified as they are passed up the chain. The highest fluoride concentrations were found in slaters which are soil dwelling invertebrates. The high fluoride concentration in slaters may be associated with soil fluoride.

TABLE A10.4

FLUORIDE IN INVERTEBRATES
(μgF/g dry weight)

Location	Description		Fluoride
Kooragang	Carnivorous invertebrates	1.	126 to 9.2
Karuah	Carnivorous invertebrates		10 to 1.4
Kooragang	Omnivorous invertebrates	2.	55 to 11
Karuah	Omnivorous invertebrates		4.4 to 3.7
Kooragang	Herbivorous invertebrates	3.	43 to 5 (≃982,881; 4)
Karuah	Herbivorous invertebrates		13 to 1.2(≃180, 45; 5)

Comments:
1. Includes spiders, flies, carob beetles, preying mantis
2. Includes ants, cockroaches, click beetle
3. Includes grasshoppers, moth, mole cricket, scarab beetle
4.) Values cited are the fluoride levels in slaters which
5.) are soil dwelling invertebrates.

Murray (1980) determined that fluoride contamination or fumigations may cause the following:-

i. Natural selection, that is, replacement of fluoride intolerant individuals by tolerant individuals.

ii. Reduced numbers or reductions in insect speciation.

iii. Reduced fertilisation of flowering plants.

iv. Reduced stability in insect populations causing exaggerated fluctuations in insect numbers with certain species reaching population sizes which destroy areas of valuable vegetation.

v. Increased concentrations of fluorides in insects may also lead to serious consequences to wildlife feeding upon insects.

The measured average ambient fluoride level at the proposed site for the February 1980 to June 1980 period was 0.06 $\mu gF/m^3$, which is approximately one tenth of the average fluoride level measured at Stockton (0.62 $\mu gF/m^3$) during 1978 by the State Pollution Control Commission. Therefore, the existing fluoride levels in invertebrates on Tomago would be considerably less than the levels measured on Kooragang because of the lower atmospheric fluoride levels.

10.7 POTENTIAL EFFECTS OF EMISSIONS ON WILDLIFE

10.7.1 Fluorides and Animals

Fluorides enter animal systems largely through ingestion of food. *Suttie (1977)* found that the direct inhalation of fluoride from the atmosphere is a negligible component of the total fluoride intake of animals.

Both particulate fluoride deposited on leaves, and fluorides which have been absorbed into the leaf tissue are ingested by herbivores and passed on through the food chain to carnivores.

Fluorides tend to accumulate in the skeleton of vertebrates and the exoskeletons of most invertebrates. The effects of fluoride on domestic grazing animals has been well documented in contrast to wild fauna populations. Excess fluorides in grazing animals cause stiffness, lameness and lesions in the bones and teeth. Fluoride analyses of a dead Koala found on the Tomago site indicate that in this species too, the bones are the main repository of fluorides.

The National Academy of Sciences (1971) found that the following features control the levels of fluoride in animals:-

* the amount of fluoride ingested
* solubility of fluoride ingested
* fluctuations of intake over time
* species of animal
* age of animal
* level of nutrition of animal
* stress
* individual biological response.

A10.7.2 Effects of Emissions

Studies of terrestrial fauna in other countries have shown that fluorides influence wildlife in much the same way as domestic stock. *Balazova and Hluchan (1969)* found that House Sparrows accumulated fluorides in an atmosphere of 14 to 20 $\mu g/m^3$. *Kay et al (1975)* found fluorosis in both Mules and Whitetail Deer feeding on vegetation containing up to 430 ppm fluoride.

It appears that high fluorides are passed up the food chain from plants to herbivores to carnivores. *Newman (1975)* describes *Korstad's (1970)* finding that high fluoride levels occur in the carnivore, the Red Fox *(Vulpes vulpes)* and the Barn Owl *(Tyto alba)* .

The House Martin *(Delichon urbica)* was found to be absent from areas of high fluoride and other types of airborne emissions *(Newman, 1977)*.

Suttie (1977) suggested that the minimum tolerance level of wildlife species would be unlikely to be lower than that of the most sensitive domestic species of cattle.

Details of mutagenic effects of fluoride are discussed in *Appendix A9.6.1.*

Native fauna on the site may be affected by emissions in two ways;

1. *Direct effects resulting from the ingestion of fluoride*

   The main source of fluoride for herbivores is fluoride in leaves which is passed up the food chain. Carnivores ingest fluoride fixed in the bones of herbivores and other carnivores. *Murray*

(1980) found that this probably occurs in insect populations on Kooragang Island.

Variables which complicate the prediction of effects on Australian native fauna are the mobility of fauna, their dietary preference, the fluoride uptake rate of the preferred feed (be it plant or animal) and their susceptibility.

The behaviour of the particular species itself decides the final impact of fluoride ingestion. The Koala spaces itself according to individual proximity rather than the availability of food (*New South Wales National Parks and Wildlife Service)*. Fluorides combining with soil calcium may in the long term have a severe impact on Koala numbers within the zone of influence. Koalas occasionally eat soil thus supplementing their diet with elements such as calcium which may become unavailable when combined with fluoride in the soil.

Mead et al (1979), found that Western Australian Brush-tailed Possums were much more resistant to fluoroacetate (a compound found in fumigated plants) intoxication than were the same species in South Australia. *Mead et al (1979)* quote other studies which show that Australian Possums, Bush Rats and the Grey Kangaroo, all of which occur on the Tomago Sandbeds, are capable of defluorination of fluoroacetate. This suggests that such animals may be resistant to increased fluoride levels.

The natural pond northeast of the disused airstrip is probably a significant source of water for native animals and effects on native species drinking from the lagoon will possibly be significant because of the high fluoride levels expected. The fluoride intake of each species resulting from drinking, will depend on each species (i.e., how often it drinks, how much, and whether or if it uses the same waterhole). The Koala rarely drinks at all, whereas Kangaroos are much more dependent on water. Whatever the fluoride intake from drinking, it is in addition to quantities consumed in leaves, insects and other animals.

During periods of plentiful water supply, the impact of fluorides will be limited because of dilution effects and the availability of water both near and at some distance from the smelter. However in times of drought, as exemplified by the summer and winter of 1980, few swamps or waterholes contain water. The "Blue Lagoon" in the Tomago Sandbeds catchment near pumping station 20 retains water during drought and because of its distance will be less affected by fluoride emissions.

ii. Indirect Effects

An interaction between flora and fauna which may be affected by fluoride emissions is pollenation. The ingestion of particulate fluorides on pollen and nectar by commercial honey bees reduces hive populations *(USA Department of Agriculture)*. If native insects are similarly susceptible, pollenation may not be as successful in affected areas and few insects will be available near the base of the food chain.

Appendix 11

RESIDENCES WITHIN PROXIMITY OF THE SITE

APPENDIX 11

RESIDENCES WITHIN PROXIMITY TO THE SITE

Reference	Size	Construction Material	Approximate Age	Condi- tion	Other Comments
Kooragang Island					
H1	Small	wb/c.i.	1900-1920's	B	Greyhounds and 1 dairy cow kept.
H2	Medium	bk/c.i.	1900	B	Dairy and pigs.
H3	Small	wb/f	1940's	B	
10 small fishing huts, used on weekends, are located along the bank of the north arm.					
North of the Hunter River					
H4	Small	wb/c.i.	1900's	B	Disused dairy, sheds and silos. Currently rented.
H5	Large	bk/t.	1950's	G	Farm residence.
H6	Medium	wb/t.	1950's	G	
H7	Small	wb/c.i.	1920's	G	Caretaker's residence for R & H Transport Pty.Ltd.
H8	Medium	wb/t.	1950's	G	Operates as Blue Crystal Kennels.
H9	Small	f/c.i.	1940's	G	Currently for sale.
H10	Medium	bk/t.	1960's	G	Large poultry sheds.
H11	Large	bk/f.	1960's	G	Owner-manager's residence of Ponderosa Caravan Park.
H12	Small	f/c.i.	1930's	B	Large poultry sheds.
H13	Small	wb/c.i.	1960's	B	
H14	Medium	f/c.i.	1920's	G	
H15	Small	wb/c.i.	1900-1920	O	
H16	Small	f/c.i.	1950's	G	
H17	Small	wb/c.i.	1920's	G	
H18	Small	wb/c.i.	1920's	B	
H19	Small	wb/c.i.	1900's	B	
H20	Small	wb/c.i.	1940's	B	Corgi dogs bred as a hobby.
H21	Medium	wb/c.i.	1920's	G	Disused church operating as Tomago Mutual Credit Union Ltd.
H22	Small	wb/c.i.	1940's	B	
H23	Medium	wb/c.i.	1920's	B	Assistant Superintendent's residence of Tomago Detention Centre.

APPENDIX 11 (cont'd)

RESIDENCES WITHIN PROXIMITY TO THE SITE (cont'd)

Reference	Size	Construction Material	Approximate Age	Condition	Other Comments
North of the Hunter River (Cont'd)					
H24	Medium	wb/t.	1950-1960	G	
H25	Small	wb/t.	1950-1960	G	
H26	Medium	wb/t.	1950's	G	Glasshouses for orchid propagation and display.
H27	Medium	wb/c.i.	1950's	G	
H28	Medium	wb/t.	1960's	G	
H29	Large	wb/c.i.	1930's	G	Operating dairy with numerous outhouses.
H30	Large	wb/t.	1950's	G	Extensive improvements including pool and outdoor terraces. Operated as Weltara Kennels.
H31	Large	bk/t.	1960's	G	Former Courtaulds' management residence.
H32	Large	bk/t.	1960's	G	Former Courtaulds' management residence.
H33	Large	bk/t.	1970's	G	Extensive improvements. Operated as Tomago Hobby Ceramics.
H33A	Large	bk/t.	under construction	G	Located on an industrial site.
H34	Large	bk/t.	1970's	G	Disused dairy and sheds.
H35	Large	stone/ c.i.	1843	B	Two-storey Tomago House, designed by J. Verge. House, grounds and adjacent chapel classified by National Trust of Australia (N.S.W.)
H36	Medium	wb/t.	1950's	G	
H37	Medium	wb/t.	1930's	G	Disused dairy and sheds.
H38	Medium	f/t.	1960's	B	
H39	Medium	f/t.	1970's	G	
H40	Small	f/c.i.	1940's	B	
H41	Medium	wb/c.i.	1960's	B	
H42	Medium	f/f	1950's	B	
H43	Medium	wb/c.i.	1950's	G	Currently tenanted.
H44	Medium	f/c.i.	1970's	G	Recently sold.
H45	Medium	wb/c.i.	1920's	B	Disused dairy, shed and silo.
H45A	Large	f/t	nearing completion	G	Located on an industrial site.
H46	Medium	wb/c.i.	pre 1900's	B	Horse breeding property.

APPENDIX 11 (cont'd)

RESIDENCES WITHIN PROXIMITY TO THE SITE

Reference	Size	Construction Material	Approximate Age	Condition	Other Comments
North of the Hunter River (Cont'd)					
H47	Medium	wb/c.i.	pre 1900's	O	Used by Fire Brigade. reserve as a base.
H48	Medium	bk/t.	1960's	G	
H49	Medium	bk/t.	1960's	G	
H50	Small	c.i./c.i.	1970's	G	
H51	Medium	wb/t.	1950's	G	
H52	Small	wb/c.i.	1960's	B	Unoccupied
H53	Medium	f/c.i.	1970's	G	
H54	Small	wb/t.	1960's	G	
H55	Large	wb/t.			Currently being extended. German Shepherd dogs bred.
H56	Medium	false bk/t.	1960's	G	Currently for sale.
H57	Small	f/c.i.	1960's	B	
H58	Small	f/c.i.	1960's	G	
H59	Medium	wb/c.i.	1920's	B	
H60	Medium	f/c.i.	Under construction	G	
H61	Small	wb/c.i.	1930's	B	
H62	Large	bk/t.	1970's	G	
South of the Hunter River, vicinity of Hexham Bridge					
H63	Small	wb/f/c.i.	1900's	B	
H64	Small	wb/f/t	1920's	B	
H65	Medium	wb/c.i.	1920's	B	
H66	Small	wb/c.i.	1920's	B)	Group of small huts on the edge of the Hunter River.
H67	Small	wb/c.i.	1920's	B)	
H68	Small	wb/c.i.	1920's	B)	
H69	Small	wb/c.i.	1920's	B)	
H70	Small	wb/c.i.	1920's	B)	
H71	Small	wb/c.i.	1920's	G)	Operates as fish and prawn shop.
H72	Small	wb/c.i.	1900's	B	
H73	Small	wb/c.i.	1920's	B	Operates as fish and prawn shop.
H74	Small	wb/c.i.	1920's	B	
H75	Small	wb/c.i.	1920's	B	Currently tenanted.

Key: Size: Small: less than 93 m^2 (10 sq.) Medium: 93-186 m^2
Large: Greater than 186 m^2(20 sq.).
Construction Material: bk = brick; wb. = weatherboard; f =fibro/asbestos; c.i. = corrugated iron; t. = tile.
Condition: G = good repair; B = needing repair; O = obsolete.

Appendix 12

INDUSTRIAL AND COMMERCIAL USES WITHIN PROXIMITY OF THE SITE

APPENDIX 12

INDUSTRIAL AND COMMERCIAL USES WITHIN PROXIMITY TO THE SITE

INDUSTRY GROUP	ESTABLISHMENTS	BASIC PRODUCTS	REFERENCE *Figure 6.18*	NUMBER OF EMPLOYEES
North of the Hunter River				
Wood and Wood Products	Wade Joinery Lot 121 Enterprise Drive, Tomago	Kitchen Joinery	I 20	3
Basic Chemicals	Stauffer Chemicals Tomago Road, Tomago	Carbon Disulphide, Magnesium Sulphate	I 7	20
	Genkem Pty. Ltd. Tomago Road, Tomago	Alumina Sulphate	I 12	30
	Custom Chemicals Tomago Road, Tomago	Acids, Bulk Chemicals	I 14	5
	Omega Chemicals Enterprise Drive, Tomago	Liquid Alum	I 18	1
Cement and Cement Products	TPC Concrete Aggregate Products Enterprise Drive, Tomago	Bar-B-Ques, Incinerators	I 19	9
Fabricated Structural Metal Products	United Fabricators Pty. Ltd. 5 Old Punt Road, Tomago	Steel and metal work for building industry	I 3	5
	Firdon Fabrications Pty. Ltd. Tomago Road, Tomago	General steel fabrication	I 6	30
	Haltai Steel Contractors Pty. Ltd. Tomago Road, Tomago	General steel fabrication	I 9	14
	Allco Steel Tomago Road, Tomago	Steel fabrication and construction	I 10	230+
	Tomago Engineering Tomago Road, Tomago	Steel fabrication - steel tanks, buildings, trailers. Mechanical repairs.	I 24	2
	H.R. Forge & Engineering Company Tomago Road, Tomago	Flanges and pipe fabrication.	I 25	10
	Builder Mate Products Enterprise Drive, Tomago	Circular saw stands.	I 17	6
	Brennon Engineering Tomago Road, Tomago	Steel fabrication	I 11	3
Other Transport Equipment	Carrington Slipways Pty. Ltd. Old Punt Road, Tomago	Tugs. Oil-rig supply vessels. Barges Ships up to 6,000 tonnes.	I 5A	320
	Tomago Trawlers Pty. Ltd. Tomago Road, Tomago	Ships 17 m and over	I 23	10

APPENDIX 12 (cont'd)

INDUSTRIAL AND COMMERCIAL USES WITHIN PROXIMITY TO THE SITE (cont'd)

INDUSTRY GROUP	ESTABLISHMENTS	BASIC PRODUCTS	REFERENCE *Figure 6.18*	NUMBER OF EMPLOYEES
North of the Hunter River (Cont'd)				
Household Appliances and Electrical Equipment	Raelec Products Pty. Limited 6 Ampere Ave., Tomago	Electrical equipment for mining industry	I 5	19
	Industrial Switchgear Pty. Ltd. Tomago Road, Tomago	Electrical switchboards (industrial)	I 26	32
	J. & A. Martin, Electrical Contractors, 6 Old Punt Road, Tomago	Industrial contractors	I 4	9
Mining Industries	Rutile & Zircon Mines (Newcastle) Ltd., Pacific Highway, Tomago	Rutile, zircon, ilmenite and monazite	I 1	204
Other Industrial and Commercial	Ponderosa Caravan Park Tomago Road, Tomago	Caravan site letting	I 27	N.A.
	Jacks Caravan Repairs Tomago Road, Tomago	Caravan repairs	I 22	4
	R. & H. Transport Pty. Ltd. Old Punt Road, Tomago	'Nitrofil' storage and general transport	I 2	12
	Tomago Mutual Credit Union Tomago Road, Tomago	Finance	H 21	1
	Kell Coatings Tomago Road, Tomago	Industrial finishes	I 8	8
	Weltara Kennels Tomago Road, Tomago	Boarding for dogs and cats	H 30	3
	Tomago Hobby Ceramics 45 School Drive, Tomago	Ceramic products	H 33A	3
	J. Santos Tomago Road, Tomago	Glass blowing	I 13	1
	Hunter Valley Filter Services Tomago Road, Tomago	Filter cleaning service	I 15	3
	Baileys Discount Tyres Pty. Ltd. Lots 106 & 107 Enterprise Drive, Tomago.	Tyre sales and retreading	I 16	15
	N.A. Enterprise Drive, Tomago	Yoghurt distribution	I 21	N.A.

APPENDIX 12 (cont'd)

INDUSTRIAL AND COMMERCIAL USES WITHIN PROXIMITY TO THE SITE (cont'd)

INDUSTRY GROUP	ESTABLISHMENTS	BASIC PRODUCTS	REFERENCE *Figure 6.18*	NUMBER OF EMPLOYEES
South of the Hunter River				
Sheet Metal Products	Alan E. Clode 175 Old Maitland Road, Hexham	Stainless steel fabrications. Aluminium fabrications.	I 38	4
Other Fabricated Metal Products	Industrial Galvanisers Pty. Ltd. Pacific Highway, Hexham.	Galvanised products	I 44	50
	Ullman Engineering Pty. Ltd. Pacific Highway, Hexham.	General engineering and manufacturing.	I 45	55
Other Machinery and Equipment	Hexham Engineering Pty. Ltd. Old Maitland Road, Hexham.	Mining machinery and repairs. Winding gear.	I 35	215
	Steel Mains Pty. Ltd. Pacific Highway, Hexham.	Steel pipes.	I 31	60
Coal Washing Plant	Coal & Allied Industries Limited Pacific Highway, Hexham.	Washed coal.	I 46	80
Milk Products	The Hunter Valley Co-op. Dairy Co. Ltd. Pacific Highway, Hexham.	Ice cream. Frozen yoghurt. Butter. Skim and full-cream powdered milk. Milk.	I 28	200
Mining Industries	Associated Minerals Consolidated Ltd. Pacific Highway, Hexham.	Rutile, zircon, ilmenite and monazite	I 43	32
Other Industrial and Commercial Uses	Kloster Ford Truck Sales Pacific Highway, Hexham.	Truck sales.	I 40	46
	S. Mehan Pty. Ltd. Old Maitland Road, Hexham.	Road rollers and plant hire.	I 37	8
	Kentan Machinery Pacific Highway, Hexham.	Earthmoving equipment and supplies.	I 41	7
	Caltex Service Station Pacific Highway, Hexham.	Petrol sales.	I 33	8
	B.P. Service Station Pacific Highway, Hexham.	Petrol sales.	I 32	5
	Coal & Allied Industries Limited Old Maitland Road, Hexham.	Administration Office	I 36	30
	Vacant factory (formerly U.D. Stipewich) Pacific Highway, Hexham.		I 42	

APPENDIX 12 (cont'd)

INDUSTRIAL AND COMMERCIAL USES WITHIN PROXIMITY TO THE SITE (cont'd)

INDUSTRY GROUP	ESTABLISHMENTS	BASIC PRODUCTS	REFERENCE *Figure 6.18*	NUMBER OF EMPLOYEES
South of the Hunter River (Cont'd)				
Other Industrial and Commercial Uses (cont'd)	Sinclairs Nursery Pacific Highway, Hexham.	Plant sales.	I 29	4
	R.W. Miller & Company Pty. Limited Pacific Highway, Hexham.	Coal loading facility	I 30	4
	Max Lynch & Sons Old Maitland Road, Hexham.	Truck haulage.	I 34	7
	Salamander Hire Old Maitland Road, Hexham.	-	I 39	-

Appendix 13

HUNTER REGION ECONOMIC BASE DETAILS

APPENDIX 13

HUNTER REGION ECONOMIC BASE

A13.1 BACKGROUND

Geographically, the Hunter Region is defined as the catchment area of the Hunter River, but on a planning and economic basis it is taken to include Great Lakes Shire, which is largely outside the Hunter catchment. The region is 30,828 km^2 in area and comprises the local government areas of Newcastle, Lake Macquarie, Port Stephens Shire, Greater Cessnock, Great Lakes, Dungog, Gloucester, Singleton, Muswellbrook-Denman, Scone, Merriwa and Murrurundi.

The Hunter Region is considered to be one of the most important in economic terms in New South Wales. The region's major economic contributions are in the field of power generation, manufacture of steel and heavy engineering products, coal supply and exporting (*Hunter Regional Planning Committee, 1977)*.

The regional economic base has undergone changes from an original agricultural emphasis in the Upper Hunter and a dependence on coal mining in the Lower Hunter, to a greater reliance on coal mining in the Upper Hunter and the manufacturing industries and service sector in the Lower Hunter.

A13.2 PRIMARY INDUSTRY

Dominant primary industries within the Hunter Region are agriculture, fishing, forestry and mining. Although the region is a net exporter of products from each of these industries, it has been stated that its residents do not receive an equitable share of the benefits that accrue from the exploitation of the region's natural resources. (*Planning Workshop Pty. Limited, 1977a)*. In terms of employment, the Upper Hunter is more dependent upon primary industries. In 1971, 32.3 per cent of the Upper Hunter workforce was employed in this sector compared with 6.4 per cent for the Lower Hunter and 6.2 per cent in the State.

In line with trends throughout Australia, employment within the primary industries is declining as a result of the increasing use of labour-saving technology.

Agriculture

In 1978, 1,731,277 ha or 56 per cent of the region's area was classified as rural holdings by the Australian Bureau of Statistics, of which 95 per cent was located in the Upper Hunter. The importance of agricultural production to the region is exemplified by the diversity of products, and that the region is a net exporter of food and fodder. The Hunter Region contains 2.67 per cent of the State's rural holdings and produced 6.56 per cent of the State agricultural value of production during 1977/78. The Lower Hunter, while comprising only 0.11 per cent of the total State agricultural land, produced 2.15 per cent of the State value of production.

Table A13.1 provides details of the value of production of the major rural items. Predominant industries in the Lower Hunter are poultry, dairy, eggs and vegetables, while in the Upper Hunter, dairying and cattle breeding are the main industries.

The importance of each of the major agricultural land uses shown in the table is described below.

i. *Dairying* is the single most important industry within the region, supplying all its needs and one third of the Sydney liquid milk market. In 1977, dairying provided 28 per cent of the total regional value of agricultural production. There is little prospect of expansion in the region, due to the quota system of production allocation used by the New South Wales Dairy Board.

ii. *Poultry* is the only agricultural industry which has shown real growth in the region over the past five years. It is capital intensive, requiring little labour, and in most cases chicken farms are run on a

TABLF A13.1

VALUE OF PRODUCTION IN THE
HUNTER REGION 1977/78

Item	Newcastle Statistical Subdivision		Balance of Hunter		Hunter Region	
	Value $'000	Percentage	Value $'000	Percentage	Value $'000	Percentage
Milk	4,710	11.8	25,300	31.0	30,010	24.7
Poultry	22,871	57.5	6,032	7.4	28,903	23.8
Cattle	1,298	3.5	22,672	27.8	24,070	19.8
Wheat	3	-	6,387	7.8	6,390	5.3
Fruit	1,284	3.2	4,103	5.0	5,387	4.4
Pigs	1,500	3.8	3,861	4.7	5,361	4.4
Wool	5	-	5,014	6.1	5,019	4.1
Vegetables	3,508	8.8	1,370	1.7	4,878	4.0
Eggs	4,120	10.3	276	0.3	4,396	3.6
Lucerne-Pasture	331	0.8	3,534	4.3	3,865	3.2
Sheep	2	-	892	1.0	894	0.7
Sorghum	-	-	677	0.8	677	0.6
Barley	1	-	675	0.8	676	0.6
TOTAL	39,733	100.0	80,793	100.0	120,526	100.0

Source: *Australian Bureau of Statistics - Rural Industries Division.*

family basis, with supplies and expertise being provided by major processing firms.

iii. *Cattle* raising accounted for 19.8 per cent of the region's value of production in 1977/78. The industry has experienced instability over recent years due to a reliance on the export market and insufficient market arrangements.

Table A13.2 provides details of the value of production of these three main industries for each local government area within proximity to the site.

Rural productivity in the region has been consistently higher than the State average, as shown in *Table A13.3*.

TABLE A13.2

SELECTED RURAL STATISTICS FOR THE THREE LOCAL GOVERNMENT AREAS WITHIN PROXIMITY TO THE SITE (1977/78)

	Port Stephens	Newcastle	Maitland	Hunter Region	New South Wales
Number of holdings	201	16	199	5,582	52,866
Area of holdings (ha)	20,493	2,176	21,743	1,959,854	64,788,385
Average size (ha)	112	136	109	351.1	1,225
Total value of production ($'000)	9,566	374	16,981	96,496	1,848,352
Number of dairy cattle	6,858	360	9,033	125,294	-
Number of dairy holdings	72	2	84	1,026	-
Value of production per holding-Dairying ($'000)	24.7	42.5	31.4	28.2	23.5
Value of production per holding - Beef ($'000)	4.2	3.4	41.9	7.4	5.6
Value of production per holding - Poultry for slaughter ($'000)	276	154	n.a.	320	271

Source: *Australian Bureau of Statistics - Rural Industries Division.*

TABLE A13.3

VALUE OF PRODUCTION PER HECTARE OF RURAL HOLDINGS FOR 1974/75, 1975/76 AND 1977/78 IN DOLLARS

	1974/75	1975/76	1977/78
Newcastle Statistical Subdivision	351	282	535
Balance of Hunter	30	35	49
Hunter Region	47	49	70
New South Wales	21	23	28

Source: *Australian Bureau of Statistics - Rural Industries Division.*

This higher productivity can be explained by the region's good soil quality and water conditions, its proximity to sources of supply and farm inputs and its proximity to markets (*Planning Workshops Pty. Limited, 1977a)*.

Fishing

The region is an important supplier of the State's fishery requirements, being rated fifth in the State in terms of the commercial value of its seafood production. During the financial year 1978/79, the value of fish caught in the region was $2,764,297 compared with $2,601,351 in the previous financial year. Approximately 400 individual and associated families are dependent on the fishing industry in the Hunter Region.

The geographical extent of the fishing industry includes the Hunter River, Lake Macquarie, Port Stephens, Myall, Wallis and Smith Lakes, together with offshore areas. It is the production from the latter area that is largely offsetting declining catches from the traditional lake and river sources.

Forestry

Timber production is confined to the northeastern and southeastern areas of the region. In 1977/78, the region produced 8.5 per cent of the State's timber production.

Mining

With the development of major export markets for steaming and coking coal, and the increase in demand for power generation, coal mining in the region has assumed a role of major importance. Approximately 55 per cent of the total State and 25 per cent of the total Australian coal exports are derived from the region.

A13.3 SECONDARY INDUSTRY

The manufacturing industry has long been the mainstay of the region's economy but long-term trends show a decline in the region's share of the State level of manufacturing output. In 1954, the region's manufacturing output was 10 per cent of the State's output, but this has now stabilised at 8.7 per cent over the period 1974 to 1977.

The manufacturing industry is centred in the Lower Hunter Subregion, where 95.6 per cent of the manufacturing workforce was employed during 1977. *Table A13.4* compares the net output (value added) of the Hunter Region with the State for the period 1976/77.

TABLE A13.4

VALUE OF MANUFACTURING PRODUCTS
HUNTER REGION 1976/77

Industry	Dollars ($'000)	Value Added Percentage	New South Wales Percentage
Food, beverages and tobacco	70,890	11.3	14.9
Textiles	16,670	2.6	2.4
Clothing and footwear	12,867	2.0	4.1
Wood, wood products and furniture	17,821	2.8	5.0
Paper, paper products and printing	13,066	2.0	8.6
Chemical, petroleum and coal products	24,697	3.9	10.5
Non-metallic mineral products	18,913	3.0	4.5
Basic metal products	311,899	49.7	14.0
Fabricated metal products	46,417	7.4	7.8
Transport-Equipment	47,533	7.6	7.7
Other machinery and equipment	44,035	7.0	15.1
Miscellaneous manufacturing	3,058	0.5	5.2
TOTAL	627,866	100.0	100.0

Source: *Australian Bureau of Statistics.*

The table illustrates the dominance of the region's basic metal products sector which accounted for 49.7 per cent of the net output of the manufacturing division, compared with the State average of 14 per cent.

Table A13.5 lists employment figures for the major manufacturing establishments in the Hunter Region.

TABLE A13.5

MAJOR MANUFACTURING ESTABLISHMENTS
HUNTER REGION, 1978

Name	Employment	Rank
B.H.P.	9916	1
Tubemakers	2370	2
Commonwealth Steel Co. Ltd.	1900	3
Ryland Brothers (Aust.) Pty. Ltd.	1250	4
Steggles Pty. Ltd.	1106	5
Sulphide Corporation Pty. Limited	692	6
A. Goninan & Co. Limited	650	7
Bradmill Textiles Pty. Limited	637	8
F.J. Walker	520	9
Newcastle Abattoir	470	10
State Dockyard	461	11
Electric Lamp Manufacturers	447	12
The Newcastle Morning Herald	438	13
Bradmill Textiles Pty. Limited	425	14
Australian Industrial Refractories Ltd.	419	15
Sanitarium Health Food Co.	400	16
Bonds Wear	350	17
Carrington Slipways Pty. Ltd.	320	18
Alcan Australia Limited	320	18
Lane Amalgamated Hardware Co.	300	20
The Hunter Valley Co-op Dairy Co. Ltd.(Oak)	260	21
Allied Spring Chicken	250	22
Australian Wire Rope Works Pty. Ltd.	250	22
Greenleaf Fertilizers Ltd.	250	22
General Textiles Pty. Ltd. (Osti)	240	25
Eastern Nitrogen Limited	230	26
Allis Chalmers (Aust.) Pty. Limited	220	27
John Lysaght (Aust.) Ltd.	220	27
Hexham Engineering Pty. Limited	215	29
Statham Ltd.	200	30

Source: *Hunter Valley Research Foundation (1978)*.

The four major manufacturing establishments are all classified within the basic metal products sector.

The average regional productivity of the manufacturing sector, based upon value-added per employee is similar to the State level, being \$16,400 and \$16,447 respectively in 1976/77. This is largely due to the higher than average performance of the chemical, petroleum and coal products sector. Conversely, up to three quarters of the remaining sectors are well below the State levels.

In 1976/77 the level of capital investment in the manufacturing industry for the region was $60,863,000 or 12.2 per cent of the State's total. Over 50 per cent of this investment was in the basic metals sector. The level of investment is considerably higher than either the region's share of the State's employment and value-added output of 8.7 per cent.

A13.4 TERTIARY INDUSTRY

Employment in the tertiary sector has increased over the period 1954 to 1976, representing 48.7 per cent of the workforce in 1954 and 60.3 per cent in 1976. Much of this growth can be attributed to increasing female participation rates in the workforce. In 1976, 83 per cent of female employment was within the tertiary sector compared with 56 per cent for males. The subregion accounted for 87.2 per cent of the region's workforce in this sector.

Between 1954 and 1976, there have been fluctuations in employment levels in the construction industry, a decline in employment in the transport and storage sector and an upward trend in all other sectors, particularly wholesale and retail trade, public administration, defence and community services. These latter sectors now account for over 50 per cent of employment within the tertiary sector. The changes that have taken place in the various sectors are generally similar to those that have taken place at State and national level.

Both the finance, the public administration and defence sectors are under-represented in the region compared with State levels. Within the Public administration and defence sector, defence accounted for over one-half of the group's employment in 1971, with local government employing a further 22 per cent and Federal and State Governments employing relatively minor proportions. (*Rees, 1977*).

A13.5 TOURISM

The major tourist attractions in the Lower Hunter Subregion include:-

i. *The Vineyards and Wineries:* The Hunter Valley is the oldest commercial grape growing area in Australia. The main wine grape and wine production centres are located in the Pokolbin-Branxton and the Denman-Muswellbrook areas. The industry has expanded substantially between 1965-66 and 1976-77. The total area planted in bearing and young vines increased from 905 ha to 4056 ha with 15,151 tonnes of grapes used for winemaking in 1977 by 73 producers. (*Hunter Valley Research Foundation 1979*).

   The vineyard areas are popular with tourists and many of the growers provide picnic facilities for visitors.

ii. *Lake Macquarie:* Lake Macquarie is the largest seaboard lake in Australia with an area of 110 km^2. Its outlet to the Pacific Ocean is at Swansea Heads, 27 km south of Newcastle. The lake is used extensively for water-oriented recreational pursuits.

iii. *Newcastle Beaches:* There are numerous beaches along the coastal strip to the north and south of Newcastle. The main beach is Newcastle Beach which is 180 metres from the business centre in Hunter Street. Other beaches include: North Stockton, Stockton, Nobby's Beach, Bar Beach, Merewether Beach, Dixon Park, Susan Gilmore, Dudley, Redhead, Belmont South, Blacksmiths, Hams and Caves Beach.

iv. *Port Stephens:* The district contains a large natural harbour, bays and beaches. The district is a popular tourist resort and is well known for game and deep sea fishing.

v. *Other Attractions:* Other tourist attractions in the Newcastle area include Nobby's Lighthouse, King Edward Park, the Stockton Breakwater, Blackbutt Reserve, the Civic Centre, Fort Scratchley, the B.H.P. Steelworks, Newcastle Maritime Museum, Newcastle Shell Museum and the Local Historical Museum.

The findings of the first 12 months' operation of the Australian Domestic Tourism Monitor, between April 1978 and March 1979, indicated that a total of 2,390,000 visits were made to the region of which 63.7 per cent originated from Sydney and 30.3 per cent were from the country areas of New South Wales. Pleasure holidaying was the main reason for visiting the region and stays of two nights or less were the most frequent. Flats or houses belonging to friends or relatives were the most common type of accommodation.

Of visits made to the region, 82.2 per cent were by private motor vehicle. December to January represented the peak period with 35.8 per cent of visitor nights while winter months were the least popular (*Morgan Polls, 1979)*. The survey points to the lack of overseas visitors to the region who, as a general rule, account for up to 50 per cent greater spending level. It is generally acknowledged that there is a shortage of good tourist accommodation in the region, particularly to cater for a large influx of visitors attracted to conferences and similar venues.

The gross takings and the number of persons employed in tourist accommodation establishments in the Hunter Region from 1977 to 1979 is set out in *Table A13.6*.

TABLE A13.6

GROSS TAKINGS AND EMPLOYMENT IN TOURIST ACCOMMODATION ESTABLISHMENTS IN THE HUNTER REGION

	1977-78			1978-79		
	Gross Takings from accommodation $	Full-time Employment	Other Employment	Gross Takings from accommodation $	Full-time Employment	Other Employment
Port Stephens Shire	1,792,000	60	168	2,068,000	66	164
Newcastle City	2,498,000	129	166	2,831,000	121	180
Maitland City	352,000	19	32	397,000	20	45
Newcastle Statistical Division (Lower Hunter Subregion)	5,887,000	268	565	6,768,000	273	568
Hunter Statistical Division	8,120,000	361	684	9,356,000	371	705

Source: *New South Wales Department of Tourism.*

The gross takings from tourist accommodation showed only a slight increase between 1977 and 1979. The lowest increase of 10 per cent occurred in Maitland City while Newcastle City, Port Stephens Shire and the Hunter Statistical Division as a whole all experienced an increase of 15 per cent. The growth in employment was virtually static over the corresponding period. The largest increase occurred in Maitland City where part-time and casual employment increased by 41 per cent from 1977 to 1979. A decrease in the number of full-time employees occurred in Newcastle City and other employees in the Port Stephens Shire.

A13.6 EMPLOYMENT

TABLE A13.7

EMPLOYMENT BY INDUSTRY FOR NEWCASTLE STATISTICAL SUBDIVISION, THE HUNTER REGION AND NEW SOUTH WALES, 1976

	NEWCASTLE STATISTICAL DISTRICT				HUNTER REGION	NEW SOUTH WALES
	Male	Female	Total	Total Percentage	Total Percentage	Total Percentage
PRIMARY SECTOR						
Agriculture	1,088	549	1,637	1.2	4.5	5.5
Forestry	169	8	171	0.1	0.2	0.2
Fishing	301	30	331	0.2	0.3	0.1
Mining	6,046	119	6,165	4.4	4.7	1.2
Total	7,604	706	8,304	5.9	9.7	7.0
SECONDARY SECTOR						
Food, drink, tobacco	3,101	1,420	4,521	3.3	3.3	2.9
Textiles, clothing	954	1,846	2,800	2.0	1.8	1.9
Wood, furniture	916	129	1,045	0.8	1.0	1.2
Metal products, machinery	24,157	1,871	26,029	18.7	16.2	9.4
Others	2,946	644	3,590	2.6	2.3	5.4
Total	32,074	5,912	37,986	27.3	24.6	21.0
TERTIARY SECTOR						
Electricity, gas water	3,190	325	3,516	2.5	2.7	2.0
Construction	8,374	797	9,171	6.6	6.6	6.2
Wholesale, retail trade	13,672	11,232	24,903	17.9	17.3	18.3
Transport, storage	6,556	705	7,261	5.2	5.1	5.4
Communications	1,441	403	1,844	1.3	1.4	2.1
Finance	3,714	3,362	7,076	5.1	4.8	8.0
Public administration, Defence	4,370	1,533	5,904	4.2	4.5	5.7
Community Services	6,919	12,014	18,930	13.6	12.9	12.6
Entertainment, recreation	2,733	4,186	6,919	5.0	5.0	5.2
Total	50,969	34,557	85,524	61.4	60.3	65.5
OTHER	3,769	3,348	7,117	5.1	5.3	6.6
TOTAL EMPLOYED POPULATION	94,422	44,522	138,944	100.0	100.0	100.0

Source: *Australian Bureau of Statistics (Census 1976).*

TABLE A13.8

NUMBER OF PERSONS UNEMPLOYED,
LOWER HUNTER SUBREGION
(31st August 1979)

Occupation	Male	Female
Skilled building and construction workers	305	0
Skilled metal tradesmen	319	0
Clerical and administrative	574	2865
Semi-skilled	2266	6351
Unskilled	2061	60
Service Occupations	464	664
Other skilled	95	27
Rural	137	20
Professional/semi-professional	116	15
Total	6484	4429

Source: *Commonwealth Employment Service.*

Appendix 14

DEMOGRAPHY, ACCOMODATION, AND SERVICES DATA

APPENDIX 14

DEMOGRAPHY, ACCOMMODATION AND SERVICES DATA

TABLE A14.1

AGE DISTRIBUTION OF THE POPULATION
Newcastle Statistical Subdivision

Age last Birthday (completed years)	Males	Females	Persons	Proportion percentage	National percentage
0 - 4	15,665	15,130	30,795	8.4	8.8
5 - 9	16,602	15,803	32,405	8.9	9.2
10 - 14	16,814	15,920	32,734	9.0	9.2
15 - 19	17,078	16,422	33,500	9.3	8.9
20 - 24	14,720	14,296	29,016	8.0	8.2
25 - 29	14,390	13,990	28,380	7.8	8.4
30 - 34	12,061	11,636	23,697	6.5	7.0
35 - 39	10,221	9,904	20,125	5.5	6.0
40 - 44	9,413	9,711	19,124	5.3	5.4
45 - 49	10,936	10,744	21,680	6.0	5.7
50 - 54	10,985	10,729	21,714	6.0	5.5
55 - 59	9,383	9,374	18,757	5.2	4.6
60 - 64	8,067	8,780	16,847	4.6	4.2
65 - 69	6,145	7,170	13,315	3.7	3.3
70 - 74	4,226	5,293	9,519	2.6	2.4
75	4,261	7,803	12,064	3.3	3.2
Total Population	180,967	182,705	363,672	100.0	100.0

Source: *Australian Bureau of Statistics, 1976 Census.*

TABLE A14.2

POPULATION CHANGES IN THE LOWER HUNTER SUBREGION (per cent)

Local Government Area	1966-1971	1971-1976
Cessnock City	+ 1.1	+ 3.7
Lake Macquarie Municipality	+13.9	+ 7.7
Maitland City	+ 9.2	+15.9
Newcastle City	+ 2.1	- 5.0
Port Stephens Shire	+20.2	+18.0

Source: *Planning Workshops Pty. Limited (1977b)*

TABLE A14.3

NUMBER OF HOUSES IN NEWCASTLE STATISTICAL SUBDIVISION (1976)

Local Government Area	Occupied Private Dwellings	Owner or Purchaser Occupied (Percentage)	Unoccupied Private Dwellings
Cessnock	11,212	79.9	1,050
Lake Macquarie	39,232	76.8	3,416
Maitland	10,554	69.4	678
Newcastle	46,588	68.8	2,674
Port Stephens	6,104	62.0	2,018
TOTAL	113,690	71.4	9,836

Source: *Australian Bureau of Statistics (1976 Census)*

TABLE A14.4

SALES OF LAND AND HOUSES
NEWCASTLE STATISTICAL SUBDIVISION
(Year Ended 30th June, 1976)

Local Government Area	Vacant Land Number	Vacant Land Average Value $	Houses Number	Houses Average Value $
Cessnock	225	7,232	474	26,731
Lake Macquarie	1,020	9,868	1,749	30,381
Maitland	186	9,139	441	27,284
Newcastle	139	11,709	1,724	27,659
Port Stephens	718	9,353	347	31,758
TOTAL	2,288	9,500	4,685	27,954

Source: *Australian Bureau of Statistics.*

TABLE A14.5

HOUSING COMMISSION ACCOMMODATION UNITS
WITHIN 15 km OF THE SITE

Location	Houses	Attached Dwellings	Apartments	Dwellings for the Aged	Total
Newcastle City	1137	4	936	472	2549
Lake Macquarie	407			95	502
Maitland-Thornton	878			50	928
Raymond Terrace	866*			13	879
TOTAL	3292	4	936	630	4862

* 619 of these houses are owned by the RAAF

Source: *New South Wales Housing Commission, Newcastle.*

TABLE A14.6

CARAVAN PARK ACCOMMODATION
IN THE NEAR VICINITY OF THE SITE

Caravan Park	Total Number of Sites	Sites With Power	Number of On-site Vans
RAYMOND TERRACE			
Bellhaven Caravan Park	100	95	24
Motto Farm Caravan Park	124	104	12
NEWCASTLE			
Ponderosa Caravan Park	144	144	35
Stockton Caravan Park	192	128	4
Mayfield West	40	36	12
TOTAL	600	507	87

Source: *NRMA Caravan Park and Camping Directory 1979/80.*

TABLE A14.7

HOTEL-MOTELS IN THE NEWCASTLE ENVIRONS

Location	Number of Hotel-Motels	Number of Units
Maitland-East Maitland	6	115
Raymond Terrace	3	64
Newcastle and Suburbs	23	765
Nelson Bay	6	81
Lake Macquarie	15	215
TOTAL	53	1240

Source: *NRMA Accommodation Directory 1979/80.*

TABLE A14.8

PROPOSED ADDITIONAL SCHOOL FACILITIES
IN THE LOWER HUNTER SUBREGION

Location	Extensions	New Schools
Nelson Bay	PS	
Soldiers Point		HS
Medowie		PS
Raymond Terrace		PS, HS
Thornton	HS, PS	
Green Hills		PS
Rutherford		PS, HS
Bolwarra		PS
Croudace Bay - Eleebana		3 PS
Booragul	PS	
Fennell Bay	PS	
Toronto	PS	
Coal Point	PS	
Rathmines - Wangi Wangi	PS	
Morisset		PS

Key: PS - primary school
HS - high school
Source: *New South Wales Department of Education - Hunter Regional Office (1979).*

TABLE A14.9

SCHOOL PUPIL ENROLMENTS IN THE
LOWER HUNTER SUBREGION

Local Government Area	Primary Schools			Secondary Schools		
	Number of Schools	Enrolments	Average School Size	Number of Schools	Enrolments	Average School Size
Cessnock	24	3,992	166	2	2,054	1,027
Lake Macquarie	59	6,331	276	13	10,929	841
Maitland	17	4,164	245	5	3,641	728
Newcastle	45	12,536	279	16	12,338	771
Port Stephens	17	2,560	151	2	1,650	825

Source: *Department of Education and Department of Decentralisation and Development.*

TABLE A14.10

POPULATION AND HOSPITAL BEDS FOR
THE LOWER HUNTER SUBREGION (1978)

Health/Local Government Area	Estimated Population June 1978	Permitted Hospital Beds*	Actual Hospital Beds	Deficit/Surplus Hospital Beds
Newcastle	139,000	487	1,589	1,102 (Surplus)
Lake Macquarie	138,000	483	288	195 (Deficit)
Port Stephens	22,450	79	12	67 (Deficit)
Cessnock-Maitland-Dungog	81,750	286	586	300 (Surplus)
TOTAL	381,200	1,335	2,475	1,140 (Surplus)

Note: * Based upon the ratio of 3.5 beds per 1000 population.

Source: *Australian Bureau of Statistics Summary of Vital Statistics, 1978, Health Commission of New South Wales.*

TABLE A14.11

HEALTH SERVICES FOR THE LOWER HUNTER SUBREGION
(1976)

District	Baby Health Centres		Ambulances	
	Number	Rate *	Number	Rate+
Newcastle	14	153)	49	686
Lake Macquarie	10	234)		
Cessnock	4	151	8	4399
Maitland	3	229	6	5630
Port Stephens	2	192	4	4828

Note: * Number of babies born 1973/74, per Baby Health Centre.
+ Number of persons per ambulance; population estimated at 1976.

Source: *Gordon, et al. (1976)*

Appendix 15

AIR POLLUTION DISPERSION MODELLING TECHNIQUES

APPENDIX 15

AIR POLLUTION DISPERSION MODELLING TECHNIQUES

A15.1 DESCRIPTION OF THE MODEL

A15.1.1 General

Since a major part of the potential environmental effects of a smelter relate to the resultant concentration of air pollutants, particularly fluorides, it was necessary to develop a method of predicting the dispersion of gaseous emissions.

The methods considered were as follows:-

i. *Scale Model*

Physical modelling of a dispersion situation, for example in a wind tunnel, is sometimes desirable because most of the essential variables can be simulated and controlled accurately. However, with the large building size and a potentially extensive area being studied in this case, an experiment which could provide all the answers would not be economically and technologically feasible. To reduce the model to a reasonable size would require a high scaling factor, thereby eliminating the main advantage of a physical model which is the accurate representation of a site. In particular, atmospheric conditions and other meteorological factors cannot be accurately modelled.

ii. *Measurements of Existing Sources*

No smelter in Australia has been constructed in similar topographic conditions and subject to the same weather pattern as the Tomago site. The characteristics of fluoride sources will vary with the safeguards incorporated in the project and the selected pot type. Inaccuracies would be introduced if empirical attempts were made to relate measured results in other areas to this site.

Measurements of other types of pollutant sources in the Newcastle area were not possible because no single source was available in similar conditions. Only a short period of measurement would have been possible.

iii. *Mathematical Modelling*

The study of fluid behaviour in fully controlled situations has resulted in the development of mathematical relationships to describe this behaviour. Researchers have also investigated the applicability of these relationships to large-scale situations such as pollutant dispersion and have been able to include such aspects as atmospheric stability and the behaviour of hot gas plumes. There have been empirical modifications so that the mathematical relationships give results which correspond closely to values measured in the field. Such models are continually being refined to make full use of available meteorological and other data.

The main advantage of a mathematical relationship is that, once it has been proven to give reliable estimates in a number of actual cases, it can be used in other situations where the required data are available and it is not advisable to wait for the development to be established prior to predicting effects. The use of high speed computer facilities allows the testing of a number of alternatives and the production of reliable results within practical time and economic constraints. This was therefore the favoured modelling method.

One of the most commonly used models for air pollution dispersion is based on the Gaussian equation for the diffusion of gas plumes *(Strauss, 1971)*. The US Environmental Protection Agency has developed a model based on these equations *(Christianson, 1977)*. The New South Wales Electricity Commission also employs the same methods for assessing the impact of power station emissions on ground level sulphur dioxide concentrations and dust deposition rates *(Guthrie and Lamb, 1976)*. A similar model has been developed in France by the group which carries out pollution dispersion analysis for the French Government *(ECOPOL, 1980)*.

A computer program was developed for this study based on these equations. In order to check that the programming techniques used were correct, the Company commissioned an independent study by the ECOPOL group in France.

The following sections describe the model in detail, indicate the meteorological data and the emission data used, and assess the accuracy of the model.

A15.1.2 Basic Equation

Ground level concentrations of elevated gaseous emissions are given by the following basic formula:-

$$\chi = \frac{Q}{\pi\sigma_y\sigma_z u} \exp\left[-\tfrac{1}{2}\left(\frac{y^2}{\sigma_y^2} + \frac{h^2}{\sigma_z^2} \right) \right]$$ ......Equation A

where χ = ground level concentration (gm/m^3)
Q = emission rate (gm/s)
σ_y, σ_z = horizontal and vertical dispersion parameters (m)
u = wind speed (m/s)
h = effective height of emission source (m)
y = perpendicular distance from plume centreline (m)

This basic equation can be modified to more closely model actual emissions. For example, the rising of a high velocity plume or a hot plume can be modelled by modifying the effective height, h, in Equation A. Downwash in the wake of a building can also be incorporated in this part of the equation. Other aspects which can be catered for include deposition of particulate emissions, decay of the pollutant over a period of time and the conversion of the short term concentrations calculated by the above formula to longer term averages.

The discussion of the effect of these aspects on the model is included in the following sections.

A15.1.3 Dispersion Parameters

The dispersion parameters, σ_y and σ_z, vary with distance downwind of the source and the conditions of atmospheric stability which are present at any time. *Pasquill (1961)* and *Turner (1970)* devised a method of relating the parameters to one of six stability categories varying from A - Very Unstable to F - Very Stable and equations for the parameters have been derived for each category.

The form of the equations for the Pasquill parameters is

$$\sigma_y = (a_1 . \ln x + a_2) . x$$

$$\sigma_z = \frac{1}{2.15} \exp (b_1 + b_2 . \ln x + b_3 . \ln^2 x)$$

where x = distance from source to receptor, and a_1, a_2, b_1, b_2, b_3 and coefficients depending on the stability categories. The values of the co-efficients are given in *Table A15.1*.

Other methods of evaluating the dispersion parameters are available such as the American Society of Mechanical Engineers (ASME) power equations (*Cheremisinoff and Morresi, 1977*) which are based on the work of the Brookhaven National Laboratory. These equations were not used, mainly because of the smaller number of stability categories (four as opposed to six Pasquill categories) particularly in the most common case of near neutral conditions (Pasquill C, D, E). The curves are shown for comparison in *Figure A15.1*.

TABLE A15.1

COEFFICIENTS FOR DETERMINING DISPERSION PARAMETERS

Stability Category	σ_y a_1	a_2	b_1	σ_z b_2	b_3
A	-0.0234	0.3500	0.8800	-0.1520	0.1475
B	-0.0147	0.2480	-0.9850	0.8200	0.0168
C	-0.0117	0.1750	-1.1860	0.8500	0.0045
D	-0.0059	0.1080	-1.3500	0.7930	0.0022
E	-0.0059	0.0880	-2.8800	1.2550	-0.0420
F	-0.0029	0.0540	-3.8000	1.4190	-0.0550

The assessment of probabilities of the various combinations of wind speed, wind direction and stability category is discussed in *Section A15.3*.

A15.1.4 Buoyant Plume Rise

The work of *Briggs (1969)* indicated that the transitional plume rise due to temperature differences can be estimated from

$$\Delta h = 1.6\, F^{1/3}\, u^{-1}\, x^{2/3} \qquad \text{......Equation B}$$

where F = buoyancy flux parameter = $3.12Q(T_s-T_a)/T_s$
Q = volumetric emission rate (m^3/s)
T_s= temperature of emission (^oK)
T_a= ambient temperature (^oK)
u = wind speed (m/s)
x = downwind distance (m)

For neutral and unstable conditions, a conservative approximation to this equation is to use this equation up to a distance of $x = 3x^*$, then to consider the rise at this distance to be the final rise.

In this case $x^* = 2.17F^{2/5}\, h_s^{3/5}$ for h_s <300 m

where h_s = height of emission (m)

For stable stratification, Equation B holds up to a distance

$$x = 2.4\, us^{-1/2}$$

beyond which the plume levels off at about

$$\Delta h = 2.9 \left(\frac{F}{us}\right)^{1/3}$$

where s = restoring acceleration = $(g/T_a)\,(dT/dz+0.98)$
g = gravitational acceleration
dT/dz= vertical temperature gradient

and other parameters are as detailed above.

In the case of the Tomago smelter, the buoyancy flux parameter would be given by $F = 368.3/n$

where n = number of point sources assumed per potroom.

The values assumed in deriving this are a volumetric emission rate of 20 m^3/s per pot, 120 pots per potroom, an ambient temperature of 290^oK and a 305^oK emission temperature. For neutral conditions, x^* would then be equal to $151/(n)^{2/5}$ metres for an emission height of 23 m. For example, the value of x* could vary from 80 m for 5 sources to 34 m for 100 sources.

The resultant variation in Equation B at x = 3x* is from 259/u metres for 5 sources to 42.7/u metres for 100 sources. The effect of this variation on the resultant average ground level concentration is analysed in *Section A15.4*.

A15.1.5 Momentum Plume Rise

Two formulae for the calculation of plume rise due to initial vertical velocity are:

$$\Delta h = D\,(v_s/u)^{1.4} \qquad \text{......Equation 1}$$

$$\Delta h = 1.5D\,(v_s/u) \qquad \text{......Equation 2}$$

where D = stack diameter
v_s = stack velocity
u = ambient wind speed.

Stack diameter can be calculated from the volumetric rate of emission to achieve a required stack velocity.

For the Tomago smelter, only the dry scrubber gas and the baking furnace gas will be vented through stacks. A design exit velocity of 15 m/s has been selected for these stacks. *Table A15.2* compares the results of the two equations for the values of emission relevant to the dry process stacks.

TABLE A15.2

MOMENTUM RISE FOR SCRUBBER STACKS

Ambient Wind Speed	Δh Equation 1	Δh Equation 2
1	217	110
3	47	37
5	23	22
7	14	16

Equation 2 has been selected since it will give the higher ground level concentrations at low wind speeds.

A15.1.6 Building Downwash

A 'downwash' effect can be created by turbulence behind buildings when the wind is perpendicular to the structure and can affect ground level concentrations. An increase in concentration can occur for low level sources. Alternatively, there will be a decrease if a separated wake occurs and the plume is above the wake.

In this case, the situation is complicated by several buildings, the potential for different effects for different wind speeds and directions, the surrounding vegetation and the topography. Even the most recent research efforts have done little to provide better methods of analysis and merely indicate the complexity of the problem. However, the larger effects are expected to disappear within a few building heights *(Barrett et al, 1979)* and therefore should not influence the overall dispersion analysis.

Furth and Weil (1977) indicate that the major effect of the building wake on non-buoyant effluents is an enhancement of dispersion rather than a change in the plume centreline height. For buoyant plumes, a rise is expected in the building wake particularly for the case of a line source.

Later examples will examine downwash factors which result in an emission height, prior to the addition of plume rise, varying from 0.6 times the building height perpendicular to the potrooms up to 1.0 times the building height parallel to the potrooms.

A15.1.7 Particulate Deposition Rate

Equation A assumes that any gas reaching ground level is reflected by the ground, thereby effectively doubling the ground level concentration of the gas. Dispersion of particulates emitted from a stack differs from that of gases in that the particles settle under gravity and generally when they reach the ground they are deposited.

Two techniques of estimating the rate of particulate deposition discussed by *Somers (1971)* are the 'titled plume' model and the 'sink-image' model.

In the tilted plume model, the centreline of the plume is assumed to move downward at a rate proportional to the settling velocity of the particles. The ground level concentration given by Equation A is divided by a factor of two to approximate non-reflection from the ground. The ground level concentration multiplied by the particle settling velocity gives the deposition rate.

However, the particle size which will be emitted from the potline buildings results in very low settling velocities (about 1 mm/s). The overall effect is that the particles are of aerosol size and behave largely as a gas. In this case, a more appropriate model is to assume a source plus a sink-image which combine to give zero concentration (i.e. no reflection) at ground level. All transport to the ground occurs by eddy diffusion.

The rate of absorption of particulates by the ground is given by:

$$G = \frac{k\,Q\,h}{\pi \sigma_y \sigma_z{}^3 u} \exp\left[-\tfrac{1}{2}\left(\frac{y^2}{\sigma_y{}^2} + \frac{h^2}{\sigma_z{}^2}\right)\right] \quad \text{......Equation C}$$

where k = the anisotropic diffusion coefficient = $\sigma_z{}^2 u/2x$

The comparison given by Somers indicates that the sink-image method gives higher values of deposition for particles in the size range which would be expected from the smelter. Since deposition on the sandbeds is of some concern, it is believed that the use of Equation C will give a more realistic basis for the analysis of impact.

A15.1.8 Decay of Pollutant

A contaminant can be removed from the atmosphere by physical or chemical processes. An example is the assumption of non-reflection of particles at ground level in the previous section. Other examples are reaction with vegetation or structures and washout by rain.

Modelling of long term concentrations allows for such removal by the incorporation of decay equations. The Climatological Dispersion Model *(Christianson, 1977)* used by the US Environmental Protection Agency incorporates this by a factor

$$D = \exp(-0.692\ x/uT_{\frac{1}{2}})$$

where $T_{\frac{1}{2}}$ = assumed half life of the pollutant.

Values quoted for the half life of sulphur dioxide and nitrogen dioxide are 24 hours and 4 hours respectively. The half life of hydrogen fluoride emitted by the smelter is expected to be less than 4 hours because of its high reactivity and the surrounding dense vegetation.

Figure A15.2 indicates the values of the decay function for a variety of wind speeds and half lives down to 0.25 hours.

Through discussions with experienced personnel of Aluminium Pechiney it was established that no reliable estimates of half life of gaseous fluorides were available which would permit the inclusion of an accurate decay function in this model. It was therefore decided that a situation of no reflection at ground level would be used in the model. A comparison of the effect of this assumption with the various possible half lives indicates that, for the shortest half lives, non-reflection of the plume will give a lower concentration for points closest to the source and higher concentration at more remote areas.

A15.1.9 Averaging of Estimated Values

Two aspects must be dealt with when relating the results of the dispersion equations to a long term average situation. The first is the distribution of the plume concentrations over the full wind sector. Secondly, the concentrations from the equations relate to a short period and must be averaged over the time interval of the wind readings. These aspects are considered in this section.

In order to distribute the ground level concentration over a sector, Equations A and C are integrated for the range $-\infty<y<\infty$ and then divided by the relevant length of arc *(Somers, 1971)*. Assuming eight wind sectors and no ground level reflection of the plume the equations become:-

Average concentration:

$$\bar{X} = \left(\frac{2}{\pi}\right)^{3/2} \frac{Q}{\sigma_z u x} \exp -\tfrac{1}{2}\left(\frac{h}{\sigma_z}\right)^2 \qquad \text{......Equation D}$$

Average deposition or absorption:

$$\bar{G} = \left(\frac{2}{\pi}\right)^{3/2} \frac{Qh}{x^2 \sigma_z} \exp -\tfrac{1}{2}\left(\frac{h}{\sigma_z}\right)^2 \qquad \text{......Equation E}$$

The above equations predict short term ground level concentrations where it is assumed that meteorological conditions stay constant throughout the measuring period. In this case, where the Pasquill dispersion parameters are used, the predicted ground level concentration is equivalent to a 10 minute average *(Cheremisinoff and Morresi, 1977)*. This can be converted to average times using the formula:-

$$\frac{X_2}{X_1} = \left(\frac{t_1}{t_2}\right)^{\alpha}$$

where X_1 = concentration for averaging period t_1
X_2 = concentration for averaging period t_2
α = empirical constant equal to 0.17

For longer averaging periods, the multiplying factors are

30 minutes	0.83
1 hour	0.74
3 hours	0.61
6 hours	0.54
12 hours	0.48
24 hours	0.43

A15.2 DATA USED IN THE MODEL

A15.2.1 Emission Data

In *Section 8*, the emission data for the smelter were given in the form of kilograms of fluoride emitted per tonne of aluminium produced. The total emission was calculated to be 0.76 kg.F/t on average. However, for the purposes of the dispersion analysis, a worst case emission rate of 1.0 kg.F/t has been assumed. The additional emission has been estimated based on a collection efficiency of 97 per cent (97.5 per cent previously), and a scrubbing efficiency of 99.5 per cent (99.9 per cent previously).

The emission levels can be converted to emission rates (grams per second) using the average annual production rate. Other data are also needed for substitution in the plume rise equations and the dispersion equations and this is given in a basic form in *Table A15.3*.

TABLE A15.3

DATA FOR SOURCES OF EMISSION

Source Description	Volumetric Emission Rate	Temperature of Emission	Height of Emission (m)	Stack Velocity (m/s)
Potline Buildings (4)	20 m^3/s per pot	Ambient+15^oK	22	0
Dry Scrubber Units (4)	280 m^3/s per scrubber	340^oK	60	15
Baking Furnace Stack	50 m^3/s	340^oK	50	15

The potline buildings are line sources but were modelled as several point sources. The tests detailed in *Section A15.4* indicated that an accurate representation of the dispersion from the buildings was to assume 10 point sources for each of the outer potrooms, each source having a volumetric emission rate of 20 m^3/s.

The resultant emission characteristics for all sources are given in *Figure A15.3*. The layout of the sources on the site is also shown in this figure.

A15.2.2 Particle Size Distribution

In order to assist in the choice of models for estimating particulate fluoride deposition rates, the particle size range for the emissions must be known. At the Company's test facility in Europe, a series of twenty-two 24 h measurements were made of the size distribution of the roof line emissions. The results are given in *Table A15.4*.

The settling velocities of these fractions are low, ranging from 7.2 mm/s for 11 micron particles to less than 0.01 mm/s for particles less than 0.43 microns. It was on this basis that the decision was made to use the sink-image model for particulate deposition rather than the tilted plume model.

TABLE A15.4

SIZE DISTRIBUTION FOR ROOF EMISSIONS
OF PARTICULATE FLUORIDE

Particle Size Range (microns)	Proportion of the Emission		Percentage F in the Fraction
>11	0.28		7.7
7 - 11	0.09		13.9
4.7 - 7	0.12		13.1
3.3 - 4.7	0.08		19.5
2.1 - 3.3	0.07		20.0
1.1 - 2.1	0.11		10.3
0.65 - 1.1	0.08		24.5
0.43 - 0.65	0.08		23.9
<0.43	0.09		14.7
	1.00	Average =	16.4

A15.3 METEOROLOGICAL DATA

A15.3.1 Possible Sources of Data

All sources of meteorological data in the Newcastle area were examined to assess their applicability for this study. Of these, two sources were selected for analysis, namely the Williamtown RAAF Base and Consolidated Fertilisers Pty. Limited on Kooragang Island.

Since Williamtown is only about 13 km from the Tomago site, and both are on the coastal plain, the Williamtown data will represent a reliable indication of the meteorological conditions on the site. The range of measurements taken, particularly the use of radiosondes to give vertical temperature profiles, provides a more accurate basis than is usually available for the development of relationships between wind speeds, wind directions and stability categories.

The format of the Williamtown data was such that it allowed a relatively simple analysis by computer. A magnetic tape was supplied by the Bureau of Meteorology which contained all radiosonde readings (usually twice per day) and all wind speed/wind direction readings (up to eight times per day).

The data available from Consolidated Fertilisers Pty. Limited were in the form of entries in log books at six times per day. These data were entered onto computer and analysed in detail. It was found that, due to topographical differences and the presence of large structures in relative proximity to the monitoring point, the data could not be correlated with data from Williamtown. There were major differences in both wind speed and wind direction. The Consolidated Fertiliser data have therefore not been used in the dispersion analysis.

Other sources of data rejected because of doubts as to their reliability, because they were not considered representative of conditions at the site or due to difficulties with the form of the data, included stations at Nobbys Head, Maryville and Greenleaf Fertilisers Pty. Limited. Data from other stations were generally of short duration.

A15.3.2 Analysis of Atmospheric Stability

The breakdown of the radiosonde data into the various Pasquill classifications was carried out in two stages.

Firstly, the results for each radiosonde ascent were analysed to give a temperature gradient of 1000 m. Using the classifications given in *Table A15.5*, it was found that only Categories D and E occurred at the times of recording (9 am and 9 pm) based on a total of 15,675 records over a period of some 25 years.

TABLE A15.5

STABILITY CLASSIFICATIONS

Pasquill/Turner Classification	Atmospheric Stability	Temperature Gradient (dT/dz) (^{o}C/100m)
A	Very unstable	<-1.90
B	Unstable	-1.70 to -1.90
C	Slightly unstable	-1.50 to -1.69
D	Neutral	-0.5 to -1.49
E	Stable	1.5 to -0.49
F	Very stable	>1.5

Source: *Christianson (1977).*

Although the predominance of neutral and stable conditions was expected, the complete absence of other categories was considered unrealistic. It was felt that the height at which the first temperature reading was available, namely about 1000 m, tended to mask effects such as low level inversions.

For example, the study by *ECOPOL (1980)* assumed a breakdown into stability classes based on wind speed and known average ratios for a temperate climate and coastal area. This resulted in the following proportions using a shorter period of wind recordings:-

Category A	-	0.1 per cent
Category B	-	3.0 per cent
Category C	-	8.0 per cent

Category D	-	75.2 per cent
Category E	-	10.2 per cent
Category F	-	3.5 per cent.

The high frequency of Category D is explained by the presence of clouds which form at the sea-land interface.

Therefore, as a second stage of analysis, the temperature gradients were broken down into intervals of 0.2 degrees per 100 m. The resultant frequencies for each month and the total year for 9 am and 9 pm are shown in *Table A15.6*. On the basis of this breakdown, the temperature gradients used to define the stability categories were selected to be those shown in *Table A15.6*.

From the table it can be seen that the period of highest average stability is in May and June as expected. The period of greatest instability is November and December. The morning readings show greater variation in stability which is also expected.

It should also be noted that, since radiosonde readings were not available during the afternoon periods of highest instability, the proportions of the various categories will be biased towards stable conditions.

This would tend to give an overestimate of the average ground level concentrations. However, this bias has been largely compensated for by the selection of temperature gradients which generally result in the normal proportion of the various categories.

A15.3.3 Analysis of Wind Speed and Wind Direction

In order to get a frequency of each wind speed, wind direction and stability category for each month, radiosonde readings were matched where possible with wind speed and wind direction data and the matched data put into one of six wind speed classes, one of eight wind direction classes and the appropriate Pasquill stability category.

Since the analysis involved only winds at 9 am and 9 pm, it was necessary to verify that these times were reasonably representative of the average daily wind pattern.

Figure A15.4 gives the cumulative frequency of winds at 9 am plus 9 pm and wind at all times (up to eight times per day). For each case, the wind speeds up to 19 km/h and all winds are shown for January and July.

It can be seen that the correlation is good in terms of the percentage of winds in particular directions. For both months there is a bias to lower wind speeds for the 9 am and 9 pm data. This is expected because the early afternoon period is not considered. For July the winds follow the same basic pattern but there is up to 8 per cent difference in the cumulative percentages due to the higher proportion of calms for the 9 am and 9 pm data. The method used to analyse the data resulted in the calms not being considered. The differences in the patterns would then be substantially reduced.

As an overall conclusion, the wind matrix based on readings at 9 am and 9 pm will have a bias towards the low wind speeds which will result in a slight overestimate of average ground level fluoride concentrations.

A15.3.4 Data Used in the Model

Following the analysis of the stability categories, the next stage was to derive a probability of each combination of wind speed, wind direction and stability category for each month. All readings for the period of record were examined to find those where both wind speed and direction information and radiosonde readings were available.

The resulting probabilities of each combination are presented in *Tables A15.7* to *A15.18* in the form they were used in the model.

A15.4 TESTING AND VERIFICATION OF THE MODEL

A15.4.1 General

A series of tests were carried out to determine the sensitivity of the model to ranges of values for the various parameters in the model. The factors tested and detailed below include the number of sources assumed

TABLE A15.6

FREQUENCIES OF TEMPERATURE GRADIENTS TO 1000 m

Temperature Gradient (°C/100 m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Category	Percentage in Category
	Frequencies (percentage)														
TIME: 9.00 am															
≤-1.3	0	0	0	0	0	0	0	0	0.2	0.2	0.5	0.2	0.1	A	0.1
-1.3 to -1.1	2.7	1.3	0.7	0	0.2	0.2	0.2	0.3	2.1	4.7	5.5	4.0	1.8	B	1.8
-1.1 to -0.9	21.6	18.3	12.8	7.7	3.4	2.3	3.1	6.4	16.5	26.5	25.9	23.6	14.0	C	14.0
-0.9 to -0.7	28.7	30.6	33.2	21.4	14.0	10.8	10.9	21.6	31.4	27.3	27.6	28.0	23.9	D	77.2
-0.7 to -0.5	23.0	22.9	26.1	34.9	28.3	23.5	24.6	32.1	24.6	19.0	18.9	22.2	25.0		
-0.5 to -0.3	12.9	15.5	13.5	18.1	25.0	29.3	27.0	17.1	16.1	13.3	12.3	11.2	17.6		
-0.3 to -0.1	6.4	7.1	10.7	12.9	17.2	17.7	18.5	12.5	6.6	6.0	6.0	6.9	10.7		
-0.1 to 0.1	2.7	3.8	1.9	4.4	9.1	10.5	10.4	7.7	2.2	2.4	2.2	2.5	5.0	E	5.0
0.1 to 0.3	1.6	0.3	0.9	0.6	2.1	4.1	4.3	1.6	0.3	0.7	0.8	1.0	1.5	F	1.9
0.3 to 0.5	0.2	0.2	0.2	0	0.3	1.3	1.0	0.6	0	0	0	0.3	0.3		
0.5 to 0.7	0.2	0	0	0	0.2	0.3	0	0.1	0	0	0.3	0	0.1		
>0.7	0	0	0	0	0.2	0	0	0	0	0	0	0	0		
TIME: 9.00 pm															
≤-1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	A	0
-1.3 to -1.1	0	0.2	0	0	0.2	0	0	0	0	0	0	0	0	B	0
-1.1 to -0.9	4.5	2.4	1.9	1.6	0.8	1.4	0.6	1.1	2.2	2.3	2.3	3.5	2.1	C	2.1
-0.9 to -0.7	17.2	18.4	15.9	13.7	10.1	11.5	12.1	13.8	17.2	15.8	22.3	18.8	15.6	D	84.1
-0.7 to -0.5	29.1	32.9	26.8	20.2	24.4	25.9	23.8	27.6	22.5	24.3	22.9	23.6	25.4		
-0.5 to -0.3	23.8	24.2	28.2	26.2	23.3	27.0	22.2	25.7	26.5	26.0	23.3	18.2	24.6		
-0.3 to -0.1	13.4	13.7	19.4	24.6	20.2	14.5	18.9	19.3	20.7	19.4	17.4	20.9	18.5		
-0.1 to 0.1	8.1	7.1	6.0	11.7	12.7	12.7	14.0	9.3	9.0	9.0	8.8	10.7	9.9	E	9.9
0.1 to 0.3	2.9	0.9	1.6	1.6	6.3	5.0	5.9	2.8	1.3	2.4	1.7	3.7	3.0	F	3.9
0.3 to 0.5	0.6	0	0.2	0.4	1.2	1.6	1.9	0.2	0.2	0.8	1.1	0.6	0.7		
0.5 to 0.7	0.4	0.2	0	0	0.8	0.2	0.4	0.2	0.4	0	0.2	0	0.2		
>0.7	0	0	0	0	0	0.2	0.2	0	0	0	0	0	0		

TABLE A15.7
PROPORTIONS OF READINGS IN WIND CLASSES FOR JANUARY

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000966	0.000000	0.000000	0.000966
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.WEST	0.000000	0.000000	0.000966	0.000966	0.000000	0.000000	0.001932
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.000000	0.000966	0.000000	0.000000	0.000966	0.000000	0.001932
B	EAST	0.000000	0.001932	0.004831	0.001932	0.001932	0.000000	0.010628
B	S.EAST	0.000966	0.000966	0.005797	0.001932	0.000966	0.000000	0.010628
B	SOUTH	0.000000	0.000000	0.002899	0.003865	0.001932	0.000000	0.008696
B	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	WEST	0.000000	0.000000	0.000966	0.000000	0.000966	0.000000	0.001932
B	N.WEST	0.000000	0.000000	0.000966	0.000966	0.000000	0.000966	0.002899
C	NORTH	0.000966	0.000000	0.000966	0.000000	0.000000	0.000000	0.001932
C	N.EAST	0.000966	0.006763	0.009662	0.002899	0.000966	0.000000	0.021256
C	EAST	0.000966	0.013527	0.013527	0.011594	0.000000	0.000000	0.039614
C	S.EAST	0.003865	0.021256	0.018358	0.007729	0.000000	0.000000	0.051208
C	SOUTH	0.000966	0.009662	0.016425	0.015459	0.002899	0.001932	0.047343
C	S.WEST	0.000966	0.001932	0.002899	0.001932	0.000000	0.000000	0.007729
C	WEST	0.001932	0.001932	0.007729	0.000966	0.000000	0.000000	0.012560
C	N.WEST	0.000000	0.000966	0.000966	0.000000	0.000000	0.001932	0.003865
D	NORTH	0.011594	0.022222	0.004831	0.002899	0.000000	0.000000	0.041546
D	N.EAST	0.012560	0.065701	0.042512	0.016425	0.001932	0.000000	0.139130
D	EAST	0.014493	0.065701	0.045411	0.016425	0.002899	0.000000	0.144928
D	S.EAST	0.007729	0.029952	0.037681	0.018358	0.003865	0.000000	0.097585
D	SOUTH	0.007729	0.037681	0.070531	0.041546	0.010628	0.004831	0.172947
D	S.WEST	0.003865	0.007729	0.009662	0.003865	0.000966	0.000966	0.027053
D	WEST	0.005797	0.016425	0.005797	0.007729	0.001932	0.000000	0.037681
D	N.WEST	0.008696	0.019324	0.010628	0.001932	0.000966	0.000000	0.041546
E	NORTH	0.000000	0.001932	0.000000	0.000966	0.000000	0.000000	0.002899
E	N.EAST	0.002899	0.011594	0.004831	0.001932	0.000000	0.000000	0.021256
E	EAST	0.000966	0.002899	0.001932	0.001932	0.000000	0.000000	0.007729
E	S.EAST	0.000966	0.000000	0.000000	0.000000	0.000000	0.000000	0.000966
E	SOUTH	0.000000	0.000000	0.002899	0.000000	0.000000	0.000000	0.002899
E	S.WEST	0.000966	0.000000	0.000966	0.000000	0.000000	0.000000	0.001932
E	WEST	0.000000	0.000966	0.000000	0.000966	0.000000	0.000000	0.001932
E	N.WEST	0.000000	0.000966	0.001932	0.000966	0.000000	0.000000	0.003865
F	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	N.EAST	0.000000	0.004831	0.002899	0.000966	0.000000	0.000000	0.008696
F	EAST	0.000000	0.001932	0.000966	0.000000	0.000000	0.000000	0.002899
F	S.EAST	0.001932	0.000000	0.000966	0.000000	0.000000	0.000000	0.002899
F	SOUTH	0.000966	0.000966	0.002899	0.006763	0.000000	0.000000	0.011594
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.000000	0.001932	0.000000	0.000000	0.000000	0.000000	0.001932
F	N.WEST	0.000966	0.000000	0.000000	0.000000	0.000000	0.000000	0.000966

TABLE A15.8
PROPORTIONS OF READINGS IN WIND CLASSES FOR FEBRUARY

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.001122	0.000000	0.000000	0.000000	0.000000	0.001122
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.001122	0.000000	0.000000	0.004489	0.000000	0.000000	0.005612
B	EAST	0.001122	0.002245	0.001122	0.003367	0.000000	0.000000	0.007856
B	S.EAST	0.001122	0.000000	0.001122	0.001122	0.000000	0.000000	0.003367
B	SOUTH	0.000000	0.000000	0.001122	0.001122	0.001122	0.000000	0.003367
B	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	WEST	0.000000	0.000000	0.002245	0.000000	0.000000	0.000000	0.002245
B	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
C	NORTH	0.000000	0.002245	0.000000	0.000000	0.000000	0.000000	0.002245
C	N.EAST	0.001122	0.005612	0.008979	0.002245	0.000000	0.000000	0.017957
C	EAST	0.003367	0.012346	0.017957	0.002245	0.000000	0.000000	0.035915
C	S.EAST	0.001122	0.014590	0.022447	0.006734	0.000000	0.000000	0.044893
C	SOUTH	0.002245	0.011223	0.014590	0.014590	0.000000	0.001122	0.043771
C	S.WEST	0.002245	0.002245	0.003367	0.002245	0.000000	0.000000	0.010101
C	WEST	0.000000	0.002245	0.003367	0.001122	0.000000	0.000000	0.006734
C	N.WEST	0.000000	0.000000	0.000000	0.001122	0.002245	0.000000	0.003367
D	NORTH	0.011223	0.022447	0.003367	0.001122	0.000000	0.000000	0.038159
D	N.EAST	0.015713	0.067340	0.050505	0.008979	0.001122	0.000000	0.143659
D	EAST	0.031425	0.063973	0.038159	0.016835	0.002245	0.002245	0.154882
D	S.EAST	0.010101	0.031425	0.039282	0.014590	0.003367	0.001122	0.099888
D	SOUTH	0.013468	0.056117	0.057239	0.046016	0.007856	0.005612	0.186308
D	S.WEST	0.004489	0.021324	0.019080	0.007856	0.000000	0.000000	0.052750
D	WEST	0.015713	0.021324	0.010101	0.003367	0.001122	0.000000	0.051627
D	N.WEST	0.010101	0.017957	0.006734	0.001122	0.000000	0.000000	0.035915
E	NORTH	0.000000	0.003367	0.000000	0.002245	0.000000	0.000000	0.005612
E	N.EAST	0.001122	0.005612	0.004489	0.002245	0.000000	0.000000	0.013468
E	EAST	0.002245	0.001122	0.001122	0.000000	0.000000	0.000000	0.004489
E	S.EAST	0.000000	0.001122	0.000000	0.000000	0.000000	0.000000	0.001122
E	SOUTH	0.002245	0.003367	0.002245	0.001122	0.001122	0.000000	0.010101
E	S.WEST	0.000000	0.000000	0.001122	0.000000	0.000000	0.000000	0.001122
E	WEST	0.000000	0.001122	0.000000	0.000000	0.000000	0.000000	0.001122
E	N.WEST	0.002245	0.002245	0.002245	0.000000	0.000000	0.000000	0.006734
F	NORTH	0.000000	0.001122	0.000000	0.000000	0.000000	0.000000	0.001122
F	N.EAST	0.000000	0.000000	0.001122	0.000000	0.000000	0.000000	0.001122
F	EAST	0.001122	0.000000	0.000000	0.000000	0.000000	0.000000	0.001122
F	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	SOUTH	0.000000	0.000000	0.000000	0.001122	0.000000	0.000000	0.001122
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

TABLE A15.9
PROPORTIONS OF READINGS IN WIND CLASSES FOR MARCH

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.000000	0.001139	0.000000	0.001139	0.000000	0.000000	0.002278
B	EAST	0.000000	0.000000	0.001139	0.000000	0.000000	0.000000	0.001139
B	S.EAST	0.000000	0.001139	0.001139	0.000000	0.000000	0.000000	0.002278
B	SOUTH	0.000000	0.000000	0.001139	0.000000	0.000000	0.000000	0.001139
B	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	WEST	0.000000	0.000000	0.001139	0.002278	0.000000	0.001139	0.004556
B	N.WEST	0.000000	0.000000	0.000000	0.002278	0.000000	0.000000	0.002278
C	NORTH	0.000000	0.000000	0.001139	0.000000	0.000000	0.000000	0.001139
C	N.EAST	0.000000	0.006834	0.000000	0.005695	0.000000	0.000000	0.012529
C	EAST	0.002278	0.006834	0.011390	0.000000	0.002278	0.000000	0.022779
C	S.EAST	0.002278	0.007973	0.017084	0.006834	0.002278	0.000000	0.036447
C	SOUTH	0.000000	0.007973	0.011390	0.025057	0.003417	0.001139	0.048975
C	S.WEST	0.001139	0.001139	0.002278	0.005695	0.001139	0.000000	0.011390
C	WEST	0.001139	0.001139	0.002278	0.004556	0.000000	0.000000	0.009112
C	N.WEST	0.000000	0.002278	0.002278	0.001139	0.001139	0.000000	0.006834
D	NORTH	0.007973	0.026196	0.005695	0.001139	0.000000	0.000000	0.041002
D	N.EAST	0.018223	0.070615	0.038724	0.007973	0.001139	0.000000	0.136674
D	EAST	0.014806	0.048975	0.026196	0.010251	0.000000	0.000000	0.100228
D	S.EAST	0.009112	0.035308	0.036447	0.030752	0.002278	0.001139	0.115034
D	SOUTH	0.015945	0.046697	0.050114	0.042141	0.010251	0.003417	0.168565
D	S.WEST	0.005695	0.021640	0.010251	0.010251	0.001139	0.000000	0.048975
D	WEST	0.017084	0.039863	0.020501	0.017084	0.000000	0.000000	0.094533
D	N.WEST	0.017084	0.050114	0.015945	0.004556	0.001139	0.000000	0.088838
E	NORTH	0.000000	0.001139	0.001139	0.000000	0.000000	0.000000	0.002278
E	N.EAST	0.000000	0.005695	0.002278	0.000000	0.000000	0.000000	0.007973
E	EAST	0.001139	0.002278	0.000000	0.000000	0.000000	0.000000	0.003417
E	S.EAST	0.000000	0.001139	0.000000	0.000000	0.000000	0.000000	0.001139
E	SOUTH	0.000000	0.001139	0.000000	0.000000	0.000000	0.000000	0.001139
E	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	WEST	0.000000	0.003417	0.002278	0.001139	0.000000	0.000000	0.006834
E	N.WEST	0.001139	0.002278	0.004556	0.000000	0.000000	0.000000	0.007973
F	NORTH	0.000000	0.000000	0.001139	0.000000	0.000000	0.000000	0.001139
F	N.EAST	0.001139	0.001139	0.000000	0.000000	0.000000	0.000000	0.002278
F	EAST	0.000000	0.001139	0.000000	0.000000	0.000000	0.000000	0.001139
F	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.001139	0.000000	0.002278	0.000000	0.000000	0.000000	0.003417
F	N.WEST	0.000000	0.003417	0.001139	0.000000	0.000000	0.000000	0.004556

TABLE A15.10
PROPORTIONS OF READINGS IN WIND CLASSES FOR APRIL

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	S.EAST	0.001269	0.000000	0.000000	0.001269	0.000000	0.000000	0.002538
B	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.001269	0.001269
B	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	WEST	0.000000	0.000000	0.001269	0.002538	0.000000	0.001269	0.005076
B	N.WEST	0.000000	0.002538	0.001269	0.002538	0.001269	0.001269	0.008883
C	NORTH	0.000000	0.003807	0.002538	0.001269	0.000000	0.000000	0.007614
C	N.EAST	0.001269	0.002538	0.000000	0.000000	0.000000	0.000000	0.003807
C	EAST	0.001269	0.002538	0.000000	0.001269	0.000000	0.000000	0.005076
C	S.EAST	0.001269	0.005076	0.006345	0.012690	0.000000	0.001269	0.026650
C	SOUTH	0.000000	0.006345	0.005076	0.012690	0.005076	0.000000	0.029188
C	S.WEST	0.000000	0.002538	0.001269	0.002538	0.000000	0.000000	0.006345
C	WEST	0.001269	0.001269	0.001269	0.007614	0.008883	0.002538	0.022843
C	N.WEST	0.000000	0.001269	0.001269	0.000000	0.002538	0.002538	0.007614
D	NORTH	0.019036	0.021574	0.005076	0.000000	0.000000	0.000000	0.045685
D	N.EAST	0.024112	0.039340	0.012690	0.007614	0.000000	0.000000	0.083756
D	EAST	0.015228	0.019036	0.008883	0.005076	0.001269	0.000000	0.049492
D	S.EAST	0.003807	0.019036	0.030457	0.008883	0.001269	0.001269	0.064721
D	SOUTH	0.007614	0.020305	0.038071	0.027919	0.006345	0.002538	0.102792
D	S.WEST	0.007614	0.036802	0.019036	0.011421	0.002538	0.000000	0.077411
D	WEST	0.022843	0.078680	0.072335	0.039340	0.010152	0.006345	0.229695
D	N.WEST	0.036802	0.073604	0.039340	0.024112	0.006345	0.001269	0.181472
E	NORTH	0.001269	0.002538	0.000000	0.000000	0.000000	0.000000	0.003807
E	N.EAST	0.000000	0.002538	0.001269	0.000000	0.000000	0.000000	0.003807
E	EAST	0.000000	0.001269	0.001269	0.000000	0.000000	0.000000	0.002538
E	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	SOUTH	0.000000	0.000000	0.000000	0.000000	0.001269	0.000000	0.001269
E	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	WEST	0.001269	0.002538	0.005076	0.000000	0.000000	0.000000	0.008883
E	N.WEST	0.000000	0.010152	0.002538	0.000000	0.001269	0.000000	0.013959
F	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.000000	0.001269	0.000000	0.000000	0.000000	0.000000	0.001269
F	N.WEST	0.001269	0.001269	0.000000	0.000000	0.000000	0.000000	0.002538

TABLE A15.11
PROPORTIONS OF READINGS IN WIND CLASSES FOR MAY

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	SOUTH	0.000000	0.001198	0.001198	0.000000	0.000000	0.000000	0.002395
B	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	WEST	0.000000	0.000000	0.000000	0.002395	0.000000	0.004790	0.007186
B	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
C	NORTH	0.000000	0.001198	0.000000	0.000000	0.000000	0.000000	0.001198
C	N.EAST	0.000000	0.001198	0.000000	0.000000	0.000000	0.000000	0.001198
C	EAST	0.000000	0.000000	0.001198	0.001198	0.000000	0.000000	0.002395
C	S.EAST	0.000000	0.001198	0.002395	0.001198	0.000000	0.000000	0.004790
C	SOUTH	0.000000	0.003593	0.003593	0.005988	0.002395	0.000000	0.015569
C	S.WEST	0.000000	0.000000	0.004790	0.007186	0.002395	0.000000	0.014371
C	WEST	0.000000	0.003593	0.007186	0.011976	0.005988	0.014371	0.043114
C	N.WEST	0.000000	0.001198	0.002395	0.005988	0.003593	0.001198	0.014371
D	NORTH	0.008383	0.005988	0.001198	0.001198	0.000000	0.000000	0.016767
D	N.EAST	0.005988	0.010778	0.003593	0.001198	0.000000	0.000000	0.021557
D	EAST	0.003593	0.007186	0.008383	0.003593	0.000000	0.000000	0.022755
D	S.EAST	0.000000	0.005988	0.004790	0.009581	0.001198	0.001198	0.022755
D	SOUTH	0.005988	0.025150	0.015569	0.008383	0.003593	0.003593	0.062276
D	S.WEST	0.007186	0.026347	0.032335	0.011976	0.004790	0.001198	0.083832
D	WEST	0.033533	0.099401	0.106587	0.081437	0.043114	0.025150	0.389222
D	N.WEST	0.037126	0.074252	0.049102	0.020359	0.008383	0.008383	0.197605
E	NORTH	0.001198	0.000000	0.000000	0.000000	0.000000	0.000000	0.001198
E	N.EAST	0.002395	0.000000	0.000000	0.000000	0.000000	0.000000	0.002395
E	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	SOUTH	0.000000	0.001198	0.000000	0.000000	0.000000	0.000000	0.001198
E	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	WEST	0.003593	0.009581	0.005988	0.004790	0.000000	0.000000	0.023952
E	N.WEST	0.005988	0.013174	0.010778	0.000000	0.000000	0.000000	0.029940
F	NORTH	0.002395	0.001198	0.000000	0.000000	0.000000	0.000000	0.003593
F	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.001198	0.001198	0.002395	0.000000	0.001198	0.000000	0.005988
F	N.WEST	0.001198	0.002395	0.004790	0.000000	0.000000	0.000000	0.008383

TABLE A15.12
PROPORTIONS OF READINGS IN WIND CLASSES FOR JUNE

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	S.EAST	0.000000	0.000000	0.000000	0.000000	0.001085	0.000000	0.001085
B	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.002169	0.002169
B	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
C	NORTH	0.000000	0.000000	0.001085	0.000000	0.000000	0.000000	0.001085
C	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
C	EAST	0.000000	0.000000	0.000000	0.002169	0.000000	0.000000	0.002169
C	S.EAST	0.000000	0.000000	0.001085	0.001085	0.000000	0.000000	0.002169
C	SOUTH	0.000000	0.000000	0.004338	0.003254	0.000000	0.000000	0.007592
C	S.WEST	0.001085	0.001085	0.000000	0.002169	0.000000	0.001085	0.005423
C	WEST	0.000000	0.000000	0.005423	0.005423	0.005423	0.003254	0.019523
C	N.WEST	0.000000	0.001085	0.002169	0.004338	0.001085	0.005423	0.014100
D	NORTH	0.005423	0.005423	0.002169	0.000000	0.000000	0.000000	0.013015
D	N.EAST	0.001085	0.004338	0.002169	0.000000	0.000000	0.000000	0.007592
D	EAST	0.001085	0.005423	0.002169	0.002169	0.001085	0.000000	0.011931
D	S.EAST	0.000000	0.014100	0.011931	0.006508	0.003254	0.000000	0.035792
D	SOUTH	0.000000	0.014100	0.011931	0.017354	0.007592	0.003254	0.054230
D	S.WEST	0.007592	0.039046	0.029284	0.018438	0.004338	0.001085	0.099783
D	WEST	0.026030	0.124729	0.119306	0.093276	0.036876	0.021692	0.421909
D	N.WEST	0.023861	0.093276	0.046638	0.028200	0.010846	0.008677	0.211497
E	NORTH	0.001085	0.000000	0.000000	0.000000	0.000000	0.000000	0.001085
E	N.EAST	0.001085	0.001085	0.000000	0.000000	0.000000	0.000000	0.002169
E	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	WEST	0.003254	0.017354	0.005423	0.002169	0.001085	0.000000	0.029284
E	N.WEST	0.008677	0.014100	0.005423	0.000000	0.000000	0.000000	0.028200
F	NORTH	0.000000	0.003254	0.000000	0.000000	0.000000	0.000000	0.003254
F	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.001085	0.004338	0.003254	0.001085	0.000000	0.001085	0.010846
F	N.WEST	0.001085	0.008677	0.002169	0.002169	0.000000	0.000000	0.014100

TABLE A15.13
PROPORTIONS OF READINGS IN WIND CLASSES FOR JULY

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.001134	0.001134
B	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.001134	0.001134
C	NORTH	0.000000	0.000000	0.001134	0.000000	0.000000	0.000000	0.001134
C	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
C	EAST	0.000000	0.000000	0.001134	0.000000	0.000000	0.000000	0.001134
C	S.EAST	0.000000	0.000000	0.001134	0.002268	0.000000	0.000000	0.003401
C	SOUTH	0.000000	0.002268	0.001134	0.002268	0.001134	0.000000	0.006803
C	S.WEST	0.000000	0.005669	0.002268	0.001134	0.000000	0.001134	0.010204
C	WEST	0.000000	0.001134	0.004535	0.007937	0.005669	0.006803	0.026077
C	N.WEST	0.000000	0.001134	0.002268	0.002268	0.003401	0.010204	0.019274
D	NORTH	0.003401	0.006803	0.002268	0.000000	0.000000	0.000000	0.012472
D	N.EAST	0.004535	0.007937	0.001134	0.001134	0.000000	0.001134	0.015873
D	EAST	0.001134	0.001134	0.000000	0.005669	0.001134	0.000000	0.009070
D	S.EAST	0.000000	0.002268	0.003401	0.007937	0.000000	0.001134	0.014739
D	SOUTH	0.004535	0.007937	0.015873	0.006803	0.000000	0.001134	0.036281
D	S.WEST	0.005669	0.012472	0.014739	0.010204	0.005669	0.001134	0.049887
D	WEST	0.021542	0.098640	0.158730	0.146259	0.037415	0.022676	0.485261
D	N.WEST	0.019274	0.062358	0.061225	0.049887	0.017007	0.012472	0.222222
E	NORTH	0.000000	0.002268	0.000000	0.000000	0.000000	0.000000	0.002268
E	N.EAST	0.001134	0.000000	0.000000	0.000000	0.000000	0.000000	0.001134
E	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	S.WEST	0.001134	0.000000	0.000000	0.000000	0.000000	0.000000	0.001134
E	WEST	0.003401	0.007937	0.004535	0.002268	0.000000	0.000000	0.018141
E	N.WEST	0.003401	0.018141	0.010204	0.001134	0.000000	0.001134	0.034014
F	NORTH	0.000000	0.003401	0.000000	0.000000	0.000000	0.000000	0.003401
F	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.000000	0.000000	0.002268	0.000000	0.001134	0.000000	0.003401
F	N.WEST	0.004535	0.011338	0.004535	0.000000	0.000000	0.000000	0.020408

TABLE A15.14
PROPORTIONS OF READINGS IN WIND CLASSES FOR AUGUST

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	S.EAST	0.000000	0.001089	0.000000	0.000000	0.000000	0.000000	0.001089
B	SOUTH	0.000000	0.001089	0.000000	0.000000	0.000000	0.000000	0.001089
B	S.WEST	0.000000	0.000000	0.001089	0.000000	0.000000	0.000000	0.001089
B	WEST	0.000000	0.001089	0.002179	0.003268	0.002179	0.003268	0.011983
B	N.WEST	0.000000	0.000000	0.002179	0.000000	0.001089	0.004357	0.007625
C	NORTH	0.001089	0.000000	0.001089	0.000000	0.000000	0.000000	0.002179
C	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
C	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
C	S.EAST	0.000000	0.001089	0.001089	0.001089	0.000000	0.000000	0.003268
C	SOUTH	0.000000	0.004357	0.004357	0.002179	0.002179	0.002179	0.015251
C	S.WEST	0.000000	0.002179	0.001089	0.003268	0.000000	0.001089	0.007625
C	WEST	0.000000	0.003268	0.008715	0.015251	0.008715	0.015251	0.051198
C	N.WEST	0.000000	0.003268	0.001089	0.003268	0.006536	0.006536	0.020697
D	NORTH	0.006536	0.013072	0.004357	0.000000	0.000000	0.000000	0.023965
D	N.EAST	0.007625	0.019608	0.013072	0.002179	0.000000	0.001089	0.043573
D	EAST	0.006536	0.009804	0.003268	0.002179	0.001089	0.000000	0.022876
D	S.EAST	0.000000	0.009804	0.004357	0.002179	0.000000	0.000000	0.016340
D	SOUTH	0.004357	0.009804	0.015251	0.011983	0.001089	0.001089	0.043573
D	S.WEST	0.001089	0.007625	0.026144	0.018519	0.001089	0.000000	0.054466
D	WEST	0.026144	0.096950	0.122004	0.112200	0.046841	0.014161	0.418301
D	N.WEST	0.020697	0.064270	0.052288	0.035948	0.011983	0.009804	0.194989
E	NORTH	0.000000	0.003268	0.000000	0.000000	0.000000	0.000000	0.003268
E	N.EAST	0.000000	0.003268	0.001089	0.000000	0.000000	0.000000	0.004357
E	EAST	0.001089	0.000000	0.000000	0.000000	0.000000	0.000000	0.001089
E	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	WEST	0.001089	0.001089	0.002179	0.003268	0.000000	0.000000	0.007625
E	N.WEST	0.003268	0.017429	0.006536	0.000000	0.001089	0.000000	0.028322
F	NORTH	0.000000	0.002179	0.000000	0.000000	0.000000	0.000000	0.002179
F	N.EAST	0.001089	0.000000	0.000000	0.000000	0.000000	0.000000	0.001089
F	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.000000	0.000000	0.001089	0.000000	0.000000	0.000000	0.001089
F	N.WEST	0.001089	0.006536	0.001089	0.001089	0.000000	0.000000	0.009804

TABLE A15.15
PROPORTIONS OF READINGS IN WIND CLASSES FOR SEPTEMBER

STABILITY CLASS	DIRECTION	WIND SPEED (M/S)						
		0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.001099	0.001099
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.000000	0.000000	0.001099	0.000000	0.000000	0.000000	0.001099
B	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	S.EAST	0.000000	0.002198	0.000000	0.000000	0.000000	0.000000	0.002198
B	SOUTH	0.000000	0.000000	0.002198	0.001099	0.001099	0.000000	0.004396
B	S.WEST	0.000000	0.000000	0.001099	0.000000	0.000000	0.000000	0.001099
B	WEST	0.000000	0.000000	0.001099	0.004396	0.003297	0.005495	0.014286
B	N.WEST	0.000000	0.000000	0.001099	0.001099	0.001099	0.000000	0.003297
C	NORTH	0.001099	0.001099	0.001099	0.000000	0.000000	0.000000	0.003297
C	N.EAST	0.000000	0.000000	0.004396	0.000000	0.000000	0.000000	0.004396
C	EAST	0.000000	0.000000	0.002198	0.000000	0.000000	0.000000	0.002198
C	S.EAST	0.000000	0.005495	0.008791	0.002198	0.002198	0.000000	0.018681
C	SOUTH	0.000000	0.008791	0.015385	0.006593	0.001099	0.001099	0.032967
C	S.WEST	0.001099	0.002198	0.005495	0.005495	0.001099	0.000000	0.015385
C	WEST	0.000000	0.005495	0.008791	0.026374	0.012088	0.010989	0.063736
C	N.WEST	0.000000	0.005495	0.003297	0.004396	0.004396	0.005495	0.023077
D	NORTH	0.014286	0.032967	0.008791	0.003297	0.000000	0.000000	0.059341
D	N.EAST	0.009890	0.040659	0.024176	0.004396	0.000000	0.000000	0.079121
D	EAST	0.007692	0.009890	0.007692	0.003297	0.000000	0.000000	0.028571
D	S.EAST	0.002198	0.009890	0.005495	0.005495	0.001099	0.002198	0.026374
D	SOUTH	0.003297	0.021978	0.029670	0.027473	0.008791	0.001099	0.092308
D	S.WEST	0.003297	0.018681	0.019780	0.017582	0.004396	0.001099	0.064835
D	WEST	0.012088	0.071429	0.079121	0.064835	0.016484	0.005495	0.249451
D	N.WEST	0.023077	0.070330	0.038462	0.030769	0.003297	0.005495	0.171429
E	NORTH	0.000000	0.002198	0.001099	0.000000	0.000000	0.000000	0.003297
E	N.EAST	0.003297	0.005495	0.001099	0.000000	0.000000	0.000000	0.009890
E	EAST	0.001099	0.002198	0.000000	0.000000	0.000000	0.000000	0.003297
E	S.EAST	0.001099	0.000000	0.000000	0.000000	0.000000	0.000000	0.001099
E	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	S.WEST	0.000000	0.000000	0.001099	0.000000	0.000000	0.000000	0.001099
E	WEST	0.000000	0.002198	0.001099	0.000000	0.000000	0.000000	0.003297
E	N.WEST	0.001099	0.004396	0.002198	0.000000	0.000000	0.000000	0.007692
F	NORTH	0.001099	0.000000	0.000000	0.000000	0.000000	0.000000	0.001099
F	N.EAST	0.001099	0.001099	0.000000	0.000000	0.000000	0.000000	0.002198
F	EAST	0.001099	0.000000	0.000000	0.000000	0.000000	0.000000	0.001099
F	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.001099	0.001099	0.000000	0.000000	0.000000	0.000000	0.002198
F	N.WEST	0.000000	0.001099	0.000000	0.000000	0.000000	0.000000	0.001099

TABLE A15.16
PROPORTIONS OF READINGS IN WIND CLASSES FOR OCTOBER

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.001047	0.000000	0.000000	0.000000	0.000000	0.001047
A	WEST	0.000000	0.000000	0.000000	0.001047	0.000000	0.001047	0.002094
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	N.EAST	0.000000	0.001047	0.001047	0.002094	0.000000	0.000000	0.004188
B	EAST	0.000000	0.001047	0.001047	0.000000	0.000000	0.000000	0.002094
B	S.EAST	0.000000	0.000000	0.001047	0.000000	0.000000	0.000000	0.001047
B	SOUTH	0.000000	0.000000	0.000000	0.003141	0.001047	0.000000	0.004188
B	S.WEST	0.000000	0.001047	0.004188	0.001047	0.000000	0.000000	0.006283
B	WEST	0.000000	0.000000	0.002094	0.008377	0.005236	0.005236	0.020942
B	N.WEST	0.000000	0.000000	0.001047	0.003141	0.002094	0.003141	0.009424
C	NORTH	0.000000	0.001047	0.002094	0.000000	0.001047	0.000000	0.004188
C	N.EAST	0.000000	0.010471	0.005236	0.004188	0.000000	0.000000	0.019895
C	EAST	0.001047	0.004188	0.008377	0.005236	0.000000	0.000000	0.018848
C	S.EAST	0.000000	0.006283	0.012565	0.002094	0.001047	0.000000	0.021990
C	SOUTH	0.001047	0.007330	0.016754	0.013613	0.005236	0.003141	0.047120
C	S.WEST	0.000000	0.007330	0.008377	0.007330	0.002094	0.000000	0.025131
C	WEST	0.000000	0.007330	0.023037	0.018848	0.009424	0.004188	0.062827
C	N.WEST	0.001047	0.005236	0.004188	0.005236	0.005236	0.003141	0.024084
D	NORTH	0.012565	0.030367	0.008377	0.001047	0.001047	0.000000	0.053403
D	N.EAST	0.017801	0.049215	0.040838	0.011518	0.000000	0.000000	0.119372
D	EAST	0.005236	0.029319	0.018848	0.006283	0.000000	0.000000	0.059686
D	S.EAST	0.003141	0.011518	0.023037	0.011518	0.000000	0.000000	0.049215
D	SOUTH	0.010471	0.029319	0.039791	0.026178	0.007330	0.003141	0.116230
D	S.WEST	0.005236	0.015707	0.026178	0.010471	0.005236	0.001047	0.063874
D	WEST	0.013613	0.034555	0.039791	0.017801	0.010471	0.002094	0.118325
D	N.WEST	0.014660	0.033508	0.032461	0.009424	0.006283	0.004188	0.100524
E	NORTH	0.001047	0.004188	0.002094	0.000000	0.000000	0.000000	0.007330
E	N.EAST	0.001047	0.009424	0.003141	0.000000	0.000000	0.000000	0.013613
E	EAST	0.002094	0.000000	0.000000	0.000000	0.000000	0.000000	0.002094
E	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	SOUTH	0.000000	0.002094	0.001047	0.001047	0.001047	0.000000	0.005236
E	S.WEST	0.001047	0.000000	0.000000	0.001047	0.000000	0.000000	0.002094
E	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	N.WEST	0.001047	0.001047	0.001047	0.002094	0.000000	0.000000	0.005236
F	NORTH	0.000000	0.001047	0.000000	0.000000	0.000000	0.000000	0.001047
F	N.EAST	0.001047	0.002094	0.000000	0.001047	0.000000	0.000000	0.004188
F	EAST	0.000000	0.001047	0.000000	0.000000	0.000000	0.000000	0.001047
F	S.EAST	0.001047	0.000000	0.000000	0.000000	0.000000	0.000000	0.001047
F	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	N.WEST	0.000000	0.001047	0.000000	0.000000	0.000000	0.000000	0.001047

TABLE A15.17
PROPORTIONS OF READINGS IN WIND CLASSES FOR NOVEMBER

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.001017	0.003052	0.001017	0.001017	0.006104
A	N.WEST	0.000000	0.000000	0.001017	0.001017	0.000000	0.000000	0.002035
B	NORTH	0.000000	0.001017	0.000000	0.000000	0.000000	0.000000	0.001017
B	N.EAST	0.000000	0.001017	0.000000	0.000000	0.000000	0.000000	0.001017
B	EAST	0.000000	0.001017	0.002035	0.001017	0.000000	0.000000	0.004069
B	S.EAST	0.000000	0.002035	0.001017	0.001017	0.000000	0.000000	0.004069
B	SOUTH	0.000000	0.002035	0.003052	0.004069	0.000000	0.001017	0.010173
B	S.WEST	0.000000	0.002035	0.004069	0.001017	0.001017	0.000000	0.008138
B	WEST	0.000000	0.000000	0.003052	0.009156	0.001017	0.006104	0.019329
B	N.WEST	0.000000	0.000000	0.003052	0.001017	0.002035	0.002035	0.008138
C	NORTH	0.000000	0.003052	0.001017	0.001017	0.000000	0.000000	0.005086
C	N.EAST	0.000000	0.004069	0.003052	0.004069	0.000000	0.000000	0.011190
C	EAST	0.001017	0.007121	0.013225	0.004069	0.000000	0.000000	0.025432
C	S.EAST	0.001017	0.008138	0.015259	0.004069	0.001017	0.000000	0.029502
C	SOUTH	0.003052	0.012208	0.022381	0.008138	0.000000	0.002035	0.047813
C	S.WEST	0.001017	0.003052	0.005086	0.002035	0.003052	0.000000	0.014242
C	WEST	0.001017	0.006104	0.008138	0.014242	0.004069	0.006104	0.039675
C	N.WEST	0.002035	0.005086	0.004069	0.005086	0.001017	0.002035	0.019329
D	NORTH	0.009156	0.034588	0.010173	0.000000	0.000000	0.000000	0.053917
D	N.EAST	0.016277	0.050865	0.039675	0.014242	0.000000	0.000000	0.121058
D	EAST	0.009156	0.040692	0.031536	0.012208	0.002035	0.000000	0.095626
D	S.EAST	0.003052	0.023398	0.025432	0.006104	0.002035	0.000000	0.060020
D	SOUTH	0.014242	0.036623	0.054934	0.031536	0.011190	0.001017	0.149542
D	S.WEST	0.003052	0.009156	0.009156	0.007121	0.005086	0.001017	0.034588
D	WEST	0.004069	0.030519	0.027467	0.018311	0.004069	0.002035	0.086470
D	N.WEST	0.011190	0.031536	0.025432	0.011190	0.002035	0.002035	0.083418
E	NORTH	0.002035	0.002035	0.001017	0.000000	0.000000	0.000000	0.005086
E	N.EAST	0.000000	0.013225	0.000000	0.002035	0.000000	0.000000	0.015259
E	EAST	0.000000	0.006104	0.000000	0.001017	0.000000	0.000000	0.007121
E	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	SOUTH	0.000000	0.002035	0.001017	0.002035	0.000000	0.000000	0.005086
E	S.WEST	0.001017	0.000000	0.000000	0.000000	0.001017	0.000000	0.002035
E	WEST	0.000000	0.000000	0.003052	0.001017	0.000000	0.000000	0.004069
E	N.WEST	0.000000	0.002035	0.001017	0.000000	0.000000	0.000000	0.003052
F	NORTH	0.000000	0.001017	0.000000	0.000000	0.000000	0.000000	0.001017
F	N.EAST	0.001017	0.001017	0.002035	0.000000	0.000000	0.000000	0.004069
F	EAST	0.001017	0.001017	0.001017	0.000000	0.000000	0.000000	0.003052
F	S.EAST	0.000000	0.001017	0.001017	0.000000	0.000000	0.000000	0.002035
F	SOUTH	0.000000	0.001017	0.001017	0.001017	0.000000	0.000000	0.003052
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	N.WEST	0.000000	0.002035	0.002035	0.000000	0.000000	0.000000	0.004069

TABLE A15.18
PROPORTIONS OF READINGS IN WIND CLASSES FOR DECEMBER

STABILITY CLASS	DIRECTION	WIND SPEED (M/S) 0-1.5	1.5-3	3-5	5-8	8-10	>10	TOTAL
A	NORTH	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	N.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	S.EAST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	SOUTH	0.000000	0.000000	0.000000	0.001003	0.000000	0.000000	0.001003
A	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
A	WEST	0.000000	0.000000	0.000000	0.001003	0.000000	0.000000	0.001003
A	N.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
B	NORTH	0.000000	0.000000	0.001003	0.000000	0.000000	0.000000	0.001003
B	N.EAST	0.000000	0.001003	0.000000	0.001003	0.000000	0.000000	0.002006
B	EAST	0.001003	0.000000	0.003009	0.002006	0.000000	0.000000	0.006018
B	S.EAST	0.001003	0.003009	0.005015	0.000000	0.000000	0.000000	0.009027
B	SOUTH	0.000000	0.000000	0.003009	0.003009	0.001003	0.000000	0.007021
B	S.WEST	0.000000	0.001003	0.001003	0.001003	0.000000	0.000000	0.003009
B	WEST	0.000000	0.001003	0.002006	0.004012	0.000000	0.002006	0.009027
B	N.WEST	0.000000	0.001003	0.000000	0.001003	0.000000	0.000000	0.002006
C	NORTH	0.001003	0.000000	0.000000	0.000000	0.000000	0.000000	0.001003
C	N.EAST	0.002006	0.005015	0.004012	0.006018	0.001003	0.000000	0.018054
C	EAST	0.003009	0.015045	0.009027	0.006018	0.001003	0.001003	0.035105
C	S.EAST	0.000000	0.013039	0.021063	0.005015	0.001003	0.000000	0.040120
C	SOUTH	0.002006	0.012036	0.020060	0.011033	0.003009	0.000000	0.048144
C	S.WEST	0.001003	0.004012	0.007021	0.003009	0.000000	0.000000	0.015045
C	WEST	0.000000	0.005015	0.007021	0.009027	0.002006	0.000000	0.023069
C	N.WEST	0.000000	0.003009	0.004012	0.003009	0.001003	0.001003	0.012036
D	NORTH	0.010030	0.024072	0.014042	0.000000	0.000000	0.000000	0.048144
D	N.EAST	0.015045	0.049147	0.049147	0.010030	0.000000	0.000000	0.123370
D	EAST	0.019057	0.063190	0.048144	0.012036	0.000000	0.000000	0.142427
D	S.EAST	0.007021	0.032096	0.040120	0.018054	0.001003	0.001003	0.099298
D	SOUTH	0.009027	0.028084	0.042126	0.046138	0.009027	0.006018	0.140421
D	S.WEST	0.001003	0.005015	0.007021	0.004012	0.001003	0.003009	0.021063
D	WEST	0.010030	0.022066	0.020060	0.005015	0.002006	0.000000	0.059178
D	N.WEST	0.013039	0.031093	0.012036	0.004012	0.000000	0.000000	0.060181
E	NORTH	0.001003	0.002006	0.000000	0.001003	0.000000	0.000000	0.004012
E	N.EAST	0.002006	0.009027	0.009027	0.000000	0.000000	0.000000	0.020060
E	EAST	0.002006	0.002006	0.003009	0.002006	0.000000	0.000000	0.009027
E	S.EAST	0.000000	0.001003	0.000000	0.000000	0.000000	0.000000	0.001003
E	SOUTH	0.000000	0.003009	0.001003	0.002006	0.000000	0.001003	0.007021
E	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	WEST	0.001003	0.000000	0.001003	0.000000	0.000000	0.000000	0.002006
E	N.WEST	0.001003	0.003009	0.001003	0.000000	0.000000	0.000000	0.005015
F	NORTH	0.000000	0.002006	0.000000	0.000000	0.000000	0.000000	0.002006
F	N.EAST	0.002006	0.005015	0.002006	0.001003	0.000000	0.000000	0.010030
F	EAST	0.001003	0.001003	0.001003	0.000000	0.000000	0.000000	0.003009
F	S.EAST	0.000000	0.000000	0.001003	0.000000	0.000000	0.000000	0.001003
F	SOUTH	0.000000	0.003009	0.001003	0.002006	0.000000	0.000000	0.006018
F	S.WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	WEST	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
F	N.WEST	0.000000	0.002006	0.000000	0.000000	0.000000	0.000000	0.002006

per building, the temperature difference assumed for the potroom emissions, the extent of downwash allowed for and the effect of assuming different stability category breakdowns.

A15.4.2 Sensitivity to Number of Sources

The first test was designed to verify the assumption that the line source could be modelled by a small number of point sources, particularly at distances downwind of the source greater than a building length. The results of this analysis are shown as Test 1 in *Figure A15.5* for wind speeds of 1, 3 and 5 m/s.

The assumptions in this analysis included a non-buoyant plume, no building downwash effects and neutral atmospheric conditions. The plume centreline concentrations are perpendicular to the centre of the long axis of the building. Total emission is assumed to be 10 g/s and the sources are assumed to be equally spaced along the building.

The results indicate that for four or more sources per building there is no significant difference in predicted concentrations beyond 2 km from the buildings. Up to 2 km significant differences do occur because no source is located on the centreline. This effect will be eliminated by averaging the concentration from each source over the 45 degree wind sector so that overlapping of plumes will occur prior to 500 m downwind. For winds parallel to the building axis, overlapping will occur within the building length and no significant differences will occur due to the number of sources.

The conclusion is that, beyond the immediate vicinity of the plant, assuming eight or more sources per building gives an accurate prediction of ground level concentration for a non-buoyant plume.

A15.4.3 Sensitivity to Buoyant Plumes

A series of tests were carried out to determine the effect of possible variations in the emission gas temperature and volume on downwind concentration.

The buildings are line sources as discussed in *Section A15.1.4* and plume rise will depend on the number of sources chosen per building. However, the rate of variation decreases as the number of sources increases and there is a compensating interaction between adjacent sources which will tend to increase the plume rise. In this case, a volumetric emission rate of 20 m^3/s has been chosen which is equivalent to the design emission rate per pot. Interaction between the sources was ignored.

The roof vents are designed to give a volumetric emission rate of 20 m^3/s per pot at a minimum temperature increase of 10°C over outside temperature. Test 2 shown on *Figure A15.5* indicates the effect on ground level concentration when a temperature rise of 10°C is assumed. Tests 3 and 4 on *Figure A15.6* indicate the effect of temperature rises of 15°C and 20°C respectively. These are compared with the non-buoyant plume in Test 5 on *Figure A15.7*.

For this study a temperature rise of 15°C has been assumed. This condition would be expected when wind velocity across the vents and outside temperatures are both low. The worst case for dispersion conditions fall into this class. The above tests also show that possible small variations in temperature rise throughout the year will not have a significant effect on the ground level concentration when compared with other factors such as wind speed.

A15.4.4 Sensitivity to Downwash

Test 6 on *Figure A15.7* indicates the effect of assuming downwash factors of 1.0, 0.8, and 0.6 perpendicular to the building centreline. Downwash gives the greatest proportional reduction in effective emission height at higher wind speeds. At low wind speeds the effect of downwash is reduced by plume rise.

For this case, a conservative assumption was made that downwash would result in an emission height, prior to the addition of plume rise, of 0.6 times the building height when wind is perpendicular to the buildings and 0.8 times the building height when wind is at 45 degrees to the buildings. No downwash is assumed when wind is parallel to the long axis of the building.

It should be noted that the selection of the layout with the buildings orientated east-west will result in lower average downwash than the alternative north-south orientation because the buildings are aligned more to the prevailing wind directions.

A15.4.5 Number of Buildings Assumed

A series of four parallel buildings will house the two potlines. *Figures A15.5 to A15.7* indicate the die-off in ground level concentration downwind of a single building located at the origin. It can be seen that there is a slow rate of die-off after the maximum concentration. Therefore, assuming four buildings 100 m apart, each with one quarter of the emission rate, and adding the concentration from each will give the same answer.

The only area where some difference will occur is adjacent to the point of maximum concentration. The peak concentration would be marginally reduced and concentrations up to about 1 km from the origin would be slightly increased.

For this study we have assumed 10 sources for each of the two outermost potrooms. This will give slightly higher concentrations adjacent to the buildings but there will be no effect on predicted concentrations perpendicular to the buildings at distances greater than 1 km. The overlapping of sources within the building length will result in no significant difference in predicted concentrations for wind parallel to the buildings.

In an effort to reduce the computer time required to produce the dispersion patterns, tests were carried out to determine the effect of further reducing the number of sources. For the assumption of a single potroom building, that is a total of 15 sources, no significant difference in concentration was evident beyond about 2 km. For an assumption of only 3 sources, one for the potrooms, one for the dry scrubbers and one for the anode furnace, no difference was evident beyond 4 km. These assumptions were used in producing the regional dispersion patterns in this report.

A15.4.6 Meteorological Data

A trial run of the dispersion model was carried out using the assumption that only stability Category D occurred, in a further attempt to reduce programming complexity and required computer time. It was found that both the predicted annual average and maximum monthly ground level concentration of fluoride were about 5 per cent higher on average if only Category D was assumed. The greatest increase was up to 15 per cent in areas closest to the smelter, decreasing to zero at about 15 km from the smelter. Because of the refinement in answers which could be achieved with the use of the full range of stability categories, particularly on a monthly basis, it was decided that the additional computer time this involved was warranted.

When considering the question of calms, it was decided that these events would not be incorporated in the dispersion analysis. This is due to the fact that, even at the minimum temperature rise of 10^{o}C for the potroom gases, the plume rise at wind speeds less than 1 m/s is considerable, varying from about 150 m for a speed of 0.2 m/s to about 40 m for a speed of 0.8 m/s. The resultant ground level concentrations up to about 5 km from the site are then much lower than the concentrations which would be expected for moderate wind speeds.

A15.5 RESULTS OF DISPERSION ANALYSIS

A15.5.1 General

This section briefly presents the results of the dispersion analysis carried out using the model discussed above. The results are discussed in more detail in *Section 9.6.2* of *Volume 1* of this Statement in relation to effects on air quality, *Section 9.6.6* which discusses potential effects on native vegetation and *Section 9.6.5* which assesses potential effects on the groundwaters used for domestic water supply.

The results of the dispersion analysis were in the following form:

* Ground level concentration of gaseous fluoride ($\mu g.Fg/m^3$)
* Ground level concentration of particulate fluoride ($\mu g.Fp/m^3$)
* Ground level concentration of total fluoride ($\mu g.Ft/m^3$)
* Ground level absorption of gaseous fluoride ($mg.Fg/m^2.d$)
* Ground level deposition of particulate fluoride ($mg.Fp/m^2.d$)
* Ground level deposition of total fluoride ($mg.Ft/m^2.d$).

These results were calculated for each point on a grid, based on the average meteorological pattern for each month. The results for each point were also examined to determine the average annual value and the maximum monthly value.

A15.5.2 Presentation of Results

The following figures give the results of the dispersion analysis overlayed on backgrounds of some of the relevant land uses in the area:

Figure 7.1 : Predicted Monthly Average Ground Level Gaseous Fluoride Concentrations - January to June.

Figure 7.2 : Predicted Monthly Average Ground Level Gaseous Fluoride Concentrations - July to December.

Figure 7.3 : Predicted Annual Average Ground Level Gaseous and Total Fluoride Concentrations in the Vicinity of the Plant.

Figure 7.4 : Predicted Maximum Monthly Average Ground Level Gaseous and Total Fluoride Concentrations in the Vicinity of the Plant.

Figure 7.5 : Predicted Annual Average Ground Level Gaseous and Total Fluoride Concentrations for the Region.

Figure 7.6 : Predicted Maximum Monthly Average Ground Level Gaseous and Total Fluoride Concentrations for the Region.

Figure 7.7 : Predicted Average Removal of Particulate and Total Fluorides Around the Site.

Figure 7.8 : Predicted Average Removal of Particulate and Total Fluorides in the Tomago Sandbeds Catchment Area.

Figure 7.9 : Predicted Annual Average Ground Level Concentration of Sulphur Dioxide.

A15.5.3 Interaction with Other Sources of Fluoride

In order to assess the overall impact of this proposed smelter with other existing or proposed sources of fluorides in the Hunter Valley, emission rates were extracted from data published by the *State Pollution Control Commission (1980)*.

Power stations are a source of significant quantities of fluoride but, because of the superior dispersion characteristics of tall stacks, the ground level concentrations at sensitive vineyard areas due to the power station emissions will only be about 0.02 $\mu g/m^3$. Since concentrations at the Tomago site will be even lower than this, the power stations were not included in the following analysis.

The sources of fluoride which are closest to the Tomago smelter are the brickworks in the East Maitland area which emit a total of 53 t.F/y, the chemical works on Kooragang Island which emit 83 t.F/y, the steel works complex with an emission of 93 t.F/y and other fuel burning sources in the Newcastle area which emit 4 t.F/y. A trial run of an emission source of 180 t.F/y was carried out using the emission characteristics of the Tomago smelter. It was found that, by using these characteristics and locating the source at the northern end of Rotten Row (as shown in the State Pollution Control Commission's report), a good correlation could be achieved with the long term average concentration of total fluoride at Stockton (0.533 $\mu g/m^3$) and Fern Bay (0.184 $\mu g/m^3$) where the State Pollution Control Commission has monitoring stations. However, the split between particulate and gaseous fluoride is about 35 per cent particulate for the smelter emissions and 67 per cent particulate for industrial emissions.

The other sources of fluoride are the two aluminium smelters at Kurri Kurri and that proposed by Alumax at Lochinvar. The Alcan Australia Pty. Limited plant at Kurri Kurri is expected to be expanded in the near future to a capacity of 135,000 t.Al/y by the addition of a third potline. At the same time, the connection of the existing line to additional pollution control equipment will reduce the total fluoride emissions from the plant to 1.0 kg/t of aluminium produced. This plant was modelled as being similar to the Tomago smelter but incorporating an additional plume rise for the roof vent emissions due to the initial vertical velocity of the air flow through the roof fans. A smelter proposed by Hunter Valley Aluminium Pty. Limited at Lochinvar will have a production rate of 236,000 t.Al/y. An emission rate of 1.0 kg.F/t.Al has been assumed for this source as a worst case and roof vents similar to the Tomago smelter have been assumed.

The above data were incorporated in the dispersion model developed during this study to give a pattern of interaction between present and possible future sources. This was shown in *Figure 1.1* at the beginning of this Statement. The figure shows only isopleths of gaseous fluoride concentrations because this is the most reactive fraction of the emission and the cause of most concern.

The analysis indicates an overlap at a concentration of about 0.1 $\mu g.Fg/m^3$ in the area between Tomago and Kooragang Island. This includes the north-east corner of Kooragang Island, the western side of Fullerton Cove and the north arm of the Hunter River. Since most native vegetation in this zone of overlap are Mangrove and Salt Marsh communities which are resistant to salt and hence expected to be resistant to fluoride *(State Pollution Control Commission, 1980)* potential effects are expected to be minimal.

The predicted additional concentration at the Tomago site due to existing sources on Kooragang Island is only about 0.04 $\mu g.Fg/m^3$. This is generally confirmed by the short period of monitoring which has been carried out on the site to date. The level at Rotten Row on Kooragang Island due to the Tomago smelter would be about 0.07 $\mu g.Fg/m^3$ and adds only slightly to existing levels. There will be no significant increase in predicted ground level concentrations to the north of the smelter or to the south of Kooragang Island due to the interaction of all sources. There will be no overlap with fluoride sources other than Kooragang Island at significant fluoride levels. There will be no influence from the Tomago smelter at the Hunter Valley vineyard areas. The concentration at the orchard areas of Medowie is only about 0.02 $\mu g.Fg/m^3$ which is well below possible damage levels. No increase in the health risks to residents of the region could be attributed to the interaction of all fluoride sources.

Appendix 16

HOODING EFFICIENCY DERIVATION

APPENDIX 16

HOODING EFFICIENCY DERIVATION

CALCULATION

Primary collection efficiency can be calculated using the following data:-

i. The work time necessary for each pot operation.

ii. The level of fluoride generated during such operations.

Such calculations have been made for two cases.

i. Using U.S. Environmental Protection Agency data for i and ii, minimum collection efficiency is 97.46 per cent. (*Table A16.1*).

ii. Using Aluminium Pechiney data for i and ii, derived from actual operation on four prototype pots (similar to those to be used at Tomago) enclosed in a completely leakproof building, minimum collection efficiency is 97.77 per cent. (*Table A16.2*).

MEASUREMENT

A series of measurements were made over a period of time on the four prototype pots previously described, in the period August 1976 to January 1977.

The fully enclosed potroom allowed all emissions, primary and secondary, to be monitored.

Measurements over the period included all pot operations. In addition, sources such as cooling anodes and bath handling were also included, thus underestimating collection efficiency.

Since the work was completed, improvements to the pot tending crane have allowed a significant reduction in the time taken for anode changing.

The series of tests resulted in an overall collection efficiency of 97.4 per cent.

TABLE A16.1

PRIMARY COLLECTION EFFICIENCY CALCULATION
(U.S. Environmental Protection Agency)

Cell Function	Fluoride Generation Severity Index (A)	Function Time (Minutes) (B)	Generation Rate A x B	Leakage %	
Normal operation	1 x	1401	1401	2	28.02
Anode effects	5.5 x	6	33	2.5	0.825
Anode changing	6 x	15	90	10	9.0
Metal tapping	2 x	8	16	2.5	.4
Bath metal measurement	1 x	2	2	6.1	.122
Short side crust)(1) breaking) Long side crust) breaking)	6 x	1	6	10	.6
Bath addition	1 x	5	5	6.1	.305
Alumina addition	1 x	Continuous		2	
Other controls	2.5 x	2	5	6.1	.305
Totals		1440	1558x		39.577

$$\text{Primary Collection Efficiency} = \frac{100 \times (\text{Generation} - \text{Secondary Loading})}{\text{Generation}}$$

$$= 100 \left(\frac{1558 - 39.577}{1558}\right)$$

$$= 97.46.$$

(1) Crust breaking for anode changing.

TABLE A16.2

PRIMARY COLLECTION EFFICIENCY CALCULATION
(Aluminium Pechiney Australia Pty. Limited)

Cell Function	Fluoride Generation Severity Index (A)	Function Time (Minutes) (B)	Generation Rate A x B	Leakage %	
Normal operation	1 x	1346	1346	1.8	24.22
Anode effects	4.2 x	6	25.2	2.5	0.63
Anode changing	4.6 x	15	69	10	6.9
Metal tapping	1.2 x	8	9.6	2.5	0.24
Bath metal measurement	1 x	2	2	6.1	0.122
Short side crust) breaking) Long side crust) breaking)	6 x	1	6	10	0.6
Bath addition	1.5 x	60	90	1.8	1.62
Alumina addition	1 x	Continuous	-	-	-
Other controls	2.5	2	5	6.1	0.305
Totals			1552.8		34.637

$$\text{Primary Collection Efficiency} = \frac{100\ (\text{Generation - Secondary Loading})}{\text{Generation}}$$

$$= 100\ \frac{(1552.8 - 34.637)}{1552.8}$$

$$= 97.77$$

Appendix 17

ENERGY STATEMENT

APPENDIX 17

ENERGY STATEMENT

A17.1 AN OVERVIEW

A17.1.1 Background Information

When in full production in 1986 the Tomago smelter will have a primary energy consumption of 39.53×10^{15} J, a power demand of 380 MW, will consume 3.2×10^{9} kW.h of electrical energy and 21.2×10^{6} m^{3} py of natural gas whilst 1.08×10^{6} l of diesel fuel and 6.19×10^{6} l of bunker oil will be used in materials handling activities related to smelter operations. These energy consumptions are related to forecasted future use patterns in New South Wales in *Table A17.1.*

A17.1.2 Primary Fuel Consumption

The total primary energy consumption in the Tomago smelter at full capacity is estimated at 39.53×10^{15} J. Smelting operations at Tomago will use only 2.8 per cent of the forecasted total New South Wales' consumption of primary energy in 1985/86 of 1409.4×10^{15} J.

A17.1.3 Electrical Energy Consumption

Against a background of the New South Wales Government's plan to double electrical generating capacity within a decade, the impact of the Tomago smelter on electrical power supply in New South Wales will be small, amounting to only 2.64 per cent of the total capacity to be in service by 1987. The low level of impact can be further gauged by considering that one of the four 660 MW generators to be installed at the Eraring Power Station would have nearly twice the output needed to supply the Tomago smelter.

TABLE A17.1

ENERGY REQUIREMENTS OF THE SMELTER AND
FORECAST FOR NEW SOUTH WALES

Energy Source	Forecast N.S.W. Supply or Consumption (1985/86)	Smelter Requirements	Percentage Total
1. Primary Energy (10^{15} J)	1409.4	39.47	2.8
2. Electrical Total generating capacity (MW) to 1987	14,400	380	2.64
3. Electrical Energy (GW.h)	48,600	3200	6.58
1. Natural Gas (m^3)	1.28×10^9	21.2×10^6	1.66
4. Diesel Fuel (1)	2196×10^6	1.08×10^6	0.05
5. Bunker Oil (1)	6646×10^6 (Australia)	6.19×10^6	0.09

Sources: 1. Demand for Primary Fuels in Australia (1978). *Department of National Development (Table 7).*
2. Information supplied by Electricity Commission of New South Wales.
3. Extrapolation of 1970/71 to 1978/79 consumption data plus 1986 smelter consumption.
4. *Department of National Development (Table 16)*
5. *Department of National Development (Table 15)*

Electrical energy consumption in New South Wales in 1985/86 will be the aggregate of increases due to normal rise in economic activity and increases due to substantial new users of electricity. Total energy consumption in New South Wales in 1985/86 is estimated to be 42,000 GWh based on a continuance of the 1970/71 to 1978/79 trend. Both the Tomago and Alumax smelters are planned to be in full production at this time adding a further 6600 GWh to the consumption which would total 48,600 GWh. Smelting operations at Tomago would consume only 6.58 per cent of the forecasted total energy consumption in New South Wales in 1985/86.

A17.1.4 Coal Consumption

Approximately 1.4 mtpy of coal will be required to provide electrical energy to the Tomago smelter allowing for 30 per cent efficiency in the conversion of coal to electrical energy in thermal power stations and 5 per cent transmission loss. This is less than 6.7 per cent of projected exports of black coal from the northern New South Wales coalfields in 1985 *(Joint Coal Board, 1979)*.

An assessment in 1978/79 by the Joint Coal Board puts the insitu measured and indicated reserves of black coal on the northern New South Wales coalfields at 17,600 mt *(Joint Coal Board, 1979)*.

Operation of the Tomago smelter over a 50 year life would not deplete these reserves by more than 0.4 per cent.

A17.1.5 Natural Gas

The use of natural gas for heating purposes in the Tomago smelter would have minimal impact on the forecast New South Wales' consumption in 1985/86, being approximately 1.66 per cent of the total.

Total consumption of 1.06×10^9 m^3 over a projected 50 year life span for the Tomago smelter is small compared to the current reserves in the Cooper Basin, from which New South Wales currently draws it gas supplies, of 104×10^9 m^3 *(Bureau of Mineral Resources, 1979)* or the 300×10^9 m^3 demonstrated economic reserves in Eastern and Central Australia *(National Energy Advisory Committee, 1977)*. Natural gas supply problems which might emerge in New South Wales by the end of this century will not be exacerbated by the small usage in the Tomago smelter.

A17.1.6 Petroleum Products

i. Diesel Fuel

Raw materials for the smelter will be transported by road from unloading facilities at the Port of Newcastle whilst materials handling within the smelter will be by diesel powered vehicles. Aluminium metal will be taken by road to the port at Newcastle.

Diesel fuel consumption by these vehicles will be insignificant compared to total New South Wales usage being estimated at 0.05 per cent of the forecasted consumption of automotive distillate in New South Wales in 1985/86.

ii. Bunker Oil

Alumina will be shipped from Gove and Gladstone to Newcastle in bulk ships. Approximately ten voyages will be made per year from each alumina refinery and fuel oil consumption each year is estimated at 6.19×10^6 l. This is insignificant in comparison with the 6646×10^6 l of fuel oil forecast to be consumed in Australia in 1985/86.

A17.1.7 Summary

This overview of the broad energy impact of the proposed Tomago smelter shows that the operation of the Tomago smelter will not result in significant depletion of New South Wales energy resources, particularly coal reserves in the Hunter Valley. Use of petroleum based fuels is small compared with the total consumption in New South Wales, as is the electrical power generating capacity needed to supply the smelter. Electrical energy use is consistent with requirements of electrolytic processes and is compatible with the New South Wales Government's strategy of employment creation through strategic deployment of the Hunter Valley's energy resources.

A17.2 CONSTRUCTION ENERGY REQUIREMENTS

Construction energy requirements for the project are estimated in *Table A17.2* These cover the normal range of constructional activities for a project of this type including onsite fabrication of steelwork and plant, workshop power and fuels used to power mechanical equipment.

TABLE A17.2

ESTIMATED ENERGY CONSUMPTION
DURING CONSTRUCTION

Year	Electrical Power (kWh)	Diesel Fuel (1)	Petrol (1)
1980	16,000	43,000	4,000
1981	745,000	2,067,000	214,000
1982	1,423,000	3,951,000	409,000
1983	858,000	2,381,000	246,000
1984	608,000	1,689,000	174,000
1985	250,000	693,000	72,000
Total	3,900,000	10,824,000	1,119,000

These energy consumptions are normal for a project of this magnitude.

A17.3 OPERATIONAL ENERGY REQUIREMENTS

The process for producing aluminium by the electrolytic reduction of alumina in a bath of molten cryolite is described in detail in *Section 5* of the Environmental Impact Statement. In energy terms, the process is primarily one of:

i. passing DC current between the electrodes of an electrolytic cell

ii. using thermal energy to bake the carbon anodes

iii. using thermal energy to keep molten the liquid aluminium formed in the pots during purification and alloying processes and

iv. petroleum fuel consumption in the transport of raw materials and finished goods and in onsite materials handling.

A17.3.1 Electrical Energy Requirements

Electrical power will be supplied to the proposed smelter in two stages, the first 190 MW in 1983 and the second in 1985. This will enable aluminium metal production to be increased in stages to full rated capacity. Metal production and energy consumption during this build up to full capacity are shown in *Table A17.3.*

TABLE A17.3

METAL PRODUCTION AND ENERGY CONSUMPTION

Year	Aluminium Production (t)	Electrical Energy Consumption (10^9 kWh)
1983	47,000	0.68
1984	110,000	1.6
1985	158,000	2.3
1986	220,000	3.2

The essential feature of the power supply to an aluminium smelter is that it must be stable and reliable. Consequently, two 330 kV transmission links are to be provided each capable of supplying maximum demand to the plant.

Electrical energy usage is continuous, seven days a week over the entire year without peak load periods or seasonal patterns. This stable base-load from smelter operations improves the efficiency of power generation and generating capacity utilisation.

The main electrical energy consumption stages in the process are shown in *Table A17.4.*

The theoretical energy consumption for the electrolysis reaction can be calculated from the cell reaction equation and the enthalpy required to heat the bath contents to 950^{o}C. Theoretical energy consumption is approximately 6300 kWh/t (compared to 14,500 kWh/t in practice) comprising 3600 kWh/t of electrical decomposition energy and 2700 kWh/t to heat the bath contents *(Note - it is not practical because of design and operating parameters of the pots to use thermal energy to heat them).*

TABLE A17.4

ELECTRICAL ENERGY CONSUMPTION DURING
ALUMINIUM PRODUCTION AT TOMAGO

Process Stage	Electrical Energy Consumption (kWh/t.Al)
Potline	
DC power for electrolysis	13,640
Conversion losses	200
Auxiliaries	50
Total	13,890
Anode Fabrication	
Paste plant	60
Baking furnaces	40
Rodding shop	40
Total	140
Cast House	40
Emission Control	
Potlines	280
Anode fabrication	30
Miscellaneous Uses	
Alumina handling	70
General services	50
Total Consumption in the Process	14,500 kWh/t

Potline efficiency based on theoretical energy consumption is 47 per cent due to the combined effects of electrode polarisation, voltage drop across the pots and busbars, and heat losses. Efficiency on current is 91 per cent as some aluminium reoxidizes before it reaches the cathode.

As can be readily seen from *Table A17.4*, 94 per cent of the total electrical energy is consumed in the pots. For commercial reasons, it is imperative that smelter design and operation be aimed at achieving maximum efficiency in the use of electrical energy. Steps to be taken to achieve this are detailed in *Appendix A17.5*.

A17.3.2 Thermal Energy Requirements

Natural gas is used to provide thermal energy mainly for the anode baking furnace and the cast house with minor quantities being used for miscellaneous heating purposes around the plant. The breakdown of thermal energy consumption in the process is shown in *Table A17.5*.

TABLE A17.5

THERMAL ENERGY CONSUMPTION
IN THE TOMAGO SMELTER

Process Stage	Thermal Energy Use MJ/t.Al
Anode Fabrication	
Paste plant	178
Baking furnace	1786
Total	1964
Cast House	1608
Miscellaneous Heating	210
Total	3782 MJ/t.Al

A17.3.3 Petroleum Fuels

i. *Transport Options*

Alumina will be brought by ship from Gove and Gladstone to Newcastle. Estimated fuel oil consumption is 6.19×10^6 l each year.

Alumina, petroleum coke and possibly pitch will be transported by road from the bulk unloading facilities at Rotten Row Basin and aluminium metal will be returned by road to the port. Diesel fuel consumption in road transport operations is estimated at 0.78×10^6 l per year.

ii. *Materials Handling on Site*

All materials handling on site will be by diesel powered vehicles. Diesel fuel consumption is estimated at 0.3×10^6 l per year together with 5000 l of motor oil.

iii. Maintenance

Maintenance operations will consume 100,000 l of lubricating oils and 15 t of greases each year.

A17.4 SUMMARY OF ENERGY CONSUMPTION IN SMELTER OPERATIONS

Energy consumption in the smelter at full capacity in 1986 is summarised below:

Energy Source	Annual Consumption
Electrical energy	11.5×10^{15} J
Thermal energy	0.832×10^{15} J
Bunker oil	0.252×10^{15} J
Diesel fuel	0.041×10^{15} J
Total direct energy consumption	12.625×10^{15} J

By converting the electrical energy component back to the black coal from which it was derived and combining with the other energy components an equivalent total primary energy consumption can be calculated.

The total primary energy consumption in the Tomago smelter at full capacity is estimated at 39.53×10^{15} J. Total New South Wales usage of primary fuel in 1985/86 is estimated at 1409.4×10^{15} J.

The impact of the Tomago smelter on total energy consumption in New South Wales in 1986 will be small being 2.8 per cent of the total.

A17.5 ENERGY MANAGEMENT

Smelter profitability depends on careful energy management and a basic design that incorporates the latest technology in pot design. To achieve the highest practical energy efficiency it is necessary to minimise voltage drop across the pot and maximise current efficiency and thermal stability in the cell.

Voltage drop across the pot is dependent on the alumina concentration in the bath and passes through a minimum at an alumina content of from 2 to 4 per cent which varies with the acidity of the bath. Successful monitoring of the alumina ratio in the bath and maintenance at an optimum pre-set ratio leads to a significant saving in electrical energy consumption. Optimisation of busbar design minimises energy losses.

Current efficiency is maximised by minimising the quantity of liquid aluminium that is reoxidised by coming in close proximity to the anodes. In order to maintain high thermal stability in the cell a "pad" equivalent to about one week's production of liquid metal is maintained at the bottom of the cell and acts as a liquid cathode. Magnetic fields created by current flow through the busbars and the cell itself generate electromagnetic (Laplace) forces which cause the metal surface to be unstable. Careful design of the aluminium busbars and their layout is necessary to minimise magnetic effects that reduce current efficiency. Pechiney research has led to busbar arrangements that have reduced the vertical magnetic fields in a pot by a factor of 6 to 7 with significant energy savings.

The Pechiney design technology used in the Tomago smelter will ensure that the smelter is capable of operating at an energy efficiency comparable to any in the world. The key to achieving high energy efficiency in potline operation is the use of a sophisticated microprocessor fitted to each pot that measures and controls pot resistance and voltage and alumina content in the bath and regulates these parameters to maintain the pot at optimum current efficiency. The processor performs other tasks aimed at ensuring efficient use of energy. These include maintaining the anode - cathode distance at a constant or pre-set value, detecting, signalling and/or correcting pot abnormalities (such as voltage instability) and suppressing anode effects. Each microprocessor is connected to a central computer which calculates and prints out daily performance data used for accurate technical management of the potline.

Losses in the conversion from AC to DC current have been minimised using silicon rectifiers of the latest design and increasing the number of cells in the potline. The substation conversion factor at the Tomago smelter will be approximately 98 per cent.

Natural gas consumption in the anode baking furnace has been minimised by a furnace design in which volatiles emitted during baking are drawn into the combustion section where they contribute to the furnace heat requirements. Natural gas consumption has been further minimised by using a sophisticated burner control system. The burners are controlled to match a pre-set temperature programme designed to give optimum fuel usage. Heater gases are recirculated within the furnace to preheat anodes in the entry section of the furnace.

A17.6 ALTERNATIVE TECHNOLOGY

Smelter technology to be used at Tomago is the culmination of 90 years of refinement of the Hall Heroult process. This process remains the only commercial process currently available for the large-scale production of aluminium from alumina.

A process involving the conversion of alumina to aluminium chloride which is then electrolysed to yield aluminium and chlorine is still at the pilot plant stage. Although this is claimed to offer prospects for a reduction in electric power consumption significant operational problems have to be overcome and it is not viable at present.

A17.7 RESOURCE STERILISATION

The site is underlain by up to 30 mt of a high fluidity, low ash coking coal at depths between 81 m and 335 m. Recovery rates would be reduced if the deposit should ever become economically mineable to avoid surface subsidence. The small extent of this deposit in relation to the measured and indicated reserves in the northern New South Wales coalfields (17,600 million tonnes) does not justify the selection of an alternative location for the smelter.

Appendix 18

STANDARDS FOR AIR QUALITY AND FORAGE

APPENDIX 18

STANDARDS FOR AIR QUALITY AND FORAGE

A18.1 AIR QUALITY STANDARDS

U.S.A.

Substance	State	Fluoride level $\mu g/m^3$	ppb	Averaging time	Foot-note
Fluorides,gaseous as HF	Kentucky	0.82	1	1 mth.	
		1.64	2	7 d	
		2.86	3.5	24 hr.	
		3.68	4.5	12 hr.	
Fluorides,as HF	Kentucky	-	40	Growing season	
	(Jefferson County)	-	60	2 mths.	
		-	80	1 mth.	
Fluorides,gaseous	Maryland	0.002	-	24 hr.	
		$5\mu g/100cm^2$	-	30 d	a
Fluoride	Montana	$0.3\mu g/cm^2$	-	30 d	b
Fluoride,total	New Hampshire	-	40	1 mth	c
		-	60	2 mths	
		-	80	1 mth	d
Fluorides,as HF	New Hampshire	-	1.0	1 mth	
		-	2.0	7 d	
		-	3.5	24 hr.	
		-	4.5	12 hr	
Fluorides,gaseous as HF	New York	-	1.0	30 d	
		-	2.0	7 d	
		-	3.5	24 hr.	
		-	4.5	12 hr.	
Fluorides,total sol.F as HF	Pennsylvania	-	5.0	7 d	
Fluorides,gaseous as HF	South Carolina	$0.3\mu g/cm^2$ mth.	-	30 d	b
Fluorides,as HF	Tennessee	1.2	1.5	1 mth.	
		1.6	2.0	7 d	
		2.9	3.5	24 hr.	
		3.7	4.5	12 hr.	
Fluorides,gaseous as HF at STP	Texas	-	1.0	30 d	

A18.1 (cont'd)

Substance	State	Fluoride $\mu g/m^3$	Level ppb	Averaging time	Foot-note
		-	2.0	7 d	
		-	3.5	24 hr.	
		-	4.5	12 hr.	
Fluorides, gaseous as HF at STP	Washington	8.4	-	1 mth.	
		1.7	-	7 d	
		2.9	-	24 hr.	
		3.7	-	12 hr.	
		0.5	-	March 1 to Oct.3	
Fluorides, gaseous as HF	Wyoming	0.8	∿1	24 hr.	b
		0.3 $\mu g/cm^2$	-	-	

a. As measured by static limed filter paper.

b. As measured by calcium formate paper.

c. During growing season.

d. For whole year.

Source: *Hodge and Smith (1979).*

A18.1 (cont'd)

Countries other than U.S.A.

Substance	Country	Long-term $\mu g/m^3$	Long-term ppb	Long-term Averaging time	Short-term $\mu g/m^3$	Short-term ppb	Short-term Averaging time
Fluorides as F	Bulgaria	5	2	24 hr.	20	10	20 min.
	Canada (a)	1	0.5	30 d	-	-	-
	(Ontario)(a)	2	1	24 hr.	-	-	-
	Czechoslovakia (b)	10	5	24 hr.	30	15	30 min.
	East Germany(b,c)	5	2	24 hr.	20	10	30 min.
	Hungary (d)	30	15	24 hr.	100	50	30 min.
	(d)	10	5	24 hr.	30	15	30 min.
	Israel (e)	10	5	24 hr.	30	15	30 min.
	Italy (f)	20	10	24 hr.	60	30	30 min.
	Romania	5	2	24 hr.	20	10	30 min.
	Spain (g)	20	10	24 hr.	60	30	30 min.
As F, gaseous compounds	U.S.S.R. (b,h)	5	2	24 hr.	20	10	20 min.
Gaseous and salt combined	East Germany (c)	10	-	24 hr.	30	-	30 min.
Fluorides as HF	Canada (i)	1.5	2	24 hr.	-	-	-
	(Manitoba)(a)	0.8	0.6	24 hr.	-	-	-
	Newfoundland	0.45	5	30 d	0.9	1	24 hr.
	Saskatchewan (j)	3	4	24 hr.	-	-	-
	Hungary (d)	20	15	24 hr.	20	15	30 min.
	(d)	1.3	1	24 hr.	5	4	30 min.
	Netherlands	10	8	24 hr.	-	-	-
	Spain (g)	10	8	24 hr.	30	22	30 min.
	U.S.S.R. (h,k)	10	8	24 hr.	30	22	30 min.
	West Germany	2	1	30 min.	5	4	30 min.
	Yugoslavia	5	4	24 hr.	20	15	30 min.
Fluorides readily sol. inorganic	Bulgaria (k)	10	-	24 hr.	30	-	20 min.
	East Germany(c,k)	10	-	24 hr.	30	-	30 min.
	Poland (l)	10	-	24 hr.	30	-	20 min.
	(m)	3	-	24 hr.	10	-	20 min.
	Yugoslavia	10	-	24 hr.	30	-	30 min.
Fluorides sparingly sol.	East Germany(c,n)	30	-	24 hr.	200	-	30 min.
	U.S.S.R (h,n)	30	-	24 hr.	200	-	30 min.
Fluorides in mixture with gaseous	Bulgaria	10	-	24 hr.	30	-	30 min.
Fluorides insol.	Yugoslavia	30	-	24 hr.	200	-	30 min.

(a) Criteria for desirable ambient air quality.

(b) HF, SiF_4

(c) Permissible standard, averaging time is defined as 10 to 30 min.

(d) Protected and highly protected areas, respectively.

(e) Tentative as of 1974

(f) Once in 8 hr.

(g) Proposed standards as of 1974.

(h) When several substances with synergistic toxic properties are present, the (relative) maximum permissible concentration of the mixture is calculated as follows:

$$MPC = \frac{A}{MPC_A} + \frac{B}{MPC_B} + \ldots$$

where A,B,$\cdots$ are the concentrations of the components of the mixture, and MPC_A, MPC_B,$\cdots$are their respective maximal permissible concentrations. When HF is present with SO_2, the MPC for the mixture should not exceed 1.

(i) Maximum acceptable level.

(j) Provisional maximum quantities, 1970.

(k) NaF, Na_2SiF_4

(l) For protection areas.

(m) Special protection areas.

(n) AlF_3, $NaAlF_4$, CaF_2

Source: *Martin and Stern (1974).*

A18.2 FORAGE STANDARDS

Province or State	Averaging Time 12 month average	6 month average	2 month average	1 month average	No average specified
Canada					
Newfoundland	-	-	-	-	35ppm by wt individual sample
Manitoba	-	-	-	40µg/100 cm^2	35ppm individual sample
Ontario	-	-	-	40µg/100 cm^2	35 ppm
New Zealand (dry basis)	40 ppm	-	60ppm	80 ppm	-
U.S.					
Idaho	40 ppm	-	-	60 ppm(30 days for 2 consecutive months 80 ppm (max)	-
Kentucky (dry basis)	-	-	60ppm	40ppm (30 days for 6 consecutive months) 80 ppm (max)	-
Maryland (dry basis)	40 ppm unwashed forage.	-	60ppm unwashed forage.	80 ppm unwashed forage	-
Montana	-	-	-	-	35ppm (max in 28 days)
New York(total F.dry basis)	-	40ppm	60ppm	80 ppm	-
Texas	40 ppm	-	-	60 ppm (30 days for 3 consecutive months) 80 ppm(for 2 consecutive months)	-
Washington (dry basis)	40 ppm	-	60ppm	80 ppm	40 ppm*
Wyoming	-	-	-	-	25 ppm

* Cured forage.

Appendix 19

ROAD FACILITIES AND TRAFFIC VOLUMES

APPENDIX 19

ROAD FACILITIES AND TRAFFIC VOLUMES

The traffic volumes in *Tables A19.1* and *A19.2* have been derived or estimated from information supplied by the New South Wales Department of Main Roads, Newcastle Divisional Office.

Estimates of 1979 traffic volumes are derived from 1976 traffic counts except where 1979 figures are available. The 1979 estimates are based on a 10 per cent increase between 1976 and 1978, and a 5 per cent increase between 1978 and 1979. This increase has been adopted following discussions with officers of the New South Wales Department of Main Roads, Newcastle.

i. *Tomago Road - East of the intersection with the Pacific Highway*

The most recent traffic figures available for Tomago Road were derived from counting carried out in 1976. These figures have been extrapolated to derive an estimation for 1979 average annual daily traffic. The hourly distribution of traffic, both total and heavy vehicles, is proportional to that for the Pacific Highway north of the intersection with the New England Highway. Traffic figures for 1979 are available for this section of the Pacific Highway although heavy vehicle numbers were only counted on weekdays and cannot be calculated for weekends.

The number of heavy vehicles using Tomago Road has been estimated at 200 vehicles per day (6.9 per cent of the total traffic volume).

Data for the hourly distribution of traffic volumes on Saturday and Sunday are available only for the Pacific Highway north of the New England Highway. Consequently, this information has been used to estimate weekend traffic volumes for all roads.

ii. *Pacific Highway - North of the intersection with the New England Highway*

The traffic distribution for this section of road was derived from actual counts done by the New South Wales Department of Main Roads in 1979.

iii. *Pacific Highway - South of the intersection with the New England Highway*

For this section of road, actual 1979 traffic counts were used to derive traffic volumes.

iv. *Industrial Drive - West of the intersection with Maude Street*

Average annual daily traffic numbers for 1979 were derived from 1976 traffic counts. The number of heavy vehicles is assumed to be 17 per cent of the A.A.D.T., based on a traffic count conducted by the New South Wales Department of Main Roads at the intersection with the Pacific Highway.

Volumes for Industrial Drive between Maude Street and Tourle Street, and for Tourle Street north of Industrial Drive are assumed to be proportional to the section of the Industrial Drive east of Maude Street.

Traffic volumes in *Table A19.1* for the two alternative road haulage routes considered have been derived as discussed above.

TABLE A19.1

ROAD FACILITIES AND TRAFFIC VOLUMES

Route 1	Road Widths and Number of Lanes	1976 A.A.D.T.	Estimated 1979 A.A.D.T.
Tomago Road - east of the intersection with Pacific Highway	2 Lanes, 6.1 m wide	2,520	2,911
Pacific Highway - North of Tomago Road	4 Lanes, 14 m wide	11,300	13,052
- at Hunter River Bridge, Hexham	2 Lanes, 6.7 m wide	13,480	15,310 (Actual)
- south of New England Highway, Hexham	7.38 km of dual carriageway, 4 to 6 Lanes	33,080	38,370 (Actual)
- north of SH23, Wallsend Road		29,160	33,680
- south of SH23, Wallsend Road		24,400	28,182
Industrial Drive - west of intersection with Maud St.	1.32 km of dual carriageway, 4 Lanes	11,370	13,132
- east of intersection with Maud St.		19,560	22,592
Tourle Street - north of intersection with Industrial Highway	4 Lanes, 14.5 m wide	13,370	15,442
- at bridge over south arm of Hunter River		12,270	14,172

Route 1a	Road Widths and Number of Lanes	1976 A.A.D.T.	1979 Estimated by Dept. Main Roads, (vpd)
Tomago Road - west of Nelson Bay Road	2 Lanes, 6.1 m wide	1,660	1,917
- north of Tomago Road	12.43 km of 2 Lanes 6.7 m wide	5,360	6,191
- south of Tomago Road		6,500	7,508
- Port Stephens Shire Boundary		7,440	8,593
- at Stockton Bridge		9,480	10,949

TABLE A19.2

AVERAGE ANNUAL DAILY TRAFFIC (1979)

TIME	*i. TOMAGO ROAD - east of the intersection with the Pacific Highway*				*ii. PACIFIC HIGHWAY - north of the intersection with the New England Highway*				*iii. PACIFIC HIGHWAY - south of the intersection with the New England Highway*				*iv. INDUSTRIAL DRIVE - west of the intersection with Maud Street*			
	Total Volume Week-days	Heavy Vehicle Volume Week-days	Total Volume Satur-days	Total Volume Sun-days	Total Volume Week-days	Heavy Vehicle Volume Week-days	Total Volume Satur-days	Total Volume Sun-days	Total Volume Week-days	Heavy Vehicle Volume Week-days	Total Volume Satur-days	Total Volume Sun-days	Total Volume Week-days	Heavy Vehicle Volume Week-days	Total Volume Satur-days	Total Volume Sun-days
2400-0100	17	3	57	43	90	27	300	220	411	26	752	551	141	24	232	298
0100-0200	15	4	30	31	80	41	160	160	103	22	401	401	35	6	124	217
0200-0300	16	6	23	19	82	62	120	100	101	58	301	251	35	6	93	136
0300-0400	8	2	21	16	44	21	110	80	71	27	276	200	24	4	85	108
0400-0500	13	4	23	12	70	39	120	60	133	47	301	150	46	8	93	81
0500-0600	29	6	63	21	152	54	330	110	370	71	827	276	127	22	255	149
0600-0700	199	8	82	53	1045	77	430	270	1595	192	1078	677	888	151	332	369
0700-0800	214	13	114	74	1128	123	600	380	3506	295	1504	952	1200	204	463	515
0800-0900	204	15	173	111	1073	148	910	570	3179	342	2281	1428	1088	185	703	773
0900-1000	165	16	203	175	869	154	1070	900	2029	324	2682	2255	694	118	826	1220
1000-1100	191	18	215	214	1002	165	1130	1180	2008	330	2832	2756	684	116	872	1491
1100-1200	162	15	205	195	851	140	1080	1000	1827	285	2707	2506	625	106	834	1355
1200-1300	165	12	219	199	870	114	1150	1020	1437	234	2882	2556	492	84	888	1383
1300-1400	161	13	194	197	848	129	1020	1010	1795	319	2556	2531	614	104	788	1369
1400-1500	202	13	167	199	1061	122	880	1020	2319	300	2205	2556	794	135	679	1383
1500-1600	276	13	162	240	1450	127	850	1230	3276	298	2130	3082	1121	191	656	1667
1600-1700	247	9	150	257	1297	88	790	1320	3908	226	1980	3308	1337	227	610	1789
1700-1800	204	5	135	240	1072	47	710	1230	3148	172	1779	3082	1077	183	548	1667
1800-1900	109	4	183	187	575	39	960	960	1535	67	2406	2405	525	89	741	1501
1900-2000	88	4	160	138	463	35	840	710	1343	42	2105	1779	460	78	649	962
2000-2100	59	5	67	107	311	50	350	550	885	61	877	1378	303	52	270	746
2100-2200	60	4	48	70	317	42	250	360	768	43	627	902	263	45	193	488
2200-2300	66	5	131	60	349	46	690	310	905	40	1729	777	310	53	553	420
2300-2400	40	3	122	49	211	29	640	250	728	35	1604	626	249	42	494	539
Total	2910 (6.9% heavy vehicles)	200	2944	2907	15310 (12.5% heavy vehicles)	1919	15490	14930	38370 (10.0% heavy vehicles)	3857	38822	37385	13132 (17.0% heavy vehicles)	2232	11961	20223

Appendix 20

PUBLIC ATTITUDES TO THE DEVELOPMENT OF AN ALUMINIUM SMELTER

APPENDIX 20

PUBLIC ATTITUDES TO THE DEVELOPMENT OF AN ALUMINIUM SMELTER

A20.1 BACKGROUND

Preliminary responses from residents to the siting of an aluminium smelter within the district were canvassed prior to the completion of the Environmental Impact Statement for the following reasons:

i. to ensure all residents within proximity to the site were aware of the proposal,

ii. to provide residents with an opportunity to ask questions and to inform them of their prerogative to read and to make written submissions concerning the proposal during the period of public display of the Environmental Impact Statement,

iii. to obtain useful comments which could be of assistance in the preparation of the Environmental Impact Statement.

All residences north of the Hunter River as shown in *Figure 6.18* were visited and contact was made with 86 per cent of the householders of these residences. Where residents were absent, a letter was placed in the mail box on the second occasion. A copy of this letter is included as *Appendix A20.4*.

South of the Hunter River, responses were considerably different to those in the Tomago area, for reasons outlined below, and so a much smaller sample of ten residents was used and letters placed in 40 mail boxes.

A20.2 POPULATION CHARACTERISTICS

The average length of residency in the area of those persons interviewed north of the Hunter River, was approximately 15 years and ranged from 2 months to 46 years. Most of the older residents settled in the area with either the establishment of the Courtaulds textiles factory, or were involved in agricultural pursuits. During the last 10 years, new residents have moved into the area because of the need to maintain a large non-urban area for their hobby, e.g., dog breeding, or were seeking a rural retreat. At the time of interviewing, few residents had discussed the proposed smelter with their neighbours. The lifestyle of the residents is distinctly rural; 90 per cent have their own vegetable gardens and many keep poultry.

The population south of the Hunter River comprises a high proportion of retired couples or elderly single persons. Their lifestyle is essentially urban orientated.

A20.3 RESULTS OF INTERVIEWS

Of the fifty residents interviewed in the Tomago area fifteen (30 per cent) indicated concern with the smelter, twenty eight (56 per cent) were not concerned, and seven (14 per cent) were undecided.

Of the ten residents interviewed at Hexham, five were concerned and five were not. The views expressed by all residents are summarised in *Table A20.1*.

North of the Hunter River

Concerned residents at Tomago lived mainly on Tomago Road east of the site. Many were in the path of prevailing westerly winds and were relatively new to the area. Many of these residents had heard unfavourable comments concerning aluminium smelters at a number of public meetings held during late 1979. Only two residents had prior knowledge of aluminium smelters.

Twelve Tomago residents were concerned with the effects of the smelter on human health. The majority of these residents also expressed concern for the wildlife in the area, particularly the Koalas.

Seven residents stated they were resigned to the fact that a smelter would go ahead and their views would not be heeded. These residents accepted such

TABLE A20.1

VIEWS EXPRESSED BY RESIDENTS IN THE TOMAGO AND HEXHAM AREAS ABOUT THE PROPOSED SMELTER

REASON	Number of Residents Indicating this Reason*
Residents Showing Concern (20)	
Likelihood of deterioration in human health	12
Destruction of rural environment and/or rural pursuits	8
No specific reason stated other than opposition to the present governmental decision-making processes and the inevitability of such development in an industrial area	7
Effect on the Hunter River and the fishing industry	5
Livelihood will be affected	3
Increase in traffic	3
Effect on the Tomago Sandbeds and water quality	2
Residents Not Concerned (33)	
Increased employment opportunities	17
Pollution levels not likely to be higher than ambient levels	14
Insufficient knowledge at present to be concerned	7
There was no adverse effects associated with the Courtaulds textiles factory	6
Not concerned provided adequate pollution standards were met	4
Temporary residence period	3
The Alcan smelter at Kurri Kurri has not created any adverse effects	3
Reassured by Company representatives at a Council meeting that there would be no adverse effects	2
Residents with Mixed Feelings (7)	
Concern for health but can see employment advantages	7

*Note: A number of residents expressed more than one reason for supporting their view.

developments as inevitable in an industrial area. Many of these residents felt that any protests would be ignored by relevant authorities, as had happened previously when they protested against the transfer of women inmates from Cessnock Gaol to the Tomago Detention Centre.

Most of the older residents were not concerned with the proposed smelter as they perceived the impacts of the smelter to be similar to those of the Courtaulds textiles factory. They felt that they had adjusted to living in an industrial area and valued the smelter more as a source of jobs for the unemployed. Newer residents, who favoured the smelter, had hobbies incompatible with an urban environment, e.g., dog breeding, and were not concerned with the industries.

All residents interviewed on the Pacific Highway north of the Hexham Bridge and on Old Punt Road, were not concerned with the smelter, as were some residents on Tomago Road, particularly those west of the site. Residents on Old Punt Road and Tomago Road in the vicinity of the International Motordrome felt that the effects of the smelter could not be as detrimental as the noise and dust from the motordrome.

Nineteen residents were indecisive and may easily change their opinions. These included residents who required more information, those who were not concerned with pollution standards, and those with mixed feelings. Only three concerned residents based their view on experience with aluminium smelters elsewhere.

Approximately 500 m east of the site, a retired resident grows orchids as a full-time hobby. The owner is the President of the Orchid Society of Newcastle and has developed a large range of Australian and overseas varieties over the past 20 years. These are grown both indoors in glasshouses and outdoors, as some species, particularly Cymbidiums cannot be grown under cover. During recent years, he has built up a small export trade in sales. This resident expressed particular concern regarding the possible effects of fluoride emissions on his orchids.

A number of graziers expressed concern about the effect of fluoride uptake in their herds and also the possibility of increased industrialisation causing rezoning of rural land with resultant higher rates.

South of the Hunter River

Interviewing in the Hexham area was restricted to the occupants of ten residences, representing a 10 per cent sample. In all cases, there was no absolute opposition to the proposal provided adequate pollution control levels were maintained. The main concern expressed by at least half of the residents related to the likelihood of increased effluents in the Hunter River and the associated deterioration in the fishing industry.

A number of residents were more concerned with their local environment and stated that emission levels from an aluminium smelter could not be worse than the noise and dust from trains, highway traffic and adjacent coal stockpiles.

Summary

Residents on the Pacific Highway and Old Punt Road, as well as at Hexham, cannot view the smelter site and do not pass the site daily. These residents consider the smelter to be too distant to be of concern even though they are situated as close as many of the more concerned citizens to the east of the site.

The majority of concerned residents live along Tomago Road east of the site.

The comparison of the smelter to the Courtaulds textiles factory and the lack of information most residents have concerning the smelter, e.g., its magnitude, type of emissions and its effects on traffic and existing facilities, indicate that many residents had not thought of, or discussed the smelter proposal or its implications.

APPENDIX A20.4

JAMES B. CROFT and ASSOCIATES

CONSULTING ENVIRONMENTAL SCIENTISTS,
ENGINEERS, PLANNERS.

13th December 1979

JBC/cw.

Dear Resident,

James B. Croft and Associates are undertaking environmental investigations on behalf of Aluminium Pechiney Australia Pty. Limited for their proposed aluminium smelter, to be located at the former Courtaulds' site, Tomago.

We are visiting residents within proximity of the proposed development to discuss the project with them.

As we have called on your residence and you were absent, could you please telephone either Mr. Wayne Perry or Miss Liz Paslawskyj on 26 1828, as we would very much like to talk with you about the project.

Thanking you in anticipation,

Yours faithfully,

DR. JAMES B. CROFT
JAMES B. CROFT & ASSOCIATES

Suite 7
Corona Building
275a Hunter St.
NEWCASTLE
Ph. (049) 26 1828

Laboratory
3 Bowser St.
Broadmeadow
NEWCASTLE
Ph. (049) 61 6114

Sydney Office
Thirteenth Floor
175 Pitt St.
SYDNEY
Ph. (02) 233 3736

Appendix 21

COST BENEFIT ANALYSIS OF INFRASTRUCTURE SUPPLIED BY THE NEW SOUTH WALES GOVERNMENT

APPENDIX A21

COST-BENEFIT ANALYSIS OF INFRASTRUCTURE SUPPLIED BY THE NEW SOUTH WALES GOVERNMENT

In the analysis all costs and benefits have been included in the years in which they are expected to accrue. *Table A21.1* shows the timing and amounts of these figures represented in thousands of 1980 dollars. For the purposes of discounting, a rate of 4 per cent has been used; this being the real cost of funds given the interest on long term government borrowing of 12.6 per cent and assuming 8 per cent long term inflation.

From 1989 the net benefit becomes constant at a value of $3.05 million per annum over the remaining 49 year life of the smelter, assuming a 52 year life from commencement of full production in 1986. This represents an annuity which has a 1989 value of $64.092 million which is then discounted with the earlier net benefits to achieve a 1980 net present value of $60.4 million.

Allowances have been made for the fact that the smelter takes some time to construct and to reach full production. Also, the full effect of employment and income multipliers has been lagged to simulate the flow-on effects within the regional economy.

TABLE A21.1

COST-BENEFIT ANALYSIS
(1980 $,000's)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989 and after
COSTS										
Rotten Row Berth	355	1,369	644							
Tomago Road Upgrading		300								
Road Maintenance				19	45	65	90	90	90	90
Cost of Loan Funds	31	40	48	56	64	73	73	73	73	--
TOTAL COSTS	386	1,709	692	75	109	148	163	163	163	90
BENEFITS										
Harbour Charges				111	261	375	522	522	522	522
Berth Charges				18	41	59	82	82	82	82
Payroll Tax	100	410	510	1,260	1,160	920	750	750	750	750
Consumption Taxes	160	630	790	1,399	1,327	1,047	878	878	878	878
Income Tax	--	150	560	710	1,257	1,182	932	789	789	789
Fuel Tax				4	9	14	19	19	19	19
Land Tax	--	100	100	100	100	100	100	100	100	100
TOTAL BENEFITS	260	1,290	1,960	3,602	4,155	3,697	3,283	3,140	3,140	3,140
NET BENEFITS	-126	-419	1,268	3,527	4,046	3,549	3,120	2,977	2,977	65,092*
DISCOUNTED NET BENEFITS	-121	-387	1,127	3,015	3,326	2,805	2,371	2,175	2,092	43,973

* Value of the $3.05 m annuity over 49 years.

NET PRESENT VALUE (1980) = $60.4 million

References

REFERENCES

APPENDICES

Australian Groundwater Consultants Pty. Limited, 1980. Proposed Smelter Site, Tomago. Preliminary Groundwater Appraisal. *in* Report on Site Investigation Proposed Smelter, Tomago. *Ground Test Pty. Limited, 1980.*

Balazova, G. and Hluchan, E., 1969. Der Einfuss Von Fluoroexhalten auf die Tiere in der Urngebung einer Aluminium fabrik. *Proc. Eur. Congr. Influence Air Pollution, 1st Wageningen, 1968. 41-48.*

Barrett, C.F., Hall, D.J. and Simmonds, A.G., 1978. Dispersion from Chimneys Downwind of Cubical Buildings - A Wind Tunnel Study. Proceedings of the Ninth International Technical Meeting on Air Pollution Modelling and its Application. *North Atlantic Treaty Organisation.*

Beadle, N.C.W., 1972. Student Flora of North Eastern N.S.W. *University of New England, Armidale.*

―――――――― *, Evans, O.D. and Carolin, R.C., 1972.* Flora of the Sydney Region. *Reed, Sydney.*

Benedict, H.M., Ross, J.M. and Wade, R.W., 1965. Some Responses of Vegetation to Atmospheric Fluorides. *J.Air.Polln.Cont. Assoc. 15, 253-255.*

Briggs, G.A., 1969. Plume Rise. *US Atomic Energy Commission, Division of Technical Information.*

Bureau of Mineral Resources, 1979. Petroleum Newsletter, No.79.

Chang, C.W., 1975. Fluorides *in* Responses of plants to Air Pollution J.B. Mudd and T.T. Kozlowski. *Eds Academic Press N.Y.*

Cheremisinoff, P.N. and Morresi, A.C., 1977. Environmental Assessment and Impact Statement Handbook. *Ann Arbor Science Publishers Inc.*

Christianson, G.A., 1977. Climate and Air Quality. A Technical Supplement to the West-Central North Dakota Regional Environmental Impact Study. Prepared by the Division of Environmental Engineering of the *North Dakota State Department of Health, G.A. Christianson, Director.*

Cogger, H.G., 1975. Reptiles and Amphibians of Australia. *Reed, Sydney.*

Condon, H.T., 1975. A Check-List of the Birds of Australia - Part 1, non-passerines. *R.A.O.U.*

REFERENCES (cont'd)

Corlette, J.M.C., 1944. Water Supply for Newcastle, N.S.W., from the Tomago Sandbeds. *J. Inst. Eng. Aust. 16 (7-9).*

James B. Croft and Associates, 1979. Environmental Assessment of Three Potential Sites for an Aluminium Smelter in the Newcastle Area for *Aluminium Pechiney Australia Pty. Limited (unpubl.)*

Dakin, W.J., 1960. Australian Seashores. *Angus and Robertson, London.*

Department of National Development, 1978. Demand for Primary Fuels in Australia.

Doley, D., 1975. The Response of Typical Plants to atmospheric fluoride fumigation. *Report on Research sponsored by Comalco Limited. Department of Botany, University of Queensland.*

ECOPOL, 1980. Etude Previsionnelle de la Dispersion Atmospheric des Effluents Gazeuz - Project N.S.W., *Usine de Tomago (Australie) by ECOPOL (Paris) for Aluminium Pechiney.*

Environmental Protection Agency, 1979. Primary Aluminium Draft Guidelines for Control of Fluoride Emissions from Existing Primary Aluminium Plants. *PB-294938, National Technical Information Service, 1979.*

Furth, W.F. and Weil, J.C., 1977 . Calculated Particular and Sulphur Dioxide Ground-level Concentrations for the Present and Proposed Eastalco Aluminium Plant *Martin Marietta Corp., Environmental Technology Centre, Maryland.*

Galbraith, J., 1977. Wild Flowers of South-east Australia. *William Collins Sons. London.*

Garrec, J.P., Plebin, R., Lhoste, A.M. and Grenoble, F., 1978. The Effect of Fluoride on the Mineral Composition of Polluted Fir Needles *(Albies Alba mill). Fluoride 11(2), 68-75.*

Gerard, R. and Herzog, A., 1971. Results of Pumping Tests at Tomago, N.S.W. Final Report for Rutile and Zircon Mines (Newcastle) Limited. *University of Newcastle (unpubl.)*

Goodrick, G.N.A., 1970. Survey of Wetlands of Coastal N.S.W. *CSIRO Technical Memo No. 5.*

Gordon, M., Jarvie, W. and McCalden, G., 1976. The Newcastle and Hunter Region Year Book 1976. *The Datex Co-Operative Limited, Newcastle.*

REFERENCES (cont'd)

Gow, G.F. and Swanson, S., 1977. Snakes and Lizards of Australia. *Angus and Robertson, Sydney.*

Griffin, R.J., 1964. The Tomago Sandbeds. Part 1. *Geological Survey of New South Wales. Report GS1964/199 (unpubl.)*

Guderian, R., 1977. Ecological Studies 22 - Phytotoxicity of Acidic Gases and It's Significance in Air Pollution Control *Springer - Verlag, Berlin.*

Guthrie, A.C.M. and Lamb, A.N., 1976. Ground Level Concentrations from Power Station Emissions. *Clean Air, May, 1976.*

Hansen, E.D., Wiebe, H.H. and Thorne, Wynne, 1958. Air Pollution with Relation to Agronomic Crops:VII. Fluoride Uptake from Soils. *J. Agronomy, 50, 565-568.*

Harwood, C.E. and Jackson, W.D., 1975. Atmospheric losses of four plant nutrients during a forest fire. *Australian Forestry 38(2), 92-99.*

Hodge, H.C. and Smith, F.A., 1970. Air Quality Criteria for the Effects of Fluorides on Man. *Journal of the Air Pollution Control Association, 20(4), 225-232.*

——————————— *1977.* Occupational Fluoride Exposure *in* Fluorides: a new critical review. Hughes, J.P. (ed.) *J. Occup. Med. 19(1).*

——————————— *1979.* Airborne Fluorides and Man. Part II. *Critical Reviews in Environmental Control. Feb. 1979.*

Hunter District Water Board, 1957. Water Supplies from Underground Sources. *Paper No. 1. Report of the Proceedings of the 8th Conference of Professional Officers representing the Authorities controlling Water Supply and Sewerage undertakings serving the Cities and Towns of Australia.*

Hunter Regional Planning Committee, 1977. Hunter Regional Plan - Discussion Paper No. 1. *New South Wales Planning and Environment Commission.*

Hunter Valley Research Foundation, 1978. Directory of Manufacturing Establishments for the Hunter Region. *Research Centre, Hall Street, Maryville, N.S.W.*

——————————— *1979.* This is Newcastle, 1979. 20th Edition. *Newcastle City Council.*

REFERENCES (cont'd)

Hutchison, R.D., 1979. Fluoride uptake and translocation in *Avicennia marina*. Unpublished B.Sc. Honours Thesis *University of Newcastle (Botany Department) N.S.W.*

Israel, G.W., 1973. Evaluation and Comparison of three atmospheric fluoride monitors under field conditions. *Atmospheric Environment 8, 159-166.*

Jacobson, J.S., Weinstein, L.H., McCune, O.C. and Hitchcock, A.E., 1966. The accumulation of fluorine by plants. *J. Air.Poll.Contr. Assoc. 16, 412-417.*

Joint Coal Board, 1979. A Statistical Year Book 1978/79.

Kay, C.E., Tourangeau, P.C. and Gordon, C.C., 1975. Industrial fluorosis in wild mule and whitetail deer from Western Montana. *Fluoride 8, 182-191.*

Karstad, L., 1970. Wildlife in Changing Environment *in* Environmental Change, focus on Ontario. *Elrich, D.F. (Ed.) 73-80 N.Y.*

Keller, T., 1974. Translocation of Fluoride in Woody Plants. *Fluoride 7(1), 31-35.*

Lamp, C. and Collet, F., 1976. A Field Guide to Weeds in Australia. *Ikata Press, Melbourne.*

Larsen, S. and Widdowson, A.E., 1971. Soil Fluorine. *J. Soil Science 22, 210-221.*

Lavada, R.S. and Reinaudi, N., 1979. Fluoride in Salt-affected Soils of La Pampa (Republica Argentian) *Fluoride 12, 28-32.*

Lee, C.J., Miller, G.W. and Welkie, G.W., 1966. The Effects of hydrogen fluoride and wounding on respiratory enzymes in soybean leaves. *Int.J.Air Water Pollut. 10, 169-181.*

MacIntyre, W.H., 1957. Fate of Air-Borne Fluorides and attendant effects upon Soil Reaction and Fertility. *Journal of Official Agricultural Analytical Chemists 40, 958-973.*

Macoboy, S., 1969. What Flower is that? *Paul Hamlyn, London.*

Martin, W. and Stern, A.C., 1974. The World's Air Quality Management Standards. Volume 1. EPA-650/9-75-001a, *US Environmental Protection Agency, Office of Research and Development, Washington D.C.*

Martin, G.R., Brown, K.S., Matheson, D.W. et al, 1979. *Mutation Research Vol.66, 159.*

REFERENCES (cont'd)

McClenahen, J.R., 1976. Distribution of Soil Fluorides near an Airborne Fluoride Source. *J. Environ.Qual.5(4), 472-475.*

McCune, D.C., Hitchcock,A.G., Jacobson, J.S., and Weinstein, L.H., 1965. Fluoride Accumulation and growth of plants exposed to particulate cryolite in the atmosphere. *Contrib.Boyce Thompson Instit.23, 1-12.*

McGrath, C.A., 1967. A Water Balance of the Tomago Sandbeds. *University of Newcastle* - B.A. Thesis (Department of Geography).

McLaughlin, S.B. and Barnes, R.L., 1975. Effects of Fluoride on Photosynthesis and Respiration of South-East American Forest Trees. *Environ.Pollut.8*

McNulty, I.B. and Newman, D.W., 1957. Effects of atmospheric fluoride on the respiration rate of bush bean and gladiolus leaves. *Plant Physiol.32, 121-124.*

McQuaker, N.R. and Gurney, M., 1977. Determination of total fluoride in soil and vegetation using an alkali fusion-selective ion electrode technique. *Analytical Chemistry 49(1),53-56.*

Mead, R.J., Oliver, A.J. and King, D.R., 1979. Metabolism and Defluorination of Fluoroacetate in the Brush-tailed Possum *(Trichosurus vulpecula). Aust. J.Biol.Science 32,15-26.*

Mohamed, A.H. and Chandler, M.E., 1977. Congr.Rec., 42.

Morris, A.K., 1975. The Birds of Gosford, Wyong and Newcastle (County of Northumberland). *Aust. Birds 9(3).*

Murray, F., 1980. A Study of Fluoride Concentrations and Injury Indicators on Kooragang Island. A Report to State Pollution Control Commission. *Dept.Biol.Science Univ. Newcastle.*

National Academy of Sciences, 1971. Fluorides. *National Academy of Sciences. National Research Council, Washington, D.C. 1971, 163-221.*

National Energy Advisory Committee, 1977. Australia's Energy Resources An assessment. December, 1977.

National Health and Medical Research Council, 1979. Submission to the Committee of Inquiry into the Fluoridation of Victorian Water Supplies. *CSR Occup.Health.*

Newman, J.R., 1975. Effects of Industrial Air Pollution on Wildlife, *Biol. Conserv. Applied Science, Publishers, England.*

REFERENCES (cont'd)

Newman, J.R., 1977. Sensitivity of the House Martin *(Delichon urbica)* to fluoride emissions. *Fluoride 10, 73-76.*

Oelschlager, W., 1971. Fluoride uptake in soil and its depletion. *Fluoride 4(2), 80-84.*

——————————, *Feyler, L. and Schwatz. E., 1972.* Fluorine Content of Tissue, Blood and Milk of Cows Outside of and Within Fluoride Emission Areas. *Adv. Vet. Sci. A19:743 - 52/1972.*

Omueti, J.A.I. and Jones, R.L., 1977. Fluoride Adsorption by Illinois Soils. *J. Soil Science 28, 564-572.*

Parker, C.D. and Herzog, A., 1970. Summary and Conclusions from investigations (to 7.9.'70) into the Influence of Mineral Sand Mining on Hunter District Water Board Tomago Sandbeds Aquifer Conditions for *Rutile and Zircon Mines (Newcastle) Limited (unpubl.).*

Pasquill, F., 1961. The Estimation of the Dispersion of Windborne Material. *The Meteorological Magazine 90(1), 33-49.*

Planning Workshop Pty. Limited, 1977a. Primary Industry in the Hunter Region. *Hunter Regional Plan. Working Paper No. 5. New South Wales Planning and Environment Commission.*

—————————————— *1977b.* Land Use and Settlement. *Hunter Regional Plan. Working Paper No. 12. New South Wales Planning and Environment Commission.*

Rees, J., 1977. Tertiary Industry. *Hunter Regional Plan. Working Paper No. 7. New South Wales Planning and Environment Commission.*

R.A.O.U., 1975. Interim List of Australian Songbirds - Passerines.

Ride, W.D.L., 1970. A Guide to the Native Mammals of Australia. *Oxford Uni. Press, London.*

Robinson, W.O. and Edgington, Glen, 1946. Fluorine in Soils. *Soil Sci. 61, 341-353.*

Ross, C.W., Wiebe, H.H. and Miller, G.W., 1962. Effect of Fluoride on glucose catabolism in plant leaves. *Plant Physiol. 37, 305-309.*

Ruello, N.V., 1976. Environmental and Biological Studies of the Hunter River. *Operculum 5(2), 76-84.*

Singer, L. and Armstrong, W.D., 1968. Determination of fluoride in bone with the fluoride electrode. *Analytical Chemistry 40(3), 613-615.*

REFERENCES (cont'd)

Slater, P., 1970. A Field Guide to Australian Birds. Volume 1, non-passerines. *Rigby Limited, Adelaide.*

————, *1974.* A Field Guide to Australian Birds. Volume 2, passerines. *Rigby Limited, Adelaide.*

Soil Mechanics Limited, 1971. Tomago Aquifer Study, Newcastle, N.S.W., Australia. Volumes I, II and III for *Hunter District Water Board (unpubl.).*

Solberg, R.A. and Adams, D.F., 1956. Historical responses of some plant leaves to hydrogen fluoride and sulphur dioxide. *American J. of Botany 43, 755-760.*

Somers, E.V., 1971. Dispersion of Pollutants Emitted into the Atmosphere *in* Air Pollution Control. *Volume 1 ed W. Strauss, Wiley Interscience Publication.*

Specht, R.L., Roe, Ethel M. and Boughton, V.H., 1974. Conservation of Major Plant Communities in Australia and Papua New Guinea. *Aust. J. Botany Supplementary Series No. 7.*

State Pollution Control Commission, 1980. Pollution Control in the Hunter Valley with particular reference to Aluminium Smelting. 1980.

Stewart, D.J., Manley, J.R., White, D.A., Harrison, D.L. and Stringer, E.A., 1974. Natural Fluoride Levels in the Bluff Areas, New Zealand. I: Concentrations in Wildlife and Domestic Animals. *New Zealand J. of Science 7, 105-113.*

Strauss, W., 1971. Air Pollution Control. *Wiley-Interscience Publication.*

Suttie, J.W., 1977. Effects of Fluoride on Livestock *in* Fluorides: a new critical review. *J. Occup.Medicine 19(1).*

Thompson, L.K., Roberts, B.A. and Sidhu, S.S., 1979. Fluoride Accumulations in Soils and Vegetation in the Vicinity of a Phosphorus Plant. *Environ.Pollut. 18, 221-234.*

Troughton, E., 1941. Furred Animals of Australia. *Angus and Robertson, Sydney.*

Turner, D.B., 1961. A Diffusion Model for an Urban Area. *Journal of Applied Meteorology. Vol.3, pp83-91.*

————, *1970.* Workbook of Atmospheric Dispersion Estimates. *US Environmental Protection Agency.*

REFERENCES (cont'd)

Vallentine, H.R. and Herzog, A., 1968. Assessment of the Effects of Rutile Mining on the Yield of Aquifers near Tomago, N.S.W. Progress Report No. 1 for Rutile and Zircon Mines (Newcastle) Limited. *University of Newcastle, Department of Civil Engineering (unpubl.).*

Vines, R.G., 1968. Heat Transfer through bark and the Resistance of Trees to Fire. *Aust. J. Botany 16, 499-514.*

Weinstein, L.H., 1977. Fluoride and Plant Life. *J. Occupational Medicine 19, 49-78.*

Wood, D.H., 1970. An Ecological Study of *Antechinus stuartii (Marsupialia)* in a Southeast Queensland Rainforest. *Aust.J.Zool.18, 185-207.*

Wright, D.A. and Davison, A.W., 1975. The Accumulation of Fluoride by Marine and Intertidal Animals. *Environ.Pollut. (8).*

Yiamouyiannis, J. and Burk, D., 1977. Fluoride 10. p.102.

Borrower's name	Date	Ex: